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Excessive Daytime Sleepiness and Commercial Motor Vehicle Driver Safety

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Policy Statement

This evidence report was prepared by MANILA consulting group which holds the prime contract GS-10F-0177N/DTMC75-06-F-00039 with the Department of Transportation's Federal Motor Carrier Safety Administration. The purpose of this evidence report is to provide information regarding the current state of knowledge on the impact of excessive daytime sleepiness on Commercial Motor Vehicle driver safety. This evidence report is not intended as instruction for medical practice or for making decisions regarding individual patients.

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Executive Summary

Purpose of Evidence Report

According to the U.S. Department of Transportation¹ (Federal Motor Carrier Administration [FMCSA], 2009), there were 144,171 large trucks and 13,195 buses involved in fatal and non-fatal crashes in 2007. Of these, there were 83,908 and 15,888 injuries resulting from large truck and bus crashes, respectively. Similarly, 4,584 and 278 crashes for large trucks and buses, respectively, resulted in 4,808 (from trucks) and 322 (from buses) fatalities.

Numerous studies have highlighted the significant role that excessive daytime sleepiness plays in a large number of reported crashes. Estimates of its contribution to accidents range from as low as 1 percent to 3 percent (Knipling and Wang, 1995; U.S. Department of Transportation, National Center for Statistics and Analysis, 1998) to as high as 35 percent to 42 percent (Dingus et al., 1987; Leger, 1994), and it has been suggested that sleepiness is second only to alcohol as the most frequent cause of both single and multiple motor-vehicle accidents (Dingus et al. 1987).

This report aims to assess the role that sleep-related disorders play in crash risk for commercial motor-vehicle (CMV) drivers, particularly those that result in excessive daytime sleepiness and fatigue. Although this report was meant to exclude obstructive sleep apnea (OSA) and narcolepsy, because of previous research (FMCSA Evidence Report – Obstructive Sleep Apnea and Commercial Motor Vehicle Driver Safety, 2007), these disorders are highlighted among the other sleep disorders, because their primary symptoms are excessive daytime sleepiness, the focal point of this report. Also, the disorders each have their own classification in the 2005 International Classification of Sleep Disorders, 2nd Edition (ICSD-2) developed by the American Academy of Sleep Medicine (AASM).

The primary objectives of this report are to:

- Identify and describe the various sleep disorders relevant to CMV drivers, their prevalence and incidence, diagnosis and treatment, and their implications for the FMCSA. Of particular interest are sleep conditions (e.g., organically-based and/or environmentally-induced) that result in excessive daytime sleepiness and/or fatigue.
- Identify and describe literature that is available on the topic of sleep disorders and crash risk, and the implications for commercial drivers and for FMCSA, charged with developing regulations, policies and practices, which will to serve to reduce crashes, injuries, and fatalities involving large trucks and buses.
- Identify and describe awareness of driver fatigue within the trucking industry; current hours-of-service regulations; practices and management policies of trucking companies; campaigns, initiatives and programs aimed at reducing driver fatigue; evaluations of

¹These statistics are derived from two sources: the Fatality Analysis Reporting System (FARS) and the Motor Carrier Management Information System (MCMIS): http://ai.fmcsa.dot.gov/CrashProfile/n_overview.asp.

driver fatigue countermeasures; and recommended countermeasures for regulators and the trucking industry.

The primary question originally identified for assessment in this report was, “Are individuals with sleeping disorders other than OSA and narcolepsy (of which there are many) at an increased risk for a motor-vehicle crash, and if so, what is the level of that risk?” For example, in the FMCSA-sponsored OSA report regarding crash risk in CMV drivers (FMCSA, 2007), one of the primary questions was, “*Are individuals with obstructive sleep apnea (OSA) at an increased risk for a motor-vehicle crash when compared to comparable individuals who do not have the disorder?*” In this report, a comparable question for all sleep disorders, not including OSA and narcolepsy, is difficult to pose for several reasons.

First, dozens of sleep disorders have been described in the background of this report. Even after excluding sleep-disordered breathing conditions, OSA, and hypersomnias of central origin, such as narcolepsy, there remain numerous other potentially relevant sleep disorders. Using an approach similar to that used in the FMCSA-sponsored OSA report would require identifying one or more of the other many remaining sleep conditions, presumably those most relevant to the CMV driver population, to assess systematically. Unfortunately, the literature for each of these specific conditions, particularly as they pertain to crash risk of CMV drivers, is sparse to non-existent. This is unlike that which exists regarding OSA and crash risk, for which there is an extensive literature base to support systematic review. Thus, such an approach to the remaining conditions would be inefficient.

A second difficulty can be attributed to a large number of sleep disorders not being diagnosed and/or treated, and their individual rates of occurrence are somewhat unknown. In fact, it has been suggested that collectively, sleep-disordered breathing conditions and hypersomnias represent approximately 70 percent of the disorders people suffer. As a result, the literature available to pose systematic questions for other sleeping disorders is negligible.

The third and final difficulty described here is that a number of sleep-related conditions are inherent byproducts of the commercial truck-driving occupation itself. This is particularly true of the sleep disorders that are relevant in the current discussion (e.g., environmentally-induced sleep disorders, shift-work sleep disorders, etc). As a result, examining crash risk for the purpose of assessing the role of the medical examiner in evaluating drivers’ fitness to drive may be an ineffective approach to assessing and/or remedying the problem.

In large part, the functional impact of potentially relevant sleep conditions (e.g., insomnia, circadian rhythm sleep disorders, such as shift-work sleep disorders, and sleep-related movement disorders) are the same. The primary symptom of numerous conditions (particularly those relevant to the population of interest in this report—CMV drivers) is excessive daytime sleepiness and fatigue.

As a result, we have reframed the questions of this report. Rather than looking at individual disorders and their associated risks for crash, we have evaluated the functional impact of excessive daytime sleepiness and fatigue on driving. More specifically:

- Is excessive daytime sleepiness and fatigue related to crash risk?
- Are there other sleep-related risk-factors associated with crash and/or falling asleep while driving?

- Related to the above questions, are there screening tests available that will enable medical examiners to identify those individuals with relevant sleep disorders and/or disturbances who are at an increased risk for a motor-vehicle crash?

In addition to assessing the questions noted above, this report offers a review of efforts to reduce the role of sleepiness and fatigue in driving that go beyond regulations directed at drivers and/or the medical examiners who evaluate their fitness to drive. Specifically, the latter section of this report focuses on policies and practices of motor carriers and the trucking industry (e.g., health and wellness approaches, sleep- and fatigue-related countermeasures) to combat the risk associated with sleepiness and driving. In addition, driver-level efforts and technological approaches are summarized.

Identification of Evidence and Literature

Electronic searches of PubMed and the Transportation Research Information Services (TRIS) databases were conducted (through January 2009). In addition, we examined the reference lists of all obtained articles with the aim of identifying relevant articles not identified by our electronic searches. Hand searches of the “gray literature” were also performed.

General Characteristics of the Studies Evaluated

The studies identified and examined were quite heterogeneous in their study designs and methodologies. A number of the studies recruited participants from specialized sleep labs while others utilized commercial drivers sampled from rest areas, truck stops, and/or motor carriers. The literature was also separated generally into two distinct groups: studies utilizing commercial drivers or general passenger drivers. These studies are identified as such in the following sections. In addition, the studies varied in the methods of determining driving risk, including police records, self-reported crash histories, performance on simulators, and/or performance in prospectively designed real-world scenarios.

Because of the extensive heterogeneity of the studies assessed in this report, no attempt was made to quantitatively synthesize their results. Instead, this report offers a qualitative assessment of studies assessed for each of the questions addressed.

General Findings

Sleep- and Fatigue-related Driving: Review of Data

More than 80 sleep disorders exist within eight major classifications of the ICSD-2, which are identified by the American Academy of Sleep Medicine (AASM) in the ICSD-2. Most of those disorders’ primary symptoms are excessive daytime sleepiness and fatigue.

Three questions were assessed in this section:

- Is excessive daytime sleepiness and fatigue related to crash risk?
- Are there identifiable and/or correctable risk-factors associated with falling asleep while driving?

- Related to the above questions, are there screening tests available that will enable examiners to identify those individuals with relevant sleep disorders and/or disturbances who are at an increased risk for a motor-vehicle crash?

Not surprisingly, the results of the literature assessment for the first question revealed that a majority of studies found a significant association between subjective measures of excessive daytime sleepiness (most often measured using Epworth Sleepiness Scale [ESS]) with the risk of crash in both commercial and passenger drivers. Adjusted odds ratios for sleep-related crash as determined using ESS scores ranged from 0.7 to 21.03.

Given the finding that excessive daytime sleepiness and/or fatigue is associated with an increased risk for crash, the next question of interest was whether or not there are identifiable factors that can reasonably predict falling asleep at the wheel and/or becoming fatigued while driving. As assessment of the literature available regarding this question identified several risk factors most commonly associated with falling asleep at the wheel. These included the following factors:

- Excessive Daytime Sleepiness (as measured by ESS):
 - Prior Sleep
 - Time of Day
 - Work Duration

In studies described, these and other factors were associated to varying degrees, with falling asleep at the wheel. Excessive daytime sleepiness was generally the strongest predictor of falling asleep at the wheel.

Based on the findings of the above question, the obvious question arises: *Are there screening options for factors that may predict whether an individual will be likely to fall asleep at the wheel or become fatigued while driving?* Based on the studies evaluated, one risk factor identified for potential use in screening drivers was the ESS for excessive daytime sleepiness. Most studies found this to be one of the strongest predictors of falling asleep at the wheel. ESS is a simple tool that could be used to determine the presence of excessive sleepiness and increased likelihood of falling asleep at the wheel among truckers. In addition, excessive daytime sleepiness is a major risk factor for numerous sleep disorders. Thus, screening for this factor might also identify individuals with undiagnosed and/or treated sleep disorders. A problem with this approach, however, relates to the fact that ESS scores are based on self-report. A driver suffering from excessive daytime sleepiness might be motivated to minimize and/or under-report their sleep issues based on employment concerns.

Other factors, such as work duration and prior sleep, are not amenable to medical screening. As a result, further discussion is provided about efforts that go beyond regulations directed at drivers and/or the medical examiners who evaluate their fitness to drive, targeting instead efforts that focus on policies and practices of motor carriers and the trucking industry (e.g., health and wellness approaches, sleep- and fatigue-related countermeasures) to combat the risk associated with sleepiness and driving.

Policies and Practices Sections

Although CMV drivers are getting more sleep under FMCSA's revised hours-of-service regulations, they are continuing to spend long hours on the road. Awareness of driver fatigue has

increased over the past decade, but a gap exists between truckers and trucking companies on what is believed to cause driver fatigue. This gap, as well as inherent practices of trucking companies, has prevented trucking companies from implementing effective driver fatigue management strategies.

The Best Practices Compendium of Fatigue Countermeasures in Transport Operations, which has evaluated known countermeasures, offers recommendations that would significantly impact the way trucking companies operate, such as limiting night-time driving and split-shift patterns.

To help companies implement better practices without jeopardizing their businesses, FMCSA is currently participating in “The North American Fatigue Management Program for Commercial Motor Carriers,” which aims to improve fatigue management plans. The results of this program will not be seen for a year or so.

In-vehicle Devices

Among the dozens of in-vehicle sleep detection devices studied in an Australian systematic review (Wright et al., 2007); only 15 devices were identified as worth being further evaluated for the purpose of combating driver fatigue. By analyzing the status of devices currently available or in the late stages of development, the review focuses on those devices that are suitable for driving task. The 15 devices are categorized into four types (although five types are reviewed):

- Physiological sleepiness detection devices
- Sleepiness detection devices based on physical activity
- Devices based on behavioral measures
- Model-based predictions of sleepiness
- Devices based upon a combination of more than one approach or measure

The most promising of the devices are the physiological sleeping detection devices that follow eye activity. Many of the devices met many or all of the requirements needed to be successful for CMV drivers. No devices that monitor physical activity were recommended for further study. Several devices using a combination of driver steering-wheel measures and other sleepiness detection approaches were recommended.

Preface

Organization of Report

This report contains six major sections:

Section 1: Background – Sleepiness and Sleep Disorders

This section provides background information on sleep and sleep disorders in general, including:

- Normal sleep characteristics (biology of human sleep and sleepiness)
- A description of the 2005 International Classification of Sleep Disorders, 2nd Edition (ICSD-2) developed by the American Academy of Sleep Medicine (AASM)
- The prevalence, diagnosis, and treatment of sleep disorders as classified in the ICSD-2

Section 2: Crash Statistics, Sleep-related Crash Data, and Relevant Regulations

This section provides a summary of relevant crash statistics in CMV drivers, including common characteristics of crashes related to drowsy driving and sleepiness, the risks for crashes attributed to drowsy driving, and the population groups at highest risk.

This section also includes information pertaining to current regulatory standards and guidelines for driver fitness from the FMCSA and three other government transportation safety agencies considered to have well-developed medical fitness programs; the Federal Aviation Administration (FAA), the Federal Railroads Administration (FRA), and the Maritime Administration (MARAD). In addition, we summarize State-level standards for both commercial and private passenger drivers as they pertain to sleepiness and sleep-related disorders.

Section 3: Methods

This section outlines the methods utilized in this report, including the details of the literature search (search strategies, databases search) and how individual studies were reviewed and evaluated, including a description of the information sought from each study.

Section 4: Sleep- and Fatigue-related Driving: Review of Data

This section of this report provides an assessment of literature related to sleep disorders and sleep- or fatigue-related driving and its impact on crash risk. It also provides a summary and assessment of the literature related to identifying risk factors for falling asleep while driving.

Section 5: Policies and Practices in Management of Fatigue

This section reviews awareness of fatigue at the driver, fleet and government levels, and analyzes the strengths and weaknesses of policies and practices in place, as well as current initiatives and campaigns aimed at reducing driver fatigue. The section concludes with the evaluation and recommendation of countermeasures to reduce driver fatigue.

Section 6: In-Vehicle Detection Devices

With growing interest in utilizing sleepiness detection devices as a countermeasure to combat driver fatigue, this section highlights the requirements needed for such devices to work efficiently and non-hazardously for CMV drivers, as well as a wide range of devices that exist.

Scope

The primary mission of the U.S. Department of Transportation's (DOT's) Federal Motor Carrier Safety Administration (FMCSA) is to reduce crashes, injuries and fatalities involving commercial motor vehicles (including large trucks and buses) involved in interstate commerce. Their mission was authorized and mandated by the Motor Carrier Safety Improvement Act (MCSIA) of 1999, which aimed to curb the relatively high number of commercial motor vehicles (CMV) involved in injurious and/or fatal crashes.

This report aims to assess the role that sleep-related disorders, particularly those that result in excessive daytime sleepiness, play in crash risk for commercial drivers. This study does not specifically assess the impact of individual sleep disorders, such as FMCSA's systematic review of OSA (FMCSA Evidence Report—Obstructive Sleep Apnea and Commercial Motor Vehicle Driver Safety, 2007).

Objectives

The primary objectives of this report are to:

- Identify and describe the various sleep disorders, their prevalence or incidence, diagnosis and treatment, and their implications for the FMCSA. Of particular interest are sleep conditions (e.g., organically-based and/or environmentally-induced) that result in excessive daytime sleepiness and/or fatigue.
- Identify and describe literature that is available on the topic of sleep disorders and crash risk, and the implications for commercial drivers and for FMCSA, charged with developing regulations, policies and practices, which will serve to reduce crashes, injuries, and fatalities involving large trucks and buses.
- Identify and analyze current policies and practices within the trucking industry, as well as government regulations, which aim to reduce driver fatigue.

The primary question originally identified for assessment in this report was, “Are individuals with sleeping disorders other than OSA and narcolepsy (of which there are many) at an increased risk for a motor-vehicle crash, and if so, what is the level of that risk?” For example, in the FMCSA-sponsored OSA report regarding crash risk in CMV drivers (FMCSA, 2007), one of the primary questions was, “*Are individuals with obstructive sleep apnea (OSA) at an increased risk for a motor-vehicle crash when compared to comparable individuals who do not have the disorder?*” In this report, a comparable question for all sleep disorders, not including OSA and narcolepsy, is difficult to pose for several reasons.

First, dozens of sleep disorders have been described in the background of this report. Even after excluding sleep-disordered breathing conditions, OSA, and hypersomnias of central origin, such as narcolepsy, there remain numerous other potentially relevant sleep disorders. Using an

approach similar to that used in the FMCSA-sponsored OSA report would require identifying one or more of the other many remaining sleep conditions, presumably those most relevant to the CMV driver population, to assess systematically. Unfortunately, the literature for each of these specific conditions, particularly as they pertain to crash risk of CMV drivers, is sparse to non-existent. This is unlike that which exists regarding OSA and crash risk, for which there is an extensive literature base to support systematic review. Thus, such an approach to the remaining conditions would be inefficient.

A second difficulty can be attributed to a large number of sleep disorders not being diagnosed and/or treated, and their individual rates of occurrence are somewhat unknown. In fact, it has been suggested that collectively, sleep-disordered breathing conditions and hypersomnias represent approximately 70 percent of the disorders people suffer. As a result, the literature available to pose systematic questions for other sleeping disorders is negligible.

The third and final difficulty described here is that a number of sleep-related conditions are inherent byproducts of the commercial truck-driving occupation itself. This is particularly true of the sleep disorders that are relevant in the current discussion (e.g., environmentally induced sleep disorders, shift work sleep disorders, etc). As a result, examining crash risk for the purpose of assessing the role of the medical examiner in evaluating drivers' fitness to drive may be an ineffective approach to assessing and/or remedying the problem.

In large part, the functional impact of potentially relevant sleep conditions (e.g., insomnia, circadian rhythm sleep disorders, such as shift-work sleep disorders, and sleep-related movement disorders) are the same. The primary symptom of numerous conditions (particularly those relevant to the population of interest in this report—CMV drivers) is excessive daytime sleepiness and fatigue.

As a result, we have reframed the questions of this report. Rather than looking at individual disorders and their associated risks for crash, we have evaluated the functional impact of excessive daytime sleepiness and fatigue on driving. More specifically:

- Is excessive daytime sleepiness and fatigue related to crash risk?
- Are there other sleep-related risk-factors associated with crash and/or falling asleep while driving?
- Related to the above questions, are there screening tests available that will enable medical examiners to identify those individuals with relevant sleep disorders and/or disturbances who are at an increased risk for a motor-vehicle crash?

In addition to assessing the questions noted above, this report offers a review of efforts to reduce the role of sleepiness and fatigue in driving that go beyond regulations directed at drivers and/or the medical examiners who evaluate their fitness to drive. Specifically, the latter section of this report focuses on policies and practices of motor carriers and the trucking industry (e.g., health and wellness approaches, sleep- and fatigue-related countermeasures) to combat the risk associated with sleepiness and driving. In addition, driver-level efforts and technological approaches are summarized.

Section 1: Background – Sleepiness and Sleep Disorders

Driving is a complicated psychomotor performance, which depends on fine coordination between the sensory and motor systems. It is influenced by factors such as arousal, perception, attention, concentration, emotion, reflex speed, time estimation, auditory and visual functions, decision making and personality. Safe driving requires skills to maintain effective and reliable control of vehicles, the capacity to respond to the road, traffic, and other external clues, and the ability to follow the “rules of the road.” Any condition or lowered state-of-arousal that interferes with perception, cognition (including alertness, attention, and recall), or motor function, has the potential to interfere with driving ability.

Excessive drowsiness and/or falling asleep at the wheel have been identified in numerous reports, as primary factors in injurious and fatal crashes caused by both passenger and CMV drivers. The purpose of this report is to summarize literature that is available on the topic of sleep disorders and crash risk, and the implications for commercial drivers and for FMCSA, which is charged with developing regulations, policies, and practices that will to serve to reduce crashes, injuries, and fatalities involving large trucks and buses.

Definitions of Sleepiness and Fatigue

Box 1 provides definitions for relevant terms as they are used in this report. Sleepiness is synonymous with drowsiness and/or somnolence, which is defined as difficulty staying awake and/or a need to fall asleep. Fatigue, synonymous with tiredness, is defined as a feeling of weariness and a lack of energy that is generally associated with decrements in performance. Fatigue is most often a consequence of physical exertion, boredom, or a prolonged experience associated with the disinclination toward effort, eventually resulting in reduced performance efficiency. In the context of driving, fatigue is a psychologically-based conflict that occurs between the disinclination to drive and the need to drive. One result can be a progressive withdrawal of “attention” to the tasks required for safe driving. Inattention, however, can result from other, non-fatigue factors such as preoccupation, distractions inside the vehicle (e.g., use of cell phone, etc.), and other behaviors. The latter condition is outside the scope of this report.

Feeling drowsy or sleepy during the day is often related to not getting enough quality sleep. Lack of, or diminished, sleep over a period of time results in the accumulation of what is called a “sleep debt.” Studies have shown that the effects of sleep loss are cumulative (Carskadon & Dement, 1981; Dinges, Pack et al., 1997) and that regularly losing 1 to 2 hours of sleep at night can lead to chronic sleepiness over time. Only sleep can reduce sleep debt.

Both environmental and organic factors can lead to sleep restriction. Environmental factors, some beyond an individual’s control, include extended working hours, job and family responsibilities, and personal lifestyle choices. Organic or internal factors include the use of medications that effect or interrupt sleep, and/or medical conditions, including one or more of a variety of sleeping disorders.

Box 1: Definitions Relevant to Sleepiness, Fatigue, and Sleep Disorders

Drowsiness: Feeling abnormally sleepy during the day – often with a strong tendency to actually fall asleep during inappropriate situations or at inappropriate times; the period of quiet wakefulness occurring prior to sleep onset.

Fatigue: Feeling of tiredness or weariness usually associated with performance decrements.

Sleep: A state marked by lessened consciousness, lessened movement of the skeletal muscles, and slowed-down metabolism.

Sleep Debt: Result of recurrent sleep deprivation which occurs over time when an individual does not experience a sufficient amount of the restorative daily sleep that is required to maintain a sense of feeling rested and refreshed.

Sleep Deprivation: Acute or chronic lack of sufficient sleep.

Sleep Disorders: Broad range of illnesses arising from many causes, including, dysfunctional sleep mechanisms, abnormal physiological functions during sleep, abnormal biological clock, and sleep disturbances that are induced by factors extrinsic to the sleep process.

Sleepiness (somnolence, drowsiness): Difficulty in maintaining a wakeful state so that the individual falls asleep if not actively kept aroused; not simply a feeling of physical tiredness or listlessness.

Somnolence: Sleepiness, the state of feeling drowsy, ready to fall asleep.

Normal Sleep, Disruptions to Sleep, and Circadian Rhythms

Sleep is defined as a state of unconsciousness from which a person can be aroused. Until the 1950s, sleep was believed to be a passive, dormant part of life. However, the brain is very active during sleep, and in this state, the brain is relatively more responsive to internal stimuli than external stimuli.

Sleep affects physical and mental health, and is essential for the normal functioning of all the systems of the body. Many studies have made it clear that sleep disorders are dangerous not only to a person's body, but to their basic daily function. With decreased sleep, higher-order cognitive tasks are impaired early and disproportionately. On tasks used for testing coordination, sleep-deprived people perform as poorly as or worse than people who are intoxicated.

In general, the symptoms or effects of sleep disorders cause impaired performance, including:

- Loss of attentiveness
- Slower reaction times
- Impaired judgment
- Poor performance on skill-control tasks
- Increasing probability of falling asleep
- Subjective feelings of drowsiness or tiredness

Contributory factors include:

- Long periods awake
- Inadequate amount of sleep or quality of sleep
- Sustained mental or physical effort
- Disruption of circadian rhythms (the daily cycle of waking and sleeping)
- Inadequate rest breaks
- Environmental stresses (heat, noise and vibration)

Sleep Deprivation and Cumulative fatigue Effects

Individuals who fail to achieve an adequate period of sleep (7-8 hours in 24 hours) or who have been awake longer than the conventional 16-17 hours will suffer sleep deprivation, leading to reduced performance. The deprivation accumulates with successive sleep-deprived days and is superimposed on circadian rhythm effects. Additional sleep deficits may be caused by breaking daily sleep into two shorter periods in place of a single unbroken period of sleep. Finally, unimpaired performance is not restored instantly after resuming a conventional sleep schedule, but may take two or three such sleep cycles to reach normal performance.

In humans, it has been demonstrated that the metabolic activity of the brain decreases significantly after 24 hours of sustained wakefulness. Sleep deprivation results in a decrease in body temperature, a decrease in immune system function as measured by white blood cell count, and a decrease in the release of growth hormone. Sleep deprivation can also cause increased heart rate variability.

For the nervous system to work properly, sleep is needed. Sleep deprivation makes a person drowsy and unable to concentrate the next day. It also leads to impairment of memory and physical performance and reduced ability to carry out mathematical calculations. If sleep deprivation continues, hallucinations and mood swings may develop.

Most cells of the body show increased production and reduced breakdown of proteins during deep sleep. Sleep helps humans maintain optimal emotional and social functioning while awake by giving rest during sleep to the parts of the brain that control emotions and social interactions.

Stages of sleep

During sleep, people usually pass through five phases of sleep: stages 1, 2, 3, 4, and *REM* (rapid eye movement) sleep (defined in Box 2: Stages of SleepBox 2). These stages progress in a cycle from stage 1 to REM sleep, then the cycle starts over again with stage 1. Almost 50 percent of total sleep time is spent in stage 2 sleep, about 20 percent in REM sleep, and the remaining 30 percent in the other stages.

Box 2: Stages of Sleep

- **Stage 1 NREM sleep:** Occurs while a person is falling asleep. It represents about 5% of a normal adult's sleep time.
- **Stage 2 NREM sleep:** In this stage, (the beginning of "true" sleep), the person's electroencephalogram (EEG) will show distinctive wave forms called sleep spindles and K complexes. About 50% of sleep time is stage 2 REM sleep.
- **Stages 3 and 4 NREM sleep:** Also called delta or slow wave sleep, these are the deepest levels of human sleep and represent 10-20% of sleep time. They usually occur during the first 30-50% of the sleeping period.
- **REM sleep:** REM sleep accounts for 20-25% of total sleep time. It usually begins about 90 minutes after the person falls asleep, an important measure called REM latency. It alternates with NREM sleep about every 70 to 90 minutes throughout the night. REM periods increase in length over the course of the night.

During stage 1, which is light sleep, a person can drift in and out of sleep and be awakened easily. The eyes move very slowly and muscle activity slows. People awakened from stage 1 sleep often remember fragmented visual images. Many also experience sudden muscle contractions, called *hypnic myoclonia*, often preceded by a sensation of starting to fall.

In stage 2 sleep, eye-movements stop and electrical activity in the brain slows, with occasional bursts of rapid waves called *sleep spindles*.

In stage 3, extremely slow brain activity (i.e., *delta waves*) occurs, interspersed with smaller, faster waves.

By stage 4, the brain produces delta waves almost exclusively. It is very difficult to wake someone during stages 3 and 4, which together are called *deep sleep*. There is no eye movement or muscle activity. People awakened during deep sleep do not adjust immediately and often feel groggy and disoriented for several minutes after they wake up.

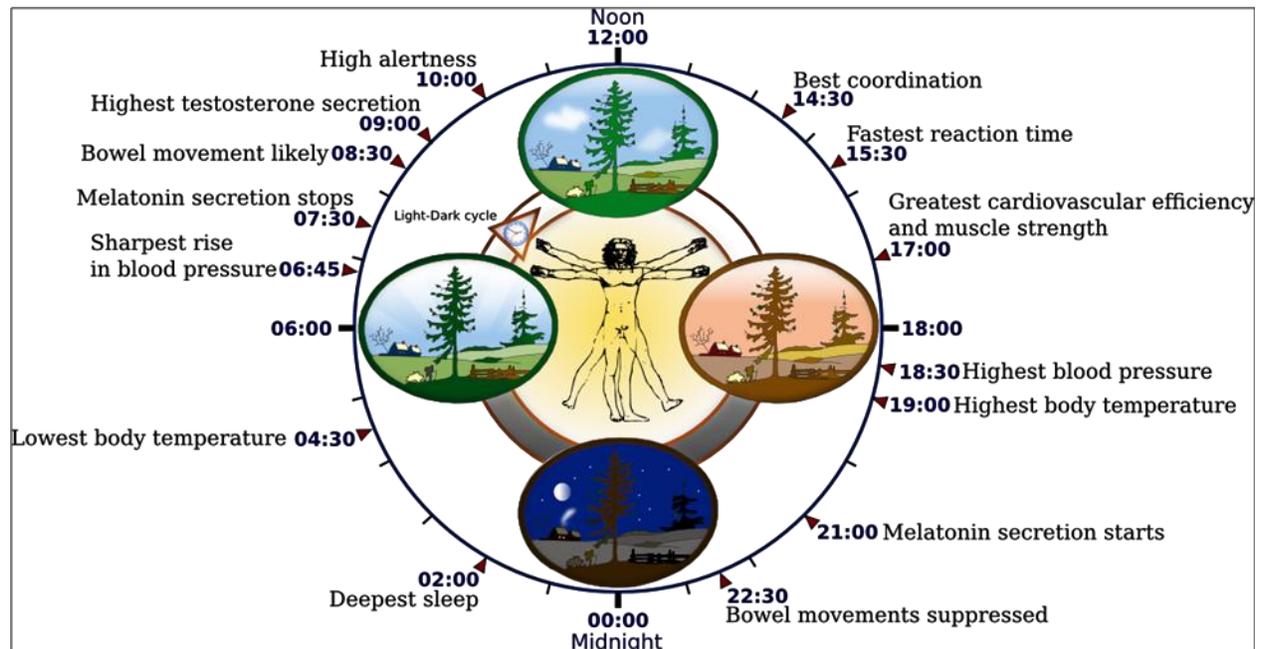
When people switch into REM sleep, their breathing becomes more rapid, irregular, and shallow, their eyes jerk rapidly in various directions, and the muscles in their limbs become temporarily paralyzed. Their heart rate increases and blood pressure rises. When people awaken during REM sleep, they often remember their dreams.

The first REM sleep period usually occurs about 70 to 90 minutes after falling asleep. A complete sleep cycle takes 90 to 110 minutes on average. The first sleep cycles each night contain relatively short REM periods and long periods of deep sleep. Near the end of sleep, the sleep cycle is comprised largely of stages 1, 2, and REM.

Circadian Rhythm

Biological variations that occur in the course of 24 hours are called circadian rhythms. Circadian rhythms are controlled by the body's biological clock (Figure 1). Many bodily functions follow the biologic clock, but sleep and wakefulness comprise the most important circadian rhythm. Circadian sleep rhythm is one of the several body rhythms modulated by the hypothalamus.

Figure 1: Overview of biological circadian clock in humans



Source: Mrabet (2004)

People who have a conventional sleep pattern (sleeping for 7 or 8 hours overnight) experience maximum sleepiness in the early hours of the morning and a smaller dip in the early afternoon (Figure 2). During the low points of the cycle, individuals have a reduced attentiveness. Similarly, people find it difficult to fall asleep during high-attentiveness periods.

Circadian rhythms can be affected to a certain degree by almost any kind of external stimulus, for example, the beeping of the alarm clock or the timing of meals. The cycle is anchored in large part by the natural sunlight and darkness cycle, but is also tied to an individual's externally imposed pattern of sleep and waking times.

Symptoms similar to those seen in people with jet lag (e.g., excessive daytime sleepiness) are common in people who work during nights or work in shifts. Because these people's wake time conflicts with powerful sleep-regulating cues like sunlight, they often become uncontrollably drowsy during work or may have difficulty falling asleep during their off time (Figure 3). As such, it follows that the performance of night shift workers is somewhat reduced.

In addition, circadian rhythms are persistent, and can only be shifted by 1 to 2 hours forward or backward per day by externally imposed changes in work/sleep routines and travel across time zones. Thus, changing the starting time of a work shift by more than these amounts, or the first night shift after a "weekend" break during which conventional sleep times are often followed will also reduce attentiveness. Because the function of sleep has not been fully determined, the exact number of hours that a person should sleep is unknown. Some persons claim to work optimally with only 3-5 hours of sleep per night, while some admit needing at least 8 hours of sleep per night (or more) to perform effectively. Therefore, sleep deprivation is best defined by group means and in terms of the tasks impaired.

In tasks requiring judgment, increasingly risky behaviors emerge as the total sleep duration is limited to 5 hours per night. The high cost of an action is seemingly ignored as the sleep-deprived person focuses on limited benefits. These findings can be explained by the fact that

Figure 2: Normal Circadian Sleep Rhythm

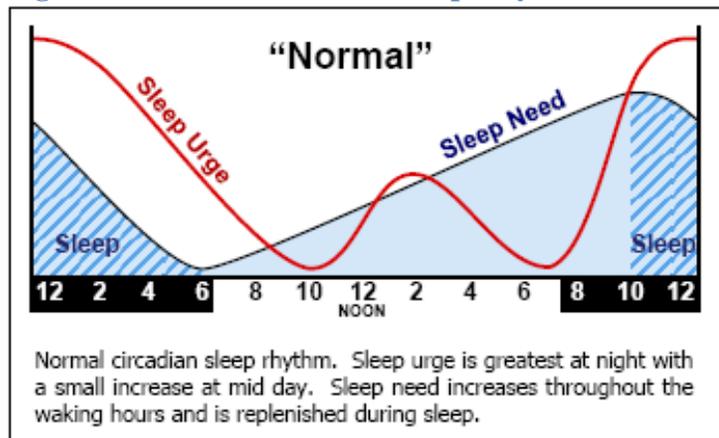
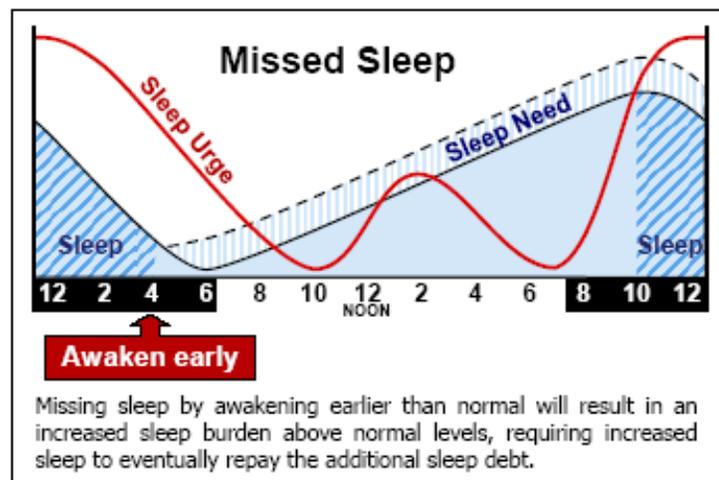


Figure 3: Disrupted Circadian Rhythm Cycle



metabolism in the prefrontal and parietal associational areas of the brain decrease in individuals deprived of sleep for 24 hours. These areas of the brain are important for judgment, impulse control, attention, and visual association.

Sleep Disorders

A sleep disorder is a condition that involves any type of difficulty that relates to sleeping. This includes difficulties falling or staying asleep, falling asleep at inappropriate times, excessive total sleep time, or abnormal behaviors associated with sleep.

More than 80 different disorders of sleeping and waking are identified in the most comprehensive classification of sleep disorders, the second edition of the International Classification of Sleep Disorders (ICSD-2, 2005), published by the American Academy of Sleep Medicine (AASM). This system classifies sleep disorders in eight sections, although two, “Other Sleep Disorders” and “Isolated Symptoms, Apparently Normal Variants of Unresolved Issues,” are excluded from this report. The major classifications of ICSD-2 highlighted in this report are (Table 1):

- Insomnia
- Sleep Related Breathing Disorders
- Hypersomnias of Central Origin Not Due to a Circadian Rhythm Sleep Disorder, Sleep Related Breathing Disorder, or Other Cause of Disturbed Nocturnal Sleep
- Circadian Rhythm Sleep Disorders
- Parasomnias
- Sleep Related Movement Disorders

The ICSD-2 was revised at the same time of The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9) to permit greater concordance between the systems.

The ICD-9, based on the World Health Organization's Ninth Revision, International Classification of Diseases (ICD-9), is the official system of assigning codes to diagnoses and procedures associated with hospital utilization in the United States. The ICD-9 is used to code and classify mortality data from death certificates.

The ICD-9 consists of:

- a tabular list containing a numerical list of the disease code numbers in tabular form;
- an alphabetical index to the disease entries; and
- a classification system for surgical, diagnostic, and therapeutic procedures (alphabetical index and tabular list).

The National Center for Health Statistics (NCHS) and the Centers for Medicare and Medicaid Services are the U.S. governmental agencies responsible for overseeing all changes and modifications to the ICD-9, which contains all changes issued through October 1, 2008. Although the ninth edition is widely used, it is now in its 10th revision, and an 11th revision is planned for 2015.

Many sleep disorders are grouped in the ICD-9 under "Diseases of the Nervous System" section, although some remain in other sections, such as the "Mental Disorders" section. The fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) of the American Psychiatric Association (APA) also classifies sleep disorders. This system, however, is not intricately linked to the ICD-9-CM classification and thus was not used in the current report.

For the purpose of this report, this section identifies sleep disorders coded in the ICSD-2. Summarizations of the disorders, including effects, risk groups and established treatments, are highlighted. Further, Tables 2-8 outline diagnoses, prevalence, symptoms and alternate names for the disorders.

Table 1: General Criteria and Prevalence of Major Sleep Disorder Classifications

| Classification | General criteria or features | Prevalence |
|---|---|---|
| Insomnia | <ul style="list-style-type: none"> • Difficulty of initiating or maintaining sleep, waking up too early or sleep that is non-restorative or poor in quality. • The sleep problem occurs despite adequate opportunity and circumstances for sleep. • At least one of the following daytime problems is reported because of sleep difficulty: <ul style="list-style-type: none"> ○ Fatigue ○ Attention, concentration or memory ○ Social or vocal dysfunction ○ Mood disturbance or irritability ○ Sleepiness ○ Motivation, energy or initiative reduction ○ Tension headaches, or gastrointestinal symptoms ○ Concerns or worries about sleep | <ul style="list-style-type: none"> • A general consensus has developed from population-based studies that approx 30% of a variety of adult samples drawn from different countries report one or more of the symptoms of insomnia. – Roth (2007) • 60 million or 69% of people who see primary care physicians (Estimate considered on lower end of true scale). – Katz & McHorney (2002) and Bixler et al. (2002) • About one-third of the adult American population is affected by insomnia. – Ancoli-Israel & Roth (1999) and Kuppermann et al. (1995) |
| Sleep Related Breathing Disorders (SRBD) | <p>This disorder group is characterized by disordered respiration during sleep. Central Sleep Apnea syndromes include those in which respiratory effort is diminished or absent in an intermittent or cyclic fashion due to central nervous system or cardiac dysfunction. The obstructive sleep apnea syndromes include those in which there is an obstruction in the airway resulting in continued breathing effort but inadequate ventilation. Adult and pediatric patients are identified separately because the disorders have different methods of diagnosis and treatment.</p> <p>SRBD constitute a subset of the broad group of sleep disorders that include many other disorders, such as insomnia (difficulty sleeping), hypersomnias (inappropriately falling asleep, for example, narcolepsy), parasomnias (activities during sleep, for example, sleepwalking and sleep terrors), and Sleep Related Movement Disorders (for example, restless leg syndrome). Snoring and sleep apnea are the most common SRBD.</p> | <ul style="list-style-type: none"> • SRBD prevalence of at least 2-5% of U.S. general population. – Carley & Radulovaki (2003) • Approx 1 in 22 or 4.41% or 12 million people in U.S. suffer from obstructive sleep apnea (OSA), the most diagnosed SRBD. – Wrong Diagnosis (2009) • Approx 1 in 27 or 3.68% or 10 million people in U.S. have OSA but have not been diagnosed. – Wrong Diagnosis (2009a) |
| Hypersomnias of Central Origin Not Due to a Circadian Rhythm Sleep Disorder, Sleep Related Breathing Disorder, or Other Cause of Disturbed Nocturnal Sleep | <p>This section includes disorders in which the primary complaint is daytime sleepiness and in which the cause of the primary symptom is not disturbed nocturnal sleep or misaligned circadian rhythm. In all cases in which a diagnosis of hypersomnia is to be made, a review of psychiatric history and drug and medication use and an assessment of other sleep and medical disorders should be performed.</p> | <ul style="list-style-type: none"> • Estimated to affect about one in every 2,000 Americans. – National Institute of Neurological Disorders and Stroke (2009) • Approx 1 in 1,359 Americans, or 0.07% of the population; about 200,000 people. – Wrong Diagnosis (2009b) • Undiagnosed prevalence rate: approx 1 in 1,813 Americans, or 0.06% of population; 150,000 people. – Wrong Diagnosis (2009b) |
| Circadian Rhythm Sleep Disorders | <ul style="list-style-type: none"> • There is persistent or recurrent pattern of sleep disturbance due primarily to one of the following: <ul style="list-style-type: none"> ○ Alterations of the circadian timekeeping system ○ Misalignment between the endogenous circadian rhythm and exogenous factors that affect the timing or duration of sleep • The circadian-related sleep disruption leads to insomnia, excessive daytime sleepiness, or both. • The sleep disturbance is associated with impairment of social, occupational, or other areas of functioning. | <ul style="list-style-type: none"> • The prevalence of circadian rhythm sleep disorders in the general population is unknown. – American Academy of Sleep Medicine (AASM, 2008a) • Approximately 7-10% of patients who complain of insomnia are diagnosed with a circadian rhythm disorder. – Cataletto and Hertz (2008) • The exact incidence and prevalence rates of circadian rhythm sleep disorders are not known, but 25% of all chronic sleep disorders are the result of a mismatch between the body's internal clock and the external 24-hour schedule. – Medindia.com (2009) |

| Classification | General criteria or features | Prevalence |
|--|--|--|
| | <p>Common symptoms for these types of disorders include Difficulty initiating and/or maintaining sleep, nonrestorative sleep, daytime sleepiness, poor concentration, impaired performance, including a decrease in cognitive skills, poor psychomotor coordination, headaches and gastrointestinal distress.</p> | <ul style="list-style-type: none"> • More than 35 million Americans suffer from circadian rhythm disorders. – Medindia.com (2009) |
| <p>Parasomnias</p> | <p>These types of disorders are undesirable physical events or experiences that occur during entry into sleep, within sleep, or during arousals from sleep. Parasomnias encompass abnormal sleep-related movements, behaviors, emotions, perceptions, dreaming, and autonomic nervous system functioning. Parasomnias are clinical disorders because of the resulting untoward psychosocial effects. Parasomnias can affect the patient, the bed partner, or both.</p> <p>Common symptoms include snoring, headaches, loss of muscle control (cataplexy), poor concentration and focus, difficulty with memory, impaired motor coordination, irritability and impaired social interaction.</p> | <ul style="list-style-type: none"> • Nightmare disorder: Unknown prevalence, although up to 50% of adults report occasional nightmares. – (Sharma, 2007); Affects about 2-8% of people. About 50-85% of adults report having at least an occasional nightmare. – (AASM, 2008b) • Sleep Terror: Information is limited at best. The DSM-IV estimates the prevalence rate in adults to be less than 1%. – (Sharma, 2007); About 2% of adults have sleep terrors. – (AASM, 2008b) • Sleepwalking: Episodes of the disorder have been documented in as many as 7% of clinical samples of adults. – (Sharma, 2007) • Confused arousals: occur in about 4% of adults. – (AASM, 2008b) • REM sleep behavior disorder: Prevalence not known. – (Sharma, 2007); Less than 1% of the population. – (AASM, 2008b) |
| <p>Sleep Related Movement Disorders</p> | <p>These disorders are conditions that are primarily characterized by relatively simple, usually stereotyped, movements that disturb sleep. Rest Leg Syndrome, although not involving stereotyped movements per se, is classified here mainly because of its close association with Periodic Limb Movement Disorder.</p> <p>Prerequisites for a diagnosis are:</p> <ul style="list-style-type: none"> • Nocturnal sleep disturbance • Daytime sleepiness or fatigue | <ul style="list-style-type: none"> • Restless Leg Syndrome: As high as 10% in general population and increases with age. – Sharma (2007) • Periodic Limb Movement Disorder: 5% of population aged 30 to 50 years, compared to 30% of population older than 50 years and 40% of population over 65. – Sharma (2007) |

Source: American Academy of Sleep Medicine (2005)

Insomnia

According to the ICSD-2, approximately 30 percent of adults have symptoms of insomnia, a common sleep complaint that occurs when a person has one or more of these problems:

- Difficult time initiating sleep
- Struggling to maintain sleep; waking up frequently during the night
- Waking up too early and not being able to go back to sleep
- Non-restorative sleep or of poor quality.

About 10 percent of adults have insomnia that is severe enough to cause daytime consequences, and less than 10 percent of adults are likely to have chronic insomnia. The symptoms of insomnia can be caused by a variety of biological, psychological and social factors. The most often result is an inadequate amount of sleep, even though the sufferer has the opportunity to get a full night of sleep. Insomnia is different from *sleep deprivation*, which occurs when an individual does not have the opportunity to get a full night of sleep. A small percentage of people who have trouble sleeping are actually *short sleepers* who can function normally on only five hours of sleep or less.

There are two types of insomnia: primary and secondary.

- **Primary insomnia** is sleeplessness that cannot be attributed to an existing medical, psychiatric, or environmental cause (such as drug abuse or medications).
- **Secondary insomnia** is when symptoms of insomnia arise from a primary medical illness, mental disorders, or other sleep disorders. It also may arise from the use, abuse or exposure to certain substances.

Types

Insomnia is considered a disorder only when it causes a significant amount of distress or anxiety, or when it results in daytime impairment. The ICSD-2 defines the following types of insomnia, listed below. Diagnostic criteria and symptoms are listed in Table 2.

Adjustment Insomnia

This is also called acute insomnia or short-term insomnia. It is usually caused by a source of stress and tends to last for only a few days or weeks. Epidemiologic studies indicate that the one-year prevalence of adjustment insomnia among adults is likely to be in the range of 15-20 percent. Adjustment insomnia can occur at any age. Adjustment insomnia is more common in women than men and in older adults than younger adults and children.

Idiopathic Insomnia

An insomnia that begins in childhood and is lifelong; it cannot be explained by other causes. Information suggests that this condition is present in approximately 0.7 percent of adolescents and 1 percent of very young adults.

Inadequate Sleep Hygiene

This form of insomnia is caused by bad sleep habits that keep people awake or bring disorder to their sleep schedule. This condition is present in 1-2 percent of adolescents and young adults. This condition typically affects 5 percent to 10 percent of sleep-clinic populations.

Insomnia Due To Drug or Substance, Medical Condition, or Mental Disorder

Symptoms of insomnia often result from one of these causes. Insomnia is associated more often with a psychiatric disorder, such as depression, than with any other medical condition. Surveys suggest about 3 percent of the population has insomnia symptoms that are caused by a medical or psychiatric condition. Among adolescents and young adults, the prevalence of this form of insomnia is slightly lower, and about 2 percent of the general population is affected by this type of insomnia. Approximately 3.5 percent of all sleep-center patients are affected by this condition.

Paradoxical Insomnia

A complaint of severe insomnia occurs even though there is no objective evidence of a sleep disturbance. The prevalence in the general population is not known. Among clinical populations, this condition is typically found in less than 5 percent of patients with insomnia. It is thought to be most common in young and middle-aged adults.

Psychophysiological Insomnia

A complaint of insomnia occurs along with an excessive amount of anxiety and worry regarding sleep and sleeplessness. This condition is found in 1 percent to 2 percent of the general population and 12 percent to 15 percent of all patients seen at sleep centers. It is more frequent in women than in men. It rarely occurs in young children, but it is more common in adolescents and all adult age groups.

Risk Groups

- A high rate of insomnia is seen in middle-aged and older adults. Although an individual's sleep need does not change as he or she ages, physical problems can make it more difficult to sleep well.
- Women are more likely than men to develop insomnia.
- People, who have a medical or psychiatric illness, including depression, are at risk for insomnia.
- People who use medications may experience insomnia as a side-effect.

Effects

- Fatigue
- Moodiness
- Irritability or anger
- Daytime sleepiness
- Anxiety about sleep
- Lack of concentration
- Poor memory
- Poor quality performance at school or work

- Lack of motivation or energy
- Headaches or tension
- Upset stomach
- Mistakes/accidents at work or while driving

Severe daytime sleepiness typically is an effect of *sleep deprivation* and is less common with insomnia. People with insomnia often underestimate the amount of sleep they get each night. They worry that their inability to sleep will affect their health and keep them from functioning well during the day. Often, however, they are able to perform well during the day despite feeling tired.

Treatments

The most widely used insomnia treatments are cognitive behavioral therapy (CBT), over-the-counter products, prescription sleeping pills and unapproved prescription drugs.

Cognitive Behavioral Therapy (CBT)

CBT can have beneficial effects that last well beyond the end of treatment. It involves combinations of the following therapies:

- **Cognitive therapy:** Changing attitudes and beliefs that hinder a person's sleep
- **Relaxation training:** Relaxing mind and body
- **Sleep hygiene training:** Correcting bad habits that contribute to poor sleep
- **Sleep restriction:** Severely limiting and then gradually increasing time in bed
- **Stimulus control:** Going to bed only when sleepy, waking at the same time daily, leaving the bed when unable to sleep, avoiding naps, using the bed only for sleep and sex

Over-The-Counter Products

Most of these sleep aids contain *antihistamine*. They can help people sleep better, but they also may cause severe daytime sleepiness. Other products, including herbal supplements, have little evidence to support their effectiveness.

Prescription Sleeping Pills

Prescription hypnotics can improve sleep when supervised by a physician. The traditional sleeping pills are *benzodiazepine receptor agonists*, which are typically prescribed for only short-term use. Newer sleeping pills are *nonbenzodiazepines*, which may pose fewer risks and may be effective for longer-term use.

Unapproved Prescription Drugs

Drugs from a variety of classes have been used to treat insomnia without FDA approval. Antidepressants such as trazodone are commonly prescribed for insomnia. Others include anticonvulsants, antipsychotics, barbiturates and nonhypnotic benzodiazepines. Many of these medications involve a significant level of risk.

Table 2: Diagnostic Criteria and Symptoms of Insomnia disorders

| Disorder/ICD-9 code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|---|--|
| Adjustment insomnia 307.41 | <ul style="list-style-type: none"> • Symptoms of insomnia • Sleep disturbance associated with an identifiable stressor that is psychological, psychosocial, interpersonal, environmental or physical in nature • Typically resolved when acute stressor resolves or when individual adapts to the stressor • Lasts for less than three months • The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder | <ul style="list-style-type: none"> • Accompanied by anxiety, worry, ruminative thoughts, sadness or depression in relation to stressor • Muscle tension • Gastrointestinal upset • Headaches • Daytime fatigue • Impaired concentration • Irritability | Acute insomnia, transient insomnia, short-term insomnia, transient psychophysiological insomnia, adjustment disorder |
| Psychophysiological Insomnia 307.42 | <ul style="list-style-type: none"> • Symptoms of insomnia • Insomnia present for at least one month • Evidence of conditioned sleep difficulty and/or heightened arousal in bed as indicated by one or more of the following: <ul style="list-style-type: none"> ○ Excessive focus and heightened anxiety about sleep ○ Difficulty falling asleep in bed at the desired bedtime or during planned naps, but no difficulty falling asleep during other monotonous activities when not intending to sleep ○ Ability to sleep better away from home ○ Mental arousal in bed characterized by intrusive thought or a perceived inability to volitionally cease sleep-preventing mental activity ○ Heightened somatic tension in bed reflected by perceived inability to relax the body sufficiently to allow the onset of sleep | <ul style="list-style-type: none"> • Deteriorated mood and motivation • Decreased attention, vigilance, energy and concentration • Increased fatigue and malaise | Learned insomnia, conditioned insomnia, functionally autonomous insomnia, chronic insomnia, primary insomnia, chronic somatized tension, internal arousal without psychopathology |
| Paradoxical insomnia 307.42 | <ul style="list-style-type: none"> • Meets insomnia criteria • Insomnia present for at least one month • One or more of the criteria apply: <ul style="list-style-type: none"> ○ Chronic patterns of little or no sleep at night ○ Sleep-log data during one or more weeks of monitoring show sleep time well below published age-adjusted normative values; typically there is an absence of daytime naps following sleepless nights ○ Patient shows constant marked mismatch between objective findings from polysomnography or actigraphy and subjective sleep estimates derived from self-report or sleep diary • At least one of the following is observed: <ul style="list-style-type: none"> ○ Constant or near constant awareness of environmental stimuli throughout most nights ○ Pattern of conscious thoughts or rumination throughout most nights while maintaining a recumbent posture • Daytime impairment is consistent with that reported with other insomnia subtypes, but it is much less severe than expected given the extreme level of | The patient doesn't exhibit features of significant psychopathology or malingering. | Sleep state misperception, subjective insomnia, pseudo-insomnia, subjective complaint of sleep initiation and maintenance difficulty, insomnia without objective findings, sleep hypochondriasis, subjective sleep complaint |

| Disorder/ICD-9 code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|--|--|--|--|
| | <p>sleep deprivation reported.</p> <ul style="list-style-type: none"> The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | | |
| Idiopathic insomnia 307.42 | <ul style="list-style-type: none"> Meets insomnia criteria The course of the disorder is chronic, as indicated by the following: <ul style="list-style-type: none"> Onset during infancy or childhood No identifiable precipitant or cause Persistent course with no periods of sustained remission The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <p>Sleep disturbance is the primary symptom. Psychological symptoms as determined by rating scales show only minor abnormalities. In attempting to cope with the disorder, patients may develop behaviors that worsen the problem, such as excessive time spent in bed, preoccupation with sleep or irregular sleep hours.</p> | <p>Childhood-onset insomnia, lifelong insomnia</p> |
| Insomnia Due to Mental Disorder 327.02 | <ul style="list-style-type: none"> Meets insomnia criteria Insomnia present for at least one month A mental disorder has been diagnosed Insomnia temporally associated with the mental disorder; insomnia may appear a few days or weeks before the disorder. Insomnia is more prominent than that typically associated with the mental disorder, as indicated by causing marked distress or constituting an independent focus of treatment. The sleep disorder is not better explained by another sleep disorder, medication use or substance abuse disorder. | <p>The insomnia is viewed as a symptom of the identified mental disorder and shares a course with the disorder. The insomnia begins and wanes in unison with the other symptoms of this condition over time.</p> | <p>Insomnia related psychopathology, psychiatric insomnia, insomnia due to depression, insomnia due to anxiety</p> |
| Inadequate Sleep Hygiene V69.4 | <ul style="list-style-type: none"> Meets insomnia criteria Insomnia present for at least one month Inadequate sleep hygiene practices are evident by presence of one of the following: <ul style="list-style-type: none"> Frequent daytime napping, selecting highly variable bedtimes or rising times, or excessive amounts of time in bed. Routine use of products containing alcohol, nicotine or caffeine Frequent use of the bed for uses other than sleeping, such as watching TV, reading, thinking, and snacking. Failure to maintain a comfortable sleeping environment. The sleep disorder is not better explained by another sleep disorder, medication use or substance abuse disorder. | <ul style="list-style-type: none"> Mood and motivational disturbance Reduced attention, vigilance and concentration Daytime fatigue or sleepiness Preoccupation with sleep difficulty | <p>Poor sleep hygiene, sleep hygiene abuse, bad sleep habits, irregular sleep habits, excessive napping, and sleep-incompatible behaviors.</p> |

| Disorder/ICD-9 code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|--|--|--|---|
| Insomnia Due to Drug or Substance 327.01 | <ul style="list-style-type: none"> • Meets insomnia criteria • Insomnia present for at least one month • One of the following applies: <ul style="list-style-type: none"> ○ Ongoing dependence on or abuse of a drug or substance known to have sleep-disruptive properties during periods of use or intoxication or during periods of withdrawal. ○ Ongoing use of or exposure to a medication, food or toxin known to have sleep-disruptive properties in susceptible individuals. • Temporally associated with the substance exposure, use or abuse, or acute withdrawal. • The sleep disorder is not better explained by another sleep disorder, medical or neurological disorder, or mental disorder. | Caffeine use symptoms: <ul style="list-style-type: none"> • Anxiety • Jitteriness • Elevated daytime sleepiness Chronic amphetamine and cocaine abuse symptoms: <ul style="list-style-type: none"> • Predominant mental problems Chronic use of sedative-hypnotic medication symptoms: <ul style="list-style-type: none"> • Tolerance • Dependence • Loss of efficacy Abrupt discontinuation of meds: <ul style="list-style-type: none"> • Rebound insomnia characterized by sudden worsening of sleep Long-term use of alcohol as a sleep aid: <ul style="list-style-type: none"> • Tolerance • Dependence • Anxiety upon withdrawal Toxin exposure: <ul style="list-style-type: none"> • Memory loss • Change in mental status • Respiratory problems • Cardiac symptoms • Gastrointestinal inflammation, leading to nausea, vomiting and diarrhea In case of food allergy symptoms, other allergy symptoms may be seen. | Substance-induced sleep disorder, alcohol-dependent sleep disorder, alcohol-dependency insomnia, stimulant-dependent sleep disorder, drug-induced sleep disorder, substance abuse, insomnia related to drug abuse, rebound insomnia, medication side effect, medication reaction, food-allergy insomnia, toxin-induced sleep disorder |
| Insomnia Due to a Medical Condition 327.01 | <ul style="list-style-type: none"> • Meets insomnia criteria • Insomnia present for at least one month • The patient has a coexisting medical or physiological condition known to disrupt sleep • Insomnia clearly associated with the medical or physiologic condition. • The sleep disorder is not better explained by another sleep disorder, mental disorder, medication use or substance abuse disorder. | <ul style="list-style-type: none"> • Excessive focus on sleep • Anxiety about not sleeping well • Complaints of daytime dysfunction • Worries about the effects of insomnia on the causative medical disorder or condition or on health in general | Sleep disorder due to a general medical condition, medically based insomnia, organic insomnia, insomnia due to a known organic condition |

| Disorder/ICD-9 code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|----------------------|-----------------|
| Insomnia Not Due to Substance or Known Physiologic Condition, Unspecified (Nonorganic Insomnia, NOS) 780.52 | This diagnosis is used for forms of insomnia that cannot be classified elsewhere but are suspected to be related to an underlying mental disorder, psychological factors, or sleep disruptive practices. In some cases, this diagnosis may be assigned on a temporary basis when an insomnia diagnosis seems appropriate but further evaluation is required to determine the specific mental condition or psychological difficulty. In other cases, this diagnosis may be assigned when psychological or behavioral factors appear to contribute to the insomnia but the patient's symptoms fail to meet criteria for one of the other insomnia diagnoses. | NA | NA |
| Physiologic (Organic), Unspecified 327.00 | This diagnosis is used for forms of insomnia that cannot be classified elsewhere but are suspected to be related to an underlying medical disorder, physiological state, or substance abuse or exposure. In some cases, this diagnosis may be assigned on a temporary basis when an insomnia diagnosis seems appropriate but further evaluation is required to determine the specified condition or toxin exposure responsible for the insomnia. This diagnosis may also be assigned when substance abuse or dependence-related insomnia is suspected but has yet to be confirmed. In other cases, this diagnosis may be assigned when an endogenous physiologic disorder or condition appears to contribute to the insomnia but the patient's symptoms fail to meet criteria for one of the other insomnia diagnoses. | NA | NA |

Source: American Academy of Sleep Medicine (2005)

Sleep Related Breathing Disorders (SRBDs)

The term breathing-related sleep disorder refers to a spectrum of breathing anomalies ranging from chronic or habitual snoring to upper airway resistance syndrome (UARS) to OSA or, in other cases, Sleep Related Hypoventilation/Hypoxemic Syndromes. According to estimates, at least 2 percent to 4 percent of the adult population experience sleep-related breathing disorders (Kushida et al., 2006).

Central sleep apnea syndromes include those in which respiratory effort is diminished or absent in an intermittent or cyclic fashion due to central nervous system or cardiac dysfunction. The OSA syndromes include those in which there is an obstruction in the airway resulting in continued breathing effort but inadequate ventilation. Alveolar hypoventilation represents a physiological outcome of one disorder or a combination of disorders leading to an elevation of PaCO₂ above 45 mm Hg. This elevation, termed hypercapnia, reflects an imbalance between metabolic production of carbon dioxide and elimination of carbon dioxide through exhaled gas.

Types

The disorders in this classification are characterized by respiration disorders during sleep. A table of diagnostic criteria and symptoms is included in

Table 3.

Primary Central Sleep Apnea

The term central sleep apnea encompasses a heterogeneous group of sleep-related breathing disorders in which respiratory effort is diminished or absent in an intermittent or cyclical fashion due to CNS or cardiac dysfunction. No epidemiologic studies have been performed to determine the prevalence of central sleep apnea in the general population. Predominant central apnea is uncommon and is seen in less than 10 percent of patients presenting for polysomnography.

These disorders are further divided into primary forms: those for which the exact etiology is unknown and those due to a known cause. With polysomnography, central sleep apnea is conventionally defined as cessation of airflow for 10 seconds or longer without an identifiable respiratory effort. In contrast, an obstructive apnea has a discernible ventilatory effort during the period of airflow cessation. The vast majority of patients with central sleep apnea have concomitant obstructive sleep apnea.

The treatment of OSA results in the emergence of central sleep apnea and vice versa, indicating the commonality of pathogenesis between the two seemingly distinct, but probably overlapping, disorders of breathing during the sleep state. In general, treatment of central sleep apnea syndrome is less promising than treatment of OSA.

Cheyne-Stokes Breathing Pattern

Cheyne-Stokes, also known as periodic breathing, is an abnormal type of breathing seen especially in comatose patients, characterized by alternating periods of shallow and deep breathing. Typically, over a period of 1 minute, a 10-20 second episode of apnea or hypopnea occurs followed by respirations of increasing depth and frequency. The cycle then repeats itself.

Patients with Cheyne-Stokes respiration usually present with the symptoms of orthopnea, paroxysmal nocturnal dyspnea, excessive-daytime sleepiness and witnessed apneas in the setting of congestive heart failure. Periodic respiration is a poor prognostic sign, most often seen in terminal care. However, it may also be present as a normal finding in children, in healthy adults following fast ascending to great altitudes, or in sleep.

High-altitude Periodic Breathing

This disorder is characterized by cyclic periods of central apnea and hypopnea, usually accompanied by frequent awakenings, poor quality sleep, sense of suffocation, and fatigue at high altitudes. High-altitude periodic breathing begins within the first few days after reaching high altitude. Although it may sometimes appear at altitudes as low as 2,000 meters, it usually occurs in 25 percent of people who ascend rapidly to altitudes higher than 2,500 meters. At altitudes higher than 4,000 meters, it almost always occurs.

Central Sleep Apnea due to Medical Condition not Cheyne-Stokes

Central sleep apneas are not common and when seen, they are usually caused by neurologic, cardiac (heart), trauma, or renal (kidney) problems. A majority of the medical conditions are associated with brainstem lesions.

Central Sleep Apnea due to Drug or Substance

At least two months of regular opioid use with central apneas five or more per hour or periodic breathing defined by 10 or more per hour crescendo-decrescendo pattern of hypernoeas with central apneas/hypopnea and arousals or disturbed sleep.

Obstructive Sleep Apnea, Adult

This disorder, the most common of all sleep-related breathing disorders, is associated with upper airway obstruction describing a spectrum of breathing abnormalities, including snoring, upper airway resistance syndrome, and obstructive sleep apnea/hypopnea syndrome. Despite airway obstruction, breathing effort continues but ventilation is impaired.

Sleep Related Hypoventilation/Hypoxemic Syndromes

Sleep Related Hypoventilation/Hypoxemic Syndromes are a subcategory of sleep-related breathing disorders. Some of these disorders are quite common, such as COPD with worsening gas exchange during sleep; while some are exceedingly rare, such as congenital central hypoventilation syndrome. All share the attribute of abnormal gas exchange that worsens, or may only be present, during sleep. The sleep state, the sleeping posture, and the circadian rhythm driving sleep all may affect respiration by altering control of breathing and/or pulmonary mechanics. These changes are largely inconsequential in the normal individual but interact with respiratory, neurologic, or neuromuscular disease to manifest as the sleep-related hypoventilation/hypoxemic syndromes. In addition to optimal treatment of the underlying disorder (when known and when possible), treatment usually involves nocturnal ventilatory support that is now most commonly provided by noninvasive positive pressure ventilation.

The following are types of Sleep Related Hypoventilation/Hypoxemic Syndromes, as defined by the ICSD-2:

Sleep Related Nonobstructive Alveolar Hypoventilation, Idiopathic

This disorder is postulated to result from a lesion of medullary chemoreceptors, leading to PSG periods (often worse in REM sleep) of decreased tidal volume lasting several minutes with sustained SaO₂ desaturation and elevated carbon dioxide levels. This often presents in adolescents or young adults.

Sleep Related Hypoventilation/Hypoxemic Due to Pulmonary Parenchymal or Vascular Pathology

Significant sleep-related hypoxemia and the presence of lung parenchymal disease or pulmonary vascular pathology are essential features. Diseases known to cause the disorder, but are not limited to, interstitial lung diseases such as desquamative interstitial pneumonitis, usual interstitial pneumonitis, and hypersensitivity pneumonitis; idiopathic and secondary forms of pulmonary hypertension; and sickle cell anemia and other hemoglobinopathies.

Sleep Related Hypoventilation/Hypoxemic Due to Lower Airway Obstruction

Obstruction of increased airflow resistance in airways below the laryngeal apparatus characterizes these disorders. COPD reflects an umbrella term for chronic bronchitis and emphysema.

Sleep Related Hypoventilation/Hypoxemic Due to Neuromuscular and Chest Wall Disorders

Those neuromuscular and chest wall disorders that are relevant to sleep-related alveolar hypoventilation share the common feature of an abnormal “ventilator pump.” Under the conditions imposed by normal sleep physiology, the abnormal pump is unable to meet the ventilator requirements for maintaining the PaCO₂ at or below 45 mm Hg.

Other Sleep Related Breathing Disorders

This diagnosis is used for forms of SRBD that cannot be classified elsewhere or may not neatly fit into one category but are believed to be a function of respiratory disturbance in sleep. And in some cases, this diagnosis is only temporary because further evaluation is required.

Risk Groups

- About 24 percent of men and 9 percent of women aged 30-60 years were reported to have sleep-disordered breathing (Young et al., 1997).
- Caples et al. (2005) reviewed pooled data from four large prevalence studies on OSA and found that 20 percent of adult Caucasians with BMI between 25 and 28 kg/m² had an apnea hypopnea index (AHI) of 5 or greater and that approximately 6 percent of these same patients had AHIs of 15 or greater.
- Patients with neuromuscular diseases may have sleep-disordered breathing. Duchenne muscular dystrophy (DMD), amyotrophic lateral sclerosis, postpolio syndrome, and myasthenia gravis are among those with increased incidence of sleep-disordered breathing.
- Prevalence studies in the elderly population show significantly higher rates, with the rate for elderly men reported as 28 percent to 67 percent and the rate for elderly women as 20 percent to 54 percent. In the subset of patients with severe OSA, men have an 8-fold increased frequency. Prevalence rates in children are estimated to be 5 percent to 6 percent (Guilleminault et al., 2005).

Effects

Obesity, advanced age, and snoring have been found to be important factors in the progression of sleep-disordered breathing.

Morbidity with OSA falls into two major categories, as follows (Cataletto and Hertz, 2008):

- Neuropsychiatric or psychosocial: This includes excessive daytime sleepiness, poor concentration and memory, decreased performance, irritability, depression, and disturbed social relationships. This population has a significantly increased risk of motor vehicle accidents, with reports of a 7-fold increased risk in patients with an AHI greater than 5.

- Cardiovascular: Systemic hypertension occurs in 45-90 percent of patients with OSA. Pulmonary hypertension has been reported in 15-20 percent.

Treatment

General treatment measures include:

- Behavior modification aimed at improving sleep hygiene and avoiding additional sleep deprivation
- Avoidance of the supine positioning during sleep
- Avoidance of ethanol and sedative medications.

Medical treatments, listed below, require major changes in lifestyle. Appropriate weight management strategies and compliance with either positive airway support or use of the dental appliance usually is a lifetime commitment. For this reason, some patients have explored surgical alternatives.

- **Weight loss:** This recommendation is critical in even mildly obese patients because even small amounts of weight loss may have significant impact on the respiratory disturbance index (RDI) and may reduce the degree of oxygen desaturation and improve sleep architecture. Depression and fatigue may hamper weight loss plans, and, at least initially, weight loss may need to be combined with psychotherapy.
- **Positive airway pressure:** Three variations of positive pressure support via nasal masks are used at home for the treatment of OSA.
 - The first is n-CPAP, which delivers a constant pressure throughout inspiration and expiration.
 - The second is bi-level positive airway pressure (BiPAP), which allows independent adjustment of inspiratory and expiratory pressures. This technique provides a lower mean airway pressure, and risk of barotrauma reportedly is decreased. No improvement in compliance has been observed with BiPAP as compared to n-CPAP.
 - The third variation, autotitrating CPAP, has also been used in the home setting and has the advantage of adjusting to the individual patient's airflow patterns. Image 3 shows a patient receiving CPAP. Images 4-5 show CPAP maintaining upper airway patency during sleep. Images 6-8 show patient interfaces, including nasal CPAP masks and nasal pillows.

Possible adverse effects related to this type of nocturnal ventilatory support include those related to pressure, airflow, and the mask-face interface. Therefore, dry mouth, barotrauma, pneumothoraces, and aerophagia, as well as air leaks and pressure sores at the mask interface, may be observed. Media file 3 shows a patient using a CPAP system.

- **Oral appliances:** Customized dental appliances are designed to increase airway size and to facilitate airflow by advancing the mandible or tongue or lifting the soft palate. Devices may be categorized into three categories:
 - Those that advance the tongue, such as the tongue-retaining device (TRD);

- Those that advance the jaw, such as the mandibular advancing device (MAD);
- Those that simultaneously lift the soft palate and advance the mandible. This combination appliance is known as the Z appliance. Adverse effects may include temporomandibular joint (TMJ) discomfort, excessive salivation, or dry mouth. In general, patients with severe OSA have had poor results. High cost, poor reimbursement, and patient discomfort have contributed to limited use of this option.
- **Surgical Care:** Surgical options include procedures designed to:
 - Increase upper airway size;
 - Bypass the upper airway;
 - Ensure weight loss. The latter two procedures have traditionally been reserved for the more severely affected and recalcitrant patients. For patients with morbid obesity who are refractory to diet and drug therapy, bariatric surgery has been associated with effective weight loss and significant improvement in sleep-disordered breathing.

Table 3: Diagnostic Criteria and Symptoms of Sleep Related Breathing Disorders

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|---|--------------------|
| Primary Central Sleep Apnea 327.21 | <ul style="list-style-type: none"> • Patient reports at least one of the following: <ul style="list-style-type: none"> ○ Excessive daytime sleepiness ○ Frequent arousals and awakenings during sleep or insomnia complaints ○ Awakening short of breath • Polysomnography shows five or more central apnea per hour of sleep • Disorder not better explained by another current sleep disorder, medical or neurological disorder, medication use, or substance abuse disorder. | <ul style="list-style-type: none"> • Snoring • Witnessed apnea • Awakening with shortness of breath | NA |
| Cheyne Stokes Breathing Pattern 786.04 | <ul style="list-style-type: none"> • Polysomnography shows at least 10 central apneas and hypopneas per hour of sleep in which the hypopnea has a crescendo-decrescendo pattern of tidal volume accompanied by frequent arousals from sleep and derangement of sleep structure. Note: <i>Symptoms are not mandatory for this diagnosis.</i> • The breathing disorder occurs in association with a serious medical illness, such as heart failure, stroke or a renal failure. • The disorder is not better explained by another current sleep disorder, medication use or substance abuse disorder. | <ul style="list-style-type: none"> • Excessive daytime sleepiness • Frequent arousals and awakenings during sleep • Insomnia complaints • Awakening short of breath | Periodic breathing |
| High-Altitude Periodic Breathing 327.22 | <ul style="list-style-type: none"> • Recent ascent to altitude of at least 4,000 meters • Polysomnography demonstrates recurrent central apneas primarily during NREM sleep at a frequency greater than five per hour. The cycle length should be 12 to 34 seconds. <p>Note: <i>Because high-altitude periodic breathing is a normal adaptation to altitude, there are no specific criteria regarding the frequency of central apnea that should be considered normal or abnormal.</i></p> | At altitude, individuals may complain of: <ul style="list-style-type: none"> • Frequent awakenings • Poor quality sleep • Sense of suffocation <p>Note: <i>This will improve with time at altitude if elevation is not extreme.</i></p> | NA |
| Central Sleep Apnea Due to Medical Condition Not Cheyne Stokes 327.27 | <p>Central sleep apnea is believed to be secondary to a medical condition and that does not exhibit a characteristic pattern of Cheyne Stokes respirations. The majority of these patients are probably individuals with brainstem lesions of vascular, neoplastic, degenerative or traumatic origin. Other etiologies include cardiac and renal disorders.</p> | NA | NA |
| Central Sleep Apnea Due to Drug or Substance 327.29 | <ul style="list-style-type: none"> • The patient has been taking a long-acting opioid regularly for at least two months. • Polysomnography shows a central apnea index of five or more or periodic breathing (10 or more central apneas and hypopneas per hour of sleep in which the hyperpnoea has a crescendo-decrescendo pattern of tidal volume, accompanied by frequent arousals from sleep and derangement of sleep structure). • The disorder is not better explained by another sleep disorder or medical or neurological disorder. | The most common offending drug is methadone; however, the condition also has been described in patients taking time-release morphine and hydrocodone. | NA |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|--|--|--|---|
| Obstructive Sleep Apnea, Adult 327.23 | <p>A, B, and D or C and D satisfy the criteria:</p> <p>A. At least one of the following:</p> <ul style="list-style-type: none"> Unintentional sleep episodes during wakefulness, daytime sleepiness, unrefreshing sleep, fatigue or insomnia The patient wakes with breath holding, gasping, or choking The bed partner reports loud snoring, breathing interruptions, or both during the patient's sleep <p>B. Polysomnographic recording shows the following:</p> <ul style="list-style-type: none"> Five or more scoreable respiratory events per hour of sleep Evidence of respiratory effort during all or a portion of each respiratory event. <p>C. Polysomnographic recording shows the following:</p> <ul style="list-style-type: none"> Fifteen or more scoreable respiratory events per hour of sleep Evidence of respiratory effort during all or a portion of each respiratory event <p>D. The disorder is not better explained by another sleep disorder, medical or neurological disorder, medication use, or substance abuse disorder.</p> | <ul style="list-style-type: none"> Feeling tired after awakening from nighttime sleeping Excessive daytime sleepiness Irritability | NA |
| Sleep Related Nonobstructive Alveolar Hypoventilation, Idiopathic 327.24 | <ul style="list-style-type: none"> Polysomnographic monitoring demonstrates episodes of shallow breathing longer than 10 seconds in duration associated with arterial oxygen desaturation and frequent arousals with arterial oxygen desaturation and frequent arousals from sleep associated with the breathing disturbances of brady-tachycardia. <p>Note: Symptoms are not mandatory to report a diagnosis.</p> <ul style="list-style-type: none"> No primary lung diseases, skeletal malformations, or peripheral neuromuscular disorders that affect ventilation are present. The disorder is not better explained by another current sleep disorder, medical or neurological disorder, mental disorder, medication use or substance use disorder. | <ul style="list-style-type: none"> Excessive daytime sleepiness Frequent arousals and awakenings during sleep Complaints of insomnia Impaired psychosocial or work functioning Frequent episodes of shallow breathing | Primary alveolar hypoventilation, idiopathic central alveolar hypoventilation |
| Sleep Related Hypoventilation/ Hypoxemia Due to Pulmonary Parenchymal or Vascular Pathology 327.26 | <ul style="list-style-type: none"> Lung parenchymal disease or pulmonary vascular disease is present and believed to be the primary cause of hypoxemia. Polysomnography or sleeping arterial blood gas determination shows at least one of the following: <ul style="list-style-type: none"> An SpO₂ during sleep of less than 90% for more than 5 minutes with a nadir of at least 85%. More than 30% of total sleep time at a SpO₂ of less than 90%. Sleeping blood arterial gas with PaCO₂ that is abnormally high or disproportionately increased relative to level during wakefulness. The disorder is not better explained by another current sleep disorder, medical or neurological disorder, mental disorder, medication use or substance use disorder. | Diseases known to cause this disorder subtype are interstitial lung diseases, such as desquamative interstitial pneumonitis and hypersensitivity pneumonitis; idiopathic and secondary forms of pulmonary hypertension; and sickle cell anemia and other hemoglobinopathies. | NA |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|--|----------------------------------|
| Sleep Related Hypoventilation/ Hypoxemia Due to Lower Airways Obstruction 327.26 | <ul style="list-style-type: none"> The disorder is present (as evidenced by a forced expiratory volume exhaled in one-second/forced vital capacity ratio less than 70% of predicted values on pulmonary function testing) and is believed to be the primary cause of hypoxemia. Polysomnography or sleeping arterial blood gas determination shows at least one of the following: <ul style="list-style-type: none"> An SpO₂ during sleep of less than 90% for more than 5 minutes with a nadir of at least 85%. More than 30% of total sleep time at a SpO₂ of less than 90%. Sleeping blood arterial gas with PaCO₂ that is abnormally high or disproportionately increased relative to level during wakefulness. The disorder is not better explained by another current sleep disorder, medical or neurological disorder, mental disorder, medication use or substance use disorder. | NA | NA |
| Sleep Related Hypoventilation/ Hypoxemia Due to Neuromuscular and Chest Wall Disorders 327.26 | <ul style="list-style-type: none"> A neuromuscular or chest wall disorder is present and believed to be the primary cause of hypoxemia. Polysomnography or sleeping arterial blood gas determination shows at least one of the following: <ul style="list-style-type: none"> An SpO₂ during sleep of less than 90% for more than 5 minutes with a nadir of at least 85%. More than 30% of total sleep time at a SpO₂ of less than 90%. Sleeping blood arterial gas with PaCO₂ that is abnormally high or disproportionately increased relative to level during wakefulness. The disorder is not better explained by another current sleep disorder, medical or neurological disorder, mental disorder, medication use or substance use disorder. | Patients are at risk for developing the consequences of nocturnal hypoxemia, including pulmonary artery hypertension, cor pulmonale, and neurocognitive dysfunction. | Obesity-hypoventilation syndrome |
| Other Sleep Related Breathing Disorders 327.20 | The diagnosis is used for forms of SRBD that cannot be classified elsewhere or may not neatly fit into one category but are believed to be a function of respiratory disturbance in sleep. In some cases, this diagnosis may be assigned on a temporary basis when an SRBD diagnosis seems appropriate but further evaluation is required to determine the specific type of breathing abnormality in sleep. | NA | NA |

Source: American Academy of Sleep Medicine (2005)

Hypersomnias of Central Origin Not Due to a Circadian Rhythm Sleep Disorder, Sleep Related Breathing Disorder, or Other Cause of Disturbed Nocturnal Sleep

This section includes disorders in which the primary complaint is daytime sleepiness and in which the cause of the primary symptom is not disturbed nocturnal sleep or misaligned circadian rhythms. Estimated to afflict about 9 percent of the adult population (Hublin et al., 1996), daytime sleepiness is defined as the inability to stay awake and alert during the major waking episodes of the day, resulting in unintended lapses into drowsiness or sleep. The severity of daytime sleepiness can be quantified subjectively using severity scales such as the Epworth Sleepiness Scale (ESS) and objectively using the Multiple Sleep Latency Test (MSLT) and Maintenance of Wakefulness Test (MWT). These measures are poorly correlated with each other and must be used with appropriate clinical judgment.

There are two main categories of hypersomnia:

- **Primary hypersomnia** does not have a known cause and is a chronic condition.
- **Secondary hypersomnia** may be traced to medical conditions (e.g., narcolepsy), physical injury and use of certain medications (e.g., tranquilizers).

Hypersomnia is considered to be a less common sleep disorder than insomnia and is most likely to first occur in people during adolescence and young adulthood.

Types

For diagnostic criteria and symptoms of these disorders, see Table 4.

Narcolepsy With Cataplexy

Narcolepsy with cataplexy is a disabling sleep disorder affecting 0.02 percent of adults worldwide. It is characterized by severe, irresistible daytime sleepiness and sudden loss of muscle tone (cataplexy), and can be associated with sleep-onset or sleep-offset paralysis and hallucinations, frequent movement and awakening during sleep, and weight gain.

Narcolepsy Without Cataplexy

Excessive daytime sleepiness is most typically associated with naps that are refreshing in nature while nocturnal sleep is normal or moderately disturbed without excessive amounts of sleep. Sleep paralysis, hypnagogic hallucinations or automatic behavior may be present.

Narcolepsy Due to Medical Condition

The direct cause of this disorder is a coexisting medical or neurological disorder. It must be documented clinically or polysomnographically. Daytime sleepiness is associated, and some have sleep paralysis, hypnagogic hallucinations or automatic behavior.

Recurrent Hypersomnia

A rare condition, the best-characterized recurrent hypersomnia is Kleine-Levin syndrome. These patients have recurrent episodes of hypersomnia often associated with other symptoms that typically occur weeks or months apart. Episodes usually last a few days to several weeks and appear once to 10 times a year. Episodes are often preceded by fatigue or a headache lasting a few hours. Patients may sleep as long as 16 to 18 hours a day.

Idiopathic Hypersomnia With Long Sleep Time

This is a disorder of severe sleepiness. It causes a person to have disabling daytime sleepiness, and it occurs despite an increased nightly sleep time of more than 10 hours. People with this disorder may sleep 12 to 14 hours every night with few interruptions. Even after sleeping this long time at night, it is very hard for them to wake up. Once awake, they may appear to be partially asleep, confused or drunk. This is called sleep drunkenness. Confusion and sleep drunkenness are common after morning awakening and also after naps.

Idiopathic Hypersomnia Without Long Sleep Time

This disorder is similar to Idiopathic Hypersomnia With Long Sleep Time but night sleep is either normal duration or slightly prolonged but less than 10 hours.

Behaviorally Induced Insufficient Sleep Syndrome

This disorder occurs when a person regularly fails to get enough sleep at night. The result is sleep deprivation. It keeps a person from feeling alert and well rested during the day. Considered a voluntary, but unintentional disorder, a person is normally unaware that he or she needs more sleep. An exam also shows that the person is able to sleep well when given the chance. It also detects no medical reason for the person to be sleepy. A mental exam also reveals nothing abnormal.

Hypersomnia Due to Medical Condition

This condition occurs when a person is sleepy due to a medical illness or a problem involving the nerves or brain. The person is tired no matter how much sleep he or she gets. If the medical problem or the nerve disorder goes away, then so does the sleepiness. There are many different medical problems that can cause sleepiness. These are just a few examples: Parkinson Disease, head trauma, brain tumors, brain infections, and kidney failure. Many of these problems can occur at any age and in either gender. This means that virtually anyone can get this disorder.

Hypersomnia Due to Drug or Substance (Abuse and for Alcohol Use)

This condition causes a person to feel an excessive level of sleepiness. It results from the abuse of alcohol, street drugs, or even properly prescribed drugs from a doctor. People with this problem usually abuse sleeping pills, or sedatives, and also alcohol.

Hypersomnia Due to Drug or Substance (Medications)

Daytime sleepiness may result from medications, such as antiepileptic medications and opioid analgesics.

Hypersomnia Not Due to Substance or Known Physiological Condition

This disorder is characterized by excessive nocturnal sleep, daytime sleepiness, or excessive napping, which is generally found not restorative. Patients are typically focused on their hypersomnia, and psychiatric symptoms typically become apparent only after prolonged interviews or psychometric testing. This disorder accounts for 5 percent to 7 percent of hypersomnia cases and appears more common in women 20 to 50 years old.

Risk Groups

- Likely to first occur in people during adolescence and young adulthood
- Hereditary link
- Medical problems: head injuries, tumors or damage to the central nervous system depression, bipolar disorder, epilepsy, heart problems, hypercalcemia, hyperthyroidism, liver problems, lung problems, multiple sclerosis, obesity and brain infections (e.g., meningitis, encephalitis).
- Autonomic nervous system dysfunction: The autonomic nervous system regulates physiologic processes in the body that are not under a person's control, such as blood pressure. When this system is impaired, it can lead to hypersomnia.
- Chronic fatigue syndrome: This is condition in which a patient experiences prolonged tiredness that is not relieved by rest. Hypersomnia often is associated with this condition.
- Drug or alcohol abuse: Use of various illegal and legal drugs and medications can cause hypersomnia. For example, patients who abuse sleep-aid drugs may experience chronic drowsiness.

Effects

- EDS
- Dreaming while awake
- Sleep paralysis
- Prolonged night-time sleep
- Hallucinations
- Intermittent manifestations of rapid eye movement sleep during wakefulness
- Cataplexy
- Anxiety
- Decreased appetite
- Impaired memory
- Increased daytime hyperactivity in children
- Irritability and restlessness
- Slowed speech and thinking

Treatments

Treatment of narcolepsy is primarily directed at reducing excessive daytime sleepiness (EDS). Regular nocturnal sleep times with adequate time in bed is emphasized. In addition, scheduled daytime naps have been shown to improve the symptoms of severe daytime sleepiness. To enhance alertness further, pharmacologic therapy with stimulants is offered in a stepwise fashion.

- Therapy with modafinil is usually started first because of reasonable efficacy, a favorable side effect profile, and a lack of the peak and trough effects of shorter duration agents. Approved in 1998, this wake-promoting agent works via an unknown mechanism and appears to have minimal potential for addiction. Headache is the most common adverse reaction, but, unlike amphetamines, modafinil does not produce sympathomimetic effects.
- Conventional stimulants that increase synaptic amine availability, including methylphenidate, dextroamphetamine, and methamphetamine, are introduced if sleepiness persists with modafinil. Side effects such as palpitations and anxiety are not uncommon, and must be weighed against the benefits of increased alertness. High-dose stimulants carry a risk of side effects, such as weight loss and psychiatric disturbances.
- Cataplexy has traditionally been controlled with tricyclic antidepressants, and more recently with selective serotonin reuptake inhibitors and venlafaxine. The approval in 2002 of sodium oxybate for the treatment of cataplexy adds another treatment option. The drug binds γ -hydroxybutyrate, and, to a lesser extent, γ -amino butyric acid-B receptors in the brain. It is taken at bedtime and again 2.5 to 4 hours later. Sodium oxybate may improve nocturnal sleep continuity and increase slow-wave sleep. Patients with narcolepsy report improved daytime alertness when receiving therapy with the drug, and sodium oxybate received additional U.S. Food and Drug Administration approval in late 2005 for the treatment of EDS in narcolepsy patients. Its potential for abuse was demonstrated in the street drug γ -hydroxybutyrate, and sodium oxybate is available only through a single central pharmacy. Side effects include dizziness, vomiting, sleep walking, and enuresis. It can also produce respiratory depression and should not be used with other sedatives.
- Attempts at immunomodulation in a limited number of narcoleptic patients have been reported. One pediatric case report utilizing prednisone demonstrated no benefit, and a woman receiving plasma exchange had short-lived relief of cataplexy. The response of five patients undergoing treatment with IV Ig was varied; three had marked improvement in cataplexy, but objective improvement in the results of testing of the maintenance of wakefulness was seen in only one patient.

Table 4: Diagnostic Criteria and Symptoms Associated with Disorders of Hypersomnia of Central Origin Not Due to a Circadian Rhythm Sleep Disorder, Sleep Related Breathing Disorder, or Other Cause of Disturbed Nocturnal Sleep

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|---|--|--|
| Narcolepsy With Cataplexy 347.01 | <ul style="list-style-type: none"> • The patient has a complaint of excessive daytime sleepiness occurring almost daily for at least three months. • A definite history of cataplexy, defined as sudden and transient episodes of loss of muscle tone triggered by emotions, is present. • The diagnosis of narcolepsy with cataplexy should, whenever possible, be confirmed by nocturnal polysomnography followed by an MSLT; the mean sleep latency on MSLT is less than or equal to 8 minutes and 2 or more SOREMPs are observed following sufficient nocturnal sleep (min. 6 hours) during the night prior to the test. Alternatively, hypocretin-1 levels in the CSF are less than normal or equal to 110 pg/mL or one-third of mean normal control values. • The hypersomnia is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <ul style="list-style-type: none"> • Sleep paralysis • Hypnagogic hallucinations • Nocturnal sleep disruption • Memory lapse • Ptosis • Blurred vision • Diplopia • Increased BMI • RBD | Gelineau Syndrome |
| Narcolepsy Without Cataplexy 347.00 | <ul style="list-style-type: none"> • The patient has a complaint of excessive daytime sleepiness occurring almost daily for at least three months. • Typical cataplexy is not present, although doubtful or atypical cataplexy-like episodes may be reported. • The diagnosis of narcolepsy without cataplexy must be confirmed by nocturnal polysomnography followed an MSLT; the mean sleep latency on MSLT is less than or equal to 8 minutes, and 2 or more SOREMPs are observed following sufficient nocturnal sleep (min. 6 hours) during the night prior to the test. • The hypersomnia is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <ul style="list-style-type: none"> • Memory lapse • Ptosis • Blurred vision • Diplopia • Nightmares • RBD • Frequent nocturnal sleep disruption • Cataplexy-like episodes | NA |
| Narcolepsy Due to Medical Condition (Without Cataplexy) 347.10) (With Cataplexy) 347.11) | <ul style="list-style-type: none"> • The patient has a complaint of excessive daytime sleepiness occurring almost daily for at least three months. • One or more of the following must be observed: <ul style="list-style-type: none"> ○ Definite history of cataplexy; ○ If Cataplexy is not present or is very atypical, polysomnographic monitoring performed over the patient’s habitual sleep period followed by an MSLT must demonstrate a mean sleep latency on the MSLT of less than 8 minutes with 2 or more SOREMPs, despite sufficient nocturnal sleep prior to the test (minimum 6 hours). ○ Hypocretin-1 levels in the CSF are less than 110 pg/mL (or 30 percent of normal control values), provided the patient is not comatose. • A magnificent underlying medical or neurological disorder accounts for the daytime sleepiness. • The hypersomnia is not better explained by another sleep disorder, mental disorder, medication use, or substance use disorder. | <ul style="list-style-type: none"> • Daytime sleepiness • Sleep paralysis • Hypnagogic hallucinations • Insomnia | Secondary narcolepsy, symptomatic narcolepsy |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|--|---|---|----------------------|
| Narcolepsy, Unspecified 347.00 | This diagnosis is used on a temporary basis when the patient meets clinical and MSLT criteria for narcolepsy, but further evaluation is required to determine the specific diagnostic for narcolepsy. | NA | NA |
| Recurrent Hypersomnia (Including Kleine-Levin Syndrome and Menstrual-Related Hypersomnia) 327.13 | <ul style="list-style-type: none"> The patient experiences recurrent episodes of excessive sleepiness of two days to four weeks duration. Episodes recur at least once a year. The patient has normal alertness, cognitive functioning and behavior between attacks. The hypersomnia is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <ul style="list-style-type: none"> Fatigue Headache Body weight gain of a few kilograms Cognitive abnormalities such as feelings of unreality, confusion, and hallucination Binge eating Hypersexuality Irritability Aggressiveness | Periodic hypersomnia |
| Idiopathic Hypersomnia With Long Sleep Time 327.11 | <ul style="list-style-type: none"> Excessive daytime sleepiness occurring almost daily for at least three months. The patient has prolonged nocturnal sleep time (more than 10 hours) documented by interview, actigraphy or sleep logs. Waking up in the morning or at the end of naps is almost always laborious. Nocturnal polysomnography has excluded other causes of daytime sleepiness. The polysomnogram demonstrates a short sleep latency and a major sleep period that is prolonged to more than 10 hours in duration. If an MSLT is performed following overnight polysomnography, a mean sleep latency of less than 8 minutes is found, and fewer than 2 SOREMPs are recorded. Mean sleep latency in idiopathic hypersomnia with long sleep time has been shown to be 6.2 ± 3.0 minutes. The sleep disorder is not better explained by another sleep disorder, medical or neurological disorder, or mental disorder. <p>Note: <i>Of particular importance, head trauma should not be considered to be the cause of the sleepiness.</i></p> | <ul style="list-style-type: none"> Constant and severe sleepiness with prolonged but unrefreshing naps of up to three or four hours. Post-awakening confusion and difficulty waking up Nocturnal sleep of 10 or more hours | NA |
| Idiopathic Hypersomnia Without Long Sleep Time 327.12 | <ul style="list-style-type: none"> Excessive daytime sleepiness occurring almost daily for at least three months. Patient has normal nocturnal sleep Nocturnal polysomnography has excluded other causes of daytime sleepiness. Polysomnography demonstrates a major sleep period that is normal in duration (greater than 6 hours and less than 10). An MSLT following overnight polysomnography demonstrates a mean sleep latency of less than 8 minutes and fewer than 2 SOREMPs. Insomnia clearly associated with the medical or physiologic condition. The sleep disorder is not better explained by another sleep disorder, mental disorder, medication use or substance abuse disorder. Mean sleep latency in idiopathic hypersomnia with long sleep time has been shown to be 6.2 ± 3.0 minutes. | <ul style="list-style-type: none"> Severe daytime sleepiness Normal nocturnal sleeping | NA |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|---|--|-----------------|
| | <ul style="list-style-type: none"> The sleep disorder is not better explained by another sleep disorder, medical or neurological disorder, or mental disorder. | | |
| Behaviorally Induced Insufficient Sleep Syndrome 307.44 | <ul style="list-style-type: none"> Excessive sleepiness for at least three months. Habitual sleep episode usually shorter than expected from age-adjusted normative data. When habitual sleep schedule is not maintained (weekends or vacation time), individual sleeps considerably longer than usual. When polysomnography performed, sleep latency is less than 10 minutes and sleep efficiency greater than 90 percent. During an MSLT, a short mean sleep latency of less than 8 minutes may be observed. The sleep disorder is not better explained by another sleep disorder, medical or neurological disorder, or mental disorder. | <ul style="list-style-type: none"> Irritability Concentration and attention deficits Reduced vigilance Distractibility Reduced motivation Anergia Dysphoria Fatigue Restlessness Incoordination Malaise Sleep paralysis Hypnagogic hallucinations | NA |
| Hypersomnia Due to Medical Condition 327.14 | <ul style="list-style-type: none"> Excessive sleepiness for at least three months. A significant underlying medical or neurological disorder accounts for the daytime sleepiness. If an MSLT is performed, the mean sleep latency is less than 8 minutes with no more than 1 SOREMP following polysomnographic monitoring performed over the patient's habitual sleep period, with a minimum total sleep time of 6 hours. The sleep disorder is not better explained by another sleep disorder, mental disorder, medication use, or substance abuse disorder. | <ul style="list-style-type: none"> Daytime sleepiness varies in severity and may resemble narcolepsy Sleep paralysis Hypnagogic hallucinations Automatic behavior Long sleep episode and unrefreshing sleep | NA |
| Hypersomnia Due to Drug or Substance (Abuse 292.85) (For Alcohol use 291.82) | <ul style="list-style-type: none"> Excessive sleep Complaint is believed to be secondary to current use, recent discontinuation, or prior prolonged use of drugs. The hypersomnia is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | <ul style="list-style-type: none"> Excessive nocturnal sleep Daytime sleepiness Excessive daytime naps | NA |
| Hypersomnia Due to Drug or Substance (Medications) 292.85 | <ul style="list-style-type: none"> Excessive sleep Complaint is associated with current use, recent discontinuation, or prior prolonged use of a prescribed medicine. The hypersomnia is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | <ul style="list-style-type: none"> Excessive nocturnal sleep Daytime sleepiness Excessive daytime naps | NA |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|---|--|
| Physiological Condition (Nonorganic Hypersomnia, NOS) 327.15 | <ul style="list-style-type: none"> • Excessive sleep, day or night • Complaint is associated with a psychiatric diagnosis. • Polysomnographic monitoring demonstrates both of the following: <ul style="list-style-type: none"> ○ Reduced sleep efficiency and increased frequency and duration of awakenings ○ Variable, often normal, mean sleep latencies on the MSLT • The hypersomnia is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | <ul style="list-style-type: none"> • Excessive nocturnal sleep • Daytime sleepiness • Excessive daytime naps • Causative psychiatric conditions: mood disorders, conversion or undifferentiated somatoform disorder • Poor work attendance • Lack of interest and social withdrawal • Decreased energy level | Hypersomnia associated with mental disorders, psychiatric hypersomnia, secondary hypersomnia (psychiatric), sleep hypochondriasis, pseudohypersomnia or pseudonarcolepsy |
| Physiological (Organic) Hypersomnia, Unspecified (Organic Hypersomnia, NOS) 327.10 | Disorders that satisfy clinical criteria (a complaint of excessive sleepiness occurring almost daily for at least three months) and MSLT criteria (mean sleep latency less than 8 minutes with fewer than 2 SOREMPs) for hypersomnolence and are believed to be due to a physiological condition, but do not meet criteria for other hypersomnolence conditions, are classified here. | NA | NA |

Source: American Academy of Sleep Medicine (2005)

Circadian Rhythm Sleep Disorders

Circadian rhythm sleep disorders – for which the prevalence in the U.S. population is unknown – involve a problem in the timing of when a person sleeps and is awake. The human body has a master circadian clock in a control center of the brain known as the *suprachiasmatic nucleus* (SCN). This internal clock regulates the timing of such body rhythms as temperature and hormone levels. The primary circadian rhythm that this body clock controls is the sleep-wake cycle. The circadian clock functions in a cycle that lasts a little longer than 24 hours.

The circadian clock is “set” primarily by visual cues of light and darkness that are communicated along a pathway from the eyes to the SCN. This keeps the clock synchronized to the 24-hour day. Other time cues, known as *zeitgebers*, also can influence the clock’s timing. These cues include meal and exercise schedules. Circadian rhythms and their sensitivity to time cues may change as a person ages.

Each circadian rhythm sleep disorder involves one of these two problems:

- Difficulty in initiating sleep.
- Struggling to maintain sleep, waking up frequently during the night.
- Waking up too early and unable to go back to sleep.
- Sleep is non-restorative or of poor quality.

Types

For diagnostic criteria and symptoms of the disorders listed below, refer to Table 5.

Delayed Sleep Phase Disorder (DSP)

DSP occurs when a person regularly goes to sleep and wakes up more than two hours later than is considered normal. People with DSP tend to be “evening types,” who typically stay awake until 1 a.m. or later and wake up in the late morning or afternoon. If able to go to bed at the preferred late time on a regular basis, a person with DSP will have a very stable sleep pattern. DSP is more common among adolescents and young adults with a reported prevalence of 7 percent to 16 percent. It is estimated that DSP is seen in approximately 10 percent of patients with chronic insomnia in sleep clinics. A positive family history may be present in approximately 40 percent of individuals with DSP.

Advanced Sleep Phase Disorder (ASP)

ASP occurs when a person regularly goes to sleep and wakes up several hours earlier than most people. People with ASP tend to be “morning types” who typically wake up between 2 a.m. and 5 a.m. and go to sleep between 6 p.m. and 9 p.m. If able to go to bed at the preferred early time on a regular basis, a person with ASP will have a very stable sleep pattern. ASP affects approximately 1 percent in middle-aged and older adults and increases with age.

Jet Lag Disorder

Jet lag occurs when long travel by airplane quickly puts a person in another time zone. In this new location, the person must sleep and wake at times that are misaligned with his or her body clock. The severity of the problem increases with the number of time zones that are crossed. The body tends to have more trouble adjusting to eastward travel than to westward travel. Jet lag

affects all age groups. However, in the elderly, symptoms may be more pronounced and the rate of recovery may be more prolonged than in younger adults. Sleep deprivation, prolonged uncomfortable sitting positions, air quality and pressure, stress and excessive caffeine and alcohol use may increase the severity of insomnia and impaired alertness and function associated with trans-meridian travel. Jet lag is a temporary condition with symptoms that begin approximately one to two days after air travel across at least two time zones. Exposure to light at inappropriate times may prolong the time of adjustment by shifting the circadian rhythms in the opposite direction.

Shift Work Disorder

Shift-work disorder occurs when a person's work hours are scheduled during the normal sleep period. Sleepiness during the work shift is common, and trying to sleep during the time of day, when most others are awake, can be a struggle. Shift-work schedules include night shifts, early-morning shifts and rotating shifts. Depending on the type of shift, diurnal or circadian preferences may influence the ability to adjust to shift work. For example, individuals described as morning types appear to obtain shorter daytime sleep after a night shift. Persons with co-morbid medical, psychiatric and other sleep disorders, such as sleep apnea, and individuals with a strong need for stable hours of sleep may be at particular risk.

Irregular Sleep-Wake Rhythm

This disorder occurs when a person has a sleep-wake cycle that is undefined. The person's sleep is fragmented into a series of naps that occur throughout a 24-hour period. Sufferers complain of chronic insomnia, excessive sleepiness or both. A low-amplitude or irregular circadian rhythm of sleep-wake pattern may be seen in association with neurological disorders, such as dementia, and in children with mental retardation.

Free-Running (Nonentrained) Type

This disorder occurs when a person has a variable sleep-wake cycle that shifts later every day. It results most often when the brain receives no lighting cues from the surrounding environment. Occasionally, the disorder is associated with mental retardation or dementia. It has also been suggested that there may be an overlap between circadian rhythm sleep disorder, delayed sleep phase type, and circadian rhythm sleep disorder, free-running type.

Risk Groups

- *DSP* is more common in *teens and young adults*, occurring at a rate of 16 percent.
- *ASP* is more common *as people age*, occurring in about 1 percent of middle-aged and older adults.
- *Irregular sleep-wake rhythm* may occur in *nursing home residents* and other people who have little exposure to time cues such as light, activity and social schedules.
- *Free-running (nonentrained) type* occurs in more than half of all people who are totally blind.
- *Jet lag* can affect anyone who travels by air, but symptoms may be more severe and may last longer in *older people* and when anyone travels in an *eastward direction*.
- *Shift-work disorder* is most common in people who work *night shifts* and *early-morning shifts*

Effects

These are some of the effects that can occur because of a circadian rhythm sleep disorder:

- Sleep loss
- Excessive sleepiness
- Insomnia
- Depression
- Impaired work performance
- Disrupted social schedules
- Stressed relationships

Treatments

Lifestyle changes, improving sleep hygiene, bright-light therapy, medications, and melatonin therapy are used to treat circadian rhythm disorders.

Lifestyle Changes

People may cope better with certain circadian rhythm sleep disorders by doing such things as adjusting their exposure to daylight, making changes in the timing of their daily routines, and strategically scheduling naps.

Sleep Hygiene

These instructions help patients develop healthy sleep habits and teach them to avoid making the problem worse by attempting to self-medicate with drugs or alcohol.

Bright Light Therapy

This therapy synchronizes the body clock by exposing the eyes to safe levels of intense, bright light for brief durations at strategic times of day.

Medications

A hypnotic may be prescribed to promote sleep or a stimulant may be used to promote wakefulness.

Melatonin

This hormone is produced by the brain at night and seems to play a role in maintaining the sleep-wake cycle. Taking melatonin at precise times and doses may alleviate the symptoms of some circadian rhythm sleep disorders.

Table 5: Diagnostic Criteria and Symptoms of Circadian Rhythm Sleep Disorders

| Disorders/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|--|-----------------|
| Circadian Rhythm Sleep Disorder, Delayed Sleep Phase Type (Delayed Sleep Phase Disorder) 327.31 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • There is a persistent delay in the phase of the major sleep period in relation to the desired sleep time and wake-up time, as evidenced by a chronic or recurrent complaint of inability to fall asleep at a desired conventional clock time together with the inability to awaken at a desired and socially acceptable time. • When allowed to choose their preferred schedule, individuals will exhibit normal sleep quality and duration for age and maintain a delayed, but stable, phase of entrainment to the 24-hour sleep-wake pattern. • Sleep log or actigraphy monitoring (including sleep diary) for at least 7 days demonstrates a stable delay in the timing of the habitual sleep period. • The disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | This disorder is characterized by habitual sleep-wake times that are delayed, usually more than two hours, relative to conventional or socially acceptable times. Affected individuals complain of difficulty falling asleep at a socially acceptable time, but once sleep ensues, sleep is reported to be normal. A typical patient has difficulty initiating sleep and prefers late wake-up times. Attempts to fall asleep earlier are usually unsuccessful. | NA |
| Circadian Rhythm Sleep Disorder, Advanced Sleep Phase Type (Advanced Sleep Phase Disorder) 327.32 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • There is an advance in the phase of the major sleep period in relation to the desired sleep time and wake-up time, as evidenced by a chronic or recurrent complaint of inability to fall asleep at a desired conventional clock time, together with an inability to remain asleep until the desired and socially acceptable time for awakening. • When allowed to choose their preferred schedule, sleep quality and duration are normal for age with an advanced, but stable, phase of entrainment to the 24-hour sleep-wake pattern. • Sleep log or actigraphy monitoring (including sleep diary) for at least 7 days demonstrates a stable advance in the timing of the habitual sleep period. • The disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | The disorder is a stable advance of the major sleep period characterized by habitual sleep onset and wake-up times that are several hours earlier relative to conventional and desired times. Affected individuals complain of: <ul style="list-style-type: none"> • Sleepiness in the late afternoon or early evening • Early sleep onset • Spontaneous early morning awakening. When allowed to maintain and advance schedule, sleep is usually normal for age. | NA |
| Circadian Rhythm Sleep Disorder, Irregular Sleep-Wake Phase Type (Irregular Sleep-Wake Rhythm) 327.33 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • There is a complaint of insomnia, excessive sleepiness, or both • Sleep log or actigraphy monitoring (including sleep diary) for at least 7 days demonstrates multiple irregular sleep bouts (at least 3) during a 24-hour period. • Total sleep time per 24-hour period is essentially normal for age. • The disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | The disorder is characterized by lack of a clearly defined circadian rhythm of sleep and wake. The sleep-wake pattern is temporally disorganized so that sleep and wake periods are variable throughout the 24-hour period. Individuals have symptoms of: <ul style="list-style-type: none"> • Insomnia • Excessive sleepiness, depending on time of day | NA |

| Disorders/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|--|-----------------|
| Circadian Rhythm Sleep Disorder, Free-Running Type (Nonentrained Type) 327.34 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • There is a complaint of insomnia or excessive sleepiness related to abnormal synchronization between the 24-hour light-dark cycle and the endogenous circadian rhythm of sleep and wake propensity. • Sleep log or actigraphy monitoring (including sleep diary) for at least 7 days demonstrates a pattern of sleep and wake times that typically delays each day with a period longer than 24 hours. • The disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | The disorder is characterized by sleep symptoms that occur because the intrinsic circadian pacemaker is not entrained to a 24-hour period or is free-running with a non-24 hour period (usually slightly longer). Some individuals adopt a sleep pattern that is congruent with their free-running pacemaker and shift their sleep times each day in concert with their circadian rhythms. | NA |
| Circadian Rhythm Sleep Disorder, Jet Lag Type (Jet Lag Disorder) 327.35 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • Complaint of insomnia or excessive daytime sleepiness associated with transmeridian jet travel across at least two time zones. • There is associated impairment of daytime function, general malaise, or somatic symptoms, such as gastrointestinal disturbance within one or two days after travel. • The disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | The severity of symptoms, listed below, is dependent upon the number of time zones traveled and the direction of travel. <ul style="list-style-type: none"> • EDS • Decreased sleep • Decreased subjective alertness • Impaired daytime function | NA |
| Circadian Rhythm Sleep Disorder, Shift Work Type (Shift Work Disorder) 327.36 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • Complaint of insomnia or excessive sleepiness that is temporally associated with a recurring work schedule that overlaps the usual time for sleep. • The symptoms are associated with the shift-work schedule over the course of at least one month • Sleep log or actigraphy monitoring (with sleep diary) for at least seven days demonstrates disturbed circadian and sleep-time misalignment. • The disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, or medication use. | <ul style="list-style-type: none"> • Insomnia • Excessive sleepiness that occurs in relation to work hours that are during the usual sleep period • Impairment of work performance • Reduced alertness | NA |
| Circadian Rhythm Sleep Disorder Due to Medical Condition 327.27 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • There is a complaint of insomnia or excessive sleepiness related to alterations of the circadian timekeeping system or a misalignment between the endogenous circadian rhythm and exogenous factors that affect the timing or duration of sleep. • An underlying medical or neurological disorder predominantly accounts for the circadian rhythm sleep disorder. • Sleep log or actigraphy monitoring (with sleep diary) for at least 7 days demonstrates disturbed or low amplitude circadian rhythmicity. • The disorder is not better explained by another current sleep disorder, mental disorder, medication use or substance use disorder. | The etiology of this disorder is an underlying primary medical or neurological condition. Patients may present with a variety of symptoms, including: <ul style="list-style-type: none"> • Insomnia • Excessive sleepiness • Sleep-wake pattern may range from alterations in phase to irregular patterns. | NA |
| Other Circadian Rhythm Sleep Disorder (Circadian Rhythm Disorder, NOS) 327.29 | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • Disorder that are not due to drug or substance • Disorders that do not meet criteria for other circadian rhythm sleep disorders are classified here. | NA | NA |

| Disorders/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|--|----------------------|-----------------|
| Other Circadian Rhythm Sleep Disorder Due to (Drug or Substance) 292.85 (For Alcohol Use 291.82) | <ul style="list-style-type: none"> • Must meet general criteria for Circadian Rhythm Sleep Disorder • Disorders that are due to a drug or substance • Disorders that do not meet criteria for other circadian rhythm sleep disorders are classified here. | NA | NA |

Source: American Academy of Sleep Medicine (2005)

Parasomnias

Parasomnias are undesirable physical events or experiences that occur during entry into deep sleep, within sleep, or during arousals from sleep. Parasomnias, which affect about 10 percent of Americans, encompass abnormal sleep-related movements, behaviors, emotions, perceptions, dream and autonomic nervous system functioning. Parasomnias are clinical disorders because of the resulting injuries, sleep disruption, adverse health effects, and untoward psychosocial effects. Parasomnias can affect the patient, the bed partner, or both.

Abnormal sleep-related movement comprises a subset of parasomnias that is detailed in this section. Parasomnias often involve complex, seemingly purposeful, and goal-directed behaviors, which presumably are performed with some personal meaning to the individual at the time, despite the illogical and unsound nature of the behaviors enacted outside the conscious awareness of the individual. Only one parasomnia in the ICSD-2, Rapid Eye Movement Sleep Behavior Disorder (RBD), requires polysomnographic documentation as one of the essential diagnostic criteria.

Each of the three types of parasomnias is revealed in this section:

- Disorders of Arousal (From non-rapid eye movement sleep)
- Disorders usually associated with rapid eye movement sleep
- Other parasomnias

Types

For diagnostic criteria and symptoms of all the disorders, see Table 6.

Disorders Of Arousal (From Non-Rapid Eye Movement Sleep)

This category includes a group of parasomnias that typically occur in slow-wave sleep (SWS, NREM stages 3 and 4) and include confusional arousals, sleepwalking, and sleep terrors. They typically occur during the first part of the night when SWS is most prevalent. Genetic factors have a strong influence on the occurrence of arousal disorders, and both sexes are equally affected. No known specific mechanism for disorders of arousal is suggested, but impaired arousal from sleep has been postulated as a cause for their occurrence. Conditions related to sleep, such as sleep deprivation, central nervous system-depressant medications, medical conditions (e.g., metabolic, toxic or other encephalopathies), idiopathic hypersomnia, symptomatic hypersomnias, and factors that disrupt SWS (e.g., pain, stress, distended bladder, OSA, and PLMD), can trigger an attack. Experimentally induced forced arousals have been documented to induce episodes in chronic sleepwalkers.

Confusional Arousals

This disorder is characterized by mental confusion or confusional behavior during or following arousals from sleep, typically from SWS in the first part of the night, but also upon attempted awakening from sleep in the morning. Sleep talking or occasional shouting is common during confusional arousals, and bruxism also can occur.

Sleepwalking

Sleepwalking consists of a series of complex behaviors that are initiated during arousals from SWS and culminate in walking around with the altered state of consciousness and impaired judgment. Episodes often begin with sitting up in bed and looking about in a confused manner before walking; episodes also can begin with immediately leaving bed and walking or even bolting from the bed and running. Frantic attempts to escape an imminent or perceived threat can occur. Agitated, belligerent, or violent behavior can occur. There is usually amnesia for these episodes, although adults can usually remember fragments. Sleep talking and shouting can accompany these events. The eyes are usually open or wide open with a confused “glassy” stare. Sleepwalking also can occur during daytime nap.

Sleep Terrors

This disorder consists of arousals from SWS accompanied by a cry or piercing scream and autonomic nervous system and behavioral manifestations of intense fear. There is often intense autonomic discharge, with tachycardia, tachypnea, flushing of the skin, diaphoresis, mydriasis, and increased muscle tone. The person usually sits up in bed; is unresponsive to external stimuli; and, if awakened, is confused or disoriented. Violent behaviors can result, and amnesia for the episode usually occurs, although there are reports of brief dream fragments or images. The episode may be accompanied by incoherent vocalizations.

Parasomnias Usually Associated With Rapid Eye Movement

Parasomnias previously discussed have been related to dysfunctions associated with sleep-state transitions and partial arousal from NREM Stage 3 and Stage 4 sleep. Parasomnias also have been reported to occur out of Stage REM sleep. In many cases, manifestations are dissimilar and can be differentiated on clinical grounds alone. Certain REM sleep parasomnias, however, may share similar symptoms to partial arousal disorders.

Rapid Eye Movement Sleep Behavior Disorder (RBD)

Patients with RBD act out dramatic and/or violent dreams during rapid eye movement (REM) stage sleep. Another feature of RBD is shouting and grunting. RBD is a type of parasomnia, which is a condition that occurs during sleep and creates a disruptive event. It is similar to other sleep disorders that involve motor activity, such as sleepwalking and PLMD.

Unlike these conditions, RBD movements occur during REM sleep, which is usually characterized by a state of atonia, or sleep paralysis. Diagnosis and treatment involves polysomnography, drug therapy, and the exclusion of potentially serious neurological disorders. RBD is usually seen in men 60 years or older, but also occurs in younger people and in women. Incidents of REM behavior disorder are often described anecdotally to family members and not to physicians, so statistics of incidence are inexact.

Recurrent Isolated Sleep Paralysis (RISP)

Isolated sleep paralysis (ISP) results from persistence of REM activity, including typical paralysis associated with REM, after individuals begin to awaken and become aware or as they are falling asleep. During these episodes, individuals are aware of their surroundings, but are unable to move. ISP is a poorly understood phenomenon that has attracted increased attention in

recent years in the medical community and in psychological research. Although the occurrence of ISP is relatively common, recurrent ISP (RISP) is a rarer variant of sleep paralysis characterized by frequent episodes or a complex of sequential episodes in which the total duration may exceed one hour, and particularly by the range and sense of perceived reality of the subjective phenomena experienced during episodes. Although such phenomena are usually categorized as hypnagogic or hypnopompic hallucinations, there is at present no integrated model that adequately explains the ensemble of physiological, neurological, cognitive and psychological components of RISP.

Nightmare Disorder

This disorder, which causes sleep disturbance and leads to sleep avoidance, is characterized by disturbing mental experiences that generally occur during REM sleep and that often result in awakening. Emotions usually involve anxiety, fear or terror, but frequently also anger, sadness, embarrassment, disgust and other negative feelings. Nightmares typically, but not exclusively, arise during REM sleep; multiple nightmares within a single night may occur and bear similar themes. They can be idiopathic or can be precipitated by a trauma.

Sleep Related Dissociative Disorders

This disorder most often occurs in people who have been abused; a dissociative disorder is often a person's way of defending himself or herself. The abuse can be physical, sexual or verbal. They also are likely to have had a mental health disorder. It is not known how many people are affected. These disorders are much more common in women. They can begin at any age from childhood to middle adulthood.

Violent behaviors are common during an episode. You tend to direct this violence against yourself. Actions may include any of the following:

- Screaming
- Walking
- Running in a frenzied manner
- Suicide attempts

Sleep Related Groaning (Catathrenia)

Sleep-related groaning is a long-lasting disorder that often occurs nightly. It consists of vocal groaning during sleep. This sound is usually quite loud. A person's breathing becomes unusually slow during a groaning episode. He or she takes in a slow, deep breath. Then he or she makes a long exhale that includes the moaning sound. The sound can last from only a few moments to more than 40 seconds. It always ends with a sigh or a grunt. Groans often repeat in clusters for two minutes to one hour. These clusters of groaning may recur many times per night.

Facial expressions are calm and do not reflect anguish. Despite the moaning sound, the groans do not seem to be related to any emotional feelings. Groaning can occur when lying in any position. But it tends to stop when you change positions in bed. Then it may resume again later in the night. The cause is not known, and it's not related to any problem with breathing. There is also no abnormal brain activity involved. A physical exam tends to show no related medical cause.

There also does not appear to be any link to mental disorders. It does not seem to be related to sleep talking or dreaming. Sleep talking involves clear words and speech.

Exploding Head Syndrome

This disorder is a condition that causes the sufferer to occasionally experience a tremendously loud noise as originating from within his or her own head, usually described as the sound of an explosion, roar, waves crashing against rocks, loud voices, or a ringing noise.

This noise usually occurs within an hour or two of falling asleep, but is not the result of a dream and can happen while awake as well. Perceived as extremely loud, the sound is usually not accompanied by pain. Attacks appear to change in frequency over time, with several attacks occurring in a space of days or weeks followed by months of remission. Sufferers often feel a sense of fear and anxiety after an attack, accompanied by elevated heart rate. Attacks are also often accompanied by perceived flashes of light (when perceived on their own, known as a "visual sleep start") or difficulty in breathing. The condition is also known as "auditory sleep starts." It is not thought to be dangerous, although it is sometimes distressing to experience.

Sleep Related Hallucinations

Sleep-related hallucinations are imagined events that seem very real. They are mainly visual. They may involve a person's sense of sound, touch, taste and smell. They may even involve a sense of motion. It is easy to confuse them with a state of dreaming. You may not be sure if you are awake or asleep. They may be similar to nightmares. But when you wake up from a nightmare, you are aware that it occurred while you were asleep. It is clearly recognized as a dream. It is not thought to be real.

They generally occur at one of the two following times:

- As a person is about to fall asleep (hypnagogic)
- As a person's is just waking up (hypnopompic)

The hallucination and the sleep paralysis may occur at the same time but on different nights. The sufferer also may have separate episodes of sleep talking or sleepwalking.

Sleep Related Eating Disorder

This disorder is characterized by abnormal eating patterns during the night. Although it is not as common as sleepwalking, *it* can occur during sleepwalking. People with this disorder eat while they are asleep. They often walk into the kitchen and prepare food without a recollection for having done so. If it occurs often enough, a person can experience weight gain and increase their risk of developing type 2 diabetes. A closely related disorder, known as *night eating syndrome* (NES), is diagnosed when a person eats during the night with full awareness and may be unable to fall asleep again unless he/she eats.

Risk Groups

- More than one parasomnia often occurs in the same person, and they can emerge in close association with *other sleep disorders* such as obstructive sleep apnea and periodic limb movements. Many parasomnias emerge and peak during the *childhood* years.

- Some parasomnias may be related to *post-traumatic stress disorder*.
- *Medications* such as antidepressants may be related to the occurrence of a parasomnia.
- A parasomnia may be related to narcolepsy, Parkinson disease or another *neurological disorder*.
- Parasomnias are common in otherwise *healthy people*.
- In general, nonrapid eye movement (NREM) parasomnias are more prevalent in children.

Effects

- Accidental injury
- Insomnia and daytime sleepiness
- Overeating during sleepwalking leading to obesity
- Relationship difficulties
- Forensic consequences of behavior during sleepwalking, particularly if patient ventures into outside world or displays sexual behavior
- Anxiety and fear
- Depression
- Embarrassment
- Sleep avoidance and deprivation

Treatments

Because parasomnias often occur in healthy people, treatment may be unnecessary. Treatment may be necessary if the parasomnia is especially disturbing to the sleeper or to others in the household, or if it produces behaviors that are potentially dangerous. A treatment program may include the following strategies:

Sleep Hygiene

Educating the patient to avoid drugs, alcohol, and sleep deprivation, all of which may exacerbate a parasomnia.

Medications

Using antidepressants or benzodiazepine sleeping pills to limit episodes and promote sleep

Cognitive Behavioral Therapy

Providing the patient with effective, long-term strategies to overcome fear and anxiety related to the parasomnia.

Table 6: Diagnostic Criteria and Symptoms of Parasomnias

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---------------------------------------|--|--|--|
| Confusional Arousals 327.41 | <ul style="list-style-type: none"> Recurrent mental confusion or confusional behavior occurs during an arousal or awakening from nocturnal sleep or a daytime nap. The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <p>Disorder typically caused from slow-wave sleep in the first part of the night, but also upon attempted awakening from sleep in the morning.</p> <p>Symptoms include:</p> <ul style="list-style-type: none"> Sleep talking Occasional shouting during arousal Bruxism <p>Genetic factors appear to play an important role.</p> | Sleep drunkenness, (excessive) sleep inertia |
| Sleepwalking 307.46 | <ul style="list-style-type: none"> Ambulation occurs during sleep. Persistence of sleep, an altered state of consciousness, or impaired judgment during ambulation is demonstrated by at least one of the following: <ul style="list-style-type: none"> Difficulty in arousing the person Mental confusion when awakened from an episode Amnesia (complete or partial) for the episode Routine behaviors that occur at inappropriate times Inappropriate or nonsensical behaviors Dangerous or potentially dangerous behaviors The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <ul style="list-style-type: none"> Violence is not uncommon, especially in men, and a person attempting to awaken a sleepwalker can be violently attacked. On rare occasions, driving a car, inadvertent homicide and pseudosuicide can occur. | Somnambulism |
| Sleep Terrors 307.46 | <ul style="list-style-type: none"> A sudden episode of terror occurs during sleep, usually initiated by a cry or loud scream that is accompanied by autonomic nervous system and behavioral manifestations of intense fear. At least one or the following associated features is present: <ul style="list-style-type: none"> Difficulty in arousing the person Mental confusion when awakened from an episode Amnesia (complete or partial) for the episode Dangerous or potentially dangerous behaviors At least one of the following is observed: <ul style="list-style-type: none"> Constant or near constant awareness of environmental stimuli throughout most nights Pattern of conscious thoughts or rumination throughout most nights while maintaining a recumbent posture The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | Sleep terrors consist of arousals from slow-wave sleep accompanied by a cry or piercing scream and autonomic nervous system and behavioral manifestations of intense fear. There is often intense autonomic discharge, with tachycardia, tachypnea, flushing of the skin, diaphoresis, mydriasis and increased muscle tone. The person usually sits up in bed; is unresponsive to stimuli; and, if awakened, is confused and disoriented. However, bolting out of bed is not uncommon in adults and also can be associated with violent behaviors. | Night terrors, pavor nocturnus |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|--|---|---|--|
| Rapid Eye Movement Sleep Behavior Disorder (RBD) (Including Parasomnia Overlap Disorder and Status Dissociatus) 327.42 | <ul style="list-style-type: none"> • Presence of REM sleep without atonia: the EMG finding of excessive amounts of sustained or intermittent elevation of submental EMG tone or excessive phasic submental or (upper or lower) limb EMG twitching. • At least one of the following is present: <ul style="list-style-type: none"> ○ Sleep-related injurious, potentially injurious, or disruptive behaviors by history ○ Abnormal REM sleep behaviors documented during polysomnographic monitoring ○ Awakening short of breath • Absence of EEG epileptiform activity during REM sleep unless RBD can be clearly distinguished from any concurrent REM sleep-related seizure disorder. • The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <p>RBD is characterized by abnormal behaviors emerging during REM sleep that cause injury or sleep disruption. RBD is also associated with EMG abnormalities during REM sleep. The EMG demonstrates an excess of muscle tone or phasic EMG twitch activity during REM sleep. Patients typically complain of sleep-related injury.</p> <p>Sleep and dream-related behaviors reported by history and documented during polysomnography include talking, laughing, shouting, swearing, gesturing, reaching, grabbing, arm flailing, slapping, punching, kicking, sitting up, leaping from bed, crawling and running.</p> | NA |
| Recurrent Isolated Sleep Paralysis 327.43 | <ul style="list-style-type: none"> • Complaints of an inability to move the trunk and all the limbs at sleep onset or on waking from sleep. • Each episode lasts seconds to a few minutes. • The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder. | <p>The disorder is characterized by an inability to perform voluntary movements when going to or waking from sleep in the absence of narcolepsy. Individuals many times can't speak, move the limbs, trunk and head. Respiration is usually unaffected. Consciousness is preserved, and full recall is present.</p> | NA |
| Nightmare Disorder 307.47 | <ul style="list-style-type: none"> • Recurrent episodes of awakenings from sleep with recall of intensely disturbing dream mentation, usually involving fear or anxiety, but also anger, sadness, disgust and other dysphoric emotions. • Full alertness on awakening, with little confusion or disorientation; recall of sleep mentation is immediate and clear. • At least one of the following associated features is present: <ul style="list-style-type: none"> ○ Delayed return to sleep after episodes ○ Occurrence of episodes in the latter half of the habitual sleep period. | <p>Nightmares are coherent dream sequences that seem real and become increasingly more disturbing as they unfold. Nightmares arising immediately following a trauma or one or more after a trauma can occur during NREM sleep, especially stage 2, as well as during REM sleep and at sleep onset.</p> | Nightmares |
| Sleep Related Dissociative Disorders 300.15 | <ul style="list-style-type: none"> • A dissociative disorder, fulfilling Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition diagnostic criteria, is present and emerges in close association with the main sleep period. • One of the following is present: <ul style="list-style-type: none"> ○ Polysomnography demonstrates a dissociative episode or episodes that emerge during sustain EEG wakefulness, either in the transition from wakefulness to sleep or after an awakening from NREM or REM sleep. ○ In the absence of a polysomnography-recorded episode of dissociation, the history provided by observers is compelling for a sleep-related dissociative disorder, particularly if the sleep-related behaviors are similar to observed daytime dissociative behaviors. • The sleep disorder is not better explained by another sleep disorder, medical or neurological disorder, or mental disorder. | <p>The disorders comprise a sleep-related variant of dissociative disorders, which are a disruption in the usually integrated functions of consciousness, memory, identity, or perception of the environment.</p> | Nocturnal (psychogenic) dissociative disorders |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|---|---|--|
| Sleep Related Groaning (Catathrenia) 327.49 | A or B satisfy the criteria: A. A history of regularly occurring groaning (or related monotonous vocalization) during sleep B. Polysomnography with respiratory-sound monitoring reveals a characteristic respiratory dysrhythmia predominantly or exclusively during REM sleep. | The disorder is chronic, usually nightly, and characterized by expiratory groaning during sleep, particularly during the second half of the night. The moaning is not associated with respiratory distress or emotions, although it sounds mournful. These recurrent bradypneic episodes may closely resemble central sleep apnea, although there are usually distinguishable differences between the two conditions. | Nocturnal groaning |
| Exploding Head Syndrome 327.49 | <ul style="list-style-type: none"> The patient complains of a sudden or loud noise or sense of explosion in the head either at the wake-sleep transition or upon waking during the night. The experience is not associated with significant pain. The patient rouses immediately after the event, usually frightened. <p>Note: In a minority of cases, a flash of light or myoclonic jerk may accompany the event.</p> | Based on limited polysomnographic recordings, the events appear to arise from early drowsiness with predominant alpha rhythm, with interspersed theta activity. Slow eye movements have been noted. Arousals occur immediately following the episodes. No epileptiform activity has been reported. These findings are typical of a hypnagogic phenomenon. | NA |
| Sleep Related Hallucinations 368.16 | <ul style="list-style-type: none"> The patient experiences hallucinations just prior to sleep onset or on awakening during the night or in the morning. The hallucinations are predominantly visual. The sleep disorder is not better explained by another sleep disorder, medical or neurological disorder, or mental disorder. | <p>The disorders are hallucinatory experiences, principally visually, that occur at sleep onset or on awakening.</p> <p>The disorders may be associated with episodes of sleep paralysis, jumping out of bed in terror, sometimes injuring themselves. Some patients may experience other parasomnias, such as sleep talking or sleepwalking.</p> | Hypnagogic hallucinations, hypnopompic hallucinations, complex nocturnal visual hallucinations |
| Sleep Related Eating Disorder (SRED) 327.49 | <ul style="list-style-type: none"> Recurrent episodes of involuntary eating and drinking occur during the main sleep period. One of more of the following must be present with the recurrent episodes of involuntary eating and drinking: <ul style="list-style-type: none"> Consumption of peculiar forms or combinations of food or inedible or toxic substances Insomnia related to sleep disruption from repeated episodes of eating, with a complaint of nonrestorative sleep, daytime fatigue, or somnolence Sleep-related injury Dangerous behaviors performed while in pursuit of food or while cooking food Morning anorexia Adverse health consequences from recurrent binge eating of high-calorie foods The sleep disorder is not better explained by another sleep disorder, medical or neurological disorder, or mental disorder. | SRED consists of recurrent episodes of involuntary eating and drinking during arousals from sleep with problematic consequences. The episodes of eating typically occur during partial arousals from sleep with subsequent partial recall. Some patients cannot be easily brought to full consciousness during an episode of eating. On the hand, some patients seemingly have considerable alertness during an episode and have substantial recall in the morning. | NA |

Source: American Academy of Sleep Medicine (2005)

Sleep Related Movement Disorders

Restless Leg Syndrome (RLS) and Periodic Limb Movement Disorder (PLMD) are the most common of these disorders that are sleep-related movements, considered abnormal. Either a nocturnal sleep disturbance or a complaint of excessive daytime sleepiness or fatigue has to be present. With the exception of movements due to RLS, sleep-related movement disorders are relatively simple and usually stereotyped. Body movements that disrupt sleep are also seen in other sleep disorder categories (e.g. some parasomnias, sleep-related epilepsy, etc). However, these movements are more complex in nature, and they are classified separately.

Types

For diagnostic criteria and symptoms of all the disorders, see Table 7.

Restless Leg Syndrome (RLS)

RLS is an awake phenomenon. It is a neurological sensor-motor disorder characterized by unpleasant sensations in the legs that preclude a smooth transition from wakefulness to sleep. These symptoms can significantly interfere with personal or social evening activities. By disrupting the patient's ability to fall asleep or return to sleep after an awakening, RLS will cause excessive daytime sleepiness. Up to 80 percent to 90 percent of RLS patients can present periodic limb movements during sleep (PLMS).

RLS presents the following four diagnostic criteria in patients 12 or older:

- Akathisia (distressing, irresistible need to move legs), usually accompanied by paresthesias, a core feature
- Motor restlessness
- Symptoms worsen at rest
- Symptoms worsen at night

Periodic Limb Movement Disorder (PLMD)

PLMD is repetitive cramping or jerking of the legs during sleep. It is the only movement disorder that occurs only during sleep, and it is sometimes called periodic leg (or limb) movements during sleep. "Periodic" refers to the fact that the movements are repetitive and rhythmic, occurring about every 20-40 seconds. PLMD is also considered a sleep disorder, because the movements often disrupt sleep and lead to daytime sleepiness. PLMD may occur with other sleep disorders. It is often linked with RLS, but it is not the same thing. RLS is a condition involving strange sensations in the legs (and sometimes arms) while awake and an irresistible urge to move the limbs to relieve the sensations. At least 80 percent of people with RLS have PLMD, but the reverse is not true.

Sleep Related Leg Cramps

Sleep-related leg cramps are sudden and cause intense pain in the leg or foot. The pain is caused when a muscle contracts and tightens. The cramps occur without a person being able to control them. They may happen while still awake or after falling asleep. They normally begin very suddenly. Sometimes, they may begin slowly with less painful warning signs. The muscle

cramps can last for a few seconds or several minutes. They end as suddenly as they began. They may occur as rarely as once per year in some people. Other people can have many cramps every night. In a number of people, the cramps tend to come and go over a length of many years.

The cramps can be relieved by stretching the affected muscle. The muscle may still be tender and sore several hours after the cramp. At times, leg cramps can also be eased by the following:

- massaging the area in pain
- applying heat to the muscle
- moving the affected leg or foot

The muscle cramp not only causes pain, but it can also disturb sleep. It can make it hard for a person to fall asleep. It may also wake them up after falling asleep. The soreness felt after the cramp can also make it hard for a person to go back to sleep again.

Sleep Related Bruxism

Sleep-related bruxism involves the grinding or clenching of teeth during sleep. It is common for the jaw to contract while you sleep. When these contractions are too strong, they produce the sound of tooth grinding. This can cause dental damage by wearing the teeth down. In most severe cases, hundreds of events can occur during the night. In milder cases, the grinding may vary from night to night.

Severe bruxism may briefly disturb a person's sleep. Only at rare times will it cause a person to fully wake up. Loud sounds caused by the grinding of teeth can be very unpleasant. This can also disturb the sleep of a bed partner. It can occur during all stages of sleep. It is most common in stages one and two of non-REM sleep.

The following are signs of bruxism:

- Tooth pain
- Jaw muscle pain
- Mouth and facial pain
- Limited jaw movement
- Damaged or worn teeth
- Sore gums
- Headaches

Risk Groups

- Sleep-related cramps occur in 7 percent of children and adolescents, 33 percent in the older than 60 years of age group and in 50 percent of subjects older than the age of 80. In the adult group they occur with this frequency at least once every 2 months.
- The frequency of bruxism in adults is 3.7 percent to 4.6 percent. It was reported in 38 percent of children younger than age 17 in a survey of their parents.
- RLS has a prevalence of 2.5 percent to 10 percent in the general population. Women are affected twice as often as men.

- PLMD occurs at all ages and in both sexes. Periodic limb movements during sleep have been reported to have a prevalence of about 10 percent, but the disorder, implying a sleep disturbance, is less common.

Effects

- Daytime sleepiness
- Insomnia
- Sleep starts (hypnic jerks)
- Neuroleptic-induced akathisia
- Sleep-related leg cramps
- Pain (arthritis, peripheral neuropathy, spinal cord lesions, mouth)
- Hypotensive akathisia

Treatments

Treatment will depend on the severity of the patient's symptoms and whether an underlying cause is found. Some patients are helped by lifestyle changes and self-care; others may need medication. If an underlying condition (such as an iron deficiency or peripheral neuropathy) is found, treating that condition may alleviate the patient's RLS.

Lifestyle Changes to Help Prevent Occurrences

- Following a consistent sleep schedule
- Getting regular exercise during the day
- Practicing relaxation techniques such as meditation or yoga
- Cutting back on caffeine, alcohol and tobacco
- Keeping mentally active while sitting down

Self-Care to Alleviate Occurrences

- Walking or riding an exercise bike
- Soaking in a hot tub
- Massaging the legs
- Stretching the legs

Medications

Several different types of drugs are used (especially RLS):

- Drugs that replace dopamine (a chemical found in the brain that sends messages to control muscle movements). Although these drugs are usually used to treat Parkinson's disease, patients with RLS have no higher risk of developing Parkinson's than the general population
- Sedatives (sleeping pills)
- Anti-seizure (epilepsy) drugs
- Opioids (narcotics)

- The best medication choice may vary from one patient to another based on several factors. For example, some medications can be addictive, lose effectiveness over time, or present unwanted side effects.

Table 7: Diagnostic Criteria and Symptoms of Sleep Related Movement Disorders

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|---|---|--|--|
| Restless Leg Syndrome (RLS) 333.94 | <ul style="list-style-type: none"> • The patient reports an urge to move the legs, usually accompanied or caused by uncomfortable and unpleasant sensations in the legs. • The urge to move or the unpleasant sensations begin or worsen during periods of rest or inactivity such as lying or sitting • The urge to move or the unpleasant sensations are partially or totally relieved by movements, such as walking or stretching, at least as long as the activity continues. • The urge to move or the unpleasant sensations are worse, or only occur, in the evening or night. • Disorder not better explained by another current sleep disorder, medical or neurological disorder, medication use, or substance abuse disorder. | <p>RLS is a sensor-motor disorder often accompanied, but not always, with:</p> <ul style="list-style-type: none"> • Urge to move with symptoms worsening when lying or sitting • Relief of symptoms by walking or moving • Disturbed sleep • Involuntary jerking • Twitching movements | <p>Ekbom's syndrome</p> |
| Periodic Limb Movement Disorder (PLMD) 327.51 | <ul style="list-style-type: none"> • Polysomnography demonstrates repetitive, highly stereotyped, limb movements that are: <ul style="list-style-type: none"> ○ 0.5 to 5 seconds in duration ○ Of amplitude greater than or equal to 25 percent of toe dorsiflexion during calibration ○ In a sequence of four or more movements ○ Separated by an interval of more than 5 seconds and less than 90 seconds. • The PLMD Index exceeds five per hour in children and 15 per hour in most adult cases • There is clinical sleep disturbance or a complaint of daytime fatigue. • The PLMDs are not better explained by another current sleep disorder, medical or neurological disorder, medication use or substance abuse disorder. | <p>The disorder occurs most frequently in the lower extremities. They typically involve extension of the big toe, often in combination with partial flexion of the ankle, the knee and sometimes the hip. Typically the patient is unaware of the movements or the sleep disruption.</p> <p>Symptoms include:</p> <ul style="list-style-type: none"> • Unrefreshing sleep • Excessive daytime sleepiness | <p>Nocturnal myoclonus, periodic leg movement in sleep</p> |
| Sleep Related Leg Cramps 327.52 | <ul style="list-style-type: none"> • A painful sensation in the leg or foot is associated with sudden muscle hardness or tightness indicating a strong muscle contraction. • The painful muscle contractions in the legs or feet occur during the sleep period, although they may arise from either wakefulness or sleep. • The pain is relieved by forceful stretching of the affected muscles, releasing the contraction. • The disorder is not better explained by another current sleep disorder, medical or neurological disorder, medication use, or substance use disorder. | <p>The disorder causes painful sensations from sudden and intense involuntary contractions of muscles or muscle groups, usually in the calf or small muscles of the foot, occurring during the sleep period. Tenderness and discomfort in the muscle may persist for several hours after the cramping. Reduced sleep is often a complaint.</p> | <p>Leg cramps, "Charley horse"</p> |

| Disorder/ICD-9 Code | Diagnostic Criteria | Symptoms or features | Alternate Names |
|--|---|--|--------------------------|
| Sleep Related Bruxism 327.53 | <ul style="list-style-type: none"> • The patient reports or is aware of tooth-grinding sounds or tooth clenching during sleep. • One or more of the following is present: <ul style="list-style-type: none"> ○ Abnormal wear of teeth ○ Jaw muscle discomfort, fatigue or pain and jaw lock upon waking ○ Masseter muscle hypertrophy upon voluntary forceful clenching • The disorder is not better explained by another current sleep disorder, medical or neurological disorder, medication use, or substance use disorder. | <ul style="list-style-type: none"> • Variety of muscle and tooth sensations • Limitation of jaw movements • Oral and facial pain • Headache • Tooth wear or fractured teeth • Buccal lacerations | Nocturnal tooth grinding |

Source: American Academy of Sleep Medicine (2005)

Section 2: Crash Statistics, Sleep-related Crash Data, and Relevant Regulations

Highway-related Occupational Injuries and Fatalities

No single source of data exists for worker injuries and fatalities resulting from work-related roadway crashes, much less those resulting from fatigue or sleep-related driving incidents while working. The Census of Fatal Occupational Injuries (CFOI), a program of the Bureau of Labor Statistics (BLS), is currently one of the most widely used sources of data on occupational fatalities in the United States. According to the latest census data from the BLS (2008), there were 5,488 fatal occupational injuries in 2007. More than 2,200 (41 percent) of these fatalities were classified as transportation incidents. One quarter (n=1,423) involved workers in transportation and material moving occupations, of which approximately half occurred as highway-related incidents.

Large Truck Crash Statistics

Although occupational data from the previous section highlights total numbers of fatalities for various occupations (such as CMV drivers, bus drivers, etc.), the information masks or obscures the societal impact of these occupational fatalities (particularly those related to highway accidents) on the civilian population.

According to the National Highway Traffic Safety Administration, in 2007 there were:

- 37,248 fatal crashes
- 1,711,000 injury crashes
- 4,275,000 property damage only crashes
- 6,024,000 total crashes

Large trucks are associated with a significant portion of U.S. traffic crashes. Table 8 presents 2007 statistics on U.S. police-reported crashes based on NHTSA statistics from the Fatality Analysis Reporting System (FARS) and the General Estimates System (GES). Other sources include the most recent report on large truck crash facts for 2006, released by the Analysis Division of the FMCSA (FMCSA, 2008), and the Motor Carrier Management Information System (MCMIS). Additional but limited large truck crash data for 2007 are also described when available (FMCSA, 2009).

Table 8: 2007 Police Reported Motor-Vehicle Traffic Crashes

| Crash Types | Crashes Involving Large Trucks/Buses | All Crashes | Large Truck / Buses (%) |
|-------------|--------------------------------------|-------------|-------------------------|
| Fatal | 4,808 / 322 | 37,248 | 13% / 1% |
| Injury | 83,908 / 15,888 | 1,711,000 | 5% / 1% |

As shown in Table 8, of the 37,248 fatal crashes occurring in 2007, 13 percent of them involved large trucks, with a total of 4,808 people killed.

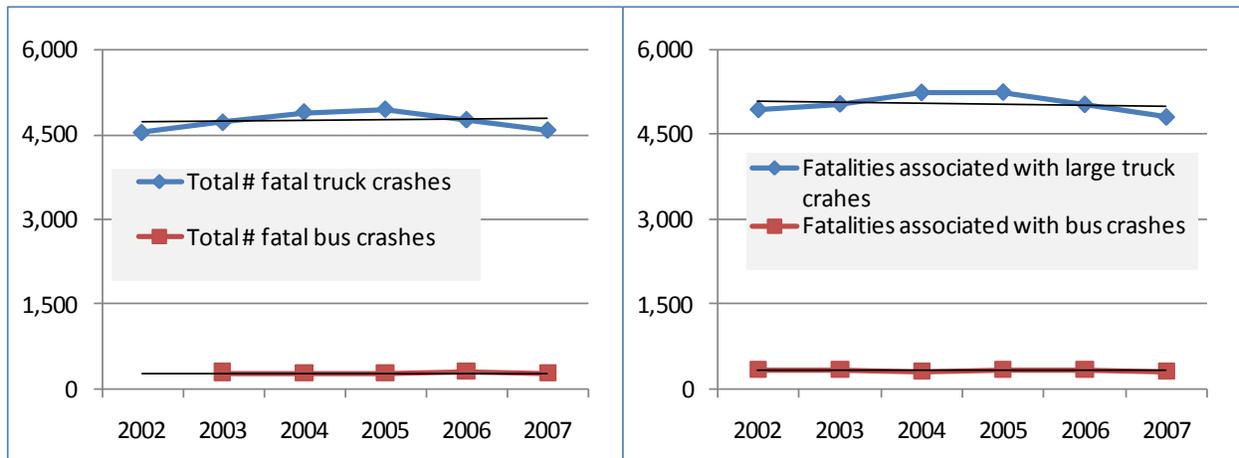
The majority of fatalities associated with large truck crashes occur to persons outside the truck. These are mostly occupants of other vehicles (e.g., passenger cars and light trucks and vans), but also include nonoccupants such as pedestrians and bicyclists. Of the 4,808 fatalities and 83,908 injuries that resulted from crashes involving large trucks in 2007, approximately 17 percent of those killed and 22 percent of those injured were large-truck occupants (FMCSA, 2009). The remainder of deaths and injuries were to passenger-vehicle occupants and/or pedestrians.

The total number of large truck and bus crashes has remained relatively constant over the past 6 years. As listed in Table 9 (also shown graphically in Figure 4), since 2002 there have been, on average, approximately 4,700 fatal crashes involving trucks, resulting in, on average, a little over 5,000 fatalities, annually.

Table 9: Fatal and Nonfatal Crash Rates with Large Trucks and Buses

| Number of LARGE TRUCKS Involved in: | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|--|---------------|--------------|--------------|--------------|--------------|--------------|
| Fatal and Nonfatal Crashes (FARS & MCMIS) | 116,651 | 127,948 | 139,317 | 147,133 | 146,931 | 144,171 |
| Fatal Crashes | 4,452 | 4,721 | 4,902 | 4,951 | 4,766 | 4,584 |
| Nonfatal Crashes (MCMIS) | 112,064 | 123,227 | 134,415 | 142,182 | 142,165 | 139,587 |
| Injury Crashes (MCMIS) | 55,646 | 58,532 | 60,776 | 61,740 | 60,166 | 56,487 |
| Fatalities (FARS) | 4,939 | 5,036 | 5,235 | 5,240 | 5,027 | 4,808 |
| Injuries (MCMIS) | 85,916 | 89,285 | 91,772 | 93,497 | 90,187 | 83,908 |
| Number of BUSES Involved in: | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| Fatal and Nonfatal Crashes (FARS & MCMIS) | 7,039 | 8,555 | 9,167 | 11,146 | 12,501 | 13,195 |
| Fatal Crashes | | 291 | 279 | 280 | 305 | 278 |
| Nonfatal Crashes (MCMIS) | 6,765 | 8,264 | 8,888 | 10,866 | 12,196 | 12,917 |
| Injury Crashes (MCMIS) | 3,944 | 5,033 | 5,214 | 6,140 | 6,903 | 6,953 |
| Fatalities (FARS) | 331 | 337 | 315 | 340 | 337 | 322 |
| Injuries (MCMIS) | 9,946 | 12,153 | 12,730 | 14,985 | 16,223 | 15,888 |

Figure 4: Fatal and Nonfatal Truck and Bus Crashes (2002-2006)



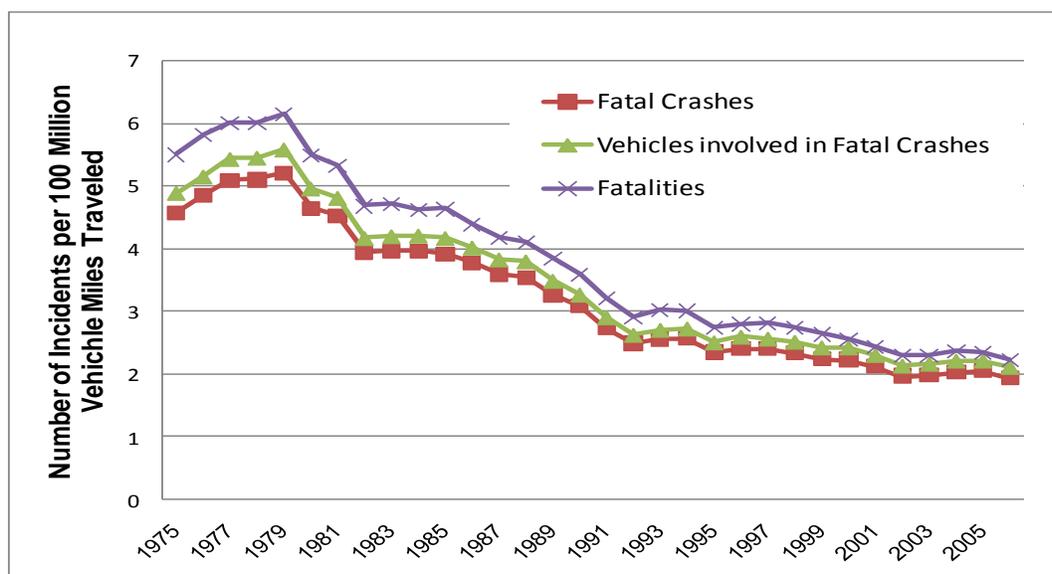
While the number of large trucks and buses involved in fatal crashes and fatalities have remained constant over the years, the number of fatalities per 100 million vehicle miles travelled has decreased (See Table 10 and Figure 5). In 2007, the number of large trucks in fatal crashes per 100 million vehicle miles traveled by large trucks was 2.02 – down 20 percent since 1998 when it was 2.52. Similarly, the number of large trucks involved in injury crashes per 100 million vehicle miles traveled was 33.4 – down 26 percent since 1998 when it was 45.1. Of these, large truck tractors pulling semi-trailers accounted for 62 percent of the large trucks involved in fatal crashes.

Table 10: Large Truck Crash Statistics by Exposure, 1975-2006

| Year | Vehicles involved in Fatal Crashes per 100 MVMT | Fatalities per 100 MVMT | # of Large Trucks Registered |
|------|---|-------------------------|------------------------------|
| 1975 | 4.89 | 5.51 | 5,362,369 |
| 1976 | 5.15 | 5.82 | 5,575,185 |
| 1977 | 5.43 | 6.02 | 5,689,903 |
| 1978 | 5.45 | 6.01 | 5,859,807 |
| 1979 | 5.58 | 6.15 | 5,891,571 |
| 1980 | 4.96 | 5.50 | 5,790,653 |
| 1981 | 4.81 | 5.34 | 5,716,278 |
| 1982 | 4.17 | 4.69 | 5,590,415 |
| 1983 | 4.20 | 4.73 | 5,508,392 |
| 1984 | 4.21 | 4.63 | 5,401,075 |
| 1985 | 4.17 | 4.64 | 5,996,337 |
| 1986 | 4.02 | 4.40 | 5,720,880 |
| 1987 | 3.83 | 4.19 | 5,718,266 |
| 1988 | 3.80 | 4.12 | 6,136,884 |
| 1989 | 3.49 | 3.85 | 6,226,482 |
| 1990 | 3.27 | 3.60 | 6,195,876 |
| 1991 | 2.91 | 3.22 | 6,172,146 |
| 1992 | 2.63 | 2.91 | 6,045,205 |
| 1993 | 2.71 | 3.04 | 6,088,155 |

| Year | Vehicles involved in Fatal Crashes per 100 MVMT | Fatalities per 100 MVMT | # of Large Trucks Registered |
|---------------|---|-------------------------|------------------------------|
| 1994 | 2.73 | 3.02 | 6,587,885 |
| 1995 | 2.51 | 2.76 | 6,719,421 |
| 1996 | 2.60 | 2.81 | 7,012,615 |
| 1997 | 2.57 | 2.82 | 7,083,326 |
| 1998 | 2.52 | 2.75 | 7,732,270 |
| 1999 | 2.43 | 2.65 | 7,791,426 |
| 2000 | 2.43 | 2.57 | 8,022,649 |
| 2001 | 2.31 | 2.45 | 7,857,675 |
| 2002 | 2.14 | 2.30 | 7,927,280 |
| 2003 | 2.17 | 2.31 | 7,756,888 |
| 2004 | 2.22 | 2.37 | 8,171,364 |
| 2005 | 2.22 | 2.35 | 8,481,999 |
| 2006 | 2.12 | 2.24 | 8,819,007 |
| 2007 (Prelim) | 2.02 | -- | -- |

Figure 5: Large Truck Crash Rates by Miles Traveled, 1975-2006



Impact of Fatigue, Sleepiness, and Sleep-related Disorders on Driving Ability

According to a report released by the National Highway Traffic Safety Administration (2008, updated 2009), there were 41,059 motor-vehicle deaths (including vehicle occupants, motorcyclists, pedestrians, etc.) in 2007. Another 2.5 million individuals were injured. Based on police reports of factors involved for fatal accidents, approximately 2.5 percent involved fatigue, drowsiness, and/or falling asleep at the wheel. Similar statistics for large truck crashes reported in 2006 (FMCSA, 2008) suggest that at least 1.5 percent of all fatal crashes involving large trucks were the result of driver fatigue, drowsiness, and/or falling asleep at the wheel.

Other reports, based on more detailed assessments of smaller, but representative, samples of truck crashes have identified fatigue and sleep-related factors at a much higher rate – up to 25

percent. For instance, the preliminary data from the Large Truck Crash Causation Study (LTCCS; Craft, 2007) suggests that driver fatigue and inattention (including that which arises from sleepiness) is a factor in as many as 13 percent and 9 percent, respectively, of large truck crashes that occurred during the period April 1, 2001, to December 31, 2003 (based on a sample of 1000 crashes studied).

Table 11: Crashes and Time of Day

| Time of day | Fatal | | Injury | | Property Damage Only | |
|---------------------|--------|---------|--------|---------|----------------------|---------|
| | Number | Percent | Number | Percent | Number | Percent |
| 12am-3am | 341 | 7.9% | 3,000 | 3.5% | 7,000 | 2.5% |
| 3am-6am | 407 | 9.4% | 4,000 | 4.7% | 8,000 | 2.8% |
| 6am-9am | 682 | 15.8% | 12,000 | 16.2% | 47,000 | 16.2% |
| 9am-12pm | 713 | 16.5% | 15,000 | 19.4% | 67,000 | 23.2% |
| 12pm-3pm | 808 | 18.7% | 21,000 | 27.2% | 67,000 | 23.4% |
| 3pm-6pm | 658 | 15.2% | 13,000 | 17.0% | 53,000 | 18.5% |
| 6pm-9pm | 381 | 8.8% | 6,000 | 7.9% | 24,000 | 8.2% |
| 9pm-12am | 326 | 7.5% | 3,000 | 4.0% | 14,000 | 5.0% |
| Unknown | 5 | 0.1% | | | | |
| Daytime (6am-6pm) | 2,861 | 66.2% | 61,000 | 79.8% | 233,000 | 81.4% |
| Nighttime (6pm-6am) | 1,460 | 33.8% | 16,000 | 20.2% | 53,000 | 18.6% |
| Total | 4,321 | 100.0% | 77,000 | 100.0% | 287,000 | 100.0% |

Current Medical Fitness Standards and Guidelines for CMV Drivers in the United States

Relevant Medical Fitness Standards for Medical Examiners

Under current medical qualification standards for fitness to drive a CMV [49 CFR 391.41(b)], there are no regulations that specifically address the condition of excessive sleepiness or fatigue (either that which is organic in nature or due to environmental factors). However, §391.41(b)(9)—related to mental, neurological, organic, or psychiatric disorders—is somewhat relevant to the current topic as relevant conditions considered under this rule could include primary sleep disorders and/or conditions that give rise to sleep disorders and/or fatigue secondarily. This is presented in the first component of Box 3 (see also, <http://www.fmcsa.dot.gov/rules-regulations/administration/fmcsr/fmcsrruletext.asp?section=391.41>). In addition to medical fitness-related regulations, FMCSA also presents Medical Advisory Criteria, or rather, clinical guidance that is to be used by medical examiners when conducting medical examinations. The Medical Advisory Criteria associated with §391.41(b)(9) is presented in the middle section of Box 3 (see also, <http://www.fmcsa.dot.gov/rules-regulations/administration/medical.htm>). The information relevant to sleepiness and the current discussion is highlighted in red and underlined.

Finally, in 1988, FMCSA published the outcome of a conference to review the current medical standards covering neurologic disease, which included discussion of sleepiness and sleep disorders (see: <http://www.fmcsa.dot.gov/facts-research/research-technology/publications/medreports.htm>). This report includes recommendations to FMCSA related to sleep disorders (largely those pertaining to sleep apnea syndrome [SAS] and

narcolepsy), among numerous other recommendations for other neurologically-related conditions. Recommendations for sleep disorder-related conditions included in this report are presented in the last section of Box 3.

Box 3: Relevant FMCSA Regulations, Guidance, and Medical Expert Recommendations

| Regulation |
|---|
| <p>391.41(b)(9) A person is physically qualified to drive a commercial motor vehicle if that person:</p> <p>Has no mental, nervous, organic, or functional disease or psychiatric disorder likely to interfere with the driver's ability to drive a commercial motor vehicle safely.</p> |
| Medical Advisory Criteria |
| <p>391.41(b)(9)</p> <p>Emotional or adjustment problems contribute directly to an individual's level of memory, reasoning, attention, and judgment. <u>These problems often underlie physical disorders. A variety of functional disorders can cause drowsiness, dizziness, confusion, weakness, or paralysis that may lead to incoordination, inattention, loss of functional control and susceptibility to crashes while driving. Physical fatigue, headache, impaired coordination, recurring physical ailments, and chronic "nagging" pain may be present to such a degree that certification for commercial driving is inadvisable.</u> Somatic and psychosomatic complaints should be thoroughly examined when determining an individual's overall fitness to drive. Disorders of a periodically incapacitating nature, even in the early stages of development, may warrant disqualification.</p> <p>Many bus and truck drivers have documented that "nervous trouble" related to neurotic, personality, emotional or adjustment problems is responsible for a significant fraction of their preventable crashes. The degree to which an individual is able to appreciate, evaluate and adequately respond to environmental strain and emotional stress is critical when assessing an individual's mental alertness and flexibility to cope with the stresses of commercial motor-vehicle driving.</p> <p>When examining the driver, it should be kept in mind that individuals who live under chronic emotional upsets may have deeply ingrained maladaptive or erratic behavior patterns. Excessively antagonistic, instinctive, impulsive, openly aggressive, paranoid or severely depressed behavior greatly interfere with the driver's ability to drive safely. Those individuals who are highly susceptible to frequent states of emotional instability (schizophrenia, affective psychoses, paranoia, anxiety or depressive neurosis) may warrant disqualification.</p> <p>Careful consideration should be given to the side effects and interactions of medications in the overall qualification determination. See Psychiatric Conference Report for specific recommendations on the use of these medications and potential hazards for driving.</p> <p>See Conference on Psychiatric Disorders and Commercial Drivers at: http://www.fmcsa.dot.gov/facts-research/research-technology/publications/medreports.htm</p> |
| 1988 Conference on Neurological Disorders and Commercial Drivers |
| <p>Sleep Disorders and Interstate Driving</p> <p>Regarding interstate commercial driving regulations, we are concerned mainly with those sleep disturbances which cause excessive daytime somnolence (EDS). These disorders may be classified broadly into two categories(I):</p> <ul style="list-style-type: none"> • <i>Transient disorders causing EDS.</i> • <i>Persistent or chronic sleep disorders causing EDS.</i> Persistent or chronic sleep disorders can be enumerated as follows: <ul style="list-style-type: none"> ○ Sleep apnea syndrome ○ Narcolepsy syndrome ○ Primary alveolar hypoventilation syndrome (idiopathic) ○ Central or secondary alveolar hypoventilation syndrome, which is secondary to a variety of acute and progressive neurological diseases causing EDS ○ Idiopathic CNS hypersomnolence ○ Hypersomnolence (EDS) secondary to medical or non-neurological causes (metabolic, toxic, or systemic diseases) ○ Restless legs syndrome (RLS) associated with EDS or RLS-DOES (disorder of excessive somnolence) syndrome associated usually with periodic movements of sleep ○ Disorders of sleep-wake cycles ○ Hypersomnolence (EDS) secondary to psychiatric disorders (major or minor depressive illness or schizophrenia) ○ Periodic hypersomnolence <p>The two most common causes of EDS are the sleep apnea syndrome and the narcolepsy; these two constitute about 70 percent of cases of EDS.</p> <p>Guidelines for Patients with Narcolepsy Syndrome: Narcolepsy is generally a lifelong condition, although the sleep attacks can be shortened or reduced in number by pharmacologic treatment in some patients. But these drugs also have other side effects, which generally do not control the sleep attacks completely. Patients with narcolepsy syndrome should not, therefore, be allowed to participate in interstate driving.</p> <p>Guidelines for Patients with Sleep Apnea Syndrome: The patients with sleep apnea syndrome having symptoms of excessive daytime somnolence cannot take part in interstate driving, because they likely will be involved in hazardous driving and accidents resulting from sleepiness. Even if these patients do not have the sleep attacks, they suffer from daytime fatigue and tiredness. These symptoms will be compounded by the natural fatigue and monotony associated with the long hours of driving, thus causing increased vulnerability to accidents. Therefore, those patients who are not on any treatment and are suffering from symptoms related to EDS should not be allowed to participate in interstate driving.</p> <p>Those patients with sleep apnea syndrome whose symptoms (e.g., EDS, fatigue etc.) can be controlled by surgical treatment, e.g., permanent tracheotomy, may be permitted to drive after 3 month period free of symptoms, provided there is constant medical supervision. Laboratory studies (e.g., polysomnographic and multiple sleep latency tests) must be performed to document absence of EDS and sleep apnea.</p> |

Guidelines for Idiopathic CNS Hypersomnolence and Primary (Idiopathic) Alveolar Hypoventilation Syndrome: These patients should not be allowed to drive a commercial vehicle.

Guidelines for the Patients With RLS-DOES Syndrome: These patients also should not participate in commercial driving.

Guidelines for Patients with Hypersomnolence Due to Acute and Progressive Neurological or Systematic Medical Conditions and Psychiatric Disturbances: Recommendations for these individuals should be determined by the underlying primary conditions causing EDS. In general these patients should not be allowed to participate in interstate driving.

Recommendations pertaining to sleep disorders that were derived by medical experts convened at the 1988 Conference on Neurological Disorders and Commercial Drivers have not yet been incorporated into the relevant medical regulations and/or associated Medical Advisory Criteria. This is due, in part, to the difficulties that would be encountered in trying to implement these recommendations, particularly for conditions that often go undiagnosed (e.g., insomnia and other hypersomnolence-related conditions), unreported by drivers (e.g., drivers may not report conditions or symptoms to medical examiners that would likely impede receipt of medical qualification), and/or that are created by the nature of the work of the driver.

Additional Medical Examiner, Driver, and Company Regulations Relevant to Sleep and Fatigue

An additional search of ground transportation regulations identified a number of rules, separate and apart from those specified in §391.41, that in some way or form attempt to mitigate the risk of fatigue in drivers. These rules were directed at examiners, drivers, and motor carriers.

For instance, in §391.43, an element of the physical examination form used by medical examiners when assessing drivers was found to contain a question regarding the presence of sleep disorders. This is highlighted in Table 12. Other regulations target drivers and/or motor carriers through regulations regarding: (1) training and knowledge-level requirements of drivers and carriers that include understanding the impact of fatigue on driving ability, and (2) the allowable hours-of-service rules, which are aimed at limiting the number of continuous hours a driver may perform so as to ensure drivers have adequate time to rest.

These regulations are identified to highlight areas where additional efforts may be targeted by the FMCSA to enhance current rules and/or assess effectiveness.

Table 12: Other Relevant Regulations Relating to Transportation

| 49 CFR Chapter III (300-399: Federal Motor Carrier Safety Administration) | |
|--|--|
| Subpart E—Physical qualifications and examinations §391.43 Medical examination; certificate of physical examination. | |
| 1 | Medical examiners must answer each question “yes” or “no” and record numerical readings where indicated on the physical examination form. One question in particular that is of relevance is the presence of “ Sleep disorders, pauses in breathing while asleep, daytime sleepiness, loud snoring. ” |
| §380: Special training requirements §380.503 Entry-level driver training requirements. | |
| 2 | (a) Driver qualification requirements. The Federal rules on medical certification, medical examination procedures, general qualifications, responsibilities, and disqualifications based on various offenses, orders, and loss of driving privileges (part 391, subparts B and E of this subchapter). (b) Hours of service of drivers. The limitations on driving hours, the requirement to be off-duty for certain periods of time, record of duty status preparation, and exceptions (part 395 of this subchapter). Fatigue countermeasures as a means to avoid crashes. (c) Driver wellness. Basic health maintenance including diet and exercise. The importance of avoiding excessive use of alcohol. (d) Whistleblower protection. The right of an employee to question the safety practices of an employer without the employee’s risk of losing a job or being subject to reprisals simply for stating a safety concern (29 CFR part 1978). |
| Subpart E (380.501-513) of Part 380 aims to provide entry-level driver training for the four areas identified above: (a) driver qualification requirements, (b) | |

| 49 CFR Chapter III (300-399: Federal Motor Carrier Safety Administration) | |
|--|---|
| | hours of service of drivers, (c) driver wellness, and (d) whistleblower protection. |
| §383: Commercial driver's license standards; requirements and penalties §383.111 Required knowledge. | |
| 3 | Driver-related elements of the regulations contained in 49 CFR Parts 382, 391, 392, 393, 395, 396, and 397, such as: Motor-vehicle inspection, repair, and maintenance requirements; procedures for safe vehicle operations; the effects of fatigue, poor vision, hearing, and general health upon safe commercial motor-vehicle operation; the types of motor vehicles and cargoes subject to the requirements; and the effects of alcohol and drug use upon safe commercial motor-vehicle operations. Subpart G (383.110-123) of Part 383 aims to help reduce or prevent truck and bus accidents, fatalities, and injuries by requiring drivers of commercial motor vehicles to have knowledge and skills necessary to operate a commercial motor vehicle safely |
| §385: Safety fitness procedures §385.5 Safety fitness standard. | |
| 4 | (g) The use of fatigued drivers (Part 395—which relates to hours-of-service regulations; see item 6 below) Part 385 establishes the FMCSA's procedures to determine the safety fitness of motor carriers, to assign safety ratings, to direct motor carriers to take remedial action when required, and to prohibit motor carriers receiving a safety rating of "unsatisfactory" from operating a CMV. |
| §392: Driving of commercial motor vehicles §392.3 Ill or fatigued operator. | |
| 5 | No driver shall operate a commercial motor vehicle, and a motor carrier shall not require or permit a driver to operate a commercial motor vehicle, while the driver's ability or alertness is so impaired, or so likely to become impaired, through fatigue, illness, or any other cause, as to make it unsafe for him/her to begin or continue to operate the commercial motor vehicle. However, in a case of grave emergency where the hazard to occupants of the commercial motor vehicle or other users of the highway would be increased by compliance with this section, the driver may continue to operate the commercial motor vehicle to the nearest place at which that hazard is removed. Part 392 directs every motor carrier, its officers, agents, representatives, and employees responsible for the management, maintenance, operation, or driving of commercial motor vehicles, or the hiring, supervising, training, assigning, or dispatching of drivers, to be instructed in and comply with the rules in this part, including §392.3. |
| §395: Hours-of-service of drivers | |
| 6 | This collection of rules, while not specifically addressing fatigue, is most relevant to curbing the risk of driver sleepiness and fatigue by laying down specific rules on the maximum number hours of service for both property-carrying vehicles as well as passenger-carrying vehicles. It also provides specific rules regarding the driver and carriers role in recording time on duty and status. Rules in Part 395 apply to all motor carriers and drivers. |

Regulatory Medical Fitness Standards and Guidelines in Other Countries

The effect of sleep disorders, sleepiness, and fatigue on CMV driving is a worldwide concern. This section highlights the standards and guidelines established by other countries regarding medical fitness to drive. Regulations and guideline from the following nations are included:

- **Australia** (Accessing Fitness to Drive; Medical Standards for Licensing and Clinical Management Guidelines; 2006)
- **Canada** (Canadian Council of Motor Transport Administrators [CCMTA] Medical Standards for Drivers; 2006)
- **New Zealand** (Medical Aspects of Fitness to Drive. A Guide for Medical Practitioners; Land Transport Safety Authority; 2002)
- **United Kingdom** (For Medical Practitioners: At A Glance Guide to the Current Medical Standards of Fitness to Drive, Issued by Drivers Medical Group, Driver and Vehicle Licensing Agency of the Department for Transport (DVLA), Swansea; 2008)

Regulatory standards and guidelines pertaining to sleep-related disorders (excluding OSA and narcolepsy) and fatigue in CMV driving are presented in Table 13 and Table 14.

Table 13 provides a quick-view assessment of the similarities between the regulations and guidance of other countries. Table 14 provides a more detailed assessment of these regulations

(excluding regulations for the European Union, which was observed to have no relevant regulations or guidance for this topic).

Table 13: Quick-view Assessment of the Attributes of Standards by Different Countries

| | AUS | CAN | NZ | UK |
|---|-----|-----|----|----|
| Attributes of Non-U.S. Standards and Guidelines Related to Sleep and Sleep Disorders | | | | |
| Specifically address sleeping disorders | • | • | • | • |
| Addresses sleeping disorders aside from obstructive sleep apnea and narcolepsy | • | • | | • |
| Calls for driving privileges to be revoked until disorder treated and under control | | • | • | • |
| Allows driving after taking into account the opinion of a specialist and the nature of the driving task | • | | | |
| Offers additional guidance | • | • | • | • |

Table 14: Sleep Disorders and Driving – Guidelines and Standards from Other Countries

| | |
|----------------------------|---|
| Country | Australia <i>Assessing Fitness to Drive; Austroads Inc. 2003 (reprinted 2006)</i> |
| Source | http://www.austroads.com.au/cms/AFTD%20web%20Aug%202006.pdf |
| Standard | Drivers of heavy vehicles, public passenger vehicles or bulk dangerous goods vehicles A conditional license may be granted by the Driver Licensing Authority, taking into account the opinion of a specialist in sleep disorders, and the nature of the driving task. |
| Additional Guidance | <p>20.1 RELEVANCE TO DRIVING TASK</p> <p>20.1.1 Fatigue is a major cause of road accidents. Sleepiness and sleep disorders are one important aspect of managing the risks of fatigue (Fatigue Expert Group Options for Regulatory Approach to Fatigue in Drivers of Heavy Vehicles in Australia and New Zealand, February 2001, NRTC).</p> <p>20.1.3 Motor-vehicle accidents involving commercial vehicles are associated with higher fatality rates and costs. Some commercial vehicle drivers are exposed to periods of sleep deprivation, which may increase the severity of sleep disorders and result in more severe sleepiness in drivers with sleep disorders.</p> <p>20.2 GENERAL MANAGEMENT GUIDELINES</p> <p>20.2.1 Excessive sleepiness during the day, which manifests itself as a tendency to doze at inappropriate times when intending to stay awake, can arise from many causes and is associated with an increased risk of motor-vehicle crashes. It is important to distinguish sleepiness (the tendency to fall asleep) from fatigue or tiredness, which is not associated with a tendency to fall asleep. Many chronic illnesses cause fatigue without increased sleepiness.</p> <p>20.2.2 Increased sleepiness during the daytime in otherwise normal people may be due to prior sleep deprivation (restricting the time for sleep), poor sleep hygiene habits, irregular sleep wake schedules or influence of sedative medications including alcohol. Insufficient sleep (less than 5 hours) prior to driving is strongly related to motor-vehicle crash risk. Excessive daytime sleepiness may also result from a number of medical sleep disorders including, periodic limb movement disorder, circadian rhythm disturbances (e.g. advanced or delayed sleep phase syndrome), and some forms of insomnia.</p> <p>20.3 MEDICAL STANDARDS FOR LICENSING</p> <p>20.3.1 General Recommendations for Other Sleep Disorder. All patients suspected of having disorders should be warned about potential effect on road safety. General advice may include: minimizing unnecessary driving and driving at times when normally asleep, allowing adequate time for sleep, avoiding driving after having missed a large portion of their normal sleep, avoiding alcohol and sedative medications, resting if sleepy. Patients should be advised to avoid or limit driving if they are sleepy, and, not to drive if they are at high risk until the disorder is investigated, treated effectively, and their licensing status determined, particularly in the case of commercial vehicle drivers. High-risk patients include those with severe daytime sleepiness, a history of frequent self-reported sleepiness while driving, motor-vehicle crashes caused by inattention or sleepiness, or an Epworth Sleepiness Scale Score of 16 to 24 (consistent with moderate to severe sleepiness).</p> <p>20.3.2 Patients with high-risk features have a significantly increased risk of sleepiness-related motor-vehicle accidents (odds ratio 15.2)1. (LOE-III-2) These patients should be referred to a sleep disorders specialist, particularly in the case of commercial vehicle drivers.</p> <p>20.3.3 Any patient with unexplained daytime sleepiness while driving, or involvement in a motor-vehicle crash potentially caused by sleepiness should be considered for referral to a sleep disorders specialist for assessment.</p> <p>20.3.4 It is the responsibility of the driver to avoid driving if they are sleepy, comply with treatment, maintain their treatment device, attend review appointments, and honestly report their condition to their treating physician.</p> |
| Country | Canada <i>CCMTA MEDICAL STANDARDS FOR DRIVERS (revised Jul 2006)</i> |
| Source | http://www.ccmta.ca/english/pdf/medical_standards_july06.PDF |

| | |
|----------------------------|---|
| Standard | 6.4.2 Sleep Disorders and Other Medical Conditions Causing Excessive Drowsiness May operate any class of vehicle after the condition has been adequately treated and controlled, subject to continued medical surveillance. |
| Additional Guidance | CMA 6.3 Patients with severe sleep apnea or other syndromes that chronically interfere with sleep are at increased risk of an accident or injury while driving because of daytime sleepiness. Patients with a history of pathologic daytime sleepiness should be referred to a consultant for further assessment. If their condition is severe enough to impair driving ability, they should not be allowed to drive any class of motor vehicle until the condition has been adequately treated and controlled. |
| Country | New Zealand <i>Medical aspects of fitness to drive. A guide for Medical Practitioners</i> Land Transport Safety Authority (2002) |
| Source | http://www.landtransport.govt.nz/licensing/docs/ltsa-medical-aspects.pdf |
| Standards | When driving should cease Driving should be restricted or cease for individuals who meet the high-risk driver profile as follows: <ul style="list-style-type: none"> complain of severe daytime sleepiness and a history of sleep-related motor-vehicle crashes or equivalent level of concern When driving may occur or may resume <i>Individuals may resume driving or can drive if their condition is adequately treated under specialist supervision with satisfactory control of symptoms. Consideration should be given to the type of driving and hours of driving an individual undertakes. If there is any residual risk of daytime sleepiness medical practitioners should recommend a restriction in working hours or shift work. The Director of Land Transport Safety or the Director's delegate may impose license conditions for regular medical assessment. Medical follow-up may be delegated to the General Practitioner.</i> |
| Additional Guidance | There are many medical conditions that may impair an individual's ability to drive safely. This section deals with some miscellaneous conditions that are not covered in other sections of the guidelines. 10.1 Excessive daytime sleepiness Sleepiness can be classified as follows: <ul style="list-style-type: none"> mild sleepiness — describes infrequent sleeping during times of rest or when little attention is required moderate sleepiness — describes sleep episodes that occur on a regular basis during activities requiring some degree of attention. Examples of such include attending conferences, movies or the theatre, group meetings, operating machinery or watching children severe sleepiness — describes sleep episodes that are present daily and during activities that require sustained attention. Examples include eating, direct personal conversation, walking and physical activities, as well as operating motor vehicles. The most common cause of excessive sleepiness is insufficient sleep. Shift-work, time of day (circadian factors), sedatives, and alcohol may increase sleepiness. Those with severe disease, as documented by a sleep study, or a previous sleep-related motor-vehicle accident, appear to be high risk. Medical practitioner assessment is required to evaluate the cause of symptoms, assess the severity of sleepiness, provide initial treatment recommendations and, where appropriate, refer an individual for specialist evaluation. |
| Country | United Kingdom (2008) |
| Source | http://www.dvla.gov.uk/media/pdf/medical/aagv1.pdf |
| Standards | GROUP 2 ENTITLEMENT VOC – LGV/PCV Driving must cease until satisfactory control of symptoms has been attained, with ongoing compliance with treatment, confirmed by consultant / specialist opinion. Regular, normally annual, licensing review required. |
| Additional Guidance | Other sleep-related conditions Illnesses of the nervous system, such as Parkinson's disease, MS, motor neuron disease (MND) may also cause excessive sleepiness. Although sometimes these illnesses alone may cause drivers to be unfit for driving. Tiredness or excessive sleepiness can be a non-specific symptom of Parkinson's disease, MS, MND or may also be related to prescribed medication. |

Medical Fitness Standards and Guidelines for Individuals Performing Transportation Safety in the United States

Current medical fitness standards and guidelines for individuals performing transportation safety in the United States are summarized in Table 15. Included in the table are pertinent rules and guidance for pilots, railroad workers, and merchant mariners.

Table 15: Standards and Guidelines for Sleep Disorders from other U.S. Government Transportation Safety Agencies

| Condition | FAA* (all classes of airmen) | Railroad† | Merchant Mariner‡ |
|---|---|-------------------------------------|--|
| Sleep Disorder and/or other Relevant Condition | <p>Sleep Apnea Examiners may reissue an airman medical certificate under the provisions of an Authorization, if the applicant provides the following:</p> <ul style="list-style-type: none"> • An Authorization granted by the FAA. • A current report (performed within last 90 days) from the treating physician that references the present treatment, whether this has eliminated any symptoms and with specific comments regarding daytime sleepiness. If there is any question about response to or compliance with treatment, then a Maintenance of Wakefulness Test (MWT) will be required. <p>The Examiner must defer to the AMCD or Region if:</p> <ul style="list-style-type: none"> • there is any question concerning the adequacy of therapy; • the applicant appears to be noncompliant with therapy; • the MWT demonstrates sleep deficiency; or • the applicant has developed some associated illness, such as right-sided heart failure. | No specific standards or guidelines | <p>Sleep Disorders Recommended Evaluation Data Submit all pertinent medical information and current status report from a qualified sleep medicine specialist. Include sleep study with a polysomnogram, use of medications and titration study results. If surgically treated, should have post operative polysomnogram to document cure or need for further treatment.</p> <p><u>Sleep Apnea, Central Sleep Apnea, Narcolepsy, Periodic Limb Movement, Restless Leg Syndrome or other sleep disorders</u> Recommended Evaluation Data Submit all pertinent medical information and status report. Include sleep study with a polysomnogram, use of medications and titration study results. If surgically treated, should have post operative polysomnogram to document cure or need for further treatment.</p> |

*Source of information for FAA Regulations and Guidelines:

- http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/special_iss/all_classes/glaucoma/
- http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/app_process/exam_tech/item52/amd/
- http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/app_process/exam_tech/item50/amd/

† Source of information for Federal Railroad Administration Guidelines:

- <http://www.fra.dot.gov/downloads/safety/hazmatch4.pdf>

‡ Source of information for Merchant Mariner Guidelines:

- http://www.uscg.mil/hq/g-m/nvic/2_98/n2-98.pdf

Section 3: Methods

The *Methods* section provides a synopsis of how we identified and analyzed information for this report. The section briefly covers the key questions addressed and the literature searches performed. It also describes primary qualifications regarding the literature that was examined.

Questions of Interest

The primary questions in this report are outlined below:

- Is excessive daytime sleepiness and fatigue related to crash risk?
- Are there other sleep-related risk-factors associated with crash and/or falling asleep while driving?
- Related to the above questions, are there screening tests available that will enable medical examiners to identify those individuals with relevant sleep disorders and/or disturbances who are at an increased risk for a motor-vehicle crash?

Literature Search

Electronic searches of PubMed and the Transportation Research Information Services (TRIS) databases were conducted (through January 2009).

Searches were conducted using a combination of freetext terms and controlled vocabulary concepts derived from the National Library of Medicine's (NLM's) Medical Subject Headings (MeSH). The primary search terms applied are listed in Table 16. Freetext terms included those related to commercial driving, traffic accidents and crash, as well as terms related to sleep disorders, sleepiness, excessive daytime sleepiness, and fatigue. Additional searches were performed for literature related to sleep and fatigue management strategies, including driver countermeasures, technology-based efforts, and organization/management-level approaches

Additional filter options and "related" search features, available through PubMed, were applied in subsequent searches to identify relevant literature. Filters applied to the searches included limiting the searches to English language, human studies, relevant to adults (19+ years).

Manual searches of relevant literature also were performed. This included the review of reference lists of retrieved articles, as well as searches of "gray literature." Gray literature consists of reports, studies, articles, and monographs produced by federal and local government agencies, private organizations, educational facilities, consulting firms, and corporations.

Articles and technical reports reporting primary and/or secondary data were obtained and assessed for relevance to the current topic.

Table 16: Search Terms

| Driving-Related Terms | | | |
|-----------------------|---|------------------|--|
| MeSH | Accidents, traffic Motor vehicles, buses, trucks Automobiles, automobile driving Transportation Accidents, occupational | Free-text | Accident, crash, collision Commercial driver, commercial truck driver, commercial motor vehicle, CMV, professional driver, lorry driver, long haul driver, CMV driver or operator |
| Sleep-Related Terms | | | |
| MeSH | Dyssomnias, environmental sleep disorder, sleep disorders, extrinsic Disorders of Initiating and Maintaining Sleep Intrinsic sleep disorders Fatigue Periodic limb movement disorder, sleep Sleep disorders Sleep disorders, circadian rhythm, circadian rhythm sleep disorders, shift-work sleep disorder, sleep-wake schedule disorders | Free-text | Excessive daytime sleepiness, daytime sleepiness, sleepiness Fatigue, length of sleep time, sleep deprivation, shift work |
| Other Relevant Terms | | | |
| Free-text | Organization countermeasures; organization strategies; management approaches; vehicle technology Hours of service, HOS; Hours of work, sleep schedules; Work rest schedules, workload; Rest periods, performance measures | | |

Characteristics of the Studies Evaluated and Presentation of Data

Individual studies identified and examined were quite heterogeneous in their study designs and methodologies. A number of the studies recruited participants from specialized sleep labs while others utilized commercial drivers sampled from rest areas, truck stops, and/or motor carriers. The literature was also separated generally into two distinct groups: studies utilizing commercial drivers or general passenger drivers. These studies are identified as such in the following sections. In addition, the studies varied in the methods of determining driving risk, including police records, self-reported crash histories, performance on simulators, and/or performance in prospectively designed real-world scenarios.

Because of the extensive heterogeneity of the studies assessed in this report, no attempt was made to quantitatively synthesize their results. Instead, this report offers a qualitative assessment of studies assessed for each of the questions addressed.

Data from the studies evaluated are presented in the form of evidence tables in Section 4 of this report. The tables attempt to identify the primary factors measured and controlled for in relevant studies, as well the primary outcomes and limitations of the work.

Section 4: Sleep- and Fatigue-related Driving: Review of Data

This section summarizes data related to the primary questions addressed in the current report. Each subsection provides a tabular display of key elements of the individual studies assessed followed by a table of the key findings of each question. Section 4 concludes with a discussion of some of the key limitations of the studies evaluated.

Sleep-related Factors and Crash Risk

The key question for this subsection was:

- **Is excessive daytime sleepiness and fatigue related to crash risk?**

Table 17 below provides a summary of the study design and study characteristics (including participants, factors measured and controlled, driving exposure, and outcomes measured) for each of the studies assessed for this key question. A total of 11 studies are summarized.

Table 17: Characteristics of Studies Assessing Sleepiness and/or Fatigue and Crash Risk

| Reference (Year) Study Design | Study Participants | Factors Measured | Factors Controlled | Driving Exposure | Primary Outcome | Outcome Self-reported |
|--|--|---|---------------------------------------|--|---|--|
| Commercial Drivers | | | | | | |
| Hanowski et al. (2007) Prospective cohort study | 82 CMV drivers (81 male, 1 female) working for one of three licensed trucking companies 73 drivers provided useful data | <ul style="list-style-type: none"> Hours of sleep (by actigraphy) Work time | Not stated | No Miles driven collected but not controlled for | Crash, near-crashes | No Onboard system and video monitoring |
| Dingus et al. (2006) Prospective cohort study | 47 male and 9 female participants, constituting 13 teams (2 drivers) and 30 single drivers. | <ul style="list-style-type: none"> Single vs. team driving Sleepiness at wheel (via the Karolinska Sleepiness Scale) Time of day | Age, experience driving, hours driven | Yes Hours of driving | Crash, near-crashes, crash-relevant conflicts | No Onboard system and video monitoring |
| Gander et al. (2006) Retrospective cohort study | 130 of 380 individuals involved in a crash during the study period (13 mo), who were given the survey just following the crash, responded to the survey | <ul style="list-style-type: none"> ESS score Sleep habits Snoring Sleep history 3 days prior to crash Crash details Hours of driving at crash time Hours of duty at crash time | Age, gender | No | Crash | Yes Survey |
| Perez-Chada et al. (2005) Retrospective, cross-sectional study | 738 of 905 approached long-haul drivers (independent drivers) | <ul style="list-style-type: none"> ESS score Self-rated sleepiness at wheel Sleep habits Snoring Sleep quality LMDS Strategies for sleepiness | Anthropometric factors, gender, age | Yes 800 km/day | Crash, near-miss | Yes Survey: WSCS, ESS |
| Sabbagh- | 160 of 640 drivers | <ul style="list-style-type: none"> Driver characteristics | Age, | No | Crash | Yes |

| Reference (Year) Study Design | Study Participants | Factors Measured | Factors Controlled | Driving Exposure | Primary Outcome | Outcome Self-reported |
|---|---|--|---|--|--|--|
| Ehrlich et al. (2005) Retrospective cohort study | (25%) approached at the registration points in the ports of Haifa and Ashdod | <ul style="list-style-type: none"> Workplace conditions Employer-employee relations Driving conditions Sleep quality(PSQI) Self-reported fatigue Driving frequency | BMI, smoking, experience driving, truck weight, salary | | | Interview |
| Bunn et al. (2005) Retrospective case control | 68 cases and 271 controls | <ul style="list-style-type: none"> Falling asleep Fatigue | Age, safety-belt use | No | Crash (fatal and injury crash) | No Police database |
| Souza et al. (2005) Retrospective cohort study | 260 male truck drivers (Brazil); mean age 38.2 years | <ul style="list-style-type: none"> ESS score Quality of sleep, sleep hours and habits (on both working and nonworking days) Sleep disorders Use of alcohol or stimulants | Not stated | No | Crash | Yes Survey |
| Howard et al. (2004) Retrospective cohort study | 2,342 of 3,268 (72% response rate; 97% male) Australian CMV drivers responded to a questionnaire (random sample of 98 workplaces selected from 395 workplaces on the database of the Transport Workers Union in Australia) 161 of 244 randomly selected to have polysomnograph | <ul style="list-style-type: none"> ESS score (sleepiness) Multivariable Apnea Prediction questionnaire (sleep-disordered breathing) Functional Outcomes of Sleep Questionnaire (sleep-related quality of life) Polysomnography Self-rated sleepiness at wheel Sleep habits Work habits Snoring Sleep quality LMDS Strategies for sleepiness | Height, weight, age, alcohol intake, hours of driving | Yes Hours of driving | Crash | Yes Survey |
| Carter et al. (2003) Retrospective cohort study | 1,865 of 4,000 men randomly sampled from the general population (Sweden) served as controls 1,034 of 1,389 male professional lorry and bus drivers 161 of the drivers also underwent a sleep study in their homes | <ul style="list-style-type: none"> ESS score Sleep debt (self described) Demographic data Professional driving Health status Sleep habits Work habits Crash history under variety of conditions | Height, weight, age, alcohol intake, use of medications, approximate mileage per year | Yes Professional drivers were asked to report their occupational mileage for the preceding year. Mileage was not obtained from the referents. | Crashes within past 10 years | Yes Survey |
| Mitler et al. (1997) Prospective cohort study | 80 drivers separated into 4 groups of 20 and tested in U.S. and Canada | <ul style="list-style-type: none"> Driving schedule (10 hrs vs. 13 hrs; either beginning at same time of day for 5 days or 1-2 hours earlier on each subsequent day) Self-reported amount of sleep needed Polysomnography during sleep Electrophysiological | Height, age, weight, BMI | Yes Miles driven | Crashes and/or near-misses during study period | No Onboard system electrophysiological recording and video monitoring Yes Survey data |

| Reference (Year) Study Design | Study Participants | Factors Measured | Factors Controlled | Driving Exposure | Primary Outcome | Outcome Self-reported |
|--|---|---|---------------------------|---|---------------------------|-----------------------|
| | | recording during driving | | | | |
| Maycock et al. (1997) Prospective cohort study | 996 heavy goods drivers interviewed at one of four motorway service stations in 1993; mean age 41.4 | <ul style="list-style-type: none"> • ESS score • Demographic data • Driving history • Miles driven in previous yr • Crash history past 3 yrs | Weight, age, miles per yr | Yes Miles driven in previous yr | Crashes within past 3 yrs | Yes Survey |

Abbreviations: ESS: Epworth Sleepiness Scale; LMDS: Leg Movements During Sleep; PSQI: Pittsburgh Sleep Quality Index; SSS: Stanford Sleepiness Scale WSCS: Wisconsin Sleep Cohort Study Questionnaire

Table 18 provides a summary of the key findings of the studies described above, as well as some of the primary limitations of the studies.

Table 18: Primary Results of Studies Assessing Sleepiness and/or Fatigue and Crash Risk

| Reference (Year) Study Design | Results [Adjusted Odds Ratio (Confidence Interval)] unless otherwise specified |
|--|--|
| Commercial Motor-Vehicle Drivers | |
| Hanowski et al. (2007) Prospective cohort study | <p>Quantity of sleep in previous 24 hrs:</p> <p>For drivers having a critical incident (cases reflect amount of sleep in driver in 24 hours before crash; controls were the same drivers mean sleeping time overall) (n=38)</p> <ul style="list-style-type: none"> • Drivers received less sleep (mean = 5.28 hrs) prior to being involved in a critical incident as compared to their overall sleep quantity (mean = 6.63 hrs) [p<0.0001] <p>For drivers judged to have been at fault (n=29)</p> <ul style="list-style-type: none"> • Drivers received significantly less sleep (mean = 5.25 hrs) prior to the critical incident compared to the overall mean sleep for that same driver (mean = 6.70) [p<0.0005] |
| <i>Limitations:</i> | (1) Numerous variables were not controlled: alcohol and drug use; driver medical conditions (e.g., sleep apnea) and psychological states (e.g., depression). |
| Dingus et al. (2006) Prospective cohort study | <p>Critical incidents by driver type (single vs. team driving):</p> <p>Single drivers had more critical incidents than team drivers. Total number of critical incidents for single vs. team: 1,898 and 564, respectively. Mean numbers were: 146.0 and 40.3, respectively. T-test = 13.16; p < 0.01 (these values are corrected for total number of hours driven)</p> <p>Critical incidents by driver type and hour of day:</p> <p>Two-way ANOVA for driver type (single vs. team) [$F_{1,25} = 8.49$; $p = 0.007$] and hour of day, [$F_{23,480} = 1.93$; $p = 0.006$], were significant. The highest critical incident rates occurred for single drivers during daylight hours between 11 a.m. and noon and between 3 p.m. and 6 p.m.</p> <p>Drowsiness Ratings:</p> <p>Team drivers only have cases of "very drowsy" ratings for incidents that occurred at night (10 p.m.-3:59 a.m.). In contrast, single drivers have "very drowsy" ratings throughout the day (morning, afternoon, evening, and night). Also, cases of an ORD rating of "very drowsy" were highest when critical incidents were highest.</p> |
| <i>Limitations:</i> | (1) Numerous variables were not controlled: alcohol and drug use; driver medical conditions, amount and quality of sleep. (2) Small sample size and relatively small number of incidents. |
| Gander et al. (2006) Prospectively study (retrospective control) | <p>The authors identified the following as the most predictive of sleep or fatigue-related crash:</p> <ul style="list-style-type: none"> • Amount of sleep in 24 hr prior to crash • Time awake at crash (or prior waking time) • At the time of the crash, how long was it since you had a rest period of at least 9 h (the regulatory minimum break in New Zealand) • Time since 2 consecutive nights of good sleep <p>Risk factors for sleep- or fatigue-related crash (2 or more of the following):</p> <ul style="list-style-type: none"> • Less than 6 h sleep in the last 24 h (acute sleep loss) • More than 12 h awake (extended wakefulness) • More than a week without two good nights of sleep in a row (cumulative sleep debt) • Crash occurred between 00:00 and 08:00 h |
| <i>Limitations:</i> | (1) Self-report data. (2) Recall bias. |

| Reference (Year) Study Design | Results [Adjusted Odds Ratio (Confidence Interval)] unless otherwise specified |
|---|--|
| Perez-Chada et al. (2005) Retrospective, cross-sectional study | Adjusted risk factors associated with an increased risk for accidents or near accidents were: <ul style="list-style-type: none"> • ESS score >10 [OR= 2.53 (1.61-3.97)] • Sleepiness at the wheel [OR=1.92 (1.08-1.96)] • Snoring >3 times per week [OR=1.73 (1.23-2.44)] Probability of crash or near-misses was found to be cumulative with increasing risk when more than one risk factor was present. |
| Limitations: | (1) Self-report data. (2) Recall bias. |
| Sabbagh-Ehrlich et al. (2005) Retrospective cohort study | Risk Factors for Crash 100 (15.6%) drivers reported being involved in a crash, of which 33 involved injuries or fatalities. 21 (67% out of 33) attributed the reported crash to fatigue. 11 (33% out of 33) said that the crash was related to sleep problems. Among these 33, many recalled parking problems when tired, (n=29), long working hours at least several times a week (n=24), and employer demands (n=15). For a subgroup of 12 drivers, involvement in a crash with casualties was associated with moderate to severe sleep quality (adjusted OR 2.9; p=0.04) and frequent difficulty finding parking when tired (adjusted OR 3.7; p=0.05). |
| Limitations: | (1) Self-report data. (2) Did not use a validated measure of sleepiness. |
| Bunn et al. (2005) Retrospective case control study | Risk Factors for Crash Driver sleepiness/fatigue and distraction/inattention increase the odds that a CVC will be fatal (OR 21.03, 95% CI 4.17–106.07). |
| Limitations: | (1) Self-report data from drivers. (2) Interpretations of police may not have accurately attributed sleep in fatal accidents. (3) No measures of sleepiness could be obtained from CMV drivers fatally injured in a crash. |
| Souza et al. (2005) Retrospective cohort study | Crash Risk Professional accidents (those occurring while on duty) were significantly associated with ESS score. Mean ESS score was 8.2 for drivers reporting an accident in the prior 5 years, compared to 6.3 in the group of drivers who had reported no work-related accidents in the prior 5 years (p=0.0239). |
| Limitations: | (1) Self-report data from drivers. (2) Recall bias: Drivers were asked to recall accidents occurring over previous 5 years. (3) ESS scores were measured at time of study and may not be reflective of excessive daytime sleepiness that may or may not have been present in the past 5 years or at the time of a prior accident. |
| Howard et al. (2004) Retrospective cohort study | Crash Risk CMV drivers with a very high level of sleepiness (Epworth Sleepiness Scale score of 18 to 24, sleepiest 5% of drivers) had an increased risk of any accident (OR 1.91, 95% CI 1.09–3.35) and of multiple accidents (OR 2.67, 95% CI 1.29–5.52). A forward stepwise selection model identified the following factors as the strongest independent predictors of accident: <ul style="list-style-type: none"> • Sleepiness (ESS score) [OR= 1.24 (1.10-1.34)] • Hours driving/week [OR= 1.17 (1.04–1.31)] • Interstate and country driving [OR= 2.53 (1.61-3.97)] • Narcotic analgesic use [OR= 2.10 (1.30–3.38)] • Age [OR= 0.87 (0.77–0.99)] Sleepiness, followed by age, were the only factors included in a model for single vehicle accidents. <ul style="list-style-type: none"> • Sleepiness (ESS score) [OR= 1.29 (1.14-1.45)] • Age [OR= 0.79 (0.70–0.90)] |
| Limitations: | (1) The use of subjective measures of sleepiness and self report of accidents may lead to underestimation of the degree of sleepiness and accident rates or measurement bias. (2) Self-report data is also subject to survival bias resulting in fewer serious accidents and no accidents fatal to the driver being included in the study. |
| Carter et al. (2003) Retrospective cohort study | Crash Risk With Sleepiness Multivariate ORs and 95% confidence intervals for the difference in reported accident rate between professional drivers with sleep debt and ESS scores >10 vs. those with ESS scores <8 and without sleep debt <ul style="list-style-type: none"> • At home (Commuting to work) [OR=6.1 (1.7–21.5)] • In traffic at leisure [OR=2.4 (0.9–6.5)] • At work (occupational) [OR=2.1 (1.1–3.9)] The data obtained in this study provides further support to the hypothesis that sleep debt is common among CMV drivers . The results also indicate that self-rated sleep debt is directly related to accident likelihood for males in the general population and male CMV drivers. |
| Limitations: | (1) Self-report data. (2) Information on mileage driven was not obtained for the referents. (3) Recall bias based on the use of questionnaires to retrospectively collect information on both "exposures" and "effects." (4) Potential for selective recall or under-reporting bias among professional drivers due to concerns of penalization. |

| Reference (Year) Study Design | Results [Adjusted Odds Ratio (Confidence Interval)] unless otherwise specified |
|---|---|
| Mitler et al. (1997) Prospective cohort study | No crashes or near misses observed during study period Two of 80 drivers had one episode each of stage 1 sleep while driving Forty five (56%) of drivers had at least one 6-minute interval of drowsy driving during the testing period Drivers driving at night were more likely to be judged as sleepy than drivers driving in the day |
| Limitations: | (1) Self-report data. (2) Relatively small sample size for the period of assessment. (3) Not enough power in the study to determine the effect of drowsy driving or driving time on crash risk. |
| Maycock et al. (1997) Prospective cohort study | Crash Risk With Sleepiness ESS ≥ 11 combined with large collar size, and those who snore have 2.49 times the accident liability of those who score zero. |
| Limitations: | (1) Self-report data. (2) Information on mileage driven was not obtained for the referents. (3) Recall bias. (4) Potential for selective recall or underreporting bias among professional drivers due to concerns of penalization. (5) Excludes all drivers killed in a crash. |

Abbreviations: ESS: Epworth Sleepiness Scale; LMDS: Leg Movements During Sleep; PSQI: Pittsburgh Sleep Quality Index; SSS: Stanford Sleepiness Scale WSCS: Wisconsin Sleep Cohort Study Questionnaire

Summary of Findings

The majority of studies reported a significant association between subjective measures of excessive daytime sleepiness (most often measured using ESS) with the risk of crash in both commercial and passenger drivers. Adjusted odds ratios for sleep-related crash as determined using ESS scores ranged from **0.7** to **21.03**. In addition, acute measures of sleepiness, most often determined by the quantity of sleep in the time prior to a crash or near miss, were also found to significantly increase risk for a sleep-related crash.

Table 19 below provides a quick-view summary of the results of the studies presented in Table 17 and Table 18. As can be seen, in each study, chronic sleepiness and/or acute sleepiness measures are significantly associated with increased crash or near-miss risk.

Table 19: Quick-view Summary of the Results of Studies on Sleep-related Crash Risk

| Study | Chronic Sleepiness | Chronic Sleepiness Increased Risk? | Acute Sleepiness | Acute Sleepiness Increased Risk? | Measure of Sleepiness Relative to Incident |
|---|-----------------------|------------------------------------|---|----------------------------------|--|
| Hanowski et al. (2007) Prospective cohort study | -- | -- | Objective measure of sleep quantity using actigraphy; Video monitoring of sleepiness | ▲ | Simultaneous |
| Dingus et al. (2006) Prospective cohort study | -- | -- | Karolinska Sleepiness Scale; Video monitoring of sleepiness | ▲ | Simultaneous |
| Gander et al. (2006) Retrospective cohort study | ESS | -- | General Questionnaire about immediate prior sleep | ▲ | Close in time following crash |
| Perez-Chada et al. (2005) Retrospective cohort study | ESS | ▲ | -- | -- | Variable (data report on crash at anytime in past) |
| Sabbagh-Ehrlich et al. (2005) Retrospective cohort study | General questionnaire | ▲ | -- | -- | Variable (data report on crash at anytime in past) |
| Souza et al. (2005) Retrospective cohort study | ESS PSQI | ▲ | -- | -- | Variable (data report on crash) |

| | | | | | |
|---|---------------------------------|----|---|----|--|
| | | | | | within past 5 yrs) |
| Howard et al. (2004) Retrospective cohort study | ESS FOSQ | ▲ | -- | -- | Variable (data report on crash within past 3 yrs) |
| Carter et al. (2003) Retrospective cohort study | ESS Self-assessed sleep debt | ▲ | -- | -- | Variable (data report on crash within past 10 yrs) |
| Mitler et al. (1997) Prospective cohort study | -- | -- | Objective measure of sleep quantity using polysomnography; Electroencephalography; Video monitoring of sleepiness | ▲ | Simultaneous |
| Maycock et al. (1997) Prospective cohort study | ESS | ▲ | -- | -- | Variable (data report on crash within past 3 yrs) |

Abbreviations: ESS: Epworth Sleepiness Scale; FOSQ: Functional Outcomes of Sleep Questionnaire; PSQI: Pittsburg Sleep Quality Index

Some potential issues with these findings are that drivers included in these studies were often assessed for sleep-related factors at some variable time following the crash or near miss. The use of “current” daytime sleepiness measures (i.e., measured at the time of the study) as a proxy measure for past sleepiness is likely a source of bias. This is particularly a problem for studies that measured current sleepiness relative to recalled crashes and/or near misses from some time in the more distant past. Studies that attempted to link assessments of sleepiness closer in time to the prior crash are likely to be better assessments of sleep-related crash risk (Hanowski et al., 2007; Dingus et al., 2006; Gander et al., 2006).

Perhaps the best measures of this come from more recent studies that have used naturalistic data collection systems in real-life driving scenarios, such as those by Dingus et al. (2006) and Hanowski et al. (2007). These types of studies increase the external validity of the results obtained, because drivers are evaluated in real-driving contexts. Moreover, these studies are less likely to be impacted by recall bias as described above, because assessments of sleepiness were obtained during the period with which the crash and/or near miss data were collected, simultaneously.

In Dingus et al. (2006), one of the primary findings was that the frequency of critical incidents (near misses) and fatigue-related critical incidents varied significantly by the hour of the day. The largest number of incidents (even corrected for exposure), as well as the largest number of cases of very drowsy single drivers, occurred in the late afternoon and early evening hours. Thus, combining fatigued driving at periods of high traffic appeared to be a significant risk factor in the occurrence of critical incidents. The authors further found that that approximately 20 percent of severe critical incidents were caused by extreme (i.e., headbobbing) fatigue. Interestingly, this study also assessed the occurrence of fatigue and sleepiness in single versus team drivers, and it noted that single drivers had higher levels of self-reported daytime sleepiness and were also more likely to have critical and severe critical incidents than team drivers.

In Hanowski et al. (2007), one of the primary findings was that fatigue and/or sleep-related critical incidents are significantly related to the amount of sleep a driver receives on the day prior to driving, as well as self-reported drowsiness prior to a critical incident. Driver sleep quantity was significantly less in the period before the critical incident occurred when compared to the overall mean sleep quantity over the period of time that drivers were assessed.

Collectively, the findings of these studies, along with those those obtained from epidemiological studies, suggest that crash risk is significantly related to fatigue and/or sleepiness at the wheel that arises from either chronic sleep problems and/or acute sleep restriction.

Sleep-related Risk-Factors for Falling Asleep While Driving and/or Crash

Given the finding that excessive daytime sleepiness and/or fatigue (both chronic and/or acute in nature) is associated with an increased risk for crash, the next question of interest is whether or not there are identifiable factors that can reasonably predict falling asleep at the wheel (becoming fatigued while driving) and/or crash.

The key question for this subsection was:

- **Are there other sleep-related risk-factors associated with crash and/or falling asleep while driving?**

Table 20 below provides a summary of the study design and study characteristics (including participants, factors measured and controlled, driving exposure, and outcomes measured) for each of the studies assessed for this key question. A total of 10 studies are summarized.

Table 20: Characteristics of Studies Assessing Other Sleep-related Factors Associated with Falling Asleep at the Wheel and/or Crash

| Reference (Year) Study Design | Study Participants | Factors Measured | Factors Controlled | Driving Exposure | Primary Outcome | Outcome Self-reported |
|--|--|---|--|---|---|---|
| Commercial Drivers | | | | | | |
| Heaton et al. (2008) Retrospective, cross-sectional (no control) | 843 long-haul truck drivers at trade shows (Iowa, Kentucky, and Texas) and truck stops (Kentucky) during 2003 and 2004. | <ul style="list-style-type: none"> • ESS score • Hours of sleep (<6 hrs) • Work time (13+ hrs) • Nighttime driving (+6 hrs) • Use of a driving partner • Use of medications to stay awake • Use of medications to sleep • Driving experience | Demographic factors, such as gender, race, education, income | No | Number of times asleep at the wheel within the previous 30 days and 12 months | Yes Survey |
| Hanowski et al. (2007) Prospective cohort study | 82 CMV drivers (81 male, 1 female) working for one of three licensed trucking companies 73 drivers provided useful data | <ul style="list-style-type: none"> • Hours of sleep (by actigraphy) • Work time | Not stated | No Miles driven collected but not controlled for in analyses | Crash, near-crashes | No Onboard system and video monitoring |
| Dingus et al. (2006) Prospective cohort study | 47 male and 9 female participants, constituting 13 teams (2 drivers) and 30 single drivers. | <ul style="list-style-type: none"> • Single vs. team driving • Sleepiness at wheel (via the Karolinska Sleepiness Scale) • Time of day | Age, experience driving, hours driven | Yes Hours of driving | Crash, near-crashes, crash-relevant conflicts | No Onboard system and video monitoring |
| Gander et al. (2006) Prospectively study (retrospective control) | 130 of 380 individuals involved in a crash during the study period (13 mo), who were given the survey just following the crash, responded to the | <ul style="list-style-type: none"> • ESS score • Sleep habits • Snoring • Sleep history 3 days prior to crash • Crash details | Age, gender | No | Sleepiness while driving, crash | Yes Survey |

| Reference (Year) Study Design | Study Participants | Factors Measured | Factors Controlled | Driving Exposure | Primary Outcome | Outcome Self-reported |
|--|---|--|---|--|---|--------------------------|
| | survey | <ul style="list-style-type: none"> Hours of driving at crash time Hours of duty at crash time | | | | |
| Sabbagh-Ehrlich et al. (2005) Retrospective cohort study | 160 of 640 drivers (25%) approached at the registration points in the ports of Haifa and Ashdod | <ul style="list-style-type: none"> Driver characteristics Workplace conditions Employer-employee relations Driving conditions Sleep quality(PSQI) Self-reported fatigue Driving frequency | Age, BMI, smoking, experience driving, truck weight, salary | No | Falling asleep at wheel, fatigue, crash | Yes Interview/Survey |
| Souza et al. (2005) Retrospective cohort study | 260 male truck drivers (Brazil); mean age 38.2 years | <ul style="list-style-type: none"> ESS score Quality of sleep, sleep hours and habits (on both working and nonworking days) Sleep disorders Use of alcohol or stimulants | Not stated | No | Excessive sleepiness, crash | Yes Survey |
| Perez-Chada et al. (2005) Retrospective, cross-sectional study | 738 of 905 approached long-haul drivers (independent drivers) | <ul style="list-style-type: none"> ESS score Self-rated sleepiness at wheel Sleep habits Snoring Sleep quality LMDS Strategies for sleepiness | Anthropometric factors, gender, Age | Yes 800 km/day | Crash, near-miss | Yes Survey: WSCS, ESS |
| Howard et al. (2004) Retrospective cohort study | 2,342 of 3,268 (72% response rate; 97% male) Australian CMV drivers responded to a questionnaire (random sample of 98 workplaces selected from 395 workplaces on the database of the Transport Workers Union in Australia) 161 of 244 randomly selected to have polysomnograph | <ul style="list-style-type: none"> ESS score (sleepiness) Multivariable Apnea Prediction questionnaire (sleep-disordered breathing) Functional Outcomes of Sleep Questionnaire (sleep-related quality of life) Polysomnography Self-rated sleepiness at wheel Sleep habits Work habits Snoring Sleep quality LMDS Strategies for sleepiness | Height, weight, age, alcohol intake, hours of driving | Yes Hours of driving | Excessive sleepiness while driving, crash | Yes Survey |
| Carter et al. (2003) Retrospective cohort study | 1,865 of 4,000 men randomly sampled from the general population (Sweden) served as controls 1,034 of 1,389 male professional lorry and bus drivers 161 of the drivers also underwent a sleep study in their homes | <ul style="list-style-type: none"> ESS score Sleep debt (self described) Demographic data Professional driving Health status Sleep habits Work habits Crash history under variety of conditions | Height, weight, age, alcohol intake, use of medications, approximate mileage per year | Yes Professional drivers were asked to report their occupational mileage for the preceding year. Mileage was not obtained from the referents. | Crashes within past 10 years | Yes Survey |

| Reference (Year) Study Design | Study Participants | Factors Measured | Factors Controlled | Driving Exposure | Primary Outcome | Outcome Self-reported |
|---|--|--|--------------------|--|-------------------------|--------------------------------|
| McCartt et al. (2000) Prospective cohort study | 593 long-distance truck drivers (sampled at rest stops, truck stops, and inspection sites) | <ul style="list-style-type: none"> • Driver demographic • Years driving a commercial vehicle • Annual miles driven • job characteristics • Usual work schedule • Sleep, rest and sleepiness patterns, particularly while on the road | Not stated | Yes Driving a tractor-trailer for at least 6 months, made at least occasional trips of 2 days or more, and drove a minimum of 50,000 miles a year for work | Falling asleep at wheel | Yes Interview/Survey |

Abbreviations: ESS: Epworth Sleepiness Scale; LMDS: Leg Movements During Sleep; PSQI: Pittsburgh Sleep Quality Index; SSS: Stanford Sleepiness Scale WSCS: Wisconsin Sleep Cohort Study Questionnaire

Table 21 provides a summary of the key findings of the studies described above, as well as some of the primary limitations of the studies.

Table 21: Primary Results of Studies Assessing Sleep-related Factors and Crash Risk

| Reference (Year) Study Design | Results [Adjusted Odds Ratio (Confidence Interval) unless otherwise specified] |
|--|--|
| Commercial Motor-Vehicle Drivers | |
| Heaton et al. (2008) Retrospective cohort | <p>Multivariate Analysis:</p> <p>Four of the original eight variables were shown to be predictive of falling asleep at wheel within previous 12 months.</p> <ul style="list-style-type: none"> • ESS Score >10: [2.14 (1.29-3.60)] P=.003 • Night Driving: [3.08 (1.09-8.72)] P=.034 • Sleep Duration: [2.36 (1.38-4.03)] P=.002 • Medications to stay awake: [2.70 (1.42-5.14)] P=.002 <p>Four variables also were predictive for falling asleep within the previous 30 days, but the variables did not all reach statistical significance. In addition, work duration rather than sleep duration was retained among the 4 variables.</p> <ul style="list-style-type: none"> • Driving experience was not found to be related to falling asleep at the wheel in multivariate analysis but was in bivariate analysis |
| Limitations: | (1) Data reflect a subset derived from a larger study that was not designed specifically to analyze sleep and risk of sleeping at the wheel. (2) Self-report data. (3) A retrospective, non-controlled study. |
| Hanowski et al. (2007) Prospective cohort study | <p>Quantity of sleep in previous 24 hrs:</p> <p>For drivers having a critical incident (case reflect amount of sleep in driver in 24 hours before crash; controls were the same drivers mean sleeping time overall) (n=38)</p> <ul style="list-style-type: none"> • Drivers received less sleep (mean = 5.28 hrs) prior to being involved -in a critical incident as compared to their overall sleep quantity (mean = 6.63 hrs) [p≤0.0001] <p>For drivers judged to have been at fault (n=29)</p> <ul style="list-style-type: none"> • Drivers received significantly less sleep (mean = 5.25 hrs) prior to the critical incident compared to the overall mean sleep for that same driver (mean = 6.70) [p≤0.0005] |
| Limitations: | (1) Numerous variables were not controlled: alcohol and drug use; driver medical conditions (e.g., sleep apnea) and psychological states (e.g., depression). |
| Dingus et al. (2006) Prospective cohort study | <p>Critical incidents by driver type (single vs. team driving):</p> <p>Single drivers had more critical incidents than did team drivers. Total number of critical incidents for single vs. team: 1,898 and 564, respectively. Mean numbers were: 146.0 and 40.3, respectively. T-test = 13.16; p < 0.01 (these values are corrected for total number of hours driven)</p> <p>Critical incidents by driver type and hour of day:</p> <p>Two-way ANOVA for driver type (single vs. team) [F_{1,25} = 8.49; p=0.007] and hour of day, F_{23,480} = 1.93; p=0.006], were significant. The highest critical incident rates occurred for single drivers during daylight hours between 11 a.m. and noon and between 3 p.m. and 6 p.m.</p> <p>Drowsiness Ratings:</p> <p>Team drivers only have cases of "very drowsy" ratings for incidents that occurred at night (10 p.m. to 3:59 a.m.). In contrast, single drivers have "very drowsy" ratings throughout the day (morning, afternoon, evening, and night). Also, cases of an ORD rating of "very drowsy" were highest when critical incidents were highest.</p> |
| Limitations: | (1) Numerous variables were not controlled: alcohol and drug use; driver medical conditions, amount and quality of sleep. (2) Small sample |

| Reference (Year) Study Design | Results [Adjusted Odds Ratio (Confidence Interval) unless otherwise specified] |
|---|---|
| | size and relatively small number of incidents. |
| Gander et al. (2006) Retrospective cohort | <p>The authors identified the following as the most predictive of sleep or fatigue-related crash:</p> <ul style="list-style-type: none"> Amount of sleep in 24 hr prior to crash Time awake at crash (or prior waking time) At the time of the crash, how long was it since you had a rest period of at least 9 h (the regulatory minimum break in New Zealand) Time since 2 consecutive nights of good sleep <p>Risk factors for sleep- or fatigue-related crash (2 or more of the following):</p> <ul style="list-style-type: none"> Less than 6 h sleep in the last 24 h (acute sleep loss) More than 12 h awake (extended wakefulness) More than a week without two good nights of sleep in a row (cumulative sleep debt) Crash occurred between 00:00 and 08:00 h |
| Limitations: | (1) Self-report data. (2) Recall bias. |
| Sabbagh-Ehrlich et al. (2005) Retrospective cohort study | <p>Risk Factors for Sleep While Driving</p> <ul style="list-style-type: none"> Frequent difficulty finding parking when tired (OR 12.7; p=0.001). |
| Limitations: | (1) Numerous variables were not controlled: alcohol and drug use, driver medical conditions, amount and quality of sleep. (2) Small sample size and relatively small number of incidents. |
| Souza et al. (2005) Retrospective cohort study | <p>Excessive Daytime Sleepiness (EDS)</p> <p>EDS measured by ESS was significantly associated with a reduced number of sleep hours on working days (5 to 6 hours) (p=0.0244)</p> <p>EDS measured by ESS was significantly associated with reduced sleep quality (PSQI score >5) (p=0.0218)</p> <p>Sleep Factors and Crash Risk</p> <p>Only EDS as measured by ESS, and age was significantly predictive of crash risk</p> <p>Other sleep-related factors were not predictive of crash (sleep hours, sleep quality by PSQI, driving hours, wake-up time, use of alcohol or stimulants)</p> |
| Limitations: | (1) Self-report data from drivers. (2) Recall bias: Drivers were asked to recall accidents occurring over previous 5 years. (3) ESS scores were measured at time of study and may not be reflective of excessive daytime sleepiness that may or may not have been present in the past 5 years or at the time of a prior accident. |
| Perez-Chada et al. (2005) Retrospective, cross-sectional study | <p>Adjusted risk factors associated with an increased risk for accidents or near accidents were:</p> <ul style="list-style-type: none"> ESS score >10 [OR= 2.53 (1.61-3.97)] Sleepiness at the wheel [OR=1.92 (1.08-1.96)] Snoring >3 times per week [OR=1.73 (1.23-2.44)] <p>Probability of crash or near-misses was found to be cumulative with increasing risk when more than one risk factor was present.</p> |
| Limitations: | (1) Self-report data. (2) Recall bias. |
| Howard et al. (2004) Retrospective cohort study | <p>Risk Factors for Increased Sleepiness</p> <ul style="list-style-type: none"> Time worked per week [OR 1.25 (1.12-1.41)] for increasing hours Shift type [OR 1.57 (1.26-1.95) night shift; 1.44 (1.14-1.81) afternoon] Driving location [OR 1.49 (1.20-1.85) on interstate] Sleep duration on work days of ≤5 hours [OR 2.61 (1.84-3.71)], >9 hours [OR 3.92 (1.53-10.05)] Sleep duration on nonwork days [OR 1.13 (1.01-1.27)] for increasing hours |
| Limitations: | (1) The use of subjective measures of sleepiness and self-report of accidents may lead to underestimation of the degree of sleepiness and accident rates or measurement bias. (2) Self-report data is subject to survival bias resulting in fewer serious accidents and no accidents fatal to the driver being included in the study |
| Carter et al. (2003) Retrospective cohort study | <p>Crash Risk With Sleepiness</p> <p>Multivariate ORs and 95% confidence intervals for the difference in reported accident rate between professional drivers with sleep debt and ESS scores >10 vs. those with ESS scores <8 and without sleep debt</p> <ul style="list-style-type: none"> At home (Commuting to work) [OR=6.1 (1.7-21.5)] In traffic at leisure [OR=2.4 (0.9-6.5)] At work (occupational) [OR=2.1 (1.1-3.9)] <p>The data obtained in this study provides further support to the hypothesis that sleep debt is common among CMV drivers. The results also</p> |

| Reference (Year) Study Design | Results [Adjusted Odds Ratio (Confidence Interval) unless otherwise specified] |
|---|---|
| | indicate that self-rated sleep debt is directly related to accident likelihood for males in the general population and male CMV drivers. |
| Limitations: | (1) Self-report data. (2) Information on mileage driven was not obtained for the referents. (3) Recall bias based on the use of questionnaires to retrospectively collect information on both “exposures” and “effects.” (4) Potential for selective recall or underreporting bias among professional drivers due to concerns of penalization. |
| McCartt et al. (2000) Prospective cohort study | Factor analysis reduced the large set of predictors to six underlying, independent factors most predictive of falling asleep at the wheel. <ol style="list-style-type: none"> 1. Daytime sleepiness [2.46] 2. Arduous work schedule [1.80] 3. Older, longtime driver [1.53] 4. Night-time drowsy driving [1.44] 5. Poor sleep on the road [1.43] 6. Self-reported risk factors for sleep apnea or other sleep disorder [1.39] |
| Limitations: | (1) Data reflect a subset derived from a larger study that was not designed specifically to analyze sleep and risk of sleeping at the wheel. (2) Self-report data. (3) A retrospective, non-controlled study. |

Abbreviations: ESS: Epworth Sleepiness Scale; LMDS: Leg Movements During Sleep; PSQI: Pittsburgh Sleep Quality Index; SSS: Stanford Sleepiness Scale WSCS: Wisconsin Sleep Cohort Study Questionnaire

Summary of Findings

The studies described above provide an assessment of a variety of additional sleep-related factors (beyond chronic and acute sleepiness measures) that contribute to falling asleep at the wheel and/or that increase risk of crash. Of the studies assessed, three looked specifically at a wide variety of potential factors. They are summarized in chronological order below.

McCartt et al. (2000) conducted interviews with 593 long-distance CMV drivers randomly selected at public and private rest areas and inspection stations. It found that 47 percent of the respondents reported having fallen asleep at the wheel of a large truck and that 25 percent had done so within the past year. In their factor analysis approach to assessing the various risk factors associated with falling asleep at the wheel, the authors identified six primary factors as the most meaningful predictors (See Table 22).

Table 22: McCartt et al., (2000)—Factors Related to Falling Asleep at Wheel

| Variable | Brief Description | Odds Ratio |
|---|--|------------|
| 1. Daytime sleepiness | Of the six factors, a tendency toward daytime sleepiness as measured using the ESS was most highly predictive of falling asleep at the wheel. | [OR=2.46] |
| 2. Arduous work schedule | According to the authors, these were drivers who typically drove longer than the 10 consecutive hours, took fewer than the 8 hours off-duty, falsified their log books, drove more hours in a typical 7-day week, and more frequently had schedules that precluded making on-time delivery without speeding or violating the hours-of-service regulations. | [OR=1.80] |
| 3. Older, long-time driver | An older, long-time driver factor was predictive of falling asleep at the wheel; given the criterion of ever falling asleep at the wheel of a truck, this factor captured the degree of opportunity for falling asleep at the wheel by increasing the level of driving exposure. | [OR=1.53] |
| 4. Night-time drowsy driving | Driving at night while drowsy verses being well rested. | [OR=1.44] |
| 5. Poor sleep on the road | Drivers reporting poor sleep on road, captured a split off-duty rest period, fewer hours in the longest sleep period, and self-reported poor sleep while on the road. | [OR=1.43] |
| 6. Self-reported risk factors for sleep apnea or other sleep disorder | A driver’s report of specific symptoms of obstructive sleep apnea (higher body weight, snoring, breathing stopping during sleep) and self-reported poor sleep at home comprised the factor, symptoms of sleep disorder, and were predictive of falling asleep at the wheel. | [OR=1.39] |

Howard et al. (2004) reported that, after controlling for age, there were increased odds of excessive sleepiness at the wheel with the following factors:

- Multivariable Apnea Prediction Score (disordered breathing scale)
- Hours worked per week
- Afternoon or night shift work
- Hours of sleep on work days
- Obtaining more sleep on days off
- Stimulant use
- Caffeine intake

A more recent study of risk factors for falling asleep at the wheel is the study performed by Heaton et al. (2008). This study included an analysis of data from 843 long-haul CMV drivers in an effort to identify factors associated with episodes of sleepy driving during the previous 30 days and the previous year. The authors of this report identified four of the eight original predictor variables in a model to predict falling asleep at the wheel within the past 12 months. Four variables were also retained in the final model to predict falling asleep at the wheel within the past 30 days. They are indicated in Table 23 below.

Table 23: Heaton et al., (2008)—Factors Related to Falling Asleep at Wheel

| Variable | Falling Asleep in Last 12 Months Odds Ratio (95% CI) | Falling Asleep in Last 30 Days Odds Ratio (95% CI) | P value | |
|-----------------------------|---|---|---------|---------|
| Chronic Sleepiness (ESS) | 2.14 (1.29–3.60) | 2.69 (1.42–5.10) | .003* | .002* |
| Night driving | 3.08 (1.09–8.72) | 3.50 (0.82–14.92) | .034* | .092 |
| Sleep duration | 2.36 (1.38–4.03) | ---- | .002* | ns |
| Work duration | ---- | 1.80 (0.92–3.52) | ns | .084 |
| Medications for wakefulness | 2.70 (1.42–5.14) | 4.12 (2.02–8.49) | .002* | < .001* |

Summary of Predictors

Of the factors assessed across each of the studies examined, a number of factors stand out as consistently being associated with increased likelihood of sleepiness at the wheel and/or crash. These factors are presented in Table 24 for eight of the 10 studies examined. These eight studies are shown because they assessed more than two different factors. The factors include sleep-related factors, such as chronic and/or acute measures of sleepiness, symptoms of sleep disorders, quantity of sleep, time of day, and night driving. Additional driving exposure factors generally indicated as factors that affect sleep, include work schedule and/or work duration, and time driving. Lastly, additional factors that have been assessed in sleep and driving research include age of driver and the use of alcohol and/or medications.

Of the factors most often studied and/or found to be predictive of crash or falling asleep while driving, four sleep factors stand out. These are chronic or acute sleepiness (e.g., ESS, KSS), quantity of sleep, time of day, and sleep habits/quality.

Table 24: Summary of Sleep-related Factors and Other Factors Affecting Sleep Associated with Crash and Sleepiness at the Wheel

| Study | Sleep-related | Driving | Other |
|-------|---------------|---------|-------|
|-------|---------------|---------|-------|

| | | | | | | | | Exposure | | | |
|------------------------|--|----------------------------|-------------------|-------------|----------------------|---------------|------------------------|--------------|--------------|--------------------------|--|
| | Chronic or Acute Sleepiness (e.g., ESS, KSS) | Symptoms of Sleep Disorder | Quantity of Sleep | Time of Day | Sleep Habits/Quality | Night Driving | Work Duration/Schedule | Time Driving | Older Driver | Alcohol / Medication Use | |
| | ● Indicates a significant relationship observed with increased crash risk and/or falling asleep at the wheel | | | | | | | | | | |
| Heaton et al. (2008) | ● | -- | ● | -- | -- | ● | ● | -- | -- | ● | |
| Hanowski et al. (2007) | ● | -- | ● | ● | -- | -- | -- | -- | -- | -- | |
| Dingus et al. (2006) | ● | -- | -- | ● | -- | ● | -- | -- | -- | -- | |
| Gander et al. (2006) | ● | -- | ● | ● | ● | -- | -- | ● | -- | -- | |
| Souza et al. (2005) | ● | -- | ● | -- | ● | -- | -- | -- | ● | -- | |
| Howard et al. (2004) | ● | ● | ● | ● | ● | -- | ● | ● | -- | ● | |
| Carter et al. (2003) | ● | ● | ● | -- | -- | -- | -- | -- | -- | -- | |
| McCartt et al. (2000) | ● | ● | -- | -- | ● | ● | ●* | ● | ● | -- | |

*Work duration/schedule reflects multiple work-related factors such as driving longer than 10 hours, less than 8 hours off duty time, driving longer than logged

Chronic and/or Acuted Daytime Sleepiness: All of the studies described in the table above have implicated (to varying degrees) chronic and/or acute sleepiness as a contributing factor to sleeping at the wheel.

Quantity of Sleep: A number of studies have demonstrated a link between the quantity of prior sleep and the risk of falling asleep at the wheel. In general, studies find that a person’s tendency to fall asleep during normal waking hours is increased and performance decreased following fewer hours of sleep and successive days of restricted sleep (Heaton et al., 2008; Hanowski et al., 2007, Gander et al., 2006; Souza et al., 2005; Howard et al., 2004; and Carter et al., 2003). Other related factors are the duration of a driver’s last sleep period, the total sleep obtained during the 24 hours preceding the crash, and fragmented sleep patterns.

In addition, according to Howard et al. (2004) drivers who averaged less than 7 hours of sleep per night during the working week were more likely to report excessive sleepiness than those who had 7 to 8 hours of sleep per night. For those who averaged less than 5 hours per night, the OR for excessive sleepiness was 2.74 (95% CI, 1.84–4.08).

Time of Day: A number of studies reported on the effects of time of day on both level of alertness and/or sleepiness. In most studies, self-rated sleepiness was significantly greater during late night and/or early morning hours.

Sleep Quality: Measures of sleep quality, such as with the Pittsburgh Sleep Quality Index (PSQI) have been found to be predictive of accident risk.

Screening Drivers for Factors Associated with Falling Asleep While Driving

The key question for this subsection was:

- **Related to the above questions, are there screening tests available that will enable examiners to identify those individuals with relevant sleep disorders and/or disturbances who are at an increased risk for a motor-vehicle crash?**

Based on the literature described in the two previous subsections, the obvious question arises: *Are there screening options for factors that may predict whether an individual will be likely to fall asleep at the wheel or become fatigued while driving?* For instance, with regard to OSA, there is currently a push, based on solid scientific evidence, to begin screening CMV drivers for OSA (Parks et al., 2009; Talmage et al., 2008). In the case of OSA, there are numerous identifiable risk factors that could be identified readily in drivers for this disorder during the course of a medical examination (e.g., weight, BMI, neck circumference, etc.). When an examiner identifies individuals with the presence of one or more of these risk factors, he/she can then refer the individual on for additional testing prior to making a determination of fitness to drive. For other sleep conditions, and/or risk factors for falling asleep at the wheel, the situation is more complicated.

Based on the studies reported above, one obvious risk factor that might be useful to screen for is chronic daytime sleepiness, which is, in numerous studies considered to be one of the strongest predictors of falling asleep at the wheel. For instance, Heaton et al. (2008) discussed the potential role of the occupational health nurse in screening truckers for various sleepiness predictors. As they note, the ESS is a simple tool that could be used to determine the presence of excessive sleepiness and increased likelihood of falling asleep at the wheel among truckers. In addition, excessive daytime sleepiness is a major risk factor for numerous sleep disorders, as described in Section 1 of this report, and thus screening for this factor might also identify individuals with undiagnosed and/or treated sleep disorders. A problem with this approach, however, relates to the fact that ESS scores are based on self-report. A driver suffering from excessive daytime sleepiness might be motivated to minimize and/or underreport their sleep issues based on employment concerns. Unlike OSA, there are no visible or objectively measureable signs, such as weight or BMI, that can be employed by the medical examiner to bypass relying on a driver's self-report.

Other factors, such as hours of work and prior sleep in recent 24 hours, are not amenable to medical screening. On the other hand, an extensive medication history should be elicited to identify individuals who might be taking drugs that result in sleepiness. The medication history may indicate or further support the assessment of increased risk of falling asleep at the wheel in this occupational group.

Other efforts, such as those to be discussed in Sections 5 and 6 of this report, go beyond regulations directed at drivers and/or the medical examiners who evaluate their fitness to drive. Specifically, these sections focus on policies and practices of motor carriers and the trucking industry (e.g., health and wellness approaches, and sleep- and fatigue-related countermeasures) to combat the risk associated with sleepiness and driving. In addition, driver-level efforts and technological approaches are summarized.

Limitations of the Literature Examined

The literature examined in this report ranges in quality, and, as stated in the tables above, is plagued by numerous types of bias and study design limitations. These include participant selection bias, information biases (including recall bias and self-reported data, etc.), and confounding variables (e.g., miles driven).

Selection Bias: Methods used for recruiting participants may have introduced bias. For example, the criteria for selection of participants were in some cases not reported or unclear. In others, it was targeted to individuals at very specific points or places, limiting the generalizability of results. In addition, many of the study designs relied on voluntary participation of drivers resulting in self-selection bias. Not all individuals who were sought by survey or by random approach participated. Most studies did not attempt to determine whether there were differences among individuals choosing to participate compared to those who chose not to participate.

Information Bias: Most studies relied on the self reporting of factors such as sleepiness, fatigue while driving, previous crash history, etc. This is particularly problematic in the CMV driver literature because CMV drivers with symptoms of sleepiness or sleep disorders may under-report accidents out of concern for job security, which would tend to weaken any association between sleep disorders and accidents. Secondly, for both the commercial and passenger driver literature, recall bias is also a concern. For instance, in numerous studies, drivers were asked to recall experiences, events or driving exposure over some specified period (sometimes as long as 10 years). In addition, subjective reports of sleep duration by drivers may not reliably reflect objectively measured sleep duration. It may also be difficult for drivers to recall whether a prior accident or near-miss accident was related to sleepiness or fatigue.

Another bias of concern relates to the use of “current” daytime sleepiness measures (measured at the time of the study) as a proxy measure for past sleepiness. Current sleeping patterns may not be reflective of the patterns that occurred at the time of a past accident. When this is the case, studies that link sleeping patterns as close in time to a prior crash are less likely to be affected by this type of bias.

Survival Bias: Much of the data presented in this section’s tables are based on self reports. Self-report data is subject to survival bias, resulting in fewer serious accidents and no accidents fatal to the driver being included in some of the studies.

External Validity Issues: The ability to generalize findings to populations other than those studied depends on the internal validity of the studies. For some studies, there are serious threats to the internal validity because the comparison groups do not represent the same population that the cases come from. Another issue pertains to the use of simulator studies. Simulator studies have the advantage of better experimental control (e.g., identical environmental and experimental circumstances for all the drivers), allow for the use of many indexes, and the possibility to confront the drivers with a monotonous, long and uninterrupted driving tasks or even potentially dangerous driving tasks. However, when using a simulator, drivers know that the consequences of driving errors will not affect their safety.

Confounding Variables: The potential confounding effects of age, gender, driving mileage (or driving frequency) and alcohol or drug use on the relationship between fatigue and car crash

were not adequately considered in most studies. In a number of studies, confounding variables were described, but exactly how they were accounted for was many times not described adequately. The effects of these variables, which all could have a relationship with sleep, fatigue and risk of crash, may therefore have distorted many of the estimates of crash risk.

Section 5: Policies and Interventional Efforts to Reduce the Risks of Sleep-related Driving

The majority of research on sleepiness and fatigue in the trucking industry has had a driver focus; few studies examine the managerial practices of transport companies. A number of studies show that drivers continue to violate hours of service, which can lead to fatigue and increase crash risk. Although trucking companies and their employees have become more aware of fatigue, company practices and management of fatigue still do little to countermeasure fatigue.

This section highlights hour-of-service guidelines and addresses their weakness and strengths; discusses the success and failures of companies to manage fatigue and examines an international effort to improve companies' strategies; and proposes countermeasures that will best reduce fatigue driving, based on the recommendations of the Best Practices Compendium of Fatigue Countermeasures in Transport Operations (Boivin, 2000, updated 2009). The following summarize the findings of these topics:

Hours of Service

The revised U.S. hours-of-service regulations have had little impact on reducing violations. And while CMV drivers are getting more sleep daily (Hanowski et al., 2007), another study (McCartt et al., 2008) reveals that long hours on the road remain common among drivers despite educational programs and initiatives.

Management and Monitoring of Fatigue

Most companies do not endorse practices that allow truckers to feel confident in their job security when reducing hours of service because of fatigue (Feyer et al., 2001; and Arnold et al., 1996). The Feyer and Arnold studies reveal other weaknesses among companies' strategies to reduce fatigue. Both studies found that although companies recognize that long hours of service cause fatigue, few companies pay attention to other work factors (such as loading, driving at night and poor roads) that contribute to fatigue. That drivers' and company managers' views about fatigue differ does little for companies attempting to implement effective strategies to combat fatigue.

To bridge the gap between trucking companies and their employees, Canada Transport and FMCSA are currently implementing "The North American Fatigue Management Program for Commercial Motor Carriers," which aims to improve fatigue management plans. Although the program is hailed by many, FMCSA has been recommended to work directly and monitor fatigue management plans at the fleet level.

Fatigue Countermeasures

The most effective countermeasure is based on physiology: strictly speaking, nothing but sleep restoration effectively compensates for sleep debt, according to the Best Practices Compendium of Fatigue Countermeasures in Transport Operations (Boivin, 2000).

The compendium recommends that work and rest schedules should promote adequate recovery sleep, and limitations should be put on night-shift work, split-sleep pattern, or counterclockwise rotation. Strategic napping could be used as a safety valve to improve alertness; however, it

should not be a substitute for a proper shift schedule, and its negative effects, namely sleep inertia and disruption of the main sleep episode, must be considered. The compendium also recommends technological devices, such as the Fitness-for-Duty/Readiness-to-Perform (FFD/RTP), to provide online measurement of alertness, and to initiate intervention algorithms. Comprehensive education programs regarding shift work, work and rest schedules, and proper regimens of health, diet, and rest.

Hours of Service

Regulations have been implemented to control the hours of service or the time on duty in the transport industry. Most are based on outdated rules that do not optimize safety and productivity, and do not take into account the physiology of the sleep-wake cycle (Knipling, 1998).

This section highlights the United States' current guidelines on hours of service and discusses two studies, Hanowski (2007) and McCartt (2008), which compare sleep habits and crash risk rates before and after the guidelines changed in 2004. This section also looks at other studies that show drivers commonly violate hours-of-service regulations, a large part of which can be attributed to companies' tight scheduling.

49 CFR Part 395

The U.S.'s hours-of-service regulations (49 CFR Part 395) put limits in place for when and how long CMV drivers may drive (See Table 25). These regulations are designed to ensure CMV drivers get the necessary rest to perform safe operations and are designed to continue the downward trend in truck fatalities and maintain motor carrier operational efficiencies. FMCSA reviewed existing fatigue research and worked with organizations, such as the Transportation Research Board of the National Academies and the National Institute for Occupational Safety, in devising these rules.

Although the regulations are found in Part 395 of the Federal Motor Carrier Safety Regulations, many States have identical or similar regulations for intrastate traffic.

Who Must Comply With The Hours-Of-Service Regulations?

Most drivers must follow regulations if they drive a commercial motor vehicle, or CMV. In general, a CMV is a vehicle that is used as part of a business and is involved in interstate commerce and fits *any* of these descriptions:

- Weighs 10,001 pounds or more
- Has a gross vehicle weight rating or gross combination weight rating of 10,001 pounds or more
- Is designed or used to transport 16 or more passengers (including the driver) not for compensation
- Is designed or used to transport 9 or more passengers (including the driver) for compensation
- A vehicle that is involved in Interstate *or* intrastate commerce and is transporting hazardous materials in a quantity requiring placards is *also* considered a CMV.

Table 25: Hours-of-Service Regulations

| Property-Carrying CMV Drivers | Passenger-Carrying CMV Drivers |
|--|---|
| 11-Hour Driving Limit May drive a maximum of 11 hours after 10 consecutive hours off duty. | 10-Hour Driving Limit May drive a maximum of 10 hours after 8 consecutive hours off duty. |
| 14-Hour Limit May not drive beyond the 14th consecutive hour after coming on duty, following 10 consecutive hours off duty. Off-duty time does not extend the 14-hour period. | 15-Hour On-Duty Limit May not drive after having been on duty for 15 hours, following 8 consecutive hours off duty. Off-duty time is not included in the 15-hour period. |
| 60/70-Hour On-Duty Limit May not drive after 60/70 hours on duty in 7/8 consecutive days. A driver may restart a 7/8 maximum consecutive day period after taking 34 or more consecutive hours off duty. | 60/70-Hour On-Duty Limit May not drive after 60/70 hours on duty in 7/8 consecutive days. |
| Sleeper Berth Provision Drivers using the sleeper berth provision must take at least 8 consecutive hours in the sleeper berth, plus a separate 2 consecutive hours either in the sleeper berth, off duty, or any combination of the two. | Sleeper Berth Provision Drivers using a sleeper berth must take at least 8 hours in the sleeper berth, and may split the sleeper-berth time into two periods provided neither is less than 2 hours. |

Source: FMCSA

Before and After Current Regulations

Under the previous hours-of-service regulations, CMV drivers were restricted to a maximum of 10 hours of driving, and/or 15 hours on-duty time, after 8 consecutive hours off-duty; and a maximum of 60 hours on-duty time over 7 consecutive days – or a maximum of 70 hours over 8 consecutive days for those who operated 7 days per week.

Much debate and lawsuits have resulted from the revised regulations concerning whether they actually improve road safety or endanger motorists at large. Hanowski et al. (2007) and McCartt et al. (2008) (Table 26) reveal that while CMV drivers might be getting more sleep, CMV drivers’ fatigue has not declined and that CMV drivers are driving more now than under the previous regulations.

Table 26: Hanowski and McCartt compare CMV drivers’ hour of service before and after 2003 regulation change

| | Hanowski et al. (2007) | McCartt et al. (2008) |
|----------------|--|---|
| Purpose | To determine whether CMV drivers are getting more sleep under the revised hours-of-service regulations in the U.S. | To obtain data on the prevalence and hypothesized predictors of falling asleep while driving. |
| Method | Data from 73 CMV drivers was collected during a naturalistic driving study after the implementation of the 2003 HOS regulations, were analyzed to determine overall sleep quantity (using actigraphy), along with sleep quantity prior to being involved in a critical incident. | Face-to-face interviews were conducted with 593 long-distance CMV drivers randomly selected at public and private rest areas and routine roadside truck safety inspections. Hypothesized predictor variables related to drivers’ typical work and rest patterns, extent of daytime and night-time drowsiness, symptoms of sleep disorder, measures of driving exposure, and demographic characteristics. |
| Results | Sixty-two drivers had at least seven consecutive days (Monday through Sunday) of reliable actigraphy data; mean sleep quantity per 24-h period (midnight centered using the Cole-Kripke algorithm) for these drivers was 6.28 h (S.D.=1.42 h). Fifty-eight critical incidents were recorded in the 10th and 11th driving hours. Analysis results indicated that drivers received significantly less sleep in the period prior to a critical incident as compared to their mean overall sleep quantity. | A sizeable proportion of long-distance CMV drivers reported falling asleep at the wheel of the truck: 47.1% of the survey respondents had ever fallen asleep at the wheel of a truck, and 25.4% had fallen asleep at the wheel in the past year. Factor analysis reduced the large set of predictors to six underlying, independent factors: greater daytime sleepiness; more arduous schedules, with more hours of work and fewer hours off-duty; older, more experienced drivers; shorter, poorer sleep on road; symptoms of sleep disorder; and greater tendency to night-time drowsy driving. |

| Hanowski et al. (2007) | | McCartt et al. (2008) |
|------------------------|---|---|
| Conclusion | The results of this study indicate drivers may be getting more sleep under the revised 2003 HOS regulations as compared to the old regulations. In addition, significantly less sleep in the 24-h period prior to involvement in a critical incident suggests driver fatigue may have been a potential contributing factor in these critical incidents. | The results suggest that countermeasures that limit drivers' work hours and enable drivers to get adequate rest and that identify drivers with sleep disorders are appropriate methods to reduce sleepiness-related driving by CMV drivers. |

Hanowski et al., 2007

Research by Hanowski et al. (2007) shows that commercial drivers got an average of 5.18 hours of sleep per night before the new hours of service regulations were implemented in 2004. Although revised hours-of-service regulations are in place to provide drivers with more opportunities to get sleep, Hanowski conducted a naturalist driving study to determine whether drivers were getting more sleep and to determine whether there is a relationship between sleep quantity and involvement in critical incident (crashes, near-crashes, or crash-relevant conflicts)?

Hanowski analyzed data from 73 CMV drivers to determine overall sleep quantity (using actigraphy), along with sleep quantity prior to being involved in a critical incident. Sixty-two drivers had at least seven consecutive days (Monday through Sunday) of reliable actigraphy data; mean sleep quantity per 24-h period (midnight centered using the Cole-Kripke algorithm) for these drivers was 6.28 h (S.D.=1.42 h). Fifty-eight critical incidents were recorded in the 10th and 11th driving hours.

Analysis results indicated that drivers received significantly less sleep in the period prior to a critical incident as compared to their mean overall sleep quantity. The results of the study indicate drivers may be getting more sleep under the revised regulations as compared to the old regulations. But significantly less sleep in the 24-h period prior to involvement in a critical incident suggests driver fatigue may have been a potential contributing factor in these critical incidents.

McCartt et al., 2008

A study by McCartt et al. (2008) concluded CMV driver fatigue increased after the new rule was implemented, suggesting that the rule change may not have achieved the goal of reducing fatigued driving. McCartt reported that violations of hours of service remained common and advocated the requirement of electronic recorders to control violations (Table 27).

Table 27: Driver violations

| | 2008 | 2007 | 2006 | 2005 | 2004 |
|---|-----------|-----------|-----------|-----------|-----------|
| Total driver inspections | 3,175,207 | 3,265,285 | 3,190,607 | 2,965,535 | 2,961,910 |
| Driver inspections with OOS* violations | 203,447 | 221,844 | 224,709 | 195,544 | 197,210 |
| Driver OOS rate | 6.4% | 6.8% | 7.0% | 6.6% | 6.7% |
| Total OOS violations | 258,640 | 284,396 | 286,650 | 253,064 | 254,726 |

*OOS – Out of Service violation; **Source:** FMCSA

McCartt assessed changes in long-distance CMV drivers' reported work schedules and reported drowsy driving after the rule change. Associations between reported rule violations, fatigued driving, and schedule as well as other characteristics were examined. Samples of long-distance CMV drivers were interviewed face-to-face in two states immediately before the rule change

(November-December 2003) and about 1 year (November-December 2004) and 2 years (November-December 2005) after the change.

The results showed that drivers reported substantially more hours of driving after the rule change. Most drivers reported regularly using a new restart provision, which permits a substantial increase in weekly driving. Reported daily off-duty and sleep time increased. Reported incidents of falling asleep at the wheel of the truck increased between 2003 (before the rule change) and 2004 and 2005 (after the change); in 2005, about one-fifth of drivers reported falling asleep at the wheel in the past month. The frequency of reported rule violations under the old and new rules was similar. The percentage of trucks with electronic on-board recorders increased significantly to almost half the fleet; only a few drivers were using automated recorders to report rule compliance. More than half of drivers said that requiring automated recorders on all large trucks to enforce driving-hour limits would improve compliance with work rules. Based on the 2004-2005 survey data, drivers who reported more frequent rule violations were significantly more likely to report fatigued driving. Predictors of reported violations included having unrealistic delivery schedules, longer wait times to drop off or pick up loads, difficulty finding a legal place to stop or rest, and driving a refrigerated trailer.

Other studies

Tight delivery schedules have been blamed for widespread violations of hours-of-service rules by interstate tractor-trailer drivers. The extent to which schedules are sufficiently tight to encourage violations of hours-of-service regulations, speed limits, or both was investigated through a survey of more than 1,600 tractor-trailer drivers. Beilock (2003) found that schedules had become tighter over the past decade despite increases in speed limits, which would tend to loosen schedules.

For example, assuming average speed limits of 65 mph, 24 percent had violation-inducing schedules with regard to the movement they were making at the time of the interviews. Incorporating information about previous driving, the incidence of violation-inducing schedules rose to 40 percent.

Another study, Hertz (1991), estimated the percentage of hours-of-service violators among long-haul tractor-trailer drivers. CMV drivers were interviewed at an inspection site in Spokane, Wash., and later observed arriving at inspection sites in either Moorhead or Worthington, Minn. (about 1,200 miles). The sample used for the calculation of violators consisted of truckers driving alone who reportedly did not plan to make an interim pickup or delivery stop prior to arrival in Minnesota. The percentages of drivers violating the hours-of-service rules by more than one hour at average trip speeds ranging from 35 mph to 65 mph are presented:

- Assuming that the drivers averaged 40 mph over the complete course of the trip segment, including stopped time, 90 percent were in violation by more than one hour.
- Assuming that they averaged 50 mph, 51 percent were in violation by more than one hour.

These speed assumptions are based on findings in the current study that team drivers averaged 38 mph, fleet managers' reports of scheduling single drivers at trip speeds of 45 mph to 47 mph, and reports in the literature that loaded tractor-trailers average 41 mph over flat terrain. Although the

true percentage cannot be determined without knowing actual trip speeds, the estimated range of violators at probable speeds of 40 mph and 50 mph points to a substantial problem.

Table 28 brief description of the studies listed above and others that have been conducted in the past 15 years, showing the relationship of hours of service to fatigue and/or violations and crash risk.

Table 28: Other Studies Pertaining to Hours of Service, Violations and Crash Risk

| Study | Purpose | Method | Results | Conclusion |
|-----------------------------|---|--|---|---|
| Beilock (1995) | To determine whether delivery schedules cause CMV drivers to violate road transportation laws and estimate amount of hours drivers drive and work. | Using self-reported data, the frequency of violation-inducing schedules is estimated during the ongoing movement for a sample of 498 long-distance drivers. | Assuming average legal speed limits of 55 MPH, 26% of the drivers were found to have violation-inducing schedules. Solo drivers, drivers hauling refrigerated loads, regular route drivers, and those with longer current trip distances are the most likely to have such schedules. Assuming average attained travelling speeds of 50 MPH, the average driver drives 46 hours per week and works a total of 58 hours. | At least 25 percent of drivers violate driving restrictions. |
| Beilock (2003) | To determine the extent of the problem of tight schedules and whether those schedules encourage violations of hours-of-service regulations, speed limits, or both. | 1,600 drivers of refrigerated trailers were surveyed. | The results indicate high incidence levels of tight schedules. For example, assuming average speed limits of 65 mph, 24% had violation-inducing schedules with regard to the movement they were making at the time of the interviews. Incorporating information about previous driving, the incidence of violation-inducing schedules rose to 40%. | Comparison with an earlier study suggests that, despite increases in speed limits, which would tend to loosen schedules, schedules have become tighter over the past decade. |
| Braver et al. (1992) | To estimate what proportion of long-haul tractor-trailer drivers report that they regularly violate the hours-of-service rules and to identify the drivers most likely to commit hours-of-service violations. | During December 1990 through April 1991, a total of 1,249 drivers were interviewed at truck safety inspection stations, truck stops, and agricultural inspection stations in Connecticut, Florida, Oklahoma, and Oregon. In each state, interviews were conducted during varying periods of the day over the course of seven days at inspection stations. Overall, 89 percent of eligible drivers participated in the survey. | Nearly three-fourths of the respondents violate hours-of-service rules. About two-thirds of the drivers reported that they routinely drive or work more than the weekly maximum. A primary impetus for violating rules appears to be economic factors, including tight delivery schedules and low payment rates. Many other driver, job, and vehicle characteristics were significantly associated with being an hours-of-service violator. | The high prevalence of hours-of-service violations among tractor-trailer drivers is a problem in need of urgent attention. Potential measures to reduce the prevalence of rules violations include more enforcement directed toward carriers, wider use of electronic recorders, and increasing the number of rest areas. |
| Hertz (1991) | To estimate the percentage of hours of service violators among long-haul tractor-trailer drivers. | CMV drivers were interviewed at an inspection site in Spokane, WA, and later observed arriving at inspection sites in either Moorhead or Worthington, Minnesota (about 1,200 miles). The sample used for the calculation of violators consisted of truckers driving alone who reportedly did not plan to make an interim pickup or delivery stop prior to arrival in Minnesota. The percentages of drivers violating the hours of service rules by more than one hour at average trip speeds ranging from 35 mph to 65 mph were tabulated. | Assuming that the drivers averaged 40 mph over the complete course of the trip segment, including stopped time, 90% were in violation by more than one hour. Assuming that they averaged 50 mph, 51% were in violation by more than one hour. These speed assumptions are based on findings in the current study that team drivers averaged 38 mph, fleet managers' reports of scheduling single drivers at trip speeds of 45 mph to 47 mph, and reports in the literature that loaded tractor-trailers average 41 mph over flat terrain. | Although the true percentage cannot be determined without knowing actual trip speeds, the estimated range of violators at probable speeds of 40 mph and 50 mph points to a substantial problem. |

| Study | Purpose | Method | Results | Conclusion |
|--------------------------------------|---|--|---|---|
| Morrow & Crum (2004) | To examine the effects of potentially fatigue-inducing factors inherent in CMV driving work and company safety management in explaining: (a) drivers driving while fatigued, (b) the frequency of close calls due to fatigue, and (c) actual crashes among CMV drivers. | Data for this study are derived from a survey of CMV drivers in 116 trucking firms, with all data being driver-reported. | Fatigue-inducing factors inherent in driving work and safety practices accounted for appreciable variation in driving fatigued ($R(2) = .42$) and close calls ($R(2) = .35$), but not crash involvement. Driving while fatigued also accounted for incremental increases in the amount of variation in close calls, after consideration of inherent factors and safety practices. | Findings indicated that fatigue-inducing factors inherent in driving work and safety practices accounted for appreciable variation in driving fatigued ($R(2) = .42$) and close calls ($R(2) = .35$), but not crash involvement. Driving while fatigued also accounted for incremental increases in the amount of variation in close calls, after consideration of inherent factors and safety practices. |
| Moses & Savage (1994) | To expand an earlier analysis of the effect of firm characteristics and safety practices on truck accident rates. | The data for the investigation was derived from the initial "Safety Review" (SR) audits of U.S. interstate motor carriers conducted by inspectors from the FHWA. In the course of these audits, mandated by the 1984 Motor Carrier Safety Act, data are collected on firms' physical characteristics, goods carried, accident record, and compliance with federal motor carrier safety regulations. The data are kept in the FHWA's Motor Carrier Management Information System (MCMIS). Obtained was the entire database for 92,529 firms that were audited between October 1986 and November 1991. Canadian and Mexican firms, bus companies, and firms that did not operate any vehicles were removed from the dataset, as were firms for which there were obvious data entry errors. As a result we had a useable dataset of 75,577 firms. | Evidence revealed that compliance with hours-of-service regulations is related to accident performance. The 30% of firms that were unfamiliar with the drivers' hours-of-service rules, and did not keep records of duty status of individual drivers, had accident rates 30% above those of firms that did comply. These results give some indirect support to the concept that driver fatigue is a major cause of truck accidents. | The keeping of records on accidents, and using this data to take disciplinary action against or educational action for the drivers involved, appears to be a safety practice that is effective in reducing accident rates. Such actions may be a clear signal from management to drivers that the company takes accidents very seriously. There also appears to be a strong link between compliance with hours-of-service rules and accident rates. Firms that monitor and keep records of hour of-service of drivers and use this information in dispatching have lower accident rates. When compared with the poor showing of questions on maintenance procedures, these findings are consistent with the well-documented |
| Sabbagh-Ehrlich et al. (2005) | Trucks represent 6% of all vehicles, but truck crashes account for 20% of road deaths in Israel, even though travel distances are usually short (<200 km) and overnight travel is uncommon. This aim of this study was to determine occupational and individual predictors of fatigue, falling asleep at the wheel, and involvement in crashes with injuries and deaths in CMV drivers. | Field interviews were conducted with 160 port CMV drivers regarding driver characteristics, workplace and driving conditions, employer-employee relations, medical conditions, sleep quality and fatigue, falling asleep at the wheel, and involvement in road crashes. | One day before interview, 38.1% of the drivers had worked more than the 12 hour legal limit. More than 30% reported falling asleep at the wheel recently, and 13% had prior involvement in a sleep-related crash. Sixty seven (41.9%) drivers said that their employer forced them to work beyond the legal 12 hour daily limit. Involvement in a crash with casualties was associated with poor sleep quality (adjusted OR = 2.9; $p = 0.042$) and frequent difficulty finding parking when tired (OR = 3.7; $p = 0.049$). Self assessment of fatigue underestimated fatigue from the Pittsburgh Sleep Quality Questionnaire. However fatigue occurred in many drivers without sleep problems and many crashes occurred without fatigue. | Prevention requires measures to reduce work stresses, screening drivers, speed control, and modal shifts. The work risks and adverse outcomes of CMV drivers in large countries with long overnight journeys occur in a small country with small distances, relatively short work journeys, and little overnight travel. |

Management and Monitoring of Fatigue

Although an international campaign, “The North American Fatigue Management Program for Commercial Motor Carriers,” is currently being implemented to bridge the gap between trucking companies and their employees for effective fatigue management strategies, it’s important to understand why current strategies are not reducing incidents of driver fatigue.

This section first examines two Australian studies, Feyer et al. (2001) and Arnold et al. (1996), which surveyed fatigue management policies among trucking companies, and then summarizes the current effort by Canada Transport and FMCSA to improve upon trucking companies’ fatigue management policies.

Studies’ Differences

Both Feyer and Arnold conclude that unrealistic delivery schedules and violations of work rules remain common among CMV drivers despite increased awareness of fatigue and companies’ fatigue management strategies. There are differences between the studies’ findings, which may reflect a combination of factors, but are likely to primarily reflect the impact of regulated vs. unregulated zones, and are therefore more appropriately discussed in that context.

The Feyer study decided to exclude Western Australia from its survey because a code of practice had been established there just before its survey began. The authors felt this may have changed the way companies there managed fatigue, making those companies more like regulated states and somewhat more interventionist than the Northern Territory, the only unregulated state included in its study.

The Feyer study also compares the perspective of drivers to that of companies. The drivers’ perspectives were obtained in a companion study conducted at the same time of the Feyer study. The results reveal perceptions among companies and drivers vary greatly, showing there is considerable scope for improving understanding and management of fatigue.

The Arnold study describes companies’ practices that are consistent with, and antagonistic to, the characteristics of safe organizations described by Cohen (1977), Pidgeon (1991) and Zimolong (1997). The three authors conclude that cultural changes are needed to improve fatigue management within the trucking industry, as well as closer interaction among workers, supervisors and managers with open communications regarding safety. Because the Arnold study was conducted when discussion of fatigue was minimal, it reflects the practices and policies of a time when company methods for gathering information were unlikely to allow them to detect fatigue and be proactive in management.

Some comparisons between the Arnold and Feyer studies are pinpointed in **Table 29**, which reveals the methodology of both studies, sizes of companies and driving restrictions. More in-depth insight to both studies is revealed below.

Table 29: Comparison of Two Studies on Fatigue Management

| Criteria | Arnold et al. (1996) | Feyer (2001) | | |
|--|---|--|---|------------------|
| Method | | | | |
| Year study was conducted | Western Australia | All regulated states in Australia (New South Wales, Victoria, South Australia and Queensland) and one unregulated state (Northern Territory) | | |
| Location of study | 1995 | 2000 | | |
| Number of companies contacted | 88 | 711 | | |
| Number of companies that participated | 84 (4 refused) | 200 (65 refused; 296 were unsuitable; 94 were unavailable; 56 couldn't be reached) | | |
| Type of questions | Standardized questionnaire | Standardized questionnaire | | |
| Information obtained | Policies and practices that: <ul style="list-style-type: none"> • Create a safe-working environment • Manage driver fatigue • Contribute to driver fatigue | <ul style="list-style-type: none"> • Company operations • Company fatigue management policies and strategies • Scheduling practices • Views of fatigue and its management • Views of the current regs | | |
| Company sizes | | | | |
| 10 trucks or less | More than 50% | 53% (<5 trucks = 21%; 5-10 trucks = 32%) | | |
| 11-50 trucks | NA | 36% | | |
| >50 trucks | NA | 10.5% | | |
| Driver types hired | | | | |
| Employee | 92.9% | 92.5% | | |
| Subcontractor/owner-driver | 56% | 42% | | |
| Independent/freelancer | 22.6% | 24% | | |
| Partial rundown of management results | | | | |
| Companies with formal fatigue management policy or plan | 16.7% | Employee | Subcont. | Freelance |
| | | 47.6% | 2.5% | 20.8% |
| Companies with formal medical policies | NA | Little more than 50% | | |
| Strategies for management fatigue | Restriction on driving hours: 59.5% | Monitor work hours: 44.5% | Fatigue education: 9% | |
| | Self-regulation: 48.8% | Flexible scheduling: 38.5 | No un/loading: 6.5% | |
| | Rostering system: 36.9% | Restricting hours: 26.5% | Health education: 2.5% | |
| | Crewing systems: 17.9% | Monitor schedules: 16.5% | Minimize night driving: 1.5% | |
| | Driver education: 11.9% | Compulsory rest breaks: 11.5% | None: 2.5% | |
| | Other: 50% | Providing time to sleep between trips: 11% | Companies endorsing more than one strategy: 67% | |
| Companies with daily driving restrictions | >50% | Employee | Subcont. | Freelance |
| | | 77.3% | 38.1% | 43.8% |
| Companies with daily driving limits in excess of 14h or no limits | 69% | NA | | |
| Companies with weekly driving limits | About 50% | Employee | Subcont. | Freelance |
| | | 70.3% | 38.1% | 39.6% |
| Companies with weekly limits that exceed national limit of 72h or not limits | About 50% | NA | | |
| Companies with continuous day limits | Just over 50% | Employee | Subcont. | Freelance |
| | | 81.6% | 40.5% | 37.5% |
| Companies with continuous day limits of 10 or more days or do not place any limits | 46.5% | NA | | |

Feyer et al., 2001

The findings of the survey suggest that there has been some progress in companies' knowledge and understanding of driver fatigue. The importance of sleep and rest is now well appreciated in the industry. Yet, the contributions of some of the other key determinants of fatigue remain under-recognized or under-emphasized in the industry, notably the impact of non-driving work and night work. Management of fatigue reflected these emphases: Restriction of night work and non-driving work were not as high priorities for companies as were other fatigue management strategies. Feyer noted it was not surprising that these structural features of the industry, which were clearly very difficult to modify, remained most resistant to change. Extent of control over schedules, one of the most often cited structural impediments to better management of fatigue, was underestimated by companies. The ability to change other structural features may be similarly underestimated.

Feyer concluded that companies did not seem to be doing all they could to facilitate fatigue management. This could at least partly be due to lack of understanding of the phenomenon of fatigue. Many line haul managers either did not understand (or were not prepared to acknowledge) how fatigue arises, the role of night work in exacerbation of the problem, the role of night sleep in assisting with management of the problem or the contribution of non-work tasks to overall toll on drivers of total work.

Fatigue Awareness

Although the majority of respondents reported that awareness of fatigue had increased both for themselves and for the industry, the study showed numerous discrepancies between the views of drivers and the views of companies regarding fatigue. The authors concluded that increased company awareness of driver fatigue has not yet translated into effective practice (Table 30).

Table 30: Perceived Changes in Awareness of Fatigue Over the Last 5 Years For Companies (%) Compared With Driver Survey Data (Williamson et al., 2001).

| Nature of change in fatigue awareness | In Industry | | Personally | |
|---------------------------------------|----------------|---------------|----------------|---------------|
| | Company survey | Driver survey | Company survey | Driver survey |
| Increased a lot | 60.5 | 34.3 | 49.5 | 26.1 |
| Increased | 33.0 | 39.9 | 35.5 | 32.5 |
| No change | 3.5 | 20.0 | 14.0 | 38.4 |
| Decreased | 1.0 | 3.1 | 0.5 | 1.9 |
| Decreased a lot | 0.5 | 2.6 | 0.5 | 1.2 |
| Don't know | 1.5 | N/A | 0 | NA |

Source: Feyer et al., 2001

Contributing Behaviors to Fatigue

Knowledge of contributors to fatigue provided a mixed picture of accurate awareness of the causes of fatigue (Table 31). Nearly all companies recognized that inadequate rest, both before and during a trip, and long driving hours were important contributing factors to fatigue, but many other key contributors were not well acknowledged.

The pattern of contributors to fatigue endorsed by companies was different to that found among drivers. First, there seemed to be much less consistency among drivers than among companies about the contributors. The most commonly endorsed factors among companies were endorsed by more than 90 percent of survey participants, whereas the most common factors for drivers were only endorsed by 50 percent to 60 percent of the survey sample. The pattern of contributors was also somewhat different. For drivers, common contributors to fatigue were waiting to unload, long driving hours, poor roads and poor weather.

The top six factors for both companies included long driving hours and irregular sleep during trips, however companies endorsed two personal factors: family problems and the effects of alcohol among its top six factors. In contrast, there were in the bottom five contributors for drivers. Inadequate pre-trip sleep was in the top six factors for companies, but ranked lower on the list for drivers. The top driver contributors, on the other hand, long delays in unloading and dawn driving, were well down the list among companies, and in the bottom 50 percent of contributing factors.

The authors concluded that companies did not seem to be doing all that they could to facilitate fatigue management. This could at least partly be due to lack of understanding of the phenomenon of fatigue. The authors stated there needs to be greater understanding in the industry that the problem requires a more sophisticated approach than simply restricting hours of driving. Although current regulations do not emphasize anything but the length of time at the wheel, more needs to be done to make transport managers more aware of fatigue and its characteristics.

Table 31: Contributors to Fatigue (%) Reported by Companies Compared with Driver Survey Data (Williamson et al., 2001)

| Contributing factor | Company survey* | Driver survey** |
|---|-----------------|-----------------|
| Inadequate pre-trip sleep | 96.5 | 22.8 |
| Insufficient rest breaks | 93.0 | 23.2 |
| Long driving hours | 92.0 | 47.9 |
| Family problems | 90.5 | 15.7 |
| Use of alcohol | 90.0 | 7.2 |
| Irregular/inadequate sleep during trips | 87.5 | 38.2 |
| Poor diet/irregular eating | 87.5 | 27.2 |
| Poor weather conditions | 86.0 | 38.5 |
| Poor road conditions | 82.5 | 41.9 |
| Poor truck ventilation | 81.5 | 18.4 |
| Boring/monotonous route | 78.0 | 32.4 |
| Poor cab design | 73.5 | 14.8 |
| Dawn driving | 72.0 | 59.4 |
| Heavy city traffic | 70.5 | 23.2 |
| Too much non-driving work | 66.5 | 30.0 |
| After-effects of stay-awake drugs | 66.5 | 8.5 |
| Waiting to unload | 66.0 | 56.2 |
| Truck vibration | 63.5 | 11.0 |
| Heavy highway traffic | 62.5 | 13.6 |
| Having to unload | 59.5 | 35.8 |

| Contributing factor | Company survey* | Driver survey** |
|--------------------------|-----------------|-----------------|
| Insufficient night sleep | 58.5 | 23.4 |
| Dusk driving | 48.0 | 22.8 |
| Working to regulations | 48.0 | NA |
| Night driving | 33.5 | 11.1 |
| Early afternoon driving | 26.0 | 18.3 |
| Rest away from home | 24.5 | 11.3 |
| Checking the load | 17.5 | 3.5 |
| Other | 25.0 | 6.8 |

Source: Feyer et al., 2001

*Companies were asked whether each factor was a contributor

**Drivers were asked to identify contributors to their own fatigue

Strategies to Combat Fatigue

Strategies that offer temporary relief to fatigue were commonly rated as helpful (e.g., Kicking the tires, listening to music, and increasing ventilation), but companies were well aware that very helpful strategies were the ones that provided more substantial and direct fatigue relief (Table 32).

Table 32: Driver Strategies Rated by Companies as Helpful and Very Helpful to Manage Fatigue (%).

| Driver strategy | Very helpful | Helpful |
|--------------------------------|--------------|---------|
| Stop to sleep | 76.0 | 23.0 |
| Stop to rest | 65.5 | 34.0 |
| Shower | 43.0 | 51.5 |
| Stop for a meal | 34.0 | 55.0 |
| Stop to eat | 23.0 | 68.5 |
| Adjust ventilation | 22.5 | 69.0 |
| Kick tires/walk around | 19.5 | 64.0 |
| CB | 15.5 | 59.5 |
| Music | 14.5 | 65.0 |
| Non-caffeinated drinks | 3.5 | 61.0 |
| Singing | 3.5 | 45.5 |
| Stay-awake drugs | 2.5 | 23.5 |
| Caffeinated drinks | 2.0 | 61.5 |
| Eat while driving | 2.0 | 33.0 |
| Ignore regulations to get home | 1.5 | 27.5 |
| Smoking | 0 | 21.5 |

Source: Feyer et al., 2001

Stopping for a rest and stopping to sleep were the strategies rated as very helpful by the majority of companies and by far more often than other strategies. In stark contrast, although the majority of drivers said they used sleep and rest to manage fatigue, only one-third said they found those strategies helpful. Used by a minority of drivers (about one in five drivers), the proportion of those who did use them and who rated drugs as most helpful was similar to the proportion

reporting that sleep was helpful. Only a relatively small minority of companies endorsed drugs as a helpful strategy, and only a handful of those reported they were very helpful.

Fatigue Management

Fatigue was seen as being at least quite well-managed in the industry by only just over half of companies (Table 33). Only half of companies indicated that the current regulations allow effective fatigue management (Table 36)

Table 33: Company views of fatigue management in the industry (%) compared with driver survey data (Williamson et al., 2001).

| How well is fatigue managed in the industry? | Company survey | Driver survey |
|--|----------------|---------------|
| Extremely badly | 4.5 | 21.7 |
| Quite badly | 17.5 | 30.6 |
| Quite well | 50.5 | 28.2 |
| Extremely well | 7.0 | 5.2 |
| No opinion | 6.0 | 12.3 |
| Other | 14.5 | NA |

Source: Feyer et al., 2001

Table 34: Views of fatigue management by current regulations

| Current regulations allow effective fatigue management | Driver survey |
|--|---------------|
| Yes | 56.0 |
| No | 40.0 |
| Don't know | 4.0 |

Source: Feyer et al., 2001

Formal company policies were more commonly reported for employee drivers compared with sub-contractors and independent drivers. For employee drivers, just less than half of companies reported that formal management policies were in place in their company. Only one-fifth to one quarter of respondents reported their company had “sort of” a policy in place for non-employee drivers.

The majority of companies reported that they monitor fatigue (Table 37). Most commonly companies reported that they reviewed log books or other work records, and that they asked drivers about their current state. The focus on hours of service evident in monitoring strategies was also reflected in the most commonly used fatigue management strategies. Monitoring work hours, flexible scheduling and restricting hours were the most common strategies reported by companies (Table 36).

Table 35: Fatigue monitoring strategies reported by participating companies (participants were allowed more than one response)

| Fatigue monitoring strategy | % of companies |
|---|---------------------|
| Companies who reported monitoring fatigue | 74% (148 companies) |
| Review log books | 48.0 |
| Other work records (trip diaries, departure times, arrival times) | 30.4 |
| Ask drivers | 29.1 |
| Review truck computer records | 18.9 |
| Use monitoring devices | 13.5 |
| Observe drivers* | 7.4 |
| Review accidents and incidents | 2.0 |
| Other | 6.8 |

* Category volunteered by company
Source: Feyer et al., 2001

Table 36: Fatigue management strategies reported by participating companies (participants were allowed more than one response)

| Fatigue monitoring strategy | % of companies |
|--|----------------|
| Companies endorsing more than one strategy* | 67 |
| Don't know | 0 |
| None | 2.5 |
| Monitor work hours | 44.5 |
| Flexible scheduling | 38.5 |
| Restricting hours | 26.5 |
| Monitor schedules | 16.5 |
| Compulsory rest breaks on trips | 11.5 |
| Providing time to sleep between trips | 11.0 |
| Fatigue education | 9.0 |
| No unloading | 6.5 |
| Health education | 2.5 |
| Minimizing night driving | 1.5 |
| <i>Breakdown of "other" strategies volunteered</i> | |
| Relief drivers | 7.0 |
| Leave rostering arrangements | 5.5 |
| Driver consultation | 5.5 |
| Work to regulations | 4.5 |
| Provide sleeping facilities | 3.5 |
| Two-up operation | 2.0 |
| Regular medicals | 1.5 |
| Maximize truck comfort | 1.0 |
| Staged/shuttle operation | 1.0 |
| Not elsewhere classified | 8.5 |

* Mean number of strategies reported by all companies = 2.02, SD = 1.06, Median = 2.00
Source: Feyer et al., 2001

Comparison of Company and Driver Views of Fatigue Management in the Industry

There were key differences between drivers and companies in their views about current and possible management of fatigue in the industry. The majority of drivers (75.9 percent) reported that fatigue was a substantial or major problem in the industry. They viewed the management of fatigue by the industry considerably more negatively than did companies, with 53 percent reporting that fatigue was badly managed in the industry, compared with about one in five companies.

When drivers were asked about what their company does, should do and should not do to better manage fatigue, they confirmed the most common strategies that companies reported doing, namely easing tight schedules and allowing more time for sleep on the road. Drivers also confirmed that it was relatively less common for companies to minimize night driving as a fatigue management strategy.

About 75 percent of drivers reported that companies should have more efficient unloading and about two-thirds reported that companies should not involve drivers in unloading. Companies rarely reported restricting loading activities or streamlining them in order to better manage fatigue. Drivers did not support minimization of night driving, more time off between trips and more breaks between trips, in agreement with the low priority accorded to these strategies by companies. Notable, very few companies reported staged or two-up operations and two-thirds reported that companies should not use staged operations.

Management of Schedules

Companies are attempting to tackle some of the pressing scheduling issues confronting the industry. In the study, companies reported monitoring hours, restricting hours and offering flexibility in scheduling among the most common fatigue management strategies used. Despite such tactics, drivers still reported tight schedules as a major source of driver fatigue. The discrepancy is most likely to reflect that while companies aim for flexibility, they nevertheless reported altering schedules to accommodate customer demands much more often than altering schedules to accommodate driver fatigue.

Nearly half of companies reported that all or most of their work has regular trip times and destinations. Only one quarter of companies reported that their work was rarely or never regular (Table 37). In line with this level of control of schedules, only half of companies reported that they always had estimated time of arrivals (ETAs) for their work, and most companies reported sometimes being late (Table 37). When ETAs were in place for work, most companies reported that they and/or the drivers set these times (Table 38). Trip times were most likely to be based on management and/or driver estimates (Table 38).

Companies were also asked about whether they monitor arrival times. While 57 percent of companies with ETAs reported monitoring actual arrival times, bonus systems for early arrival and penalty systems for late arrival were rare. Only about 2 percent of companies reported the use of such systems. The majority of companies reported changing schedules to suit customer demands at least sometimes, with nearly one-third reporting that they most did so (Table 37). In contrast, only one in 10 companies reported changing schedules to accommodate driver fatigue, and only about half of companies reported doing so sometimes.

Table 37: Scheduling Practices Reported by Companies (%)

| | Most or often/always | Sometimes | None or rarely/never |
|---|----------------------|-----------|----------------------|
| Amount of work with regular trip times and destinations (n=200) | 48.0 | 27.0 | 25.0 |
| Amount of work that has an ETA (n=200) | 52.5 | 22.0 | 25.5 |
| For those with an ETA, frequency of late arrival (n=149) | 5.4 | 88.6 | 4.7 |
| Schedule changes | | | |
| Frequency of delays for driver fatigue (n=200) | 9.5 | 44.2 | 45.2 |
| Frequency of changes to suit customer demands (n=200) | 30.5 | 39.5 | 28.0 |

Source: Feyer et al., 2001

Table 38: Control of Schedules Reported by Participating Companies

| | % of companies (n=200) |
|--|------------------------|
| Who sets ETA? | |
| Company | 52.0 |
| Customer | 26.5 |
| Driver | 23.0 |
| Other | 1.5 |
| How are trips times determined? | |
| Driver and management estimates | 40.0 |
| Km/day (or average speed) | 18.5 |
| Management estimates | 18.0 |
| Trial trip | 16.5 |
| Driver estimates | 8.5 |
| Other | 13.5 |

Source: Feyer et al., 2001

Comparison of Schedule Management in the Company and Driver Surveys

The rareness with which companies reported using bonus/penalty systems was confirmed by the low profile of such schemes indicated by the driver survey. When asked whether such schemes influenced decisions to break the working hours regulations or the road rules, drivers rarely reported them as reasons (7.6 percent or 9.3 percent, respectively). However, in contrast to the considerable control that companies reported having over schedules, drivers reported that tight schedules were among the top 3 reasons for breaking hours-of-service regulations (reported by nearly one-third of drivers). Frequent rule breakers among drivers were more likely to cite reasons associated with schedules and work organization, while drivers who barely breached the rules were more likely to do so due to the desire to reach home, maximize sleep at the end of a trip or because of the needs of livestock. Similarly, the main reasons for breaking the road rules (much less common overall than breaking the working hours rules) were related to operational and scheduling problems of tight schedules, getting enough trips done, and pressures of unloading.

Company Size and Awareness of Fatigue

Irrespective of company size, the vast majority of companies reported an increase in awareness of fatigue in the industry (Table 39). Smaller companies tended to be slightly more likely to

report that awareness in the industry had not changed, or that they did not know about fatigue awareness in the industry. Similarly, the vast majority of companies reported that their own awareness of fatigue had increased over the last 5 years (Table 39). Larger companies tended to be more likely to report an increased awareness, with smaller companies most likely to report that it had not changed.

Table 39: Company Size by Perceived Changes in Fatigue Awareness Over the Last 5 Years (%)

| Nature of change in fatigue awareness | ≤ 10 trucks (n=106) | 11-50 trucks (n=72) | >50 trucks (n=21) |
|---------------------------------------|------------------------|------------------------|----------------------|
| For Industry | | | |
| Increased a lot | 60.4 | 62.5 | 57.1 |
| Increased | 28.3 | 36.1 | 42.9 |
| No change | 6.6 | 0.0 | 0.0 |
| Decreased | 0.9 | 1.4 | 0.0 |
| Decreased a lot | 0.9 | 0.0 | 0.0 |
| Don't know | 2.8 | 0.0 | 0.0 |
| Personally | | | |
| Increased a lot | 49.1 | 51.4 | 47.6 |
| Increased | 32.1 | 36.1 | 47.6 |
| No change | 17.0 | 12.5 | 4.8 |
| Decreased | 0.9 | 0.0 | 0.0 |
| Decreased a lot | 0.9 | 0.0 | 0.0 |

Source: Feyer et al., 2001

Company Size and Management of Fatigue

Irrespective of size, the majority of companies reported that fatigue was at least quite well managed (Table 40). Small companies tended to be more likely to report that they had no opinion on the issue. Company size also had little influence on companies' assessment of the effectiveness of the current regulations for fatigue management: Only approximately half of companies reported that the regulations were effective (Table 41). The remainder did not believe that the current regulations allowed effective fatigue management.

Table 40: Company Size by Perceived Changes in Fatigue Management in the Industry (%)

| How well is fatigue managed in the industry? | ≤ 10 trucks (n=106) | 11-50 trucks (n=72) | >50 trucks (n=21) |
|--|------------------------|------------------------|----------------------|
| Extremely badly | 4.7 | 4.2 | 4.8 |
| Quite badly | 16.0 | 20.8 | 14.3 |
| Quite well | 52.8 | 44.4 | 57.1 |
| Extremely well | 4.7 | 11.1 | 4.8 |
| No opinion | 8.5 | 2.8 | 4.8 |
| Other | 13.2 | 16.7 | 14.3 |

Source: Feyer et al., 2001

Table 41: Company Size by Views of Fatigue Management by Current Regulations (%)

| Current regulations allow effective fatigue management | ≤ 10 trucks (n=106) | 11-50 trucks (n=72) | >50 trucks (n=21) |
|--|------------------------|------------------------|----------------------|
| Yes | 56.6 | 56.9 | 47.6 |
| No | 38.7 | 40.3 | 47.6 |
| Don't know | 4.7 | 2.8 | 4.8 |

Source: Feyer et al., 2001

Overall, the formal fatigue management policies and formal medical policies were considerably more common for larger companies (Table 42). However, the pattern of usage of such policies for drivers with different employment arrangement did not vary by company size. For companies of all sizes, formal policies were more common for employee drivers than for either subcontractors or independent drivers-freelancers (Table 42). The size of company was also evident in formal fatigue monitoring. While the majority of companies reported monitoring fatigue among their drivers, small companies were significantly less likely to do so than medium and large companies.

Table 42: Formal Company Policies by Company Size (%)

| | ≤ 10 trucks (n=93) | | | 11-50 trucks (n=71) | | | >50 trucks (n=20) | | |
|---|-----------------------|------------------|------------|------------------------|------------------|------------|----------------------|------------------|------------|
| | Em- ployee | Sub- contract | Free-lance | Em- ployee | Sub- contract | Free-lance | Em- ployee | Sub- contract | Free-lance |
| Formal Fatigue management policy | | | | | | | | | |
| Yes | 36.6 | 15.0 | 19.0 | 53.5 | 25.0 | 15.8 | 75.0 | 58.3 | 37.5 |
| No | 63.4 | 82.5 | 81.0 | 45.1 | 71.9 | 78.9 | 20.0 | 41.7 | 62.5 |
| Don't know | 0.0 | 2.5 | 0.0 | 1.4 | 3.1 | 5.3 | 5.0 | 0.0 | 0.0 |
| Formal medical policy | | | | | | | | | |
| Yes | 49.5 | 27.5 | 38.1 | 69.0 | 25.0 | 10.5 | 85.0 | 33.3 | 12.5 |
| No | 48.4 | 72.5 | 57.1 | 28.2 | 65.6 | 84.2 | 15.0 | 66.7 | 75.0 |
| Don't know | 2.2 | 0.0 | 4.8 | 2.8 | 9.4 | 5.3 | 0 | 0.0 | 12.5 |

Source: Feyer et al., 2001

The primary strategies used by companies of all sizes were first and foremost review of log books, and secondly review of other work records. Smaller companies reported asking drivers about fatigue levels twice as often as large companies, reporting this strategy as commonly as they did use of work records. However, the major difference found in monitoring strategies was that medium and larger companies were significantly more likely to report the use of truck computer records and monitoring devices, compared with small companies (Table 43).

Table 43: Company Size by Fatigue Monitoring Strategies (%)

| Fatigue monitoring strategy | ≤ 10 trucks (n=106) | 11-50 trucks (n=72) | >50 trucks (n=21) |
|---|------------------------|------------------------|----------------------|
| Companies who reported monitoring fatigue* | 65.1 | 83.3 | 85.7 |
| Strategies used by companies who monitor fatigue | n=69 | n=60 | n=18 |
| Review book logs | 43.5 | 53.3 | 44.4 |
| Other work records (trip diaries, departure times, arrival times)** | 30.4 | 31.7 | 27.8 |
| Ask drivers | 33.3 | 26.7 | 16.7 |
| Review truck computer records*** | 7.2 | 30.0 | 27.8 |

| Fatigue monitoring strategy | ≤ 10 trucks (n=106) | 11-50 trucks (n=72) | >50 trucks (n=21) |
|--------------------------------|------------------------|------------------------|----------------------|
| Use monitoring devices | 8.7 | 15.0 | 27.8 |
| Observe drivers** | 8.7 | 6.7 | 0.0 |
| Review accidents and incidents | 0.0 | 3.3 | 5.6 |
| Other | 7.2 | 3.3 | 16.7 |

* $X^2_{(2)}=9.10, p=0.01$; **Category volunteered by company; *** $X^2_{(2)}=11.79, p=0.003$

Source: Feyer et al., 2001

Most companies, irrespective of size, reported that they used fatigue management strategies, with the majority reporting that they used more than one such strategy (Table 44). However, small companies reported using significantly fewer strategies than larger companies. Among the provided strategies, the predominant ones reported by companies, irrespective of size, were monitoring work hours, restricting hours and using flexible scheduling (Table 44). There was a trend toward fatigue education being more likely to be reported by larger companies, and rarely by small or medium companies. Among the strategies volunteered by companies, small and medium companies tended to report the use of relief drivers, leave rostering arrangements and driver consultation. In contrast, large companies tended to report providing sleeping facilities and working to the regulations, with the only significant difference being more frequent reporting of the use of regular medicals by large companies.

Table 44: Fatigue Management Strategies Reported By Participating Companies (Participants Were Allowed More Than One Response)

| Fatigue monitoring strategy | ≤ 10 trucks (n=106) | 11-50 trucks (n=72) | >50 trucks (n=21) |
|--|------------------------|------------------------|----------------------|
| Companies endorsing more than one strategy* | 58.5 | 76.4 | 76.2 |
| <i>Strategies endorsed</i> | | | |
| None | 4.7 | 0.0 | 0.0 |
| Monitor work hours | 36.8 | 52.8 | 52.4 |
| Flexible scheduling | 41.5 | 36.1 | 33.3 |
| Restricting hours | 20.8 | 30.6 | 42.9 |
| Monitor schedules | 15.1 | 19.4 | 14.3 |
| Compulsory rest breaks on trips | 10.4 | 16.7 | 0.0 |
| Providing time to sleep between trips | 10.4 | 13.9 | 4.8 |
| Fatigue education** | 5.7 | 9.7 | 23.8 |
| No unloading | 6.6 | 8.3 | 0.0 |
| Health education | 0.9 | 4.2 | 4.8 |
| Minimizing night driving | 2.8 | 0.0 | 0.0 |
| <i>Breakdown of "Other" strategies volunteered</i> | | | |
| Relief drivers | 7.5 | 6.9 | 4.8 |
| Leave rostering arrangements | 4.7 | 6.9 | 4.8 |
| Driver consultation | 3.8 | 9.7 | 0.0 |
| Work to regulations | 3.8 | 4.2 | 9.5 |
| Provide sleeping facilities | 0.9 | 5.6 | 9.5 |
| Two-up operation | 2.8 | 1.4 | 0.0 |
| Regular medicals*** | 0.0 | 1.4 | 9.5 |
| Maximize truck comfort | 0.9 | 1.4 | 0.0 |

| Fatigue monitoring strategy | ≤ 10 trucks (n=106) | 11-50 trucks (n=72) | >50 trucks (n=21) |
|--------------------------------|------------------------|------------------------|----------------------|
| Staged/shuttle operation | 0.0 | 2.8 | 0.0 |
| Other/Not elsewhere classified | 4.7 | 12.5 | 9.5 |

* Mean number of strategies reported by companies with ≤ 10 trucks = 1.8(0.9), 11-50 trucks = 2.3 (1.2), and >50 trucks= 2.2(0.9). $F_{(2,198)}=7.24$, $p=0.001$, such that $1.8 < 2.3$. **Statistical trend $X^2_{(2)}=7.10$, $p=0.03$; *** $X^2_{(2)}=10.72$, $p=0.005$
Source: Feyer et al., 2001

Arnold et al., 1996

The companies that participated in this study fitted Reason’s (1990) descriptions of “calculative” and “pathological” organizations. Most of the companies could be described as “calculative,” engaging rulebook safety strategies. A small number could be described as “pathological,” sacrificing safety in pursuit of productivity. None of the companies interviewed appeared to be “generative,” engaging in unconventional safety activities that go beyond accepted minimum standards to manage safety, including fatigue. Cultural change across the road transport industry should result in disappearance of pathological companies and the appearance of generative companies as the industry moves toward its desired goal of self-management of driver fatigue (Arnold and Hartley, 2000).

Fatigue Management Policies and Antagonistic Practices

The majority of companies reported they did not have a formal fatigue management policy or plan for their drivers (78.6 percent). One in only six companies (16.7 percent) said they had such a policy or plan. Respondents were asked to briefly describe how their companies attempt to control driver fatigue. Responses were categorized into six general areas (Table 45). The most common responses were that fatigue is managed by restricting hours and allowing drivers some degree of self-regulation within their delivery schedules. This question was open-ended and respondents were given minimal prompts (the six headings) to help them describe what they did. The following sections of the questionnaire asked specific questions about these strategies.

Table 45: Fatigue Management Strategies Used by Companies*

| Strategy | Frequency | Percentage |
|-------------------------------|-----------|------------|
| Restrictions on driving hours | 50 | 59.5 |
| Self-regulation | 41 | 48.8 |
| Rostering systems | 31 | 36.9 |
| Crewing systems | 15 | 17.9 |
| Driver education | 10 | 11.9 |
| Other | 42 | 50.0 |
| No. of companies | 84 | |

*Companies made multiple responses – percentages do not sum up to 100.

Source: Arnold et al., 1996

Policies Restricting Driving Hours

Pidgeon (1991) suggested that for a safe workplace the rules and norms for dealing with hazards should be known, endorsed and supported throughout the organization. A little more than one-half of the companies placed restrictions on daily driving hours (Table 46). Overall, 69 percent

of companies reported they have limits in excess of 14h (the suggested national limit on daily driving at the time) or set no limits for daily driving hours. Half of the companies place restrictions on the number of hours driven in a week and about half of these exceeded the suggested national limit of 72h of driving in one week. Nearly half (65 percent) set limits of 10 or more days or do not place any limit on the number of continuous days of driving.

Table 46: Maximum Daily and Weekly Driving Hours

| | Frequency | Percentage |
|---------------------|-----------|------------|
| Daily hours | | |
| Up to 14h | 26 | 31.0 |
| 15-18h | 21 | 25.0 |
| No limit | 37 | 44.0 |
| Weekly hours | | |
| Up to 70h | 34 | 40.5 |
| Over 70h | 8 | 9.5 |
| No restriction | 34 | 40.5 |
| No response | 8 | 9.5 |
| No. of companies | 84 | 100 |

Source: Arnold et al., 1996

Amongst the 57 companies who set some limits on daily or weekly driving, the most common method used to communicate them was verbal instructions provided by depot managers. Nearly half provided written instructions in some form, including the Award or in company bulletins (Table 47). However, more than one-third said they do not communicate their policies on hours to drivers.

When drivers exceed company driving limits, most companies (82.5 percent) give them extra time off at the end of the trip, restrict hours of driving on following trips, or, if necessary, allow the driver to take an in-trip break. One in six companies (17.5 percent) reported they do nothing, allowing the drivers to exceed the companies' driving restrictions.

All respondents were asked what they would do when an urgent load must be transported, but on rested driver is available. Several companies (6.0 percent) said they send drivers out again despite having not had adequate breaks.

Table 47: Methods Used to Explain Limits on Daily and Weekly Driving*

| Methods | Frequency | Percentage |
|--|-----------|------------|
| Verbal instruction by depot manager | 27 | 47.4 |
| Written instruction | 19 | 33.3 |
| Driver referred to award and bulletins | 6 | 10.5 |
| Do not communicate limits | 22 | 38.6 |
| No. of companies | 84 | |

*Companies made multiple responses – percentages do not sum up to 100.

Source: Arnold et al., 1996

The majority of companies (89.3 percent) indicated they investigate the causes of frequent late arrivals by a driver. Nearly one-half (46.7 percent) indicated that if a driver is consistently late,

then his or her employment or contract could be terminated. Only one in 10 companies said it was normal procedure to warn drivers who delivered late and, following two or three warnings, terminate their employment. These punitive actions that might be applied to nearly 50 percent of drivers must represent a considerable imperative for them to adhere to their companies' schedules.

So some companies set limits that are within proposed national restrictions on driving. However, these limits may not be well known or attended to amongst drivers because they are not communicated, and exceeding them may not have any repercussions.

Monitoring Fitness to Drive and Fatigue

Cohen (1977) and Zimolong (1997) identified deficiencies in defense planning, hazard control and environmental control as features of unsafe organizations. In organizations with better safety records, close contact and interaction between workers, supervisors and managers enables open communication on safety. Companies were asked about how they assess drivers' fitness for work and obtain feedback about their experience of fatigue.

Two-thirds of companies indicated that they have no formal policy to regularly assess fitness to drive. However, all but one reported ways in which they monitor drivers' performance or fitness to drive (Table 48). Frequently used methods provided only indirect assessment, and included customer feedback about drivers and reports from other drivers. Some strategies used to gather information about driver fitness were invoked only after problems arose. More than half of the companies interviewed problem drivers or undertook accident analyses.

Table 48: Methods Used to Monitor Drivers' Performance or Fitness to Drive*

| Methods | Frequency | Percentage |
|---|-----------|------------|
| Visually assess drivers' fitness to drive | 63 | 75.0 |
| Reports from customer feedback | 60 | 71.4 |
| Reports from other drivers | 54 | 64.3 |
| Interview of problem drivers | 52 | 61.9 |
| Conduct accident analyses | 45 | 53.6 |
| Examine trip sheets | 40 | 47.6 |
| Medical examination | 23 | 27.4 |
| Use technical measures | 15 | 17.9 |
| Other | 9 | 10.7 |
| Nothing | 1 | 1.2 |
| No. of companies | 84 | |

*Companies made multiple responses – percentages do not sum up to 100.

Source: Arnold et al., 1996

When asked specifically about fatigue, a little more than half of the companies (51.2 percent) reported that they monitor drivers' fatigue. Many companies reported that they send home drivers thought to be fatigued or unfit for duty, effectively giving them extra time off (Table 49). Other companies give such a driver yard duties, or engage a variety of other strategies, such as interviewing or counseling the driver, or directing them to medical assistance.

If fatigued, almost half of the companies said the driver is not given a strip and another driver takes his/her place. If a driver is assessed as being unfit, 12 percent of company representatives indicated their employment would be terminated. One even suggested that subcontract drivers would be “given the option of selling their vehicle.” Drivers’ anecdotal reports provide evidence that they are aware of this attitude within some companies. Successful fatigue management relies upon collaboration between managers/supervisors and drivers, but while the risk of suspension or termination exists, it is unlikely that drivers trust their companies enough to freely discuss their experience of fatigue with them.

Table 49: Action taken if driver is thought to be fatigued*

| Actions | Driver fatigued | Driver unfit to drive |
|---|-----------------|-----------------------|
| Send driver home | 54 (64.3) | 47 (56.0) |
| Give time off | 60 | 29 (34.5) |
| No trip for driver; another driver used | 40 (47.6) | |
| Give driver yard duties | 15 (17.9) | 24 (28.6) |
| Suspend/terminate employment | 1 (1.2) | 10 (11.9) |
| Other | 14 (16.7) | 10 (11.9) |
| No. of companies | 84 | 84 |

*Companies made multiple responses – percentages do not sum up to 100.

Source: Arnold et al., 1996

Addressing Drivers’ Concerns

The most frequent topic of feedback (24.7 percent of companies) is drivers’ concerns about their vehicles and maintenance. One-fifth of companies (20.2 percent) reported that drivers’ main concerns were difficulties with loading and unloading and delays at loading depots. Similarly, about one-fifth (19.0 percent) of reported drivers were concerned with safety measures such as hazardous road conditions, and other drivers’ attitudes and behavior (such as cutting in front of them). One in eight companies (13.1 percent) said that drivers have no consistent concerns.

Almost two-thirds of the companies (65.5 percent) reported that concerns about driving hours and delivery schedules are rarely mentioned in feedback. Less than 20 percent of the companies reported getting frequent feedback about work hours or schedules. Those who did receive such feedback said it made up only a small proportion of all feedback. About 5 percent reported that their drivers’ concerns were about having to work too few hours of work.

Respondents were asked how feedback was used to modify work practices. Of the 67 companies that responded to the question, 70.1 percent reported that they investigate and take appropriate action to deal with the problem for the driver. This includes actions such as accommodating individuals’ desires for more or different working hours, modifying procedures and contacting clients. One in six companies used feedback to develop and adjust trip schedules or hours of work.

Effort to Improve Fatigue Management

Recognizing that fatigue management requires major changes in both organizational culture and operator behavior, a collaborative, international effort, sponsored by Transport Canada, the U.S. Department of Transportation and other agencies is in the process of developing, implementing,

evaluating, and finalizing a comprehensive, integrated fatigue management program for the trucking industry operating under the various regulatory jurisdictions of North America.

The project, “The North American Fatigue Management Program for Commercial Motor Carriers,” involves four phases:

- **Phase 1:** Identify fatigue management requirements and developed a comprehensive approach designed specifically for drivers, dispatchers, and company managers.
- **Phase 2:** Development of educational and training materials as well as the development and assessment of procedures for field testing the fatigue management plan (FMP).
- **Phase 3:** A field operational test is to be conducted in two stages: protocol development; and field testing of the effectiveness of the comprehensive FMP compared to current industry practices.
- **Phase 4:** Based on the results of Phase 3, a decision will be made whether to proceed to Phase 4, in which the program would be improved if necessary, and recommended practice guidelines, manuals, and other training materials would be finalized. These would be available to any company in the industry interested in improving its road safety record

Progress to Date

Phase 1 began with a series of focus groups with motor carriers to assist in the project design. Subjective and objective tools were identified for use in data collection and a beta test with six drivers was undertaken.

Field data collection under Phase 2 was completed in Alberta, Quebec, and Texas. Screening and treatment for sleep apnea was added to the initial program. Drivers were tested beforehand to provide a basis for comparison and then again afterwards to determine whether the pilot program helped. The evaluation involved six fleets and 38 drivers in Alberta and Quebec. An additional eight drivers in Texas joined later.

Phase 3, the operational field trial, is currently underway at companies in Alberta, Quebec, and California. The trial, expected to last 2 years, involves:

- Baseline data collection during drivers’ regular routes
- Sleep disorder assessment and treatment
- Educational workshops on fatigue for drivers, their families, dispatchers, and management
- Ongoing support and consultation to help companies develop policies and implement practices consistent with an FMP (scheduling, etc.)
- Post-FMP data collection during drivers’ regular routes

Recommendations

While many hail the program as one that will bridge the gap between trucking companies and their drivers, there is concern that insufficient oversight could jeopardize the goals of the program. In a 2009 safety recommendation letter to FMCSA (NTSB, 2009), the NTSB calls for FMCSA to be involved in the evaluation of companies’ FMPs to determine whether they successfully mitigate fatigue and how to make the programs more successful. As it stands, the

North American FMP calls for evaluation at the motor carrier level to determine how well each FMP is working for its individual carrier.

The Safety Board recognized that the program is currently being tested in an operational setting, but it considers that the assessment process should be continual. The Safety Board concluded that for FMPs to be successfully implemented by motor carriers over time, FMCSA's oversight is needed. The Safety Board has recommended FMCSA to develop and use a methodology that will continually assess the effectiveness of the FMPs implemented by motor carriers, including their ability to improve sleep and alertness, mitigate performance errors, and prevent incidents and accident. Table 50 lists other programs, campaigns and initiatives currently used to combat drowsy driving.

Table 50: Programs and Initiatives to Combat Driver Fatigue

| Initiative or program (Year of origin) | Purpose | Partners/sponsors | Web link |
|--|--|--|--|
| United States | | | |
| Drowsy Driving Prevention Week (DDPW) | A national campaign to save the lives of young drivers by raising awareness of the dangers of drowsy driving and providing resources for advocacy at the state level. The campaign offers an online toolkit of press materials, PSAs, fact sheets, quizzes, mini-posters and PowerPoint presentations to inform communities about healthy sleep and drowsy driving . | National Sleep Foundation | www.drowsydriving.org/site/c.lqLPIROCKtF/b.2708421/k.BD17/Home.htm |
| Georgia Ticketing Aggressive Cars and Trucks (G-TACT) (November 2007) | G-TACT is a program to reduce the number of crashes between passenger vehicles and CMVs. The program combines educational outreach and media coverage with enforcement by law enforcement officers in traffic corridors with sustained increases in the number of passenger vehicle and CMV crashes. New highway signs also are posted that promote the safety campaign. | The Georgia Department of Public Safety; Motor Carrier Safety Assistance Program (MCSAP); Federal Motor Carrier Safety Administration (FMCSA); National Highway Traffic Safety Administration (NHTSA); Department of Transportation; Georgia Motor Trucking Association; Publix Super Markets. | www.georgiactact.net/Home_Page.php |
| Lupe Medina Program (1998) | This program strives to prevent drowsy driving through awareness and a unique partnership with participating hotels that offer discounts during late-night hours to drowsy drivers. The program resulted after A&N student Lupe Medina fell asleep at the wheel while driving to College Station from Huntsville on April 23, 1998. | Texas A&M University; Baylor University Student Government; Super 8; Hampton Inn | www3.baylor.edu/Drowsy_Driving/lupe.htm |
| New York State Partnership Against Drowsy Driving (NYPDD) (2004) | The partnership is a joint effort to educate the public and high-risk groups about the dangers of drowsy driving and promote the adoption of preventive strategies. Partners meet regularly to share traffic data on drowsy driving and work cooperatively to conduct projects to raise public awareness of the risks of drowsy driving and encourage the adoption of prevention strategies among the general public and high-risk populations. | Representatives from the New York State Governor's Traffic Safety Committee (GTSC), New York State Thruway Authority, New York State Police, New York State Department of Motor Vehicles (DMV), New York State Motor Truck Association, New York State Association of Traffic Safety Boards, New York State Movers and Warehousemen's Association and New York State Department of Transportation. | www.nysgtsc.state.ny.us/drow-ndx.htm |
| Sleep Well, Drive Safe program (November 2008) | The program, devised by Royal Philips Electronics, is designed to educate trucking company owners of possible ways to reduce drowsy driving. The program incorporates five elements: Education (at tradeshow), Screening, Testing, Therapy and Compliance. Philips Respironics, a company in the sleep therapy and diagnostics market, works with sleep labs and home-care providers to successfully execute the program for trucking companies. | Royal Philips Electronics; Philips Respironics; Mid-America Trucking Show (MATS); The Great West Truck Show (GWTS); American Trucking Associations (ATA) Management Conference and Exhibition | www.philips.com/trucking |
| Truck Safety Coalition (1990) | The coalition is dedicated to reducing the number of deaths and injuries caused by truck-related crashes, providing compassionate support to truck crash survivors and families of truck crash victims, and educating the public, policy-makers and media about truck safety issues. | The Citizens for Reliable and Safe Highways (CRASH) Foundation; Parents Against Tired Truckers | www.trucksafety.org |

| Initiative or program (Year of origin) | Purpose | Partners/sponsors | Web link |
|---|--|---|--|
| Unite To Treat Sleep Apnea Initiative (June 2008) | An integrated program connecting physicians, sleep labs, treatment providers and patients to improve the diagnosis and treatment of those afflicted with obstructive sleep apnea. The initiative offers comprehensive sleep management program dedicated exclusively to the health and safety of those in the transportation industry. Mobile Sleep Solution Centers are built on 53-foot trailers, feature private bedrooms, bathrooms and a fully functional sleep technician room and will be available at many locations across the country. | Covidien, Sleep Pointe | www.covidien.com/sleepapnea/pagebuilder.aspx?page=Main:Main&toPicID=170803 |
| Wake Up And Get Some Sleep. (1996) | An educational program to increase shift workers' awareness of the dangers of drowsy driving, help them to improve the quality of their sleep and reduce sleepiness, and ultimately, reduce the incidence of drowsy driving. This comprehensive program is specifically designed for businesses and organizations that employ workers beyond the typical 9-to-5 workday. Program materials include a Better Sleep Video, Workplace Posters, Shift Worker Brochure, Tip Card, Employer Administrator's Guide with PowerPoint Training Sessions, and a Brochure for Shift Work Families. | National Highway Traffic Safety Administration (NHTSA); National Center on Sleep Disorders Research (NCSDR) | www.nhtsa.dot.gov/people/injury/drowsy_driving1/human/drowsy_driving/index.html |
| Washington Ticketing Aggressive Cars and Trucks initiative (TACT) (July 2005) | Washington was the first pilot state for the program that offers a combination of effective messages and outreach activities coupled with targeted enforcement blitzes in selected high-risk areas. The campaign was used to build awareness and educate motorists about safe driving behaviors around CMVs. The rigorous evaluation of the Washington TACT project showed a considerable reduction in unsafe driving behaviors as well as a sharp increase in motorist awareness of the proper way to share the road safely with CMVs. | Federal Motor Carrier Safety Administration (FMCSA) and National Highway Traffic Safety Administration (NHTSA) NW Region, Federal Highway Administration, Washington State Department of Transportation, Washington Association of Sheriffs and Police Chiefs, Washington State Patrol, and the Washington Trucking Association | www.wtsc.wa.gov/programs/tact.php |
| What Is Restless Leg Syndrome? | A national initiative to increase awareness about restless legs syndrome (RLS). The initiative, which includes the first-ever public service announcement, also offers a Web site featuring people who live with RLS and how the disorder and its symptoms have impacted their lives. | Boehringer Ingelheim Pharmaceuticals; Restless Legs Syndrome Foundation; National Sleep Foundation | http://whatisrls.org/ |
| International | | | |
| BP International Driving Championship (IDC) (June 2003) | BP, a global energy group, sponsors the IDC, which is open to all BP professional drivers for the heavy vehicle and light vehicle competition categories. The IDC and associated events aim to build awareness and understanding of safe driving techniques and behaviors which all can adopt in their driving-related activities. The event also provides an opportunity for drivers, other participants, line leadership and functional specialists to better understand the challenges being faced and good practices being employed by the driving workforce from around BP, and to use the knowledge gained to share best practices and help shape future driving safety needs. | BP employs more than 96,000 people and operates in more than 100 countries | www.bp.com/sectiongenericarticle.do?categoryId=9002042&contentId=7003849 |

| Initiative or program (Year of origin) | Purpose | Partners/sponsors | Web link |
|---|--|--|--|
| Driver Reviver Rest Stop Campaign (2001) | Each holiday season up to 220 Driver Reviver Sites open right across Australia. Driver Reviver is a community program operated by volunteers from a wide range of Service organizations and community groups, whose members give up their own time to help reduce the road toll. Driver Reviver Sites are an ideal place to take a break on a long journey. They offer a free cup of Bushells tea, coffee, an Arnott's biscuit, or simply a place to stop and chat with the friendly volunteers before continuing safely on your journey. | Bushells Tea; The Arnott's Foundation; Bushells Coffee | www.driverreviver.com.au/index.htm |
| Safe-T-Cam | Safe-T-Cam is an initiative in South Australia that looks to reduce heavy vehicle driver fatigue, speeding and crashes via a network of fixed data collection (camera) sites strategically placed on major arterial roads that record, verify and store information on heavy vehicle movements within South Australia. | Transport Services; New South Wales Road Traffic Authority (RTA); South Australian Police (SAPOL) | www.transport.sa.gov.au/pdfs/freight/safe_t_cam/TSASafeTcam.pdf |
| The Road Safety Partners of Ontario (RoadSafe) (Oct. 5, 2004) | RoadSafe's purpose is to promote road safety through public awareness events and literature in order to help change driver behavior. The alliance hopes to reduce by 30% the average number of road users killed or seriously injured between 2008 and 2010 compared to the 1996 to 2001 period. | Human Resources and Skills Development Canada (HRSCD); Insurance Bureau of Canada (IBC); Ministry of Transportation (MTO); Ministry of Labour (MOL); Ontario Provincial Police (OPP); Transport Canada; Transportation Health & Safety Association of Ontario (THSAO); Ontario Workplace Safety & Insurance Board (WSIB); Industrial Accident Prevention Association (IAPA); Ontario Service Safety Alliance (OSSA); Office of the Chief Coroner; Passport to Safety | www.roadsafe.ca |

Fatigue Countermeasures

A driver fatigue panel comprising members of the National Center on Sleep Disorder Research (NCSDR) and National Highway Safety Administration (NHTSA) concluded no “driving strategy” could get drowsy drivers safely to their destination and that such strategies are no substitute for good sleep habits (NCSDR/NHTSA, 2000).

While the first two parts of the Policies and Practices section examine problems within the trucking industry on managing and implementing fatigue strategies, this part evaluates countermeasures of fatigue, and recommends countermeasures, based upon extensive research and continual updating from the “Best Practices Compendium of Fatigue Countermeasures in Transport Operations.”

This compendium responds to one of the recommendations emerging from the 1999 “Proceedings of the Fatigue in Transportation Workshop: Multimodal Issues and Solutions.” The aim of the compendium is to develop knowledge on fatigue countermeasures applicable to transport operations by critically evaluating research findings. The compendium contains key facts, results, and implementation strategies related to the optimal use of various countermeasures. It reviews the strategies used to manage work-related fatigue.

Evaluation of Countermeasures

Strategies designed to increase the level of stimulation for CMV drivers on the road could be light physical activity, controlled noise, interaction with workmates, cold/fresh air. However, these countermeasures seem effective only while the stimulation is on and their effectiveness is short-lived. The following are evaluations of such types of countermeasures:

- Increased physical activity, such as walking around, appears to be the favorite countermeasure of fatigued individuals. But very heavy physical work should be avoided because it is followed by aftereffects on alertness, resulting in a more rapid onset of sleepiness.
- So far, there is no strong evidence for the effectiveness of commonly accepted remedial approaches such as brief exercise, listening to the car radio, or opening the car windows.
- The effectiveness of low doses of caffeine as a measure to improve alertness in sleepy people has been demonstrated (NCSDR/NHTSA, 2000). The minimum dose needed can be obtained in two cups of coffee.
- Limited evidence suggests that physical discomfort (sitting in an uncomfortable position and shivering or sweating) may improve alertness temporarily (NCSDR/NHTSA, 2000).
- The ingestion of sugar could help in alleviating drowsiness, whereas heavy food could increase drowsiness levels. The alerting effects of food intake are speculative and research is limited.
- Considering the arousal effects of sudden stimuli, high frequency noise could have performance-enhancing effects, whereas low-frequency noise and monotonous noise can cause drowsiness.

- Åkerstedt reported the results of a study in which a sudden reduction of the ambient temperature for 4-8 minutes (activated by the driver who perceived a drop in alertness) was effective in improving vigilance.
- Poor ventilation of the work environment should be addressed since it could be a cause of drowsiness.
- Increased lighting could have a direct stimulating effect independent of its circadian phase-shifting effect. No current data linking bright light treatment to changes in rates of motor-vehicle crashes is available. Further research is needed to clarify these issues.

Evaluation of Operational Strategies

The organization of work and rest is imperative to reduce drowsiness levels and the risk of fatigue-related crashes. Suggested measures that companies could use to help drivers with their first trip are:

- Limiting the number of hours worked from midnight to 6 a.m.
- Providing night-start drivers with additional time off daily
- Providing good sleeping facilities
- Providing nominal financial incentives
- Increasing the off-duty period for drivers changing from day to night shifts (Vespa et al., 1998). It is generally agreed that two full nights of sleep are required for recovery from acute and cumulative fatigue over an extended period of time (Vespa and Eng, 1998).

These measures, however, are of limited value without good education and incentive programs. Even when given substantially more sleep opportunity, drivers do not necessarily use it to obtain their reported ideal sleep.

Incentive programs for accident-free performance seem to be the most promising in affecting people's motivation towards safety (Barton et al., 1998). Accident reductions of at least 80 percent have been reported with the use of such programs. Moreover, the cost of bonuses and program administration is considerably smaller than the savings due to accident reduction. Indeed, some companies interviewed in the context of a pilot study in Canada reported a three to one benefit/cost ratio for their incentive programs (Barton et al., 1998).

Fatigue management programs that would use behavior-based safety principles have been proposed (Krause et al., 1999). These are designed to encourage self-management rather than the implementation of procedures. In self-management, the effect of performance feedback is important to allow for a positive change in safety behavior. It is proposed that feedback data, available through performance measurement technologies, could generate valuable data for the driver, company management, and regulatory agencies. Various levels of feedback could be provided, without the identification of any individual driver.

Health management systems also should be developed and include the assessment of sleep disorders or other fatigue-related conditions and health problems, e.g., diabetes.

Numerous social awareness programs in America educate the public about the potential consequences of drowsy driving, however, the benefit of such campaigns cannot be directly determined.

Evaluation of In-Vehicle Fatigue Detection Devices

Great interest has been invested in technology to manage fatigue-related performance impairment in commercial motor-vehicle operations (See Section 6: In-Vehicle Sleepiness Detection Devices). An inherent deficiency in all types of alerting devices is that many people continue to drive even when they know they are drowsy and fighting to stay awake. An example of a simple and useful device is the SNAP (Sonic Nap Alert Pattern), designed by the Pennsylvania Turnpike to produce enough vibration and sound to be perceptible in a truck cab and yet not too severe for cars or motorcycles. It was shown that use of the SNAP can reduce drift-off road accidents by 65-70 percent. Panelists agreed that shoulder rumble strips placed on high-speed, controlled-access, rural roads could reduce drive-off-the-road crashes by 30-50 percent. However, drivers should see them only as a warning that they should take some countermeasure such as a nap, fresh air, coffee, a walk or change drivers.

Technology must be acceptable to the driver and unobtrusive. It must be validated and normative, and quantitative data must be obtained. It should be easy to learn, to use, and to maintain, including the calibration steps. Technology could be used as a continuous “fuel gauge” display of alertness or “alertometer” that informs the driver of his or her vigilance level. However, it may encourage drivers to continue driving, whereas a single threshold alarm would communicate that falling asleep at the wheel is imminent. Loss of driver alertness is almost always preceded by a period of measurable performance decrements and associated psychophysiological signs (Knipling et al., 1996).

Proposed Countermeasures

The compendium’s recommended countermeasures include:

- Implementation of a fatigue management program with a good education program about sleep and behavior to prevent drowsy driving
- Incentive programs for accident-free performance
- Health management systems to screen for sleep disorders or other fatigue-related conditions
- Recognized strategies to increase levels of alertness:
 - napping before a long drive
 - strategic napping (10-30 minutes nap) when drowsy while driving
 - coffee (two cups)
- Strategies to increase the level of stimulation (short-lived, of limited value, and not well validated):
 - light physical activity
 - sitting in an uncomfortable position
 - controlled noise
 - interaction with workmates

- cold/fresh air
- ingestion of sugar
- increased lighting
- Reorganization of work and rest schedules:
 - limit night driving
 - minimum of two full nights of sleep after an extended driving period
 - some degree of flexibility in driving hours
 - alternative work schedules, different from HOS regulations, closer to a natural circadian
 - sleep-wake cycle
 - restriction of long duty period (e.g., a maximum of 12 hours driving per day)
 - protected rest and break periods (e.g., a maximum of 5 hours driving before a 30-minute break, a minimum of 9 hours between two consecutive shifts)
- Improved cabin environment (air, temperature, sound, vibrations)
- Improved sleeping facilities
- Technological devices that can be used as “alertometers” and/or to warn about dangerous levels of sleepiness

Recommendations for Industry and Regulators

Cooperative efforts are needed at several levels to promote a fast and valuable transfer of knowledge to real-life situations, according to the Best Practices Compendium of Fatigue Countermeasures in Transport Operations (Boivin, 2000). The following research and implementation approaches are recommended in the compendium:

- Provide comprehensive education programs on shift work, work and rest schedules, and proper regimens of health, diet, and rest
- Implement fatigue management programs in all transportation industries to educate drivers, navigators, pilots, ATCs, family members, unions, management, governmental agencies, and politicians on the safety issues related to fatigue and sleep loss
- Promote behavior-based safety approaches and self-management with performance feedback through measurement technologies
- Incorporate the latest research on sleep and circadian rhythms into work scheduling
- Limit or avoid 12-hour shifts
- Limit or avoid counterclockwise rotating schedules
- Improve the regularity of duty periods on reserve and on-call assignment and reduce the element of unpredictability
- Promote a good solid night of sleep prior to a trip
- Encourage strategic napping en route, especially during night shift or on the cruise portion of long-haul flight operations
- Limit night shifts to a succession of two to three consecutive nights
- Avoid 12-hour night shifts
- Provide a minimum of two full days of rest after an extended duty period, especially if it involved night work

- Provide a minimum of nine hours of rest between two consecutive shifts
- Limit overtime to an operationally viable minimum
- Increase the number of rest areas nationwide
- Increase the visual signals and number of rumble strips on highways
- Provide adequate areas for strategic napping
- Improve commuting home arrangements
- Support research to develop reliable and practical technologies to detect and alleviate drowsiness while operating a vehicle
- Support research to develop tools to better assess the influence on the endogenous circadian system in the field

Section 6: In-Vehicle Sleepiness Detection Devices

Notwithstanding advice for CMV drivers to avoid drowsy driving, interest is growing for sleepiness detection devices that warn drivers when they are becoming sleepy by sounding a warning tone or providing vocal instructions to “take a break.”

A systematic review of in-vehicle sleepiness detection devices for the Department of Transport in Melbourne, Australia (Wright et al., 2007), reveals that a wide range of sleepiness detection devices exist, and that no single method is commonly accepted to detect driver fatigue in an operational context.

Among the dozens of devices studied, the review identifies only 15 devices as potentially worth being evaluated in experimental study. By analyzing the status of devices that are commercially available or in the late stages of development, the review focuses on those devices that are suitable for driving task, although mentions some intended specifically for other contexts. The 15 devices are categorized into four types (although five types are reviewed in this report):

- **Physiological sleepiness detection devices**
 - CoPilot
 - ETS-PC Eye Tracking System
 - FaceLAB 2.0
 - MTI AM eye
 - Onguard
 - Optalert™
 - PERCLOS
 - Smart Eye
 - APL Drowsy Driver System
- **Sleepiness detection devices based on physical activity**
 - No devices found to be acceptable at this time
- **Devices based on behavioral measures**
 - DAS 2000 Road Alert System (methodology)
 - SAMG-3Steer
 - SAFETRAC
- **Model-based predictions of sleepiness**
 - Sleep Watch
- **Devices based upon a combination of more than one approach or measure**
 - ASTid
 - SmartCar Driver Behaviour

Based on information from Dinges and Mallis (1998), Hartley et al. (2000) and Williamson and Chamberlain (2005), the review developed requirements to determine which devices are most suitable for detecting sleepiness in drivers (Box 4). The review found it important to clarify that the purpose for such devices is intended to warn drivers of unexpected sleepiness, and is no way

intended to “keep the driver awake.” In particular, within commercial driving settings, it is emphasized that driver scheduling seeks to ensure that the driver has sufficient opportunity within each day to obtain adequate sleep, and within driving periods has time available to take regular breaks. This approach is key to fatigue management for both commercial and non-commercial drivers, and the role of sleepiness detection devices should only be seen as a fall-back safety aid.

Box 4: Criteria for In-Vehicle Sleepiness Detection Devices

Requirements for Sleepiness Detection Device for Drivers

- The ability to detect sleepiness at a sufficiently early stage, before the likelihood of an accident is increased by sleepiness;
- Absence, or minimal rate, of false alarms that alert the driver when sleepiness is not present;
- Non-intrusiveness to the driver: A device that does not intrude on the ability of the driver to perform the driving task, or cause irritation, for example, by requiring the wearing of various attachments;
- A high-level of driver acceptance, whereby the device is seen to be acceptable in terms of how the data from the device is to be used, and that the driver perceives the device to be beneficial;
- Understanding of whether and under what circumstance the use of sleepiness detection devices could be mandatory;
- Presence of an effective strategy and implementation of warning alerts to inform the driver of impending sleepiness and that he/she is unsafe to drive;
- The device operates effectively for all individuals without the need for frequent individual calibration i.e. at the start of every journey;
- The device must operate under all environmental conditions, including bright sunlight, darkness and rain;
- There is a clear statement of the exact purpose of the device. For example, it should not be used to prolong the amount of time for which an individual can drive.

Physiological Sleepiness Detection Devices

The review focuses on three types of physiological sleepiness detection devices (Table 51): eye activity, the Electroencephalogram (EEG, representing brain electrical activity), and electrodermal activity (galvanic skin resistance).

Sleepiness Detection Devices Based On Eye Activity

More sleepiness detection devices were found that followed eye activity than devices that followed EEG or electrodermal activity. Eye activity devices include monitoring blinking behavior, saccadic eye movement patterns (that is, changes in fixation point), pupil size, eye point of regard and eye closure for brief periods. There is a strong relationship between sleepiness and eye activity, although indices are also affected by other factors such as visual task information processing demands and environmental conditions such as ambient illumination (Wierwille et al., 1994; Hyoki et al., 1998; Dinges and Grace, 1998; Stern et al., 1984, 1994).

The main technologies that have been used to measure eye activity for the purpose of sleepiness detection are infrared reflectance devices and the analysis of video imagery. The infrared technique typically uses a transmitter and receiver that are mounted to a pair of spectacles worn by the driver, and directs a beam of infrared light at the eyelids of the driver. The method may allow the driver to wear prescription glasses or sunglasses if they are suitably modified.

Image analysis of eye activity is achieved using a dashboard-mounted camera pointed at the driver's face, and uses image processing techniques to locate the driver's head and eye positions, although operational problems may be encountered with large head movements. They do, however, enable eye point of regard to be measured through the combined use of head and eye position (eye point of regard can provide an indication of the driver's focus of visual attention, and therefore may provide information additional to predict sleepiness).

Both technologies can have difficulty coping with the wide range of illumination levels typically encountered while driving, such as bright sunlight, darkness and rainy conditions. Therefore a careful assessment of practical issues associated with measuring eye activity to detect sleepiness is required.

EEG-based Sleepiness Detection Devices

The EEG is a sensitive measure of sleepiness (Belyavin and Wright, 1987; Ogilvie et al., 1997; Makeig and Inlow, 1993; Lafrance and Dumont, 2000) where changes in theta (3.5-7.5 Hz), alpha (8-13 Hz) and beta (14-30 Hz) frequencies are associated with brief periods of sleepiness (microsleeps) and the onset of sleep. Instabilities in EEG, involving short-duration changes in alpha and theta activity, are associated with falling asleep while carrying out a monotonous task (Wright et al., 1987). As with eye activity, the EEG is affected by factors such as workload. However, the changes in EEG as sleepiness develops are sufficiently distinct that sleepiness can be reliably identified, although the simultaneous use of Electrooculography (EOG: a technique for measuring the resting potential of the retina) is highly recommended.

Although several devices predict sleepiness, practical problems associated with using the EEG as a detector, such as the requirement for scalp electrodes, have not been addressed. Relatively non-intrusive methods of recording the EEG have been developed the past few years, and use an alertness device developed by Advanced Brain Monitoring, Inc. (2002). In this system, the EEG electrodes are housed in a baseball cap with amplification being carried out by a microprocessor situated at the back of the cap. The signals may be transmitted to a base station using telemetry. However, the entire system has not yet been systematically validated in terms of accuracy to detect sleepiness.

Although a few systems appear to be promising, the conclusion at present is that the technology for recording EEGs is not yet sufficiently mature for use by drivers on a day-to-day routine basis.

Devices Based on Electrodermal Activity

Skin resistance increases with sleepiness and fatigue (Nishimura and Nagumo, 1985; Boucsein and Ottmann, 1996), although the changes have been found to be unrelated to specific incidences of sleepiness or sleep (Wright and McGown, 2001). Furthermore, electrodermal activity is affected by many factors, including biophysical properties of the skin (Adhoute et al., 1992), psychological stress (Trimmel et al., 2003), workload (Collet et al., 2003) individual differences (Wilken et al., 1999), and variations in environmental factors such as noise, physical movement and humidity.

The device has the advantage of being relatively unobtrusive, as it is worn in the form of a wrist-watch, however, the above factors which modify skin resistance in addition to sleepiness are likely to reduce the effectiveness of the device. The review also found that devices appear to detect sleep rather than sleepiness.

Table 51: Physiological Sleepiness Devices Studied

| Name of device | Physiological, physical, behavioral or model-based operation | Recommendation to further evaluate | Reasons for inclusion/exclusion |
|--|---|--|---|
| Eye-based | | | |
| AlertDriver | Monitors eye droop, pupil occlusion and eye closure via a camera. Uses image neural nets, fuzzy logic to locate the subject's eyes. Is also model-based. | Exclude | Does not work when the driver is wearing sunglasses. |
| CoPilot | See also PERCLOS system upon which CoPilot is based. Detects percentage of time eyes are closed over a specified time interval (PERCLOS system) via infrared camera system. | Include | Potential candidate provided that the device is effective in both daylight and night-time conditions. |
| DaimlerChrysler Eye-Gaze Detection System | Measures eye gaze via dashboard camera. | Include (provided it can be retrofitted to all cars) | Potential candidate |
| Expresseye | Measures fixation, gaze control and saccadic eye movements to a target. Uses infrared light corneal reflection technique. | Exclude | Unsuitable due to head-mounted optics, so is highly intrusive. |
| EyeHead | Measures eye position, head position and eye to point of fixation distance. Uses a magnetic head tracker. | Exclude | Unsuitable due to head-mounted optics, so is highly intrusive. |
| Eye-Gaze System | Measures gaze-direction via corneal reflection technique. Also measures pupil diameter, blinking, and eye fixation. | Exclude | Unsuitable due to requiring a head set to be worn, so is high intrusive. |
| Eyeputer | Records eye movements via corneal reflection technique. | Exclude | Unsuitable due to need for headset, so is high intrusive. |
| ETS-PC Eye Tracking System | Detects eye closure via a camera. | Include | Potential candidate |
| FaceLAB 2.0 | Measures eye-gaze and eye closure. Uses PERCLOS fatigue assessment scale. | Include | Potential candidate |
| IM-Blinkometer | Detects blinks using a piezoelectric adhesive disk attached to canthus of the eye. | Exclude | Not suitable due to sensor attached to face/eye, so is highly intrusive. |
| MTI AM eye | Detects eye blinks. Measures ration of closed to open eyes to detect sleepiness. Uses infrared reflectance. | Include | Potential candidate |
| Nissan Drowsy/Inattentive Driver Warning | Uses image processing to monitor eyelid movements. | Exclude | Insufficient information to evaluate |
| Onguard | Measures eye closure, activates an alarm after 0.5s closure period. Uses infrared reflectance. | Include | Potential candidate |
| Optalert | Uses infrared and oculography to detect eyelid movements during blinking and eye closure. The system is being further developed to measure intersaccade interval (may be more prediction of alertness, and also detect absence of changes in gaze.) | Include | Likely candidate. Although the system requires glasses to worn, these are lightweight and can accept a variety of lens types. Therefore, although the system is potentially intrusive, this may be less than most other similar systems. The independent validation in a range of occupational setting supports this. |

| Name of device | Physiological, physical, behavioral or model-based operation | Recommendation to further evaluate | Reasons for inclusion/exclusion |
|---|--|------------------------------------|---|
| Eye-based | | | |
| PERCLOS | Detects eye closure using infrared, retinal reflectance device. Measures duration of blinks and eye closures, and proportion of time eyes closed over a specified time interval. | Include | Potential candidate if problems with night driving resolved. |
| Photo Driven Alert System | Worn on ear and measures blink rate. | Exclude | Unsuitable due to need to wear device on the ear and is incompatible with wearing glasses. |
| SafetyScope TM | Ocular system in quantifying sleepiness. | Exclude | Unsuitable due to head-mounted optics, hence intrusive. |
| Smart Eye | Detects head position and point of gaze via image processing. | Include | Potential candidate |
| Toyota Driver Drowsiness Detection and Warning System | Detects eyelid movement using camera mounted on rear-view mirror. | Exclude | Not possible to retrofit due to implementation of warnings. |
| Vehicle Drivers Anti-Dozing Aid (VDAD) | Measures eye closure and head movement via infrared reflectance. Developed by U.S. military. | Exclude | Unsuitable due to need to wear device on ear, hence intrusive. |
| EEG-based | | | |
| ABM Drowsiness Monitoring Device (DMD) | Records EEG via telemetry to detect drowsiness | Exclude | Unlikely to be acceptable for routine use without the introduction of a "dry" electrode system. |
| EEG Based Algorithm to Detect Different Levels of Driver Fatigue | Uses delta, theta, alpha and beta activity on the EEG to detect "early, medium and late" sleepiness. | Exclude | Unlikely to be acceptable for routine use without the introduction of a "dry" electrode system. |
| GSR-based | | | |
| Engine Driver Vigilance Telemetric Control System 3rd generation (EDVTCS) | Measures electrodermal activity and electrodermal reactions. No information on specific parameters. | Exclude | Unlikely to work under a range of different conditions. |

Source: Wright et al., 2007

Sleepiness Detection Devices Based on Physical Activity

The measurement of actigraphy has frequently been used in research on sleep and circadian rhythms and to investigate patterns of rest (Sadeh et al., 1995). The technique is based upon the difference in the amount of body movement present during sleep compared with wakefulness (Pollack et al., 2001). These authors, along with Lockley et al., 1999, verified that consolidated sleep could be differentiated from wakefulness, but that short transitions between sleep and wakefulness are not accurately identified (Chambers, 1992). This means that short periods of waking may not be identified. The converse also has been found, that is, brief periods of sleep or sleepiness occurring when an individual is required to be awake are also not reliably identified by measuring wrist inactivity. The measure has been used as the basis of a sleepiness detection device, the "Actiwatch Alert," developed for the UK Civil Aviation (Wright and McGown, 2004; Wright et al., 2005) for use by aircrew to minimize unplanned sleep during cruise. However, the

method is unsuitable for use by drivers because it requires a relatively long period of sleepiness or sleep (four to five minutes).

Wrist activity has been used to develop other sleepiness detectors, however, as with the Active Alert, several minutes of sleep is required to identify sleep (Table 52). Several devices have been developed based upon the measurement of head movement, although as with wrist activity, a relatively long interval of sleepiness is required before an alert is activated.

The use of head movements to detect sleepiness was investigated by Wright and McGown (2001), and was found to be similar to wrist activity with regard to sensitivity to the detection of sleep. Devices that are based upon the pattern of head movements of individual drivers, for example, by measuring head position and lateral movements while scanning the road, may be more sensitive, although insufficient validation information is available.

Table 52: Sleepiness Detection Devices Based on Physical Activity

| Name of device | Physiological, physical, behavioral or model-based operation | Recommendation to further evaluate | Reasons for inclusion/exclusion |
|--|--|------------------------------------|---|
| Actiwatch-alert | Measures wrist inactivity associated with sleep. | Exclude | Unsuitable because time basis of alert is too long for driving context (5 mins of sleepiness required before alert). Developed for use in aviation environment. |
| Doze Alert | Measures head-tilt as sleep occurs. | Exclude | Insufficiently sensitive as only detects when asleep. |
| Driver Alert Warning Device | Measures head-tilt via pressure device on neck. | Exclude | Insufficiently sensitive as only detects when asleep. |
| EPAM | Measures wrist inactivity associated with sleep. | Exclude | Insufficiently sensitive as only detects when asleep. |
| MINDStim (MicroNod Detection System) | Monitors head movements. Learns typical patterns of movement, and detects those associated with drowsiness. | Exclude | Head movements unlikely to be an effective indicator of early stages of drowsiness. Also device has potential safety implications. |
| Proximity Array Sensing System (PASS) | Detects brief head movements associated with sleepiness. Uses system of electromagnetic fields to detect micro sleeps. | Exclude | Insufficiently sensitive as only detects when asleep. |
| Stay-Alert | Detects head droop by detecting chin contact with device worn round the neck. | Exclude | Insufficiently sensitive as only detects when asleep. |

Source: Wright et al., 2007

Devices Based on Behavioral Measures

Some sleepiness detection devices using behavioral measures are in routine use at present, including devices based upon responses to either the occupational task or a secondary, embedded task (Table 53). The review, however, found only one device that might be able to meet commercial driving standards.

Devices identified for monitoring sleepiness-related behavior in drivers were mainly based upon patterns of steering wheel movement, such as monitoring lane deviations, center-line and hard-shoulder crossings. While these measures are non-intrusive, have a degree of face validity, they often can be easily integrated with other in-vehicle technologies, and warning systems could readily be implemented. However, alone, the devices are relatively insensitive to sleepiness and are less effective than devices based on eye activity.

A range of devices employing secondary tasks are currently used in driving occupations in the mining industry. These operate by measuring response times to visual and auditory stimuli. Examples are the ARRB/ACARP (ACARP, 2006), used in coal mining trucks, and the FMD (Fatigue Monitoring Device; Hartley et al., 2000). However, sleepiness detection devices employing secondary tasks are usually considered intrusive to the main task, increasing workload and potentially impairing safety (Verwey and Zaidel, 1999), and so have been rejected as unsuitable.

Table 53: Devices Based on Behavioral Measures

| Name of device | Physiological, physical, behavioral or model-based operation | Recommendation to further evaluate | Reasons for inclusion/exclusion |
|---|--|------------------------------------|--|
| APRB/ACARP Device for Monitoring Haul Truck Operator Alertness | Uses secondary task to estimate alertness via an auditory and visual reaction time task (tailored to individuals). Used in mining industry trucks. | Exclude | Unsuitable as is secondary task. |
| DAS 2000 Road Alert System | Measures drivers' acceleration, braking, gear-changing, lane deviation and distances between vehicles. | Include | Potential candidate |
| FMD – Fatigue Monitoring Device | Auditory and visual reaction time test. Response pads on steering wheel. Used in mining trucks. | Exclude | Unsuitable as is secondary task. |
| Roadguard | Is a secondary task, comprising a reaction task. Only operates when vehicle is in top-gear. | Exclude | Unsuitable as is secondary task. |
| Safety Driver ws, 11Advisor | Learns normal driver steering movements and detects deviations from normal. Comprises a driving time measure, a dashboard display of recommended rest-break times and a monitor of erratic steering behavior. Recommended driving time is 2 h for day, 1h for night. | Exclude | Likely to be unsuitable due to the design of the warning system. |
| SAMG-3Steer | Monitors normal corrective movements of steering wheel. | Include | Potential candidate |
| Stay-A-Wake | Monitors speed and steering behavior. | Exclude | Unsuitable due to design of warning system. |
| SAFETRAC | Uses measurements of lane deviations and steering movements. | Include | Potential candidate |

Source: Wright et al., 2007

Model-Based Predictions of Sleepiness

Mathematical models have been developed that predict sleepiness and alertness based upon a range of factors, including circadian influences, time since sleep and duration of current work schedules (Spencer and Gundel, 1998).

Such models have been validated in terms of their correlation with behavior and validated subjective scales, such as the Karolinska Sleepiness Scale and Samn-Perelli Scale. The main application of the models to date has been in the assessment of duty schedules and rosters to predict likely levels of fatigue. Although they are not sleepiness detection devices as such, they may be used to predict the likely risk of sleepiness occurring. In particular they may be used in combination with real-time measures such as eye activity or steering wheel patterns to identify sleepiness (Table 54).

Table 54: Model-Based Predictions of Sleepiness

| Name of device | Physiological, physical, behavioral or model-based operation | Recommendation to further evaluate | Reasons for inclusion/exclusion |
|--|--|--|---|
| Fatigue Audit Interdyne System (FAID) | Mathematical model based on work/rest patterns. | Include | Potential candidate, if part of a combined system, e.g. based on a real-time measure. |
| Sleep Watch | Determines amount of sleep taken using wrist-worn accelerometer, and predicts and displays levels of alertness on watch. | Include | Potential candidate |
| U.S. Army Sleep Management | Mathematical model based on work/rest patterns over last month and circadian influences to predict impaired performance. | Include (as part of a combined system) | Potential candidate, probably as part of a combined system, e.g. based on a real-time measure. Based on same system as Sleep Watch. |

Source: Wright et al., 2007

Devices Based Upon a Combination of More Than One Approach or Measure

Several devices use a combination of driver steering-wheel measures and other sleepiness detection approaches (Table 55). “ASTiD” (Cacciabue, 2004) combines information from the steering wheel and a mathematical model to predict sleepiness, and displays a computed “fatigue index.” The system provides warnings and vocal instructions, and is currently being evaluated in field studies. Others, for example, SAFETRAC (2006) and an ASL system (RSSB, 2002), use eye activity measures combined with operator input patterns.

A combination of EEG measures and operator performance of a secondary tracking task is used by the COMPTRACK system (Makeig and Jolley, 1996), and two systems use multiple physiological and physical indices. These are the APL device, where eye movements, respiration and heart rate are used to indicate “general” activity and eye activity, JHUAPL (1999); and Sensewear Pro (Armband, 2006), where activity is measured via accelerometers, and body heat flux and galvanic skin resistance recorded via electrodes on the skin. The latter device is able to detect incidences of sleep with an accuracy of 95 percent while APL may be more sensitive to sleepiness as it includes eye activity measures.

The physiology-based systems are likely to be too intrusive with the exception of the APL device, which uses Doppler radar to monitor the driver non-intrusively. The use of a secondary task in the driving environment is considered unacceptable for safety reasons. The combinations of steering wheel measures and eye activity parameters or predictive models would, however, appear to be a promising approach.

Table 55: Devices based upon a combination of more than one approach or measure

| Name of device | Physiological, physical, behavioral or model-based operation | Recommendation to further evaluate | Reasons for inclusion/exclusion |
|--|---|------------------------------------|--|
| Advisory System for Tired Drivers (ASTiD) | Used model based on time of day, the quality of the driver's sleep in the last 24h, total driving time and monotonous conditions. Is combined with patterns of steering wheel movements, computes fatigue on a display panel. | Include | Potential candidate |
| APL Drowsy Driver Detection System (DDS) | Uses Doppler radio to measure speed, frequency, duration of eyelid closure, heart rate and respiration. Sleepiness based on general activity and eye activity monitoring. | Include | Potential candidate |
| COMPTRACK | Uses EEG frequency analysis and secondary (tracking) task. | Exclude | Unsuitable because involves a secondary task. |
| Sensewear Pro | Combination of measures of Activity via accelerometers, skin temperature and near-body temperature. Detects sleep with 95% accuracy. | Exclude | Unsuitable due to being insufficiently sensitive to sleepiness. |
| SmartCar Driver Behaviour | Uses cameras to capture traffic information outside, and inside to detect head position. Synchronized with data acquisition from braking, gear changes and steering. Gaze direction measured by camera mounted on. | Include | Potential candidate for methodology, i.e. combines eye movements, head position, and contextual driving. |

Source: Wright et al., 2007

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Appendix A: Medical-related State Regulations and Guidelines for Sleep, Sleep Disorder, and/or Fatigue

| State | Commercial | Private |
|---|--|--|
| Specific criteria? 1= yes; 2= no; 3=not stated; 4=default to federal regulations | | |
| Details | | Details |
| Alabama | 2 You should consult your physician or a local sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, gasp and choke in your sleep, and/or wake up feeling as though you have not had enough sleep. | 2 |
| Alaska | 2 You should consult your physician or a local sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, gasp and choke in your sleep, and/or wake up feeling as though you have not had enough sleep. | 2 You must control yourself before you can control a vehicle. Driving with insufficient sleep, anger, or distractions are examples of factors that will impair your ability to safely control a vehicle. |
| Arizona | 2 You should consult your physician or a local sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, gasp and choke in your sleep, and/or wake up feeling as though you have not had enough sleep. | 2 Driver's manual states people with sleep disorders are among 5 identified groups more likely to have collisions caused by sleepiness and advises getting rest, changing drivers, not driving late at night, taking rest stops, etc. |
| Arkansas | 2 Fatigue and Lack of Alertness. Fatigue (being tired) and lack of alertness are bigger problems at night. The body's need for sleep is beyond a person's control. Most people are less alert at night, especially after midnight. This is particularly true if you have been driving for a long time. Drivers may not see hazards as soon or react as quickly, so the chance of a crash is greater. If you are sleepy, the only safe cure is to get off the road and get some sleep. If you don't, you risk your life and the lives of others. | 2 Fatigue When you are tired, you cannot drive as safely as when you are rested and you do not see as well nor are you as alert as when you are rested. It takes you more time to make decisions and you do not always make good decisions. You can be more irritable and can get upset more easily. Lastly, when you are tired, you could fall asleep behind the wheel and crash. There are things you can do to keep from getting tired on a long trip. <ul style="list-style-type: none"> • Try to get a good night's sleep before you leave. • Do not leave on a trip if you are tired. Plan your trips so you can leave when you are rested. • Do not take any medicine that might make you drowsy. • Eat light meals prior to departure. Large, full meals tend to cause drowsiness. • Take breaks. Stop, regularly, or when needed. To walk around, get fresh air, and refresh yourself with some coffee, soda, or juice. The few minutes spent on a rest break can save your life. Plan for plenty of time to complete your trip safely. • Avoid long trips during hours your body is accustomed to resting. • Never drive if you are sleepy. It is better to stop and sleep for a few hours than take a chance you can stay awake. |

| State | Commercial | Private |
|---|---|---|
| Specific criteria? 1= yes; 2= no; 3=not stated; 4=default to federal regulations | | |
| California | 2 CDL applicants must have medical certificate in accordance with 49 CFR 391.41 | 2 If you are tired all the time and fall asleep often during the day, ask your physician to check for a sleep disorder. |
| Colorado | 2 If you are sleepy, the only safe cure is to get off the road and get some sleep. If you do not, you risk your life and the lives of others. Each applicant shall meet the medical and physical qualifications under FMCSR Part 391.41 and have this examination verified on a DOT medical examination form. Unless the following exceptions apply, each driver shall carry this medical examination form or the medical examiner's certificate on his/her person when operating a CMV. | 2 No mention found. |
| Connecticut | 2 Sleep disorders, pauses in breathing while asleep, daytime sleepiness, loud snoring. FOR ANY "YES" ANSWER, INDICATE ONSET DATE, DIAGNOSIS, TREATING PHYSICIAN'S NAME AND ADDRESS, AND ANY CURRENT LIMITATION. LIST ALL MEDICATIONS (Including over-the-counter medications) used regularly or recently.—from CT DMV examination to determine physical condition of driver—R-323 Rev. 3-2004. | 2 Fatigue You cannot drive as safely when you are tired as when you are rested. You do not see as well, nor are you as alert. It takes you more time to make decisions, and you may not always make good decisions. You can be more irritable and can get upset more easily. When you are tired, you could fall asleep behind the wheel and crash, injuring or killing yourself or others. There are things you can do to help from getting tired on a long trip: <ul style="list-style-type: none">• Try to get a normal night's sleep before you leave.• Do not leave on a trip if you are already tired. Plan your trips so you can leave when you are rested.• Do not take any medicine that can make you drowsy.• Eat lightly. Do not eat a large meal before you leave. Some people get sleepy after they eat a big meal.• Take breaks. Stop every hour or so when you need to. Walk around, get some fresh air, and have some coffee, soda, or juice. The few minutes spent on a rest break can save your life. Plan for plenty of time to complete your trip safely.• Try not to drive late at night when you are normally asleep. Your body thinks it is time to go to sleep and will try to do so. |
| Delaware | 2 No mention of sleep disorders, just advice to get enough sleep, to pull over and nap if sleepy while driving, and to avoid taking drugs that make a person sleepy. | 2 Driver's manual provides tips on driving rested, taking breaks if tired, but makes no mention of sleep disorders. |
| District of Columbia | 4 Requires valid and stamped US Department of Transportation Medical Examination Report/Medical Card and Medical Examiner's Certificate. | 2 No mention of sleep disorders in new or renewal license information. |
| Florida | 4 Must be in compliance with the vision and physical requirements as stated in Part 391 of the Federal Motor Carrier Safety Regulations Handbook | 3 Physical and Mental Requirements You must list any physical or mental problems on your license application that might affect your driving. Many of the physical problems can be handled by placing restrictions on your license. If you have epilepsy, fainting spells, dizziness, blackouts or any other medical condition that could impair your driving, you may be asked to have your |

| State | Commercial | | Private | |
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| | | | | doctor complete a medical report form. These forms may be requested through your local driver licenses office and are mailed directly to you. The report must be completed by your doctor and submitted to the Department before a license is issued. If you are diabetic and use insulin, you may request that "Insulin Dependent" is indicated on your license. |
| Georgia | 4 | Requires US DOT Medical Examiner's Certificate | 2 | Applicants must have physicians fill out a medical report form, but no questions pertain to sleep disorders. |
| Hawaii | 4 | Requires US DOT Medical Examiner's Certificate | 2 | No mention of sleep or sleep disorders found. |
| Idaho | 4 | No mention of sleep or sleep disorders found. Requires US DOT Medical Examiner's Certificate | 2 | No mention of sleep disorders, but caution to pull over and nap if drowsy while driving. |
| Illinois | 4 | Requires US DOT Medical Examiner's Certificate | 2 | By law, you are required to file a Medical Report Form, completed by your physician, if: you have any medical or mental condition which could result in a loss of consciousness or any loss of ability to safely drive a vehicle. |
| Indiana | 4 | | 3 | The applicant must submit an original medical examination form 3337. The form must be completed...by a licensed physician indicating that the applicant does not suffer any mental or physical impairments that would adversely affect the applicant's ability to operate a public passenger vehicle. |
| Iowa | 4 | | 2 | No mention of sleep or sleep disorders found |
| Kansas | 4 | | 2 | No mention of sleep or sleep disorders found |
| Kentucky | 3 | No mention of sleep disorders found. | 2 | No mention of sleep or sleep disorders found |
| Louisiana | | | | |
| Maine | 4 | Requires drivers to certify they meet the federal medical standards. | 3 | No mention of sleep disorders among those medical conditions requiring a functional ability driving evaluation form. |
| Maryland | 4 | Requires DOT physical card. | 3 | No mention of sleep disorders |
| Massachusetts | 3 | No mention of sleep disorders. | 3 | No mention of sleep disorders. |
| Michigan | 4 | Unless exempt, you need to comply with federal or state medical/physical requirements before receiving a CDL. When applying for your CDL, you will sign a statement that says all necessary medical/physical requirements have been met. Before taking any CDL skills tests, you must provide a valid medical examiner's card or medical waiver card to your examiner which allows you to operate your commercial motor vehicle. | 3 | No mention of sleep disorders, but driver's manual states that certain medical conditions (unspecified) could result in a restricted license. |
| Minnesota | 4 | Requires DOT medical card. | 3 | No mention of sleep disorders. |
| Mississippi | 3 | | 3 | |
| Missouri | 4 | Must be medically qualified and certified per FMCSA | 2 | Medical Referral |

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| | standards. | There are two reasons you may need a physician's statement when you renew or apply for a license: <ul style="list-style-type: none"> • You have had epileptic seizures, convulsions, or blackouts within the 6 months prior to your application for a license. • A driver examiner, license clerk, family member, law enforcement officer, or physician believes you may have some other medical condition that would make you an unsafe driver. This person must complete the Driver Condition Report (Form 4319) and submit it to the Department of Revenue. |
| Montana | 4 Must submit DOT card | 2 No mention found of sleep disorders |
| Nebraska | 4 Individuals applying for a Nebraska School Bus Permit are required to present a Department of Transportation Medical Examination Report. Forms are available by clicking on "Forms and Pubs" at the following website: www.fmcsa.dot.gov/ . | 3 |
| Nevada | 4 You have to be physically examined by a U.S. licensed physician every two years. The doctor will give you a medical report and will fill out and sign a medical certificate for you to carry with your CDL. The medical certificate must be presented when applying for your commercial driver license. You can be cited by law enforcement if you drive commercially with an out-dated medical certificate, or if you do not have a current one with you. To ensure accurate records, your medical certificate must be filed with the Nevada Department of Motor Vehicles every two years or less if required by your physician. | 2 No mention of any medical requirements, but possibility of a medically restricted license. |
| New Hampshire | 4 Must comply with FMCSR Part 391 or apply for an intrastate waiver. Those driving intrastate only must also comply with FMCSA Part 391 or apply for a state waiver. | 3 Vision only medical requirement mentioned |
| New Jersey | 3 | 2 Applicants are required to inform the examiner of any serious health problems. In certain cases, a medical review may be necessary. The examiner will discuss this with the applicant. Under federal law, commercial drivers must carry a medical examiner's fitness statement and have it renewed every two years. |
| New Mexico | 4 You must be physically capable of obtaining a valid medical examiner's card (before taking any CDL skills test). | 3 In New Mexico drivers who have epilepsy, diabetes, adverse heart conditions and other medical problems are required to send the Motor Vehicle Division periodic medical statements signed by their physicians. Consult the Motor Vehicle Division for more information |
| New York | 4 Drivers are required to hold a DOT medical card. CDL driver manual warns drivers who experience daytime sleepiness or other listed symptoms to seek help from a medical specialist for an undiagnosed sleep disorder. | 1 New York state driver's license applicants must have a physician fill out a Physician's Statement for Medical Review Unit that includes a question on sleep disorders. If the physician answers yes, there are follow-up questions on date of diagnosis, whether the patient is being treated, type of treatment, date treatment began and whether patient is compliant. In addition, the driver's manual states: People |

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| | | With Undiagnosed Sleep Disorders — The presence of a sleep disorder also increases the risk of crashes. If you find you are regularly tired during the day or experience any of these symptoms on a regular basis, you may have a sleep disorder and should seek medical help. |
| North Carolina | 4 Many commercial motor-vehicle drivers are required to have medical cards. Those who require medical cards are required to bring them at the time of both the original application and renewal. Commercial motor-vehicle driver operating out-of-state must hold a current NCDOT Medical Card certifying that he or she has passed a physical examination, as required by the ICC. You must have no physical or mental illness that interferes with your ability to control and operate a motor vehicle. You must have no established medical history or clinical diagnosis of epilepsy or any other condition which is likely to cause loss of consciousness or any loss of ability to control a motor vehicle. To operate a commercial motor vehicle, you must have no mental nervous, organic, or functional diseases or psychiatric disorder likely to interfere with your ability to drive a motor vehicle safely. | 2 Driver's manual states people with sleep disorders are at increased risk of crash. |
| North Dakota | 4 No mention of sleep disorders. | 3 No mention of sleep disorders in driver's manual. |
| Ohio | 4 No mention of sleep disorders. | 3 No mention of sleep disorders in driver's manual. |
| Oklahoma | 3 No mention of sleep disorders. | 3 No mention of sleep disorders in driver's manual. |
| Oregon | 4 To qualify for a commercial driver license (CDL) you must pass a Department of Transportation (DOT) medical examination performed in accordance with CFR 49 §391.41 and CFR 49 §391.43. | 3 No mention of sleep disorders in driver's manual, but a caution to pull over if drowsy while driving. |
| Pennsylvania | 4 | 3 PennDOT has a Medical Advisory Board that is responsible for the formulation of physical and mental criteria, including vision standards, for the licensing of drivers. The Board consists of a neurologist, a cardiologist, an internist, a general practitioner, an ophthalmologist, a psychiatrist, an orthopedic surgeon, an optometrist, and members from PennDOT, Department of Justice, Department of Health and the Pennsylvania State Police. The formulation of these regulations is open for public review and comment through the Commonwealth's Regulatory Review process. Pennsylvania law Inattentiveness to the task of driving because of, for example, preoccupation, hallucination or delusion. (ii) Contemplation of suicide, as may be present in acute or chronic depression or in other disorders. (iii) Excessive aggressiveness or disregard for the safety of self or others or both, presenting a clear and present danger, regardless of cause. (6) Periodic episodes of loss of attention or awareness which are of unknown etiology or not otherwise categorized, |

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| | | <p>unless the person has been free from episode for the year immediately preceding, as reported by a licensed physician.</p> <p>(7) Use of any drug or substance, including alcohol, known to impair skill or functions, regardless whether the drug or substance is medically prescribed.</p> <p>(8) Other conditions which, in the opinion of a provider, is likely to impair the ability to control and safely operate a motor vehicle.</p> <p>(c) Driving examination. A person who has any of the conditions enumerated in subsection (b)(1), (2), (3) or (8) may be required to undergo a driving examination to determine driving competency, if the Department has reason to believe that the person's ability to safely operate a motor vehicle is impaired.</p> |
| Rhode Island | 2 You should consult your physician or a local sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, gasp and choke in your sleep, and/or wake up feeling as though you have not had enough sleep | 3 |
| South Carolina | 3 Unable to access CDL manual and no search function on DMV data base. | 3 Unable to access driver's manual, but general description gives no medical requirements, and no search function on DMV site. |
| South Dakota | 3 Although the manual offers the possibility of a medically restricted license, no medical conditions or medical standards are listed. | 3 Although the manual offers the possibility of a medically restricted license, no medical conditions or medical standards are listed. |
| Tennessee | 4 You must have a current, valid medical card | 3 No mention of sleep disorders or any other medical disqualifiers.. |
| Texas | 3 | 3 Applicants must provide answers to medical status and history questions listed on application form. Persons with certain medical limitations may have their cases reviewed by the Texas Medical Advisory Board for Driver Licensing before the license may be issued, |
| Utah | 3 Cautions against drowsy driving, avoiding medications, and emphasizes the importance of recognizing the signals of sleepiness. Advises drivers consult a physical or local or a local sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, gasp and choke in your sleep, and/or wake up feeling as though you have not had enough sleep. | 1 Utah has guidelines and standards for health care professionals in assessing license applicants' functional abilities in driving. Category K covers alertness or sleep disorders. All applicants for licenses will complete a health questionnaire to show their functional ability to drive. If there is a significant health problem, they will take their medical form to a health care professional, who will profile the category for the condition indicated or change it to be consistent with the true medical situation. The health care professional will be expected to discuss the applicant's health as it relates to driving and to make special recommendations in unusual circumstances. Based on a completed Functional Ability Evaluation form, the Driver License Division may issue a license with or without limitations. |

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| Specific criteria? 1= yes; 2= no; 3=not stated; 4=default to federal regulations | | |
| Vermont | 3 Cautions against drowsy driving, avoiding medications, and emphasizes the importance of recognizing the signals of sleepiness. Advises drivers consult a physical or local or a local sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, gasp and choke in your sleep, and/or wake up feeling as though you have not had enough sleep. | 2 No mention of sleep disorders. |
| Virginia | 4 Default to federal regulations | 2 No mention of sleep disorders. |
| Washington | 1 Medical examination form for commercial driver fitness asks if applicant has sleep disorders, pauses in breathing during sleep, loud snoring, or daytime sleepiness. A yes answer requires a date of onset, physician's name and address, and any current limitation. | 1 Will ask driver's license applicants if they have a mental or physical condition or are taking any medications that might impair their ability to drive. If the answer is yes, the department may require examination by a medical specialist. |
| West Virginia | 4 Federal Motor Carrier Rules requires that drivers subject to those rules meet specific physical qualification standards and carry evidence of such qualification in the form of a medial certificate. | 1 You should consult your local physician or a sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, choke or gasp in your sleep, and/or wake up feeling as if you have not had enough sleep. |
| Wisconsin | 1 For school bus or passenger endorsement, applicants with a diagnosis of sleep apnea must present a physician's statement indicating treatment has been successful and the condition will not impair ability to safely operate a commercial vehicle. | 2 No mention of sleep disorders, just a warning against driving while fatigued. |
| Wyoming | 1 You should consult your local physician or a sleep disorder center if you suffer from frequent daytime sleepiness, have difficulty sleeping at night, take frequent naps, fall asleep at strange times, snore loudly, choke or gasp in your sleep, and/or wake up feeling as if you have not had enough sleep. | 2 No mention of sleep disorders. |

Web Resources for State Data

Alabama

DMV website www.dps.state.al.us/

<http://www.dps.state.al.us/DriverLicense/manuals/cdlmanual.pdf>

<http://www.dps.state.al.us/DriverLicense/manuals/DriverManual.pdf>

Alaska

DMV website: <http://www.state.ak.us/>

http://google.state.ak.us/search?q=cache:YMPtS6qsdkYJ:www.state.ak.us/local/akpages/ADMIN/dmv/cdlmanual/manual.pdf+sleep+disorder&access=p&output=xml_no_dtd&site=DMV&ie=UTF-8&client=DMV&proxystylesheet=StateWide&oe=UTF-8

<http://www.state.ak.us/local/akpages/ADMIN/dmv/dlmanual/dlman.pdf>

Arizona

DMV website: <http://www.dot.state.az.us>

www.azdot.gov/mvd/documents/CustomerserviceGuide_99-0117.pdf

<http://mvd.azdot.gov/mvd/formsandpub/viewPDF.asp?lngProductKey=567&lngFormInfoKey=567>

Arkansas

DMV website: <http://www.arkansas.gov/>

http://www.asp.state.ar.us/divisions/hp/pdf/cdl_manual_2003.pdf

http://www.asp.state.ar.us/divisions/hp/pdf/dl_study_guide_0704_rev.pdf

California

DMV website: <http://www.dmv.ca.gov/>

<http://www.dmv.ca.gov/forms/dl/dl51.pdf>

http://www.dmv.ca.gov/pubs/hdbk/hlth_safety.htm

Colorado

DMV website: <http://www.colorado.gov/revenue>

<http://www.colorado.gov/cs/Satellite?blobcol=urlldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition&blobheadername2=MDT->

[Type&blobheadervalue1=inline%3B+filename%3D714%2F305%2F2005_CDLCFinal_Manual122105+margaret%2C0.pdf&blobheadervalue2=abinary%3B+charset%3DUTF-](http://www.colorado.gov/cs/Satellite?blobcol=urlldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition&blobheadername2=MDT-Type&blobheadervalue1=inline%3B+filename%3D714%2F305%2F2005_CDLCFinal_Manual122105+margaret%2C0.pdf&blobheadervalue2=abinary%3B+charset%3DUTF-)

[8&blobkey=id&blobtable=MungoBlobs&blobwhere=1191399221447&ssbinary=true](http://www.colorado.gov/cs/Satellite?blobcol=urlldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition&blobheadername2=MDT-Type&blobheadervalue1=inline%3B+filename%3D714%2F305%2F2005_CDLCFinal_Manual122105+margaret%2C0.pdf&blobheadervalue2=abinary%3B+charset%3DUTF-8&blobkey=id&blobtable=MungoBlobs&blobwhere=1191399221447&ssbinary=true)

<http://www.sos.state.co.us/CCR/Rule.do?deptID=19&deptName=200%20Department%20of%20Revenue&agencyID=76&agencyName=204%20Division%20of%20Motor%20Vehicles&ccrDocID=1957&ccrDocName=1%20CCR%20204->

[12%20RULES%20AND%20REGULATIONS%20FOR%20COMMERCIAL%20DRIVER'S%20LICENSE%20\(CDL\)&subDocID=40471&subDocName=D.%20%20APPLICANT%20LICENSING%20REQUIREMENTS%20\[Eff.%2011/30/2008\]&version=2](http://www.sos.state.co.us/CCR/Rule.do?deptID=19&deptName=200%20Department%20of%20Revenue&agencyID=76&agencyName=204%20Division%20of%20Motor%20Vehicles&ccrDocID=1957&ccrDocName=1%20CCR%20204-12%20RULES%20AND%20REGULATIONS%20FOR%20COMMERCIAL%20DRIVER'S%20LICENSE%20(CDL)&subDocID=40471&subDocName=D.%20%20APPLICANT%20LICENSING%20REQUIREMENTS%20[Eff.%2011/30/2008]&version=2)

Connecticut

DMV website: <http://www.ct.gov/>

<http://www.ct.gov/dmv/LIB/dmv/20/29/R-323.pdf>

<http://www.ct.gov/dmv/lib/dmv/20/29/ctdriver.pdf>

Delaware

DMV website: <http://www.dmv.de.gov/>

http://www.dmv.de.gov/forms/driver_serv_forms/pdfs/dr_frm_cdlmanual_revised_050907.pdf

http://www.dmv.de.gov/forms/driver_serv_forms/pdfs/dr_frm_manual_08182006r.pdf

District of Columbia

DMV website: <http://dmv.washingtondc.gov/>

http://dmv.washingtondc.gov/serv/dlicense/commercial_howto.shtm

<http://dmv.washingtondc.gov/serv/dlicense/DLrenewal.shtm>

Florida

DMV website: <http://www.hsmv.state.fl.us/>

<http://www.flhsmv.gov/handbooks/>

<http://www.lowestpricetrafficschool.com/handbooks/cdl/en/1/3>

Georgia

DMV website: <http://www.dds.ga.gov/>

<http://www.dds.ga.gov/docs/forms/DS-287.pdf>

<http://www.dds.ga.gov/FormsandManuals/index.aspx#Manuals>

Hawaii

DMV website: <http://www.state.hi.us/>

http://www6.hawaii.gov/dot/highways/hwy-v/cdl_apply.pdf

<http://www6.hawaii.gov/dot/highways/hwy-v/HIDrvMan.pdf>

Idaho

DMV website: <http://www.itd.idaho.gov/>

http://itd.idaho.gov/dmv/MotorCarrierServices/mc_qual.htm

http://www.itd.idaho.gov/dmv/DriverServices/documents/cdl_manual.pdf

http://www.itd.idaho.gov/dmv/DriverServices/documents/driver_manual.pdf

Illinois

DMV website: <http://www.sos.state.il.us/>

http://www.sos.state.il.us/departments/drivers/drivers_license/medical_vision.html

http://www.itd.idaho.gov/dmv/DriverServices/documents/cdl_manual.pdf

Indiana

DMV website: <http://www.in.gov/>
<http://www.in.gov/bmv/3250.htm>
http://www.in.gov/bmv/files/Indiana_Driver_Manual_-_Chapter_One.pdf

Iowa

DMV website: <http://www.iamvd.com/>
<http://www.iamvd.com/ods/dlmanual/section1.pdf>

Kansas

DMV website: <http://www.ksrevenue.org/>
<http://www.cdl-course.com/faq-ks.html>

Kentucky

DMV website: <http://transportation.ky.gov/>
http://www.kentuckystatepolice.org/pdf/2006_ky_drivers_manual.pdf

Louisiana

DMV website: <http://omv.dps.state.la.us/>

Maine

DMV website: <http://www.state.me.us/>
http://www.maine.gov/search?q=CDL+medical&as_sitesearch=http%3A%2F%2Fwww.maine.gov%2Fsos%2Fbmvd&site=test_collection&output=xml_no_dtd&client=test_collection&proxystylesheet=test_collection
<http://www.maine.gov/sos/cec/rules/29/250/250c003.doc>

Maryland

DMV website: <http://www.mva.state.md.us/>
<http://www.mva.state.md.us/DriverServ/Apply/CDL/commercial.htm>
<http://www.mva.state.md.us/OnlineServices/Docs/default.htm>

Massachusetts

DMV website: <http://www.mass.gov/>
<http://www.mass.gov/rmv/medical/mabrochure.pdf>

Michigan

DMV website: <http://www.michigan.gov/>
http://www.michigan.gov/sos/0,1607,7-127-1627_8666_9060-21614--,00.html
http://www.michigan.gov/documents/SOS_WEDMK_1_Michigan_Drivers_License_Information_158263_7.pdf

Minnesota

DMV website: <http://www.dps.state.mn.us/>
<http://www.dps.state.mn.us/dvs/DLTraining/DLManual/PDF/08CDLManual.pdf>
<http://www.dps.state.mn.us/dvs/DriverLicense/DL%20Info/DL%20frame.htm>

Mississippi

DMV website: <http://www.dps.state.ms.us/>
<http://www.dps.state.ms.us/dps/dps.nsf/webFAQs/BD9DC256D817FB8A86256AF10057409D?OpenDocument>
<http://www.dps.state.ms.us/dps/dps.nsf/divpages/hp2ds-info-classR?OpenDocument>

Missouri

DMV website: <http://www.dor.mo.gov/mvdl/>
<http://dor.mo.gov/mvdl/drivers/forms/cdl.pdf>
<http://dor.mo.gov/mvdl/drivers/dlguide/chapter1.pdf>

Montana

DMV website: <http://www.doj.mt.gov/driving/driverlicensing.asp>
http://mt.gov.cdc.nicusa.com/search?entqr=0&ud=1&sort=date%3AD%3AL%3Ad1&output=xml_no_dtd&oe=UTF-8&ie=UTF-8&client=Justice&proxystylesheet=Justice&site=Justice&q=CDL+medical
http://data.opi.mt.gov/bills/mca_toc/61_5_1.htm

Nebraska

DMV website: <http://www.dmv.state.ne.us/>
<http://www.dmv.state.ne.us/examining/pdf/cdlmanual.pdf>
<http://www.dmv.state.ne.us/examining/pdf/engdrivermanual.pdf>

Nevada

DMV website: <http://www.dmvnv.com/>
<http://www.dmvnv.com/pdfforms/dlbookcomm.pdf>
<http://www.dmvnv.com/pdfforms/dlbook.pdf>

New Hampshire

DMV website: <http://nh.gov/>
<http://www.nh.gov/safety/divisions/dmv/documents/nhcdm.pdf>
<http://www.nh.gov/safety/divisions/dmv/driverlic/faq.html#A7>

New Jersey

DMV website: <http://www.state.nj.us/>
http://www.state.nj.us/mvc/pdf/Commercial/CDL_Manual_english.pdf
http://www.state.nj.us/mvc/manuals/chap_02_01.html

New Mexico

DMV website: <http://www.state.nm.us/>
<http://www.cdl-course.com/faq-nm.html>

New York

DMV website: <http://www.nydmv.state.ny.us/>
<http://www.nysdmv.com/forms/mv80u1.pdf>
<http://www.nydmv.state.ny.us/license.htm#drivermed>
http://www.nysdmv.com/broch/DM-04_07.pdf

North Carolina

DMV website: <http://www.ncdot.org/>
http://www.ncdot.gov/dmv/driver_services/commercialtrucking/requirements.html
http://www.ncdot.gov/dmv/driver_services/drivershandbook/download/NCDL_English.pdf

North Dakota

DMV website: <http://www.state.nd.us/>
http://www.dot.nd.gov/docs/class_c1.pdf
<http://www.dot.nd.gov/docs/rulesroad.pdf>

Ohio

DMV website: <http://dmv.ohio.gov/>
http://bmv.ohio.gov/driver_license/cdl.htm#Procedures
http://bmv.ohio.gov/driver_license/first_dl_exam.htm

Oklahoma

DMV website: <http://www.dps.state.ok.us/>
<http://www.dps.state.ok.us/dls/pub/ODM.pdf>
<http://www.dps.state.ok.us/dls/pub/ODM.pdf>

Oregon

DMV website: <http://www.oregon.gov/ODOT/DMV>
<http://www.odot.state.or.us/forms/dmv/37.pdf>

Pennsylvania

DMV website: <http://www.dmv.state.pa.us/>
<http://www.dot3.state.pa.us/driverSafetyCenter/medicalCriteria.shtml>
<http://www.pacode.com/secure/data/067/chapter83/chap83toc.html>
http://www.dot3.state.pa.us/pdotforms/dl_forms/dl-143cdi.pdf

Rhode Island

DMV website: <http://www.dmv.state.ri.us/>
http://www.dmv.state.ri.us/documents/manuals/CDL_Manual.pdf

http://www.dmv.state.ri.us/documents/manuals/Driver_Manual_FINAL.pdf

South Carolina

DMV website: <http://www.scdmvonline.com/>

<http://www.scdmvonline.com/DLgeneral.aspx#GetDL>

http://www.scdmvonline.com/forms/DriverManual/Eng_4_Trucks.pdf

South Dakota

DMV website: <http://www.state.sd.us/drr2/motorvehicle/>

http://www.state.sd.us/dps/dl/Online_Manuals/2005%20CDL%20MANUAL.pdf

http://www.state.sd.us/dps/dl/Online_Manuals/2005%20CDL%20MANUAL.pdf

Tennessee

DMV website: <http://www.tennessee.gov/>

<http://tennessee.gov/safety/publications/CDLManual08.pdf>

Texas

DMV website: <http://www.txdps.state.tx.us>

<http://www.txdps.state.tx.us/ftp/forms/CDLhandbook.pdf>

http://www.txdps.state.tx.us/administration/driver_licensing_control/faq/answers_dl_id.htm#q33

http://tennessee.gov/safety/dlhandbook/DL_HandbookWeb2007.pdf

Utah

DMV website: <http://driverlicense.utah.gov/>

<http://publicsafety.utah.gov/dld/docs/2005%20CDL%20DRIVER%20MANUAL%20Final%20Revised%20Oct%202007.pdf>

<http://www.rules.utah.gov/publicat/bulletin/2009/20090101/32202.htm>

http://publicsafety.utah.gov/dld/docs/functional_ability.pdf

Vermont

DMV website: <http://www.aot.state.vt.us/>

<http://www.aot.state.vt.us/dmv/documents/Manuals/CommercialVehicle/TAVN111CDLDriverManual.pdf>

<http://www.aot.state.vt.us/dmv/documents/Manuals/DriverLicense/TAVN0072007DriverManual.pdf>

Virginia

DMV website: <http://www.dmv.state.va.us/>

<http://www.dmv.virginia.gov/webdoc/citizen/drivers/applyingcdl.asp>

DMV website: <http://www.dmv.state.va.us/>

Washington

DMV website: <http://www.dol.wa.gov/>

<http://www.dol.wa.gov/forms/520061.pdf>

<http://www.dol.wa.gov/driverslicense/driversguide.pdf>

West Virginia

DMV website: <http://www.wvdot.com/>

http://www.wvdot.com/6_motorists/dmv/downloads/drivershandbook.pdf

http://www.wvdot.com/6_motorists/dmv/6g1a_licenseinfo.htm#Who%20Must%20Be%20Tested

http://www.wvdot.com/6_motorists/dmv/6g0_cdl.htm#Age%20&%20Fitness%20Requirements

Wisconsin

DMV website: <http://www.dot.state.wi.us/>

<http://www.dot.wisconsin.gov/statepatrol/docs/trans112.pdf>

<http://www.dot.state.wi.us/drivers/docs/e-handbook.pdf>

Wyoming

DMV website: <http://www.dot.state.wy.us/>

<http://www.dot.state.wy.us/Default.jsp?sCode=drvcm>

<http://www.dot.state.wy.us/Default.jsp?sCode=drvvo>

Appendix B: Sleep Scales

Epworth Sleepiness Scale (ESS) (Measure of chronic sleepiness)

This is a measure of how likely individuals are to doze off or fall asleep in the following situations, in contrast to feeling just tired? It is intended to capture an individual's usual way of life in recent times. Individuals are instructed to assign the most appropriate number for each situation.

| Situation | Chance of Dozing 0 = no chance of dozing 1 = slight chance of dozing 2 = moderate chance of dozing 3 = high chance of dozing |
|---|--|
| Sitting and reading | |
| Watching TV | |
| Sitting inactive in a public place (e.g a theater or a meeting) | |
| As a passenger in a car for an hour without a break | |
| Lying down to rest in the afternoon when circumstances permit | |
| Sitting and talking to someone | |
| Sitting quietly after a lunch without alcohol | |
| In a car, while stopped for a few minutes in traffic | |

- A score of 0 – 9: Average score, characteristic of the normal population
- A score of 10 – 24: Indicates some level of chronic sleepiness; sleep specialist advice recommended

Stanford Sleepiness Scale (Measure of acute sleepiness)

This is a quick way to assess how alert individuals are feeling at a given time. Individuals are instructed to take into account that most people have two peak times of alertness daily, at about 9 a.m. and 9 p.m. Alertness wanes to its lowest point at around 3 p.m.; after that it begins to build again. Individuals are instructed to rate their alertness at different times during the day. If the score goes below a three when the individual should be feeling alert, this is an indication of a serious sleep debt and the need for the individual to obtain more sleep.

1. Felt active, wide awake
2. Was functioning at a high level but not at peak
3. Felt relaxed, awake but not fully alert, responsive
4. Felt a little foggy headed
5. Felt foggy headed, had difficulty staying awake, was beginning to lose track

6. Felt sleepy, would have preferred to lie down, woozy
7. Could not stay awake, sleep onset was imminent