Sleepiness occurs in almost everyone at some time during each day. If sleepiness becomes moderate to severe, it can have an impact on an individual’s ability to perform tasks that are prolonged or require a high degree of concentration. Driving is a daily activity that usually involves repetitive behaviors over a prolonged period, and it may be adversely affected by an individual who is sleepy. Data from the Department of Transportation show that sleepiness and fatigue contribute to numerous accidents on the road. This article reviews information related to the effects of sleepiness on driving, the types of sleepiness, and some tools for assessing sleepiness.

(Key words: sleepiness, inattention, sleep, sleep disorders, sleep deprivation, driving, transportation, accident risk)

We are just beginning to understand the extensive problems associated with sleepiness and inattention while driving. In a recent survey by the National Sleep Foundation, 23 percent of the people who were polled admitted falling asleep while driving in the past year. An estimated 24,000 people die each year in accidents caused directly or in part by people who were polled admitted falling asleep while driving. This is a daily activity that usually involves repetitive behaviors over a prolonged period, and it may be adversely affected by an individual who is sleepy. Data from the Department of Transportation show that sleepiness and fatigue contribute to numerous accidents on the road. This article reviews information related to the effects of sleepiness on driving, the types of sleepiness, and some tools for assessing sleepiness.

(Manifest sleepiness refers to the degree of sleepiness that occurs when an individual is interacting with his or her environment. In this instance, the subject’s behavior or manifested tendency to fall asleep is the principal measure. This type of sleepiness can be viewed as “difficulty in maintaining alert wakefulness with a tendency to fall asleep.” Sleepiness is a normal physiologic phenomenon that everyone has experienced and is caused by insufficient sleep or by recurrent disruption of sleep. The actual manifestation of sleepiness depends on the environmental stimuli presented to the individual, the importance or concern that those cues elicit, and several individual factors. Individual factors such as age, medical illness, and sleep disorders can affect the quality and quantity of sleep, thereby influencing daytime sleepiness. Other factors, including boredom, alcohol ingestion, medication use, food, and the time of day (that is, circadian effects), may further affect the severity of sleepiness and may lead to inattention.

When we discuss sleepiness, there are three classifications of sleepiness that help us to better understand sleepiness: physiologic sleepiness, manifest sleepiness, and introspective, or perceived, sleepiness.

Physiologic sleepiness refers to the intensity of the drive to fall asleep that occurs at a particular time of day when external stimuli are minimized. The intensity of sleepiness is typically measured by determining the rapidity of sleep onset in an environment conducive to sleeping. In the setting of a person without disease, sleepiness is mainly affected by the time elapsed since the most recent sleep, the quantity and quality of sleep in recent days, and the circadian pattern of the individual. The Multiple Sleep Latency Test (MSLT), described later, is the most accurate tool used to assess physiologic sleepiness.

Manifest sleepiness refers to the degree of sleepiness that occurs when an individual is interacting with his or her environment. In this instance, the subject’s behavior or manifested tendency to fall asleep is the principal measure.
of sleepiness is affected by the intensity of the individual’s physiologic sleepiness, the degree of environmental stimulation, and the individual’s ability to arouse himself/herself. In contrast to the MSLT, the Maintenance of Wakefulness Test is the most commonly used assessment of manifest sleepiness and measures how long a subject is able to remain awake in a dark, comfortable reclining position with the eyes closed.

**Introspective sleepiness** refers to the self-assessment of sleepiness. It is a much more subjective measurement of sleepiness. Physiologic factors, environmental factors, and personal factors such as boredom all have a significant influence on perceived sleepiness. Questionnaires are usually used to assess the degree of introspective sleepiness. All the commonly used questionnaires gain validity and reliability by assessing the perception of sleepiness for certain circumstances. One example is the Epworth Sleepiness Scale (ESS), which was developed to provide the clinician with a simple and somewhat reliable assessment of sleepiness that could be used in the office. Without such metrics, research shows that individuals often will misjudge their degree of sleepiness.

**Inattention** is technically different from sleepiness. No clear medical definition of this term exists. From the dictionary, “inattention” can be interpreted as “unilateral neglect.” In other words, the individual attends to one activity or selectively ignores a particular sensory input. Essentially, when one concentrates on one task, he or she might ignore other tasks. For those tasks, the subject is inattentive. Therefore, inattention may be considered to exist only when multiple tasks are presented to the individual. Unfortunately, that generally includes most of our activities of daily living.

Inattention has some overlap with sleepiness, however. As the degree of physiologic sleepiness increases, the likelihood of being inattentive also increases. Thus, one can be drowsy but attentive, or be inattentive while wide awake, or be both inattentive and drowsy. Although the relationships between sleepiness and inattention are often complex and affected by task duration, they can be evaluated by performance models. The more sophisticated models will include cognitive, physiologic, and time domain components. Pioneering work that will be widely applicable to clinical medicine and public health initiatives is being done in this field at the Walter Reed Army Institute of Research (WRAIR).

Another term that is used in driving environments is **fatigue**. Fatigue has been described as a “disinclination to continue performing the task at hand.” It is different from sleepiness and can be viewed as a component of inattention that is affected by task complexity and the duration of the effort.

**Problems associated with sleepiness and inattention**

One of the major challenges facing most physicians, particularly those in primary care practice, is the explosion of information regarding sleep and sleep disorders. This is compounded by the paucity of information routinely taught in most medical schools; most physicians receive only less than 2 hours of instruction in sleep problems in their 4 years of medical school and postgraduate training. In their outstanding book, Dement and Vaughn state with respect to sleep and its disorders:

> Never before in human history has a disparity between the amount of scientific knowledge and the benefit of that...
knowledge to society been so tragically vast. As a result of this alarming lack of awareness about sleep in the medical community, doctors simply miss or ignore a veritable flood of sleep disorders. Hundreds of thousands of people worldwide are dying each year in large part because of undiagnosed and untreated sleep problems—tens of thousands in the United States alone.

Nowhere is this of greater concern than with disorders and settings where sleepiness and inattention are prevalent; such is the case with driving and other forms of transportation.

Sleepiness during driving
Sleepiness in driving is the combination of physiologic sleepiness, manifest sleepiness, and introspective sleepiness. Of the three kinds of sleepiness, the first one is the most important one with regard to accident risk. And among the causative factors, the quality of previous sleep is the most important. Fairclough and Graham found that a group, under conditions of complete sleep, deprivation exhibited a safety-critical decline in lane-keeping performance.

Many reviews have concluded that patients with sleep apnea have higher automobile accident rates than control subjects. Sleep apnea is one of the most common causes of physiologic sleepiness.

Other factors, including age and gender, can also affect physiologic sleepiness. For example, research on driving simulators has found that increasing age is related to poorer driving performance. Environmental factors induce manifest sleepiness. Familiar/boring scenes during a trip decrease the excitation state of the brain and also decrease the sensitivity to stimuli. Thereby, the subject may not respond quickly enough in an emergency situation.

Following is some information on drowsy driving from a report of the National Highway Transportation Safety Administration (NHTSA):

1. A typical crash related to sleepiness has the following characteristics: The problem occurs during late night/early morning or mid-afternoon. The crash is likely to be serious. A single vehicle leaves the roadway. The crash occurs on a high-speed road. The driver does not attempt to avoid a crash. The driver is alone in the vehicle.

2. Although evidence is limited or inferential, chronic predisposing factors and acute situational factors recognized as increasing the risk of drowsy driving and related crashes include: sleep loss; driving patterns, including driving between midnight and 6 a.m.; driving a substantial number of miles each year and/or a substantial number of hours each day; driving in the mid-afternoon hours (especially for older persons); and driving for longer times without taking a break; use of sedating medications, especially prescribed anxiolytic hypnotics, tricyclic antidepressants, and some antihistamines; untreated or unrecognized sleep disorders, especially sleep apnea syndrome (SAS) and narcolepsy; consumption of alcohol, which interacts with and adds to drowsiness. These factors have cumulative effects; a combination of them substantially increases crash risk.

3. Although no driver is immune, the following three population groups are at highest risk, based on evidence from crash reports and self-reports of sleep

Figure 4. Methods to assess sleepiness.

| Questionnaires | □ Assess perceived sleepiness; examples include:  
  - Stanford Sleepiness Scale  
  - Epworth Sleepiness Scale |
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<tr>
<td>Multiple Sleep Latency Test (MSLT)</td>
<td>□ Assesses physiologic sleepiness.</td>
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<tr>
<td>Maintenance of Wakefulness Test</td>
<td>□ Assesses manifest sleepiness.</td>
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This method is subject to the most variability but is excellent for the clinical setting.  
Advantages: Easy to apply and follow.  
Disadvantages: Questionnaires are affected by personal inclinations and testing conditions. They are less consistent than the other forms of testing.

This method is the best studied and has the widest clinical application. Most sleep centers can perform this test.  
Advantages: Reliable with good validity  
Disadvantages: Expensive and time consuming

This method is most commonly used in the airline industry for the assessment of pilots.  
Advantages: Similar methodology to the MSLT.  
Disadvantages: Expensive, not as well studied as the MSLT, interpretation of results is difficult and may vary.
performance. Following are two examples.

Inattention during driving
Driving sleepiness/fatigue is the third leading cause of accidents in America, and much research has been and is being carried out to find ways to deal with it. Not much research, however, is focused on inattention while driving. This lack is particularly unfortunate, because it is believed that driving inattention may be a larger problem than driving sleepiness/fatigue.

Inattention is particularly hard to define, and an extensive array of factors affects attention. Generally, inattention implies a failure to pay attention to a particular task. This failure may be due to distracting influences or to an inability related to a physiologic factor such as sleepiness.

One example is that of cellular phone use while driving. Recent data show that increased use of cellular phones while driving will increase the risks of a traffic accident. The combined use of cellular phones and other motor and cognitive activities while driving will also increase the risks of a traffic accident. Such tasks as dialing the telephone, writing while driving, or attending to other activities in the car all contribute to the risk of an accident. Despite the potential impact, inattention has only begun to be studied. The paucity of research was evident in that we could find no specific research reports on inattention in the literature.

Sleepiness, performance, and driving
Much is at stake with respect to the effects of sleepiness on driving performance. Although anyone who is sleepy is at risk, there are several examples of specific at-risk populations, including patients with sleep apnea, shift workers, long-haul truckers, and soldiers in mechanized operational settings. A number of organizations are conducting research into the effects of sleepiness on driving performance. Following are two examples.

Total sleep deprivation and performance
The WRAIR is a leading laboratory for research into the effects of sleep deprivation. It is, of course, primarily interested in sustaining performance during continuous military operations. This is probably one of the prototypes for activities requiring a high level of attention over long periods with significant consequences if inattention occurs. In this regard, these operations are not unlike many driving situations.

Some of the most important WRAIR findings include the following:
- Total sleep deprivation degrades human mental performance, in approximately linear fashion, by 25% for each succeeding 24 hours awake.
- Speed (such as reaction time) degrades more than accuracy.
- Sleep deprivation decreases brain activation as measured by brain glucose metabolism.
- The regions of the brain most impaired during prolonged waking are deactivated to a greater degree during sleep, suggesting that they have a greater need for sleep-mediated recuperation.

Partial sleep deprivation—driving performance
A sleep deprivation study was carried out at the Indiana University School of Medicine to test a concept of a drowsy driver alarm system. The premise was that slowed responses would indicate inattention or the effects of sleepiness. To test this hypothesis, 12 medicine residents at the Indiana University Medical Center completed five sessions on a driving simulator. Each underwent at least one familiarization trial. The residents underwent these sessions either after 2 to 3 days of normal sleep or after a night on call. During the on-call nights, the residents averaged about 1 to 2 hours of sleep. The sessions were performed in a randomized fashion, and the testing occurred about mid-day.

We found several significant effects of acute sleep deprivation. First, despite the familiarization trial, there was a learning curve in the performance on the following trials. This learning curve was likely due to the fact that the driving simulator is a novel experience to most of the subjects. Consequently, it is also likely that the residents performed better than would otherwise be expected simply because it was a relatively novel experience, a factor affecting the degree of manifest sleepiness.

Several expected and unexpected results were found during the study. Slow corrections were frequently found during large turns in the road. During sleep-deprived sessions, however, the subject tended to overcorrect the wheel, resulting in large standard deviations of wheel position with small standard deviations of lane position. These data would suggest that inattention related to partial sleep deprivation causes a bimodal model response to events. On the low side, the subject is sleepy and does not move the wheel often and may exhibit a drift in his or her driving pattern; whereas on the higher side, the subject exhibits intermittent attention and tends to overreact to situations resulting in an overcorrection in the wheel. Either one of these patterns may result in accidents, but such a pattern should begin to alert informed drivers that fatigue may be having an impact on their ability to drive.

Sleep disruption due to medical illness
The prototype of sleep disruption related to medical illness is obstructive sleep apnea (OSA). Individuals with this disease will have partial or complete closure of the airway during sleep. The resultant decrease in airflow leads to frequent arousals and the appearance of daytime sleepiness. The result is an increased risk of driving accidents, as has been documented by self-report questionnaires and accident reports. In each of these circumstances, patients with OSA have been shown to have an increase in accidents.

Clinical tools to assess sleepiness
Sleepiness manifests differently, depending on the individual’s ability to tolerate sleep deprivation, the degree of sleep deprivation, a variety of physiologic factors including time of day, and the situ-
tion. Tools to assess sleepiness try to evaluate one of three major categories of sleepiness: physiologic sleepiness, manifest sleepiness, or perceived sleepiness.

The cumulative effects of our individual ability to tolerate sleepiness, environmental effects, our physiologic level of sleepiness, and the time of day all affect the determination of sleepiness. Most individuals who frequently limit their sleep or have erratic sleep-wake schedules do not accurately judge their level of physiologic sleepiness. Thus, a variety of testing procedures has been developed to assist the clinician in the determination of sleepiness.

Multiple Sleep Latency Test

The MSLT measures how quickly a person falls sleep during several “naps” across the day. The naps are performed with the individual in street clothes lying down in a dark, comfortable room. The test usually involves four or five 20-minute opportunities to sleep offered at 2-hour intervals 2 hours after awakening. Each 20-minute opportunity to sleep is given to subjects lying in a darkened, quiet room and asked to try to fall asleep. Polysomnographic variables are monitored, and sleep is scored using standard criteria. This test must, of course, be administered by qualified technicians in a sleep laboratory. It is the most reliable measurement of physiologic sleepiness.

Maintenance of Wakefulness Test

The Maintenance of Wakefulness Test is a test similar to the MSLT, except that the patient is instructed to try not to fall asleep. The other aspects of the test are identical. This test is used to assess manifest sleepiness and is frequently used in the evaluation of airline workers.

Questionnaires—Epworth Sleepiness Scale

The Epworth Sleepiness Scale (ESS) was developed by Johns as a questionnaire that could be administered in the office or home setting. It is a simple, self-administered questionnaire that can provide a measurement of the subject’s general level of perceived sleepiness. The questionnaire attempts to assess the level of sleepiness in several situations and then uses the sum of the answers as an index of sleepiness. Data relating MSLT findings and the ESS suggest that pathologic levels of sleepiness begin to occur when the individual’s total score is 13 or above. Levels lower than 13 may indicate moderate to mild levels of sleepiness.

Countermeasures

The term countermeasures is used to describe activities that offset or counteract, usually on a temporary basis, adverse events. In the context of this article, it implies activities that delay the onset of manifest sleepiness, substances that enhance the performance of the sleepy individual, strategic napping (or power napping), or systems that alert the individual when sleepiness or inattention becomes imminent.

Strategies commonly used by the general public to offset the effects of sleepiness include listening to the radio, adjusting the window or air conditioning (or both), or drinking beverages containing caffeine. Each of these countermeasures either involves ingesting something that facilitates wakefulness or creates an environment where constant stimulation exists. Few if any of these strategies work well for anything except mild sleepiness.

Other countermeasures used during constant operations and under some typical conditions of sleep deprivation include the use of strategic naps. The original study was performed in pilots while they were in the cockpit for long flights. In these circumstances, the pilots were allotted a 40-minute period to rest and averaged about 26 minutes of sleep. These naps resulted in improved performance during both night and daytime hours of operation with a reduction in “microsleeps” (such as short episodes of spontaneous sleep lasting 5 to 15 seconds). Thus, short-lived naps may be an effective measure to maintain performance in individuals with limited sleep or under conditions of prolonged activity.

A major challenge facing engineers and scientists is designing vehicles that include minimally invasive (ideally, noninvasive) intelligent systems that can sense a driver’s inattention and sleepiness. The simplest approach would make the driver aware of the sleepy or inattentive state in some way, such as sounding an alarm. It would still be up to the driver to take corrective action. A more sophisticated approach that may be available in a few years would notify the driver of the situation and then control the vehicle in some way to reduce the risk of an accident, such as setting a maximum speed or increasing the minimum following distance (or both). (Radar-based devices that include controls for maintaining minimum following distances will be available within a few years.)

Despite the potential for such systems, researchers have been largely unsuccessful in finding a feasible way to identify sleepiness or inattention (or both). Also, some concerns exist about sleepiness/inattention alarm systems in general. It is feared that these instruments will create a false sense of security and that individuals may rely on these alert systems rather than addressing the fundamental problem of sleep deprivation and drowsiness. Under these conditions, the systems could increase the risk of accidents rather than reducing them. Thus, for the present, the only truly effective countermeasure to prevent a drowsy driver from having accidents is to stop driving or to get a good night’s sleep.

Clinical applications

The issues involved with sleepiness and inattention affect the population at large and represent a significant issue for patients of primary care physicians. For most of these individuals, the effects of sleepiness and inattention involve simply being sleepy or having difficulty with intellectual performance; however, under many circumstances, sleepiness and its cousin inattention can result in driving mistakes, accidents in the workplace, or significant declines in workplace performance.

The general tendency of our culture to allow—even encourage—individuals to push the limits and function in a sleep-deprived state makes sleepiness and inattention a difficult problem to address. These issues are further complicated by
an inability to self-determine the degree of impairment until it is severe. With an increase in the level of physiologic sleepiness, there is a concomitant increase in the likelihood of inattention, especially with prolonged or cognitively demanding activities.

The most effective intervention for the adverse effects of sleepiness is recognition and prevention. For the primary care physician, simply screening patients for irregular working hours, poor sleep hygiene, chronic limitations in the sleep period, and underlying disorders that may disrupt sleep will identify most at-risk individuals. To this evaluation can be added assessment tools that can be easily implemented, such as the Epworth Sleepiness Scale. Most of these assessments can be part of the routine evaluation of the patient or can be easily incorporated into a questionnaire given to the patient. Indicators of limited sleep, erratic sleep schedules, shift work, or overt sleepiness should be followed up by a more detailed evaluation and a discussion of the effects of sleepiness on performance.

For some individuals who may have underlying medical disorders or are involved with professional transportation endeavors, the assessment of sleepiness and related problems may require formal sleep studies to be performed. For instance, some states require patients with OSA to be reported to the bureau of motor vehicles, or pilots may lose their medical certificate until the disorder is adequately treated. Many of the legal issues vary from state to state, whereas others may be under the regulatory authority of the Department of Transportation. Physicians should realize that as the effects of sleepiness and sleep disorders become more widely recognized, it may be incumbent on them to be familiar with the regulations in their regions and to appropriately inform patients of potential problems.

Finally, education, as with many other areas of medicine, is extremely important for individuals who may be at risk for sleepiness and inattention. In this regard, the medical professional is one of the best individuals to advise people regarding the risks and preventive measures that can be incurred. For most of us, not being inattentive to these issues is one of the most difficult tasks that we face on a day-to-day basis.

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