

# Sleep Medicine, Public Policy, and Public Health

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## ABSTRACT

A sizable body of knowledge comprises the sleep medicine field and a significant proportion relates to public health in a number of ways. The prevalence of sleep disorders and the widespread occurrence of sleep deprivation in modern society affect the public through industrial and transportation accidents, and in reduced performance in the workplace and in educational settings. Sleep disturbances also may contribute to epidemic societal levels of hypertension and cardiovascular disease, obesity, and diabetes. In part, the failure of the biomedical community to translate research advances into educational messages, interventional research, individual lifestyle changes, and institutional and public policies underlies the heavy public health burden. The minimal responsiveness of policy makers in many industries and the government also contributes to the impact on public health. Health professionals in general, and sleep specialists specifically, are encouraged to participate in the translation of sleep medicine advances for the betterment of society.

Sleep is among the most basic of human needs. Waking brain function and behavioral capability depend on obtaining adequate sleep quality and quantity each day. As amply illustrated throughout this book, a person's sleep can be disrupted not only by pathologic processes but also by a person's lifestyle and by societal demands on the sleep-wake schedule.<sup>1</sup> When sleep disruption occurs, regardless of the reason, the consequences for the individual and in some circumstances for society can be serious. At present there is only limited recognition of this fundamental fact because of failure to translate advances in sleep science and medicine into educational programs and institutional action directed toward improved public health and safety.

Sleep medicine constitutes an important public health resource because of the widespread and diverse ways in which sleep and sleepiness are related to public health and safety. Health professionals have always had a major role in decisions regarding public health issues. One does not have to look far to find cogent examples of behavioral and societal changes that were initiated by and through the health care system that reduced the prevalence of catastrophic outcomes. Physicians advanced the knowledge of linkages between "unseen" microbes and disease, which led to improvements in food preparation and waste disposal. Pulmonologists led the way in reducing cigarette smoking. Emergency department physicians helped

implement mandatory seatbelt laws. These and many other public health initiatives have saved millions of lives, and improved the quality of life for many more. It can be argued that sleep loss and sleepiness are other "unseen" threats to public health. It is now appropriate and necessary to develop similar educational and regulatory approaches to improve society's understanding of sleep and sleep disorders, and to modernize public policies that affect the quantity and quality of sleep. By communicating what has been learned about the effects of sleep disturbances, sleep loss, and sleepiness on public health and safety, health care professionals can contribute to the formulation of behaviors and public policies that promote healthy sleep and prevent sleepiness on the job and during other safety-sensitive activities such as driving.<sup>2-4</sup>

The purpose of this chapter is to review aspects of sleep science and sleep medicine from a societal perspective and to facilitate translation of that knowledge into behaviors and practices that will have a positive impact on public health. The public health benefits of enhanced application of research findings in various biomedical fields have recently received increased attention.<sup>5</sup>

## SLEEP IN MODERN SOCIETY

Sleep, like many other aspects of human activity, has been irrevocably altered by the industrial revolution and its attendant artificial light and affordable energy. Around-the-clock operations are now commonplace and the time traditionally allocated to sleep has given way to expanded hours for business, long commutes, recreation, and so on. As societies make the transition from agrarian economies to industrial economies, some of the more dramatic changes that occur involve sleep. For example, the transition to industrialization typically involves elimination of daytime siesta and implementation of shift work.<sup>6-8</sup> The advent of highly technological societies has made inadequate daily sleep and substandard levels of waking alertness commonplace for many people. As a result, there is a risk of sleepiness-related human errors in many segments of society, such as public transportation, energy plants, security and public safety, and military operations. Errors in situations such as these can have catastrophic consequences. When such catastrophes have occurred on the night shift, such as the event at Three Mile Island nuclear power plant and the grounding of the *Exxon Valdez* oil tanker, public trust in these industries has been undermined.<sup>2</sup>

Technological advances have markedly reduced or eliminated many sources of accidents, but sleep deprivation and its

consequent fatigue and human error continue to contribute to performance failures and accidents throughout society.<sup>8</sup> Automation has potentiated the negative effects of reduced alertness by increasing the monotony involved in many jobs, leaving people to stand vigil—an activity that is especially susceptible to elevated sleep pressure and sleepiness.<sup>9,10</sup> At present, human error causes the majority (60% to 90%) of all industrial and transportation accidents.<sup>2,9</sup> Although the proportion that is directly related to sleep loss, fatigue, and sleepiness is unknown, the economic and human impact is undoubtedly substantial.

Unfortunately and ironically nearly 100 years of technological advances aimed at improving life has been accompanied by a parallel reduction in societal priority for adequate sleep. For example, in 1913, 8- to 12-year-old schoolchildren slept an average of 10.5 hours per night<sup>11</sup>; by 1964, the average had dropped to 9.2 hours per night.<sup>12</sup> In 1994, 13- to 14-year-olds averaged 7.7 hours on school nights and 9.5 hours on weekends.<sup>13</sup> Failure to understand the effect of inadequate sleep on the entire 24-hour cycle has created a public health problem. Even modest amounts of daily sleep loss accumulate as a *sleep debt* that is manifest as an increasing tendency to fall asleep<sup>14,15</sup> and a reduced level of neurobehavioral function.<sup>13,16</sup> Although most people can resist this tendency under normal circumstances, when physical activity is low and circadian alerting effects are minimal, the likelihood of a lapse in vigilance, a "microsleep," or a longer sleep episode can become high. People who are directly responsible for public health and safety, including but not limited to doctors and nurses, often work night shifts and long hours that make them prone to sleepiness-related errors.<sup>17</sup> In work environments where sustained attention is necessary for safety, the probability of an accident rises and falls along with the biologic tendency to fall asleep.<sup>18</sup> Thus, catastrophic accidents related to sleepiness and fatigue do not occur at random throughout the day. Rather, they are more likely at times when human beings are most prone to sleep, between midnight and 8 AM and between 1 and 3 PM.<sup>19,21</sup>

## THE CHALLENGE

Most people, including many involved in public health and public policy, do not know the fundamentals of homeostatic sleep need and circadian physiology; and most remain unaware of, or choose to ignore, important relationships between sleepiness and human waking performance capacity. Societal ignorance about the importance of sleep stems in part from the relative recency of scientific and medical advances in this area. In addition, our educational systems have been slow to integrate into course work even the most fundamental principles of the field, such as that the effects of chronic sleep restriction on the ability to perform are cumulative (see Chapter 6), or that adolescents require much more sleep than they routinely obtain,<sup>22</sup> or that driving while sleepy is as risky as driving while impaired by alcohol.<sup>23</sup> Rather, if any sleep material is presented it tends to focus on descriptive information that is largely irrelevant to public health, such as sleep stages or dreaming.

The challenge sleep specialists face is to develop methods to translate the body of sleep medicine knowledge into messages and strategies directed toward reducing or resolving the economic, social, health, and safety issues associated with insufficient or disrupted sleep. Such translation is essential if

the knowledge of sleep science is positively to influence public health. Lessons from other areas of medicine that led to major societal policy and behavior changes, and subsequently to improved public health, are instructive. For example, changes in societal behavior and institutional policies have now made it possible to limit the public health impact of communicable diseases. Similarly, changes in public policy have reduced motor vehicle crash fatalities and injuries due to alcohol. Fighting the most common cause of lung cancer required public health programs to warn consumers about the dangers of smoking and policies to create smoke-free environments. Considering the various areas of life in the 21st century that are especially vulnerable to sleepiness, it is apparent that untoward outcomes caused by sleepiness will persist until key scientific principles are translated into action for the betterment of public health.

Sleep researchers and clinicians must encourage many components of society to promote individual and institutional behavior change (e.g., increasing habitual sleep duration, planning work schedules with consideration of human biology). Also, research efforts must be hastened to provide detailed information on the prevalence of sleep-related mishaps and on the economic and personal consequences of inadequate sleep. This information is vital for designing approaches and targeting resources where they will be most likely to advance public health and safety. Much of what we know or suspect about the role of sleep and sleepiness in public and private catastrophes is gleaned inferentially from retrospective studies and time-of-day data. Some prospective efforts to obtain data on sleepiness-related catastrophes are underway, in parallel with attempts to define the biologic limits sleep places on the alertness and safety of operators in certain occupations.<sup>4,24,25</sup>

## KEY AREAS FOR TRANSLATION

A number of sleep research areas have progressed to the degree that research findings can lead to improved public health if adequately translated to various segments of society, and, if necessary, into improved public policy.

### Cardiovascular Disease

Two lines of investigation implicate an association of cardiovascular disease and habitual sleep duration. First, acute periods of experimental sleep restriction produce increased blood pressure and heightened sympathetic nervous system activity,<sup>26,27</sup> as well as elevated levels of inflammatory markers associated with cardiovascular risk.<sup>28</sup> After recovery sleep, these physiologic measures return to baseline levels, suggesting a role for sleep in maintaining physiologic homeostasis. Second, an epidemiologic study of over 71,000 female nurses found that both short and long self-reported sleep durations are associated with the risk of coronary heart disease during a 10-year follow-up period.<sup>29</sup> Consistent with the latter finding are studies demonstrating that either short or long habitual self-reported sleep lengths are associated with an increase in all-cause mortality rates.<sup>29,35</sup>

Distinct from sleep duration per se, there is also convincing evidence that sleep-disordered breathing is a contributing factor to hypertension.<sup>36,37</sup> Less well established are apparent associations between sleep-disordered breathing and coronary artery disease and heart failure.<sup>38,39</sup>

The likelihood of suffering a myocardial infarction varies significantly across time of day, with a peak between 8 and 10 AM, which is 2 hours later than the morning peak for disease-related mortality.<sup>40,41</sup> Circadian regulation may underlie the shape of the 24-hour pattern in disease-related mortality. Direct observations of platelet aggregability show diurnal variation with a prominent morning peak.<sup>42,43</sup> Moreover, disease-related mortality closely approximates the two-peak pattern throughout the 24-hour day that has been described for sleep tendency.<sup>40,41</sup> Circadian and sleep-related increases in plasma concentrations of molecules that potentiate blood clotting or vasospasm may play a role in these temporal relationships, since aspirin reduces mortality due to myocardial infarct primarily during the morning peak, which suggests that the morning peak may be related to heightened platelet aggregability.<sup>42,43</sup>

Sleep-disordered breathing may also play a role in the early morning mortality peak of cardiovascular morbidity.<sup>45</sup> Jennum et al.<sup>46</sup> found that morning awake arterial blood pressure and nocturnal arterial blood pressure decreased with nasal continuous positive airway pressure treatment and concluded that these hemodynamic changes were associated with a treatment-related decrease in the number of sleep apnea events, a decrease in sympathetic activity, and an increase in parasympathetic activity. More evidence for the putative role of sleep apnea in the timing of deaths comes from work by Ancoli-Israel and colleagues, who reported that 24% of people over age 65 years had more than 5 apneic events per hour of sleep, and 62% had more than 10 respiratory disturbances per hour of sleep.<sup>47</sup> The high prevalence of sleep apnea in older people may contribute to the shape of the 24-hour pattern in disease-related mortality.

### Metabolism, Obesity, and Diabetes

Impaired glucose tolerance has been described in healthy subjects after 6 nights of restriction of sleep to approximately 4 hours per night.<sup>36</sup> Combined with higher evening cortisol levels, and reduced leptin secretion, the results suggest endocrine changes with acute sleep loss that are consistent with the development of diabetes. A growing body of evidence also supports a link between sleep-disordered breathing and insulin resistance, independent of degree of obesity.<sup>48-50</sup> Thus, both short sleep and disrupted sleep associated with sleep-disordered breathing appear to be associated with endocrine and metabolic changes that may promote obesity and diabetes. Consistent with that interpretation is the observation of decreased nocturnal leptin levels during 3 consecutive nights of total sleep deprivation.<sup>51</sup>

An epidemiologic study found a relationship of shorter reported sleep durations and a diagnosis of diabetes, although when controlling for body mass index, the association was no longer significant.<sup>52</sup> The authors speculated that because sleep deprivation reduced leptin levels, sleep loss may affect diabetes risk through weight gain. Further, sleep restriction predicted symptomatic diabetes, even after controlling for body weight, suggesting that sleep loss may be more closely associated with more severe forms of diabetes.

### Transportation Safety

It is known that sleepiness represents a significant risk to driving safety and may pose as great a risk to driving safety as

does alcohol.<sup>23,53</sup> That sleep loss increases vehicular crash risk is evident in studies showing that crashes were more likely in sleepy patients with untreated obstructive sleep apnea,<sup>54,55</sup> and in people sleeping less than 6 hours per night.<sup>56</sup> Moreover, motor vehicle accidents do not occur randomly throughout the 24-hour day but tend to peak during early morning and mid-afternoon, in accordance with times of increased sleep propensity.<sup>19,21,57-59</sup> One study in Great Britain estimated that 27% of drivers who lost consciousness behind the wheel fell asleep, as opposed to fainting, having a seizure, or having a heart attack.<sup>62</sup> Moreover, this 27% of motor vehicle accidents accounted for 83% of the fatalities. Other investigators have also observed a high rate of fatality in sleep-related accidents.<sup>21,61</sup> The increased fatality rate is likely due to a combination of reduced vigilance, slowed reaction times, and loss of steering control (i.e., drift out of lane). Once a driver is sufficiently inattentive due to sleepiness, or has transitioned to sleep, there is little or no attempt to brake or otherwise avoid collision.<sup>21</sup>

Comparisons have been made between the behavioral impairment similarities of driving while excessively sleepy and driving under the influence of alcohol. In fact, if authorities determine that impairment from sleep deprivation has caused an accident, the driver can be considered negligent and held liable for civil and criminal penalties. However, the parallel with alcohol ends there. In contrast to measurement of breath or blood alcohol levels, accident investigators have no reliable objective measurement of the degree of sleepiness. Thus, errors due to falling asleep or impaired performance due to sleep deprivation must be inferred from the nature of the accident and the operator's prior sleep-wake schedule.

Impairment due to alcohol is heightened by sleep deprivation.<sup>22</sup> It is not yet fully appreciated how great a contributory role sleepiness may have in the overall number of transportation accidents involving drug and alcohol use. In a study of fatal-to-the-driver truck accidents, the National Transportation Safety Board (NTSB) found that fatigue plus alcohol or drugs accounted for a large proportion of lethal accidents.<sup>57,58</sup> We may speculate that sleepy individuals operating a vehicle may be very susceptible to further impairment from consumption of even modest quantities of alcohol (or other depressant drugs).

The first law to specifically criminalize drowsy driving was enacted by the state of New Jersey in 2003. Specifically, this legislation allows law enforcement officials to charge individuals with vehicular homicide if, after not sleeping for 24 hours or more, they cause a fatal accident. The legislation was termed "Maggie's Law" after Maggie McDonnell, who was killed in a head-on collision in 1997 by a driver who had gone without sleep for 30 hours.

Historically, the trucking industry has been a focus of regulation to prevent driving while fatigued. Each year in the United States there are approximately 4800 fatal crashes involving trucks, and many more nonfatal crashes. The NTSB reported a probable cause of fatigue in 57% of accidents that led to a truck driver's death,<sup>57,58</sup> although this percentage is not universally accepted by all public and private entities concerned with trucking safety. The term *fatigue* has been used throughout federal agencies to describe human performance failure attributable to a variety of factors. It is clear from the NTSB's texts that their intended meaning of the term *fatigue* is most congruent with what sleep specialists mean by the term *sleepiness*.<sup>2</sup>

When a truck driver dies in a crash, three to four other people are usually also killed.<sup>59</sup> Depending on the involvement of other vehicles and the nature of the cargo, associated damages may be substantial. The mean cost of a crash involving a single large vehicle has been calculated to be \$51,000, but when fatalities result, the cost per crash is estimated at \$2.7 million.<sup>62</sup> The trucking industry employs approximately 2.5 million drivers, operates 1 million motor carriers, and accounts for 10 billion miles per year of travel on U.S. highways. Trucks deliver products and materials to every segment of society, from local deliveries through transcontinental long hauls. There are economic incentives for driving long hours in some segments of the trucking industry. Several major studies on the quality and quantity of sleep in commercial truck drivers were completed in recent years.<sup>63-65</sup> These studies show that sleep of truck drivers is often inadequate to ensure stable alertness and performance. In one study of 80 long-haul truck drivers operating on North American routes with four demanding driving schedules, drivers slept an average of only 4.8 hours per day.<sup>63</sup>

Despite general recognition of the effects of chronically inadequate sleep on performance and safety, federal regulations promulgated in 1939 remained unaltered for years. Perhaps the complexity of the problem and the understandable fear of harming such a vital industry delayed initiation of research and the revision of hours of service regulations directed toward the reduction of accidents due to sleepiness in truck drivers.<sup>64</sup>

In April, 2003, a revised Hours-of-Service Rule was announced by the Department of Transportation's Federal Motor Carrier Safety Administration<sup>66</sup> in response to a Congressional mandate in 1995. This new legislation allows long-haul drivers (i.e., those who do not routinely return to their home base after each driving shift) to drive a maximum of 11 hours per day after 10 consecutive off-duty hours—the old rule required only 8 hours off-duty for sleep and recovery. In addition, in the new rule drivers are prohibited from driving after 14 hours on duty during a single shift, whereas the old rule allowed 15 hours on duty. Thus, the new rule allows more off-duty time for sleep and personal time (i.e., 14 hours on duty and 10 hours off duty), in contrast to the 23-hour pattern of the old rule (i.e., 15 hours on duty and 8 hours off duty). Finally, as in the earlier regulation, drivers may not drive after being on-duty for 60 hours in a 7-consecutive-day period, or after 70 hours in an 8-day period. Enforcement of the new rule begins January 4, 2004, and undoubtedly the impact on trucking safety will be closely monitored. Many in the sleep field contributed to the formulation of these new regulations—tangible evidence that we can and do have a public policy impact, which it is hoped will benefit public health.

In addition to regulatory approaches, prevention of the dangers of driving while impaired by sleepiness will require research on countermeasures such as drowsy-driving detection technologies,<sup>67-70</sup> roadside signs, safe sleeping areas, and tests to assess sleepiness. Advances in these areas may then require public policy changes and education. In addition, recognition and treatment of sleep apnea and other sleep disorders is crucial if the total health and economic impact is to be reduced. Recent projections suggest that more than 800,000 drivers were involved in sleep apnea-related vehicle crashes in the year 2000, and that those events cost

\$15.8 billion and 1400 lives that year.<sup>71</sup> Further, treating all drivers having sleep apnea with continuous positive airway pressure would produce a net savings of approximately \$11 million and save 960 lives each year.

Many of the same issues pertaining to the role of work schedules and sleep in trucking safety are common to other commercial transportation modes. Sleep-related catastrophic accidents on the railroad have been identified, for example. The NTSB concluded that sleep deprivation with its related impairment was a primary cause in at least four catastrophic railroad accidents between 1987 and 1992.<sup>72</sup>

Maritime transportation typically involves 24-hour operations, and sleep deprivation has been the cause of several catastrophes. One of the most dramatic involved the grounding of the supertanker *Exxon Valdez* on Bligh Reef in Prince William Sound, Alaska, in March 1989. The NTSB determined that a "probable cause of the grounding of the Exxon Valdez was the failure of the third mate to properly maneuver the vessel because of fatigue and excessive work load... (p v)."<sup>73</sup> The grounding of the oil tanker *World Prodigy* off the coast of Rhode Island is another example of a major maritime accident involving fatigue due to sleep deprivation.<sup>74</sup> The NTSB determined that the probable cause was the master's impaired judgment from acute fatigue. The master had been awake for 36 hours at the time of the accident. There have been other summaries of fatigue-related performance failures in transportation modes that resulted in catastrophic outcomes.<sup>75</sup>

In each of these transportation areas, little research has been conducted to identify effective measures to counter sleep-based fatigue. Impetus to begin such countermeasure research will be enhanced as more public attention focuses on human error accidents and as top management integrates the real costs of accidents due to sleepiness-based error into their overall plans for risk management. This has begun in many of these industries, under the aegis of "fatigue management."<sup>76,77</sup> As the essential principles and practices of fatigue management develop, it will be important for sleep scientists to translate research findings into policies and practices that limit sleep debt, and provide maximal opportunity for recovery sleep. Moreover, sleepiness countermeasures should be data based, as well as reasonably feasible for the industry/occupation of concern.

An area of fatigue management that has received growing federal attention in recent years concerns the development of technologies that detect or prevent sleepiness on the job. Fatigue management technologies fall into four broad categories: (1) biomathematical models of human performance,<sup>78</sup> (2) readiness-to-perform and fitness-for-duty, (3) work-based performance technologies, and (4) on-line operator status monitoring technologies. Although such efforts have a long history, they have increased markedly recently owing to the prevalence and seriousness of fatigue-related crashes, the unreliability of subjective estimates of sleepiness or impairment, the potential of drowsiness detection technologies as alternatives (in part or in whole) to prescriptive hours of service, and the fact that technological advances have made the goal of on-line drowsiness detection feasible.<sup>79</sup> As these technologies continue to develop, the sleep field should take an active role to ensure they meet stringent criteria for scientific validity, reliability, sensitivity, and specificity. In addition, there are substantive public policy questions that will have to be addressed concerning privacy, liability, and related legal issues

in the use of sleepiness prevention and drowsiness detection technologies.

### Relieving Sleepiness with Naps: Aviation as a Case Study

Although accidents caused by sleep-based fatigue imperil all modes of transportation, aviation is one mode that has a history of research on the nature of fatigue and on developing countermeasures, primarily through research initiatives at the National Aeronautics and Space Administration (NASA) Ames Research Center. One example of this work serves to illustrate how sleep science can be used to address policy (i.e., research undertaken to investigate job-specific strategies to reduce sleepiness in the work place). However, this example also serves to highlight the significant challenges involved in gaining acceptance of viable sleepiness countermeasures by government, industry, labor, and the public.

For transmeridian flight crews, inadequate sleep has been a major source of fatigue.<sup>80,81</sup> A multidisciplinary research effort was undertaken to evaluate the benefits to long-haul flight crews of preplanned naps while in the air.<sup>82</sup> The results indicated not only that crew members could safely rotate, taking a brief (40-minute) nap period in flight, but also that the naps enhanced alertness of crews during transmeridian flights. Interestingly, the brief naps did not totally eliminate the cumulative sleep debt of crews, but they did provide transient relief from in-flight fatigue, especially on night flights. Such a clear example of an evidenced-based approach to mitigating sleepiness on the job also exposes a problem in translating science into public policy. Although many European and Asian transcontinental air carriers have adopted planned cockpit napping, the Federal Aviation Administration, because of political concerns, has not yet approved it for U.S. carriers. Public policy change requires both evidence of the need and benefits of the proposed change, as well as the acceptance of evidenced-based research as the standard for implementing organizational change. Absence of the latter prevented U.S. policy makers from incorporating a viable fatigue countermeasure in long-haul flight operations.

### Health Care Workers

Health care workers can be on duty for extended shifts ranging in duration from 12 to 24 hours, with day and night shifts alternating as frequently as every few days. In any work situation, a tired and sleepy worker is less effective and at some point at higher risk for an error or accident. The nature of the risk depends on the nature of the work. When 24-hour operations are involved, the likelihood of cumulative sleep deprivation and working at an adverse circadian phase are considerable. The associated risks for diminished productivity, errors, and accidents are also higher.

In 1984, Libby Zion, an 18-year-old college freshman, died in a hospital in New York City. A grand jury found that her death was due to an undiagnosed infection and blamed inadequate supervision of residents and resident fatigue for the failure to institute proper treatment.<sup>83</sup> As a result, New York enacted laws to reduce the total number of hours that residents are permitted to work. The state of New Jersey followed in 2002 with a bill limiting residents' work hours. More recently, the Accreditation Council for Graduate Medical Education (ACGME) implemented in July, 2003, standard

requirements for work hours for all resident physicians.<sup>84</sup> In brief, the ACGME regulations prescribe no more than an 80-hour work week, a maximum shift duration of 24 hours, at least 10 hours off between shifts, 1 day off per week, and overnight on-call assignment no more than every third night. Compared with traditional schedules, shorter shifts by interns in intensive care units result in more sleep, substantially fewer serious medical errors, and fewer attentional failures.<sup>84a,84b</sup>

Although regulation is one possible approach to manage resident sleepiness, it is likely that multiple interventions will be needed significantly to reduce sleep-related risk. Approaches such as providing brief sleep opportunities during prolonged work periods are also likely to be necessary to limit the effects of fatigue even within the ACGME duty limits. While the costs and benefits of restricting work hours for physicians are being evaluated, we should note that the medical community has often used scientific knowledge as the basis for new policies and guidelines for physician behavior relative to improved public health. The widespread use of sterile technique in surgery and the modern emphasis on preventive medicine through smoking cessation are two of many examples of evidenced-based behavior changes.

### Hazardous Workplaces

Sleep is inexorably intertwined with a large number of occupations that have a potential impact on public safety and health. It is not possible here to provide an exhaustive discussion, but some obvious examples other than those already mentioned include emergency operations and military conflict. Although the need to sustain wakefulness for prolonged periods of time may be obvious in a national disaster, the consequences of human error due to sleepiness and fatigue can be particularly serious in essential but non-emergency hazardous work environments that operate around the clock (e.g., nuclear power plants and plants producing hazardous or toxic chemicals). The early morning human errors that led to the on-site disaster at Three Mile Island<sup>85</sup> and the environmental disaster at Chernobyl<sup>86,87</sup> bear all the earmarks of sleepiness-related accidents. The sequence of decisions leading up to the space shuttle *Challenger* accident in 1986 is an example of sleep deprivation being contributory, if not causal, according to a supplemental report to the investigation.<sup>88</sup> The senior manager's decision to launch was based not on engineering or safety judgments but rather on other factors, including public image and preset schedules—the latter also was found to be contributory in the official investigation of the space shuttle *Columbia* investigation. In the case of the loss of *Challenger*, a Presidential Commission concluded that specific key managers had slept less than 2 hours the night before and had been on duty since 1 AM on the day of the launch. The report stated that "time pressure, particularly that caused by launch scrubs and turnarounds, increased the potential for sleep loss and judgment errors" and that working "excessive hours, while admirable, raises serious questions when it jeopardizes job performance, particularly when critical management decisions are at stake" (p G5).<sup>88</sup> Such a cogent example serves to illustrate that any workplace in which the consequences of a human error can be catastrophic economically, environmentally, or physically must consider the role of sleep need in maintaining safe and effective functioning.

## Adolescents and Young Adults

The prevalence of significant sleepiness associated with insufficient sleep is particularly high among adolescents and young adults. The adolescent years are accompanied by decreasing parental control, growing academic challenges, increasing social activities, and more employment opportunities. All of these forces tend to push sleep to a lower priority in time management. The net result is that few adolescents obtain adequate sleep, especially during the school week. The resultant sleepiness increases the risk for fatigue-related motor vehicle accidents, contributes to negative mood, impairs memory and other measures of cognition, and increases use of stimulants and alcohol.<sup>89,90</sup> Up to 40% of high school and college students are sleep deprived, and laboratory studies have documented performance impairments in them due to sleep loss.<sup>13,90</sup> This age group is also heavily represented among those who have drowsy driving crashes.<sup>21</sup> In addition, tired students are likely to have impaired motivation and unintended sleep episodes.<sup>91,92</sup> Students earning Cs or below report obtaining less sleep and having more irregular sleep schedules than do students with higher grades, although a causal relationship has not been established.<sup>13,93</sup> In an effort to address the problem of sleep-deprived adolescents, a recent study<sup>94</sup> reported that delaying high school start times from 7:15 AM to 8:40 AM, for a Minneapolis School District, resulted in students obtaining an hour more sleep per night, and improved attendance rates. In response to growing concerns, Congresswoman Zoe Lofgren introduced to the U. S. House of Representatives the "Z's to A's Bill" (H.R. 1313) to draw the attention of policy makers to this important issue.

## MAKING SLEEP A MATTER OF PUBLIC HEALTH AND PUBLIC POLICY

As discussed earlier, scientific advances in understanding sleep, sleepiness, and the impact of sleepiness on behavior and health need to be interpreted and communicated in ways that are useful to society. Without dissemination of the necessary knowledge and concepts, it is difficult to influence public consciousness and behavior. In some instances, our society faces problems related to sleep loss and sleepiness without the knowledge to formulate solutions.

There have been some important milestones in the history of federal policy regarding sleep medicine and research. Many came about through effective communication of scientific knowledge by individuals or appointed representatives of the sleep research community to federal authorities, who then acted in the interests of the public.

From the early 1970s, when the U.S. Food and Drug Administration developed guidelines for the evaluation of hypnotic medications, and moving to the present activities of the National Center for Sleep Disorders Research (NCSDR), our history has been one of activism and progress. Here we mention only a few of the important milestones.

In 1979, the Surgeon General's office created Project Sleep to focus further governmental attention on sleep research and sleep disorders.

In 1984, the American Sleep Disorders Association created an active government affairs committee. The committee's mandate was to provide all three branches of the government with up-to-date information on sleep physiology and current

sleep research. Committee members gave congressional testimony and worked with regulatory and investigative agencies.

In 1990, the Institute of Medicine prepared a research briefing entitled "Basic Sleep Research." The briefing was prompted, in part, by the Institute of Medicine's recognition that the continuation of basic sleep research in the United States was being threatened by limited training of young researchers, limited research funding, and attacks by animal rights groups on several basic sleep research programs.

In an independent but complementary effort stimulated by the heightened federal interest in the impact of the sleep-wake cycle on society, the Office of Technology Assessment of the U.S. Congress conducted a major review of biologic rhythms and their impact in the workplace.<sup>95</sup>

The National Sleep Foundation (NSF; [www.sleepfoundation.org](http://www.sleepfoundation.org)), an independent nonprofit organization whose mission includes improving public health and safety by achieving understanding of sleep and sleep disorders, was established by the American Academy of Sleep Medicine (AASM) in 1990. The NSF's programs have contributed to a heightened public awareness of the importance of sleep for public health.

The National Commission for Sleep Disorders Research, established by Congress, completed its comprehensive report of its findings in 1993.<sup>72</sup> In the Executive Summary, the Commission called for permanent and concerted government efforts in expanding basic and clinical research on sleep disorders as well as in improving public awareness of the dangers of inappropriate sleepiness. The NCSDR was subsequently created within the National Heart, Lung, and Blood Institute at the National Institutes of Health. The NCSDR's mandate has been to conduct and support research, training, health information dissemination, and other activities with respect to sleep disorders, including biologic and circadian rhythm research, basic understanding of sleep, and chronobiology, and to coordinate the sleep activities of other federal agencies. The legislation also mandated development of a National Sleep Disorders Research Plan. This plan was recently updated, and provides an excellent presentation of the progress in sleep research over the last several years, as well as detailing the key research and training recommendations for the future. The plan is available from [www.nhlbisupport.com/sleep/research/research-a.htm](http://www.nhlbisupport.com/sleep/research/research-a.htm), and a summary was recently published.<sup>96</sup> Since the establishment of the NCSDR, total National Institutes of Health funding for sleep research has grown steadily; with the latest estimates showing an increase from \$75 million to more than \$175 million during the period 1996 to 2002.

Recognition of sleep medicine as a medical subspecialty has been significantly advanced through the efforts of the AASM. For example, in recent years the AASM has gained official recognition in the American Medical Association House of Delegates (1996); received approval of the ACGME for accreditation of sleep fellowship training programs (2003); and entered discussions with the American Board of Medical Specialties regarding the acceptance of a sleep medicine board examination.

## CONCLUSION

Sleepiness and inattention related to sleep loss and circadian rhythms adversely affect workers in many industries, as well as the general public, and lead to public health and safety problems.

Evidence is accumulating that sleep disorders and restriction may be contributing factors not only to many errors and accidents, but also to certain highly prevalent disease states that are major public health concerns, such as diabetes, obesity, and hypertension. For each of these societal concerns, sleep science must be translated to the general public, biomedical researchers, and to those in policy positions for wiser public policy and the betterment of public health. Just as massive epidemics in crowded cities of 19th century thrust the notion of disease-carrying microbes into public consciousness, industrial and transportation catastrophes of the 20th and 21st centuries should be forcing the morbidity of sleepiness and sleep loss into the public consciousness.

Education and recognition of true risk are necessary first steps toward improved public health and formulation of wise public policy. Elementary and secondary level health and science classes clearly should include the critical messages of our field. The health impact of inadequate or disrupted sleep should be known as well as the negative effects of poor nutrition or smoking. All opportunities for translation of sleep science to engender behavior change of the general public should be taken. Communication of sleep science to researchers in other biomedical areas is also necessary to encourage the interdisciplinary approaches most likely to produce rapid advances in understanding sleep-related morbidity and its prevention.

There is also ample precedent for health professionals to assume responsibility, both individually and collectively through their professional organizations, to take action to improve the health and safety of the public. This includes societal health in its broadest sense: the reduction of risk and the enhancement of quality of life. Indeed, the special expertise of sleep medicine professionals confers a unique and heightened set of obligations to address and to shape rational public policy. It is axiomatic that public policy does not change by itself. It is also axiomatic that public policy can change in a manner that is counterproductive or that poses a threat to the health of the public. There may be economic incentives involved in maintaining or increasing the risks associated with sleep deprivation. It is the responsibility of health professionals and biomedical organizations to foster knowledge transfer to the public, to industry, to policy makers, and to others in a position to influence public health and safety. By translating the scientific body of knowledge about sleep and its disorders, we may promote behavior change and the formulation of good public policy, and as a result improve public health.

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#### Clinical Pearl

*Clinicians and researchers should contribute their knowledge and expertise to the development of public and institutional policies that will serve to improve public health and safety in areas such as educational systems, public utilities, transportation, and workplace safety. In the near future there may be an increasing role for sleep specialists in dealing with major public health issues such as obesity, hypertension, and diabetes.*

authorship of this chapter in his current position at the National Institute of Neurological Disease and Stroke, National Institutes of Health.

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