The Role of Work Schedules in Occupational Health and Safety

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Adverse work schedules increase the risk of accidents, injuries, acute illness and chronically impaired health for workers. As society moves toward providing many services 24 h per day and 7 day per week, the need is increasing for work schedules characterized by shift work, rotating shifts, and early start times. According to the 2004 Current Population Survey, 18% of full-time workers in the USA spend some portion of their work schedule outside of a 6 a.m. to 6 p.m. time frame (McMenamin, 2007). Extended work hours (more than 8 h per day, or more than 40 h per week) also are increasing steadily (Caruso, Hitchcock, Dick, Russo, & Schmidt, 2004) for a variety of reasons. Some workers elect to take secondary employment to boost their earnings, particularly those with low wages or whose household income has decreased because of a partner's unemployment. Others choose, or are required to, work extended hours because of shift design (for example, 12-h shifts as a norm). Since the economic downturn that began in late 2008, there has been a trend for employers to use overtime to manage excess demand, which allows them to maintain productivity without hiring new workers (Maher & Aeppel, 2009). In the USA and Canada, employees work 200–300 h more per year than in France, Germany, or Sweden because of an absence of legal minimums for paid vacation days or holidays (Yelin, 2009).

There is little awareness of, or substantial disregard for, social determinants of health, with work schedules being one of the most salient of these social factors. This chapter is written at a time of economic downturn in the USA, and across Europe. Anecdotal comments from workers suggest that they fear loss of employment and are unwilling to advocate for improved working conditions, including work schedules, because there are scores of unemployed workers eager to replace them. Furthermore, organized labor sometimes advocates for workers' rights to work overtime rather than limiting work hours (as they have in the past). Given this climate, the incentive for employers to improve work schedules, and for employees to respond to their own need for reasonable schedules, may be challenged.

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R.J. Gatchel and I.Z. Schultz (eds.), *Handbook of Occupational Health and Wellness*, Handbooks in Health, Work, and Disability, DOI 10.1007/978-1-4614-4839-6_14,

This chapter begins with a description of adverse work schedule patterns. Next, the research literature about health and safety risks of adverse schedules is summarized. Then, the components of an ideal fatigue risk management system are explained, with documentation of the effectiveness of this approach to reduce occupational risk among workers. We then explain how governments and public policies regulate work schedules. Finally, we conclude with suggested future directions for research and policy in order to improve the health and safety of workers by improving work schedules.

Adverse Work Schedules

Shift Work

Shift work (any shift where most of the hours fall outside the typical 8 a.m. to 5 p.m. period) is common in the service industry (e.g., food service, medical and emergency workers, safety, transportation, utilities, hospitality), as well as in production industries where processes are continuous (e.g., refining, chemicals), and in capital-intensive industries that demand high production (e.g., oil drilling, maritime, construction, mining). Shift work falls disproportionately on males, racial minorities, and workers with less education (McMenamin, 2007). The most common reason given by workers for working shifts is that the job required it, with other common reasons being higher wages, less supervision, time for schoolwork, and better arrangement for family and childcare (Camarino et al., 2008; McMenamin, 2007). About 15% of US and 18–24% European full-time workers have some night work (BLS, 2005; Parent-Thirion, Fernandez-Macias, Hurley, & Vermeylen, 2007).

Night shift workers have a high risk of occupational accidents, injuries, and illnesses (Caruso et al., 2004). The mechanism for this effect is physiologically complex. Working at night against the normal endogenous circadian rhythm (misalignment), and then switching back to a nighttime sleep schedule on off-days, disrupts the body's homeostatic mechanisms. Furthermore, shift workers get about 10 h less sleep per week (Akerstedt, 2003) and poorer quality sleep than those who work daytime or evening schedules. Extensive research over the past several decades has shown that the effects of shift work can be cumulative and may be an under-recognized contributor to later ill health (Oishi et al., 2005; Suwazono et al., 2006; Suwazono et al., 2008).

Shift Rotation

Rotating shifts between day and night (or day, evening, and night) is challenging from a circadian biological perspective. The most hazardous aspect of rotating shifts is the "quick return," a pattern where the worker has fewer than 10 h off between shifts. Shifts can rotate forward (day to evening to night), or backward, and rotation can be quick (several different shifts within 1 week, or slow (blocks of shift work lasting several weeks). Both the speed and direction of rotation affect sleep duration and quality. Few full-time night shift workers (<3%) ever really make a complete circadian adjustment to their shift (Folkard, 2008), and rotating shift workers are even less likely to make this adaptation. Permanent night workers achieve slightly more sleep than workers who rotate to night shift (Pilcher, Lambert, & Huffcutt, 2000), perhaps because they learn to make accommodations over time. Night shift workers benefit from higher incomes due to shift differentials (Camarino et al., 2008), and they often prefer the autonomous nature of the work itself (fewer "bosses").

Because in 24/7 operations, evening and night shifts will always need to be covered, most employers look at the issue of worker fatigue from shifts as inevitable and are unaware of the science that supports using fatigue risk tools to examine current scheduling practices to improve outcomes. Many employers

also believe that workers want to compress work schedules to "get it over with" so that they can have larger blocks of time off. This belief was contradicted recently in a study of police officers that examined the implementation of a non-compressed pattern of rotating shifts. Even though the officers had fewer days off per month with this pattern, they now had at least 16 h off between shifts, and were more satisfied with their work schedules (Kecklund, Eriksen, & Åkerstedt, 2008). In general, evening shift workers have the longest and best quality sleep of 8 h shift workers (Akerstedt, 2003).

Early Start Times

Work start times are usually dictated by the employer. Start times before 9 a.m. are common in the transportation, mining, construction, and health care industries (BLS, 2010a, 2010b). Early start times can interfere with sleep. Because most adults are unable to sleep at all between 7 and 9 p.m. due to a circadian waking pressure in the early evening, their bedtimes often occur at 10 p.m. or later. Ingre, Kecklund, Akerstedt, Soderstrom and Kecklund (2008) showed that, for shift start times between 4:30 a.m. and 9:00 a.m., there was a linear increase in sleep time of 0.7 h for every hour that the shift start time was delayed. An experimental study where start times were manipulated showed that workers whose start time was delayed had an increased duration of sleep prior to work, and improved alertness during the shift (Rosa, Harma, Pulli, Mulder, & Nasman, 1996). Sleep deprivation is well known to increase the risk for occupational accidents (Philip & Akerstedt, 2006). The problem of curtailed sleep with early start times is often compounded by long commute times. In dense urban areas and in sparse rural areas, commutes can be an hour or more (National Academies, 2006). Teenagers with developmentally delayed sleep phase (i.e., cannot fall asleep until after midnight) are particularly vulnerable to accidents or injuries since they will have insufficient sleep with early start times (Crowley, Acebo, & Carskadon, 2007). In contrast, older workers who fall asleep early because their circadian phase has advanced may be able to accommodate early start times more easily than others (Dijk, Duffy, & Czeisler, 2000).

Other Factors Related to Work Schedules

The actual work schedule of any employee is dependent on the overall policies, procedures, and economics of the organization. In order for workers to have reasonable schedules, there must be adequate staffing to satisfy the work demands at hand. Without adequate staffing, there is no possibility of achieving adequate scheduling for workers even when management is aware of how to implement healthful schedule patterns. Some personal responsibility also falls on the individual worker. If the schedule provides adequate sleep opportunity, does the worker take advantage of time off to obtain needed rest and recovery? Is the worker free of impediments to sleep (e.g., sleep disorder or home responsibilities such as child care or elder care)? It is useful to think of the work schedule as the foundation upon which other aspects of health risk are built.

Health and Safety Consequences of Adverse Work Schedules

Adverse work schedules have been shown to increase the risk for several health conditions, and to make workers less safe on the job and on the drive home. Overtime hours have been associated with increased mortality in several population-based studies (Nylen, Voss, & Floderus, 2001; Johansson, 2004). We review several health and safety conditions in this section.

Accidents and Injuries

Shift work and extended work hours are both associated with increased accidents and injuries across a number of occupations (Dembe, Delbos, & Erickson, 2008; de Castro et al., 2010). Moore-Ede (1993) estimated the annual economic impact (in 1993 US dollars) of sleep problems due to late shifts were as follows: 50 billion in reduced manufacturing productivity; 5.7 billion in increased motor vehicle accidents; four billion in industrial accidents; 2.5 billion in accidents, injuries and deaths at work; two billion in increased medical and psychiatric illness; and one billion to account for personnel turnover and training. During the night shift, most workers are sleepier, have reduced reaction times, poorer neuromuscular coordination, and poorer cognitive executive functioning, which can contribute to injury risk. The increased risk for night shift accidents is 30% higher than for day shift workers, and this risk increases over consecutive night shifts and with longer work shifts (Folkard, Lombardi, & Tucker, 2005; Folkard & Akerstedt, 2004). Within an extended shift, the risk for injury increases after the eighth hour of work, regardless of time of day (Haneke, Tiedemann, Nachreiner, & Grzech-Sukalo, 1998). Researchers have shown industry-specific data (e.g., healthcare, aviation, maritime, etc.) that support the relationship between work schedules and injuries; detailed in a NIOSH/CDC report (Caruso et al., 2004).

Motor Vehicle Crashes

Driving accidents are a common source of injury and death for workers and the driving public. In the USA, the National Transportation Safety Board estimates that 71,000 injuries and 1,550 deaths per year are due to drowsy driving, although they admit this is probably an underestimate because of reporting problems (Moore, Kaprielian, & Auerbach, 2009). In European nations and Australia, where crash reporting is more consistent, the estimate of drowsy driving as a cause of motor vehicle crashes is 10–30% (National Sleep Foundation, 2008). In a study of 100 video-instrumented cars driven over 42,000 miles where drivers were continuously observed during naturalistic driving, 22% of all motor vehicle crashes and 16% of near-crashes could be attributed to drowsy driving (Dingus et al., 2006), Drowsy driving accidents tend to be more severe than others because the sleepy driver fails to brake before a collision.

Drowsy driving is increased in workers with extended shifts (Robb, Sultana, Ameratunga, & Jackson, 2008), after night shifts (Rogers, Holmes, & Spencer, 2001; Stutts, Wilkins, Scott Osberg, & Vaughn, 2003; Barger, Cade, Ayas et al., 2005), and with inadequate sleep prior to working (Valent, Di Bartolomeo, Marchetti, Sbrojavacca, & Barbone, 2010; Philip & Akerstedt, 2006; Gander, Marshall, Harris, & Reid, 2005). However, because of significant interindividual differences in tolerance to sleep deprivation that can be traced to genetic polymorphisms (Czeisler, 2009), there is a subpopulation of workers who may be less tolerant of sleep deprivation and thus have an even greater risk for drowsy driving. Drivers with sleep disorders, such as sleep apnea, narcolepsy, insomnia, and restless leg syndrome, also have a higher risk for drowsy driving independent of their work schedule (Volna & Sonka, 2006).

Musculoskeletal Disorders

Recent reports of nonfatal occupational injuries show nursing and health care facilities as leading the incidence rates, followed by fire protection, sports and general aviation (BLS, 2010a, 2010b). According to the US Bureau of Labor Statistics, musculoskeletal injuries (MSD) accounted for 28% of all nonfatal worker injuries (BLS, 2009). The occupations with the highest MSD incidence rates were nursing aides and orderlies, emergency medical technicians and psychiatric aides (ranging from 226 to 256 per 100 full-time employees). The next highest groups included laborers, truck drivers and fire fighters (ranging from 134 to 146 per 100 full-time employees) (BLS, 2009). As many occupations

have experienced staff cuts, job restructuring and redesign, increasingly heavy demands have been placed on the remaining workers. This is especially true in occupations with strong physical demands as part of their jobs. Such demands have been associated with increased risk of MSD (Ariens, Bongers, Hoogendoorn, van der Wal, & van Mechelen, 2002; Davis, Marras, Heaney, Waters, & Gupta, 2002; Smedley et al., 2003), leading to sick days, disability, and turnover.

Adverse work schedules can also affect the sleep–wake cycle, and working 12+ hour shifts can lead to MSD due to extended exposure to physical demands combined with insufficient recovery time between work shifts (Waersted & Westgaard, 1991; Larese & Fiorito, 1994). In workers with employment-related myalgia, symptoms increased with each successive workday and only remitted by the second day off (Lundberg et al., 1999). These workers had shorter periods of muscle rest, suggesting that continuous muscle tension was associated with musculoskeletal symptoms. Without adequate time in between shifts or enough time off to rest and sleep prior to resuming a long shift, employees are required to come to work while still injured or in pain. This situation compounds the difficulty of recovery from the injury.

Workers on schedules requiring long hours and frequent overtime are at higher risk for MSD and pain (Gordon, Cleary, Parker, & Czeisler, 1986; Parkes, 1999; Folkard, Spelen, & Toterdell, 1995). Hoogendoorn et al. (2000), using video observations and questionnaires in a 3-year study of workers, found that extreme flexion and frequent heavy lifting had a strong impact on worker low back pain. Movements that require flexion and rotation, such as in health care with patient transfers from a bed to stretcher, increase the injury risk due to a combination of compression, rotation, and shear forces and, if unavoidable, can lead to further injury (Forde, Punnett, & Wegman, 2002; Hoogendoorn et al., 2000, 2002; Hoozemans et al., 2004). Heavy lifting has also been associated with shoulder pain or injury in many occupational groups (Allen, 1990; Nahit, Macfarlane, Pritchard, Cherry, & Silman, 2001; Punnett, Fine, Keyserling, Herrin, & Chaffin, 2000). In a survey of 1428 registered nurses (RNs), over one-third had extended work schedules, and such schedules were associated with an increased likelihood of MSD (Trinkoff, Le, Geiger-Brown, Lipscomb, & Lang, 2006). The relationship was diminished when physical demands were controlled, suggesting that work schedule served to increase exposure to hazardous tasks.

Cardiovascular Disease (CVD)

Cardiovascular disease is the leading cause of death globally, with 7.3 million deaths due to coronary heart disease and 6.2 million due to stroke in 2008 (WHO, 2011). Public media campaigns focus on preventing this disease by encouraging individuals to engage in healthy behaviors, with little recognition of the role of work organization in the genesis of these serious health conditions (Landsbergis, Schnall, & Dobson, 2009). Adverse work schedules have a direct effect on CVD risk, and also an indirect effect through their detrimental influence on health risk behaviors among workers (Thomas & Power, 2010).

Health Risk Behaviors

A number of studies have examined the impact of shift work or long-work hours on healthy behaviors. Usually these ask questions about diet, weight, and smoking or alcohol use, and compare those with adverse schedules to daytime workers. A recent study of workers in a manufacturing company compared workers on 8 vs.10 and 12 h shifts, as well as daytime, night, and rotating shift workers, using 8 h daytime workers as the reference group (Bushnell, Colombi, Caruso, & Taki, 2010). Those on 12-h shifts were significantly more likely to smoke regardless of shift; rotating workers were the least likely to exercise, and night workers were significantly more likely to be obese.

A Spanish study also showed an increased likelihood of smoking among those working 51–60 hours per week (Artazcoz, Cortès, Escribà-Agüir, Cascant, & Villegas, 2009). Reeves, Newling-Ward and Gissane (2004) found the same patterns among nursing home workers, as night workers were more likely to smoke than daytime workers. Kivimäki, Kuisma, Virtanen and Elovainio, (2001) and Trinkoff and Storr (1998) also found a higher rate of smokers among night shift nurses. However, Kivimäki et al. (2001) found almost no difference in smoking by shift among workers under age 45, and almost three times the rate of smoking among night-shift workers greater than age 45. Zhao and Turner (2007) reviewed these and other studies from Europe, North America, and Asia that assessed shift work and accompanying behaviors; most noted an increase in smoking among shift workers compared to those working days only. . Nakamura et al. (1997) noted no smoking differences in Japanese workers, but the smoking prevalence was over 70% in their sample; those who rotated among all three shifts reported the highest prevalence of alcohol use. One study reported that a greater proportion of evening and night shift workers were found to be smokers prior to their entry into the workforce, suggesting that selection issues may be an additional factor to consider (Nabe-Nielsen, Garde, Tuchsen, Hogh, & Diderichsen, 2008).

Alcohol use is typically examined as part of studies conducting prevalence surveys for lifestyle behaviors in relation to adverse work schedules, including some mentioned above. Findings have been conflicting. Hermansson et al. (2003) found no differences in alcohol consumption by shift using a variety of alcohol screening tools, although workers who rotated among two-shifts (as opposed to three-shifts or not at all) had the lowest alcohol prevalence. Zhao and Turner (2007) note a study of Brazilian workers who reported higher alcohol consumption among those on the night shift, and another in which shift workers did not differ compared to day time employees. Kivimäki et al. (2001) reported some differences in alcohol use, though not significant, with more heavy drinkers and nondrinkers among nurses working night shifts. They postulate that the relationship between alcohol use and work schedule is likely nonlinear, with lower health risk among moderate drinkers; thus, studies examining a linear trend for alcohol and shift work may be mischaracterizing the relationship. Little data are available for those with long work hours in relation to alcohol and drug use. Trinkoff and Storr (1998) found that rates for drug use and alcohol, as well as smoking, were all increased among nurses working greater than 8 h shifts compared to shorter length shifts.

Reasons for disparities in risk among shift workers or those with long work hours are manifold, and include that health behaviors are altered as consequences of the work environment, sleep deprivation, and circadian rhythm disturbance (Bushnell et al., 2010). The opportunity to exercise is reduced in persons with adverse work schedules. Although exercise has been found to be an important component of weight control and CVD prevention, shift work and other nonstandard work schedules have been shown to impede participation in exercise programs, largely due to decreased opportunity to engage in sports or participate at a consistent time of day (Atkinson, Fullick, Grindey, Maclaren, & Waterhouse, 2008). A study of workers in Catalonia, Spain found that men who worked long hours were significantly more likely to report that they engaged in no physical exercise during their leisure time, although this was not true among women (Artazcoz et al., 2009). Kivimaki's (2001) study of nurses also showed no overall effect of schedule on sedentary lifestyle, although older shift workers were more likely to get little to no exercise compared to younger workers. Sleep deprivation incurred from rotating shifts or extended work schedules may further limit the desire to exert oneself. Most of the studies done on the benefits of exercise have not included shift workers (e.g., Li et al., 2004). In addition, there may be altered benefits of exercise to those who work shifts or nontraditional hours, possibly due to hormonal alterations when exercise occurs during hours that circadian rhythms support for sleep (Atkinson et al., 2008). More work is needed to explain these relationships.

CVD and Metabolic Disease Risk

Cardiovascular disease (high blood pressure, heart attack, stroke) is often a late effect of metabolic disease (glucose and insulin dysregulation, obesity). In order to understand the relationship between work schedules, metabolic and cardiovascular disease risk, one needs to appreciate the role of the circadian system in the pathogenesis of these disorders. Extensive genetic, cell, and tissue biology research clearly demonstrates that human metabolic activities are regulated by circadian pacemakers that oscillate based on the light–dark cycle of the 24-h clock (Huang, Ramsey, Marcheva, & Bass, 2011). Nearly all body cells are responsive to this pacemaker. Functionally, behaviors such as food intake and physical activity, as well as metabolic processes (e.g., glucose regulation, thermogenesis, adipose deposition, lipid regulation, bile synthesis), are regulated by circadian cycles (Cajochen et al., 2005). Shift work and long shifts increase autonomic arousal, alter neurohormones, such as cortisol, causing deranged glucose and lipid metabolism, and increase inflammatory cytokine production (Miller & Cappuccio, 2007). These processes can lead to obesity, Type-II diabetes, and atherosclerosis (Puttonen, Harma, & Hublin, 2010).

Studies linking work schedules to incident cardiovascular diseases have shown conflicting results. In two review papers summarizing 20 years of population-based studies, an increased CVD risk of 40% was evident for shift workers (Kristensen, 1989; Bøggild & Knutsson, 1999). However, this association was absent in a more recent review (Frost, Kolstad, & Bonde, 2009). Boggild (2009) suggested that methodological issues are the source of this inconsistency in association. Epidemiologic studies have shown that cardiovascular changes may begin during the earliest years of shift work, with one study showing a near doubling of the risk for metabolic syndrome in rotating shift workers in only 6 years of observation (De Bacquer et al., 2009). Another study showed increased atherosclerotic changes in the carotid artery before age 40 in shift workers, after adjusting for other health and lifestyle factors (Puttonen et al., 2009).

Researchers have moved beyond incidence studies to begin to understand the mechanisms by which adverse work schedules cause cardiovascular changes. Recent studies have shown desynchronization of cellular clock genes to the circadian day as a primary mechanism for increases in CVD in shift work (Suessenbacher et al., 2011; Manfredini, Pala, Fabbian, & Manfredini, 2011). Studies of subclinical precursors to heart disease have shown increased plasma resistin (an inflammatory cytokine) (Burgueño, Gemma, Fernández, Sookoian, & Pirola, 2010), carotid intimal thickening (Puttonen et al., 2009), increased blood pressure (Fialho, Cavichio, Povoa, & Pimenta, 2006), and increased cardiac rhythm disturbances in shift workers (van Amelsvoort, Schouten, Maan, Swenne, & Kok, 2001). Extended work hours have also been implicated in CVD risk (Landsbergis, Schnall, & Dobson, 2009).

Gastrointestinal Disorders

Night shift workers often experience gastrointestinal symptoms and disorders (gastric reflux, gastritis, peptic ulcers, irritable bowel conditions, abdominal discomfort), and use more antacids and proton-pump inhibitors than those working day shift (Bilski, 2006: Nojkov, Rubenstein, Chey, & Hoogerwerf, 2010; Sveinsdottir, 2006; Zhen Lu, Ann Gwee, & Yu Ho, 2006). Infection with *Helicobacter pylori* increases the risk of gastritis and ulcer disease, and shift work increases the risk that colonization with this bacterium will progress to disease (Pietroiusti et al., 2006). Relatedly, workers on off-shifts often lack healthful food resources when the company cafeteria and local restaurants are closed, and vending machines are the only available choice. These workers often eat to remain awake despite lower hunger at night (Lowden et al., 2001), and drink caffeinated beverages to sustain alertness, which can cause gastrointestinal distress. Many report that food is harder to digest at night (Bilski, 2006), which may be due to misalignment of food intake with circadian-controlled gastric secretion and intestinal motility.

Infectious Disease

Exposure to infectious agents is a feature of many work settings (Trajman & Menzies, 2010), most prominently in health care settings such as hospitals, dental offices, and long-term care facilities (Hosoglu et al., 2009; Leggat, Kedjarune, & Smith, 2007). Other settings with infectious exposures include social assistance (day care, funeral service, prisons, taxi and bus drivers) (Eriksen, Bruusgaard, & Knardahl, 2004; Slack-Smith, Read, Darby, & Stanley, 2006; Davidson & Benjamin, 2006; Valway et al., 1994; Hannerz & Tuchsen, 2001), as well as animal slaughtering and processing (Johnson & Ndetan, 2011). There has been little investigation into the role of work schedules in either risk exposure or host resistance. However, sleep researchers have described a reduction in immune response to infection among those who are sleep deprived, which is a common situation among shift workers (Bryant, Trinder, & Curtis, 2004). As highly infectious disease strains exist and are becoming resistant to antibiotic therapy (Brouqui, 2009), additional research is needed to understand the role of work schedules in immune response for high risk workers.

Cancer

Recent epidemiologic evidence has shown an increased risk of breast cancer among shift workers, with the International Agency on Research on Cancer (World Health Organization) classifying shift work as a "probable carcinogen" (Costa, Haus, & Stevens, 2010; IARC, 2007). Other cancers with weaker evidence for association with shift work include prostate, colorectal, endometrial, and non-Hodgkin's lymphoma (Costa et al., 2010). Light exposure during night time working hours suppresses melatonin production. Melatonin acts as a powerful antioxidant to reduce reactive oxygen species in cells, and provides an antiestrogen effect to modify cellular responses to estrogen. Sleep deprivation (which is common in night workers) also suppresses immune function that can allow cells to proliferate in abnormal ways. Moreover, shifting back and forth to sleeping at night on, days off, can cause phase disruption of circadian clock genes that regulate cell growth. There are thus multiple mechanisms by which shift work can increase the risk for cancer formation (Costa et al., 2010). Of course, shift work will always be necessary in some industries, but the increased risk for cancer in shift workers points to the need for employers and occupational sleep medicine specialists to work together to create shift schedules that are the least disruptive to circadian cycles, and to provide adequate screening, diagnosis and treatment for adverse sequelae of shift work, such as cancer. It also points to the need for workers to limit their lifetime "dose" of shift work.

Reproduction

Compared to other occupational disorders, there is less literature describing the association between shift work and reproductive outcomes, and the studies that exist are inconsistent. Studies of fertility and pregnancy outcomes must take into account many confounding factors, such as the mothers' general and reproductive health and health risk behaviors, as well as many aspects of the job and work environment (e.g., schedule, standing and other physical demands). Becoming pregnant and carrying a baby to term is physiologically complex; many occupational factors can influence the reproductive outcome. In a small sample of nurses under age 40, 53% reported changes in menstrual function when working a night shift. However, the characteristics of the change were inconsistent across workers (e.g., longer and shorter periods, heavier and lighter flow, etc.) (Labyak, Lava, Turek, & Zee, 2002). The nurses who did report changes also averaged less sleep and had other somatic complaints (gastro-

intestinal symptoms, malaise, reduced concentration), and the author concluded that menstrual changes during shift work could be a marker for shift work intolerance. Fecundity (time to pregnancy for planned pregnancies) was reduced in evening and night shift workers in a large Danish study of pregnant women although, once adjusted for confounders, was not significantly different from day shift (Zhu, Hjollund, Boggild, & Olsen, 2003). However, unplanned pregnancies were higher among night shift workers (Zhu et al., 2003, Zhu, Hjollund, & Olsen, 2004). Several large cohort studies have shown that fixed (but not rotating) night shifts increase the risk of pregnancy loss, with risk ranging from 60 to 85% (Zhu, Hjollund, Andersen, & Olsen, 2004; Whelan et al., 2007). The biological mechanism for this effect is still unclear, but may be related to hormonal changes associated with circadian misalignment. Preterm deliveries were elevated by 50% in night shift workers and in those with prolonged work hours (Pompeii, Savitz, Evenson, Rogers, & McMahon, 2005; Bonzini, Coggon, & Palmer, 2007), and small-for-gestational-age births were increased in shift workers (Pompeii et al., 2005). Given these findings, it is prudent for maternal health professionals to take a careful occupational history and counsel pregnant women to limit night shift work during their pregnancy.

Managing Fatigue Risk in Occupational Settings

The risks of occupational fatigue can be partially mitigated by health-preserving actions taken by individual workers and their employers. Fatigue risk management programs are one component of workplace safety management systems, and are a shared responsibility of workers, occupational health and safety officers, and management (Geiger-Brown & McPhaul, 2011).

Employer Occupational Health Programs

The primary elements of a comprehensive occupational safety and health program include management commitment and employee involvement, hazard analysis and accident investigation, prevention activities, training, and recordkeeping and evaluation. A further component of an overall safety and health program is a health and safety committee. However, the state of occupational fitness-for-duty testing to detect sleep deprivation in workers is in its infancy. There are instruments of high quality that are used in research settings to detect fatigue and microsleep (uncontrollable and unintended episodes of sleep lasting up to 30 s) in ambulatory research conditions, but these are not used for ”real time” testing of employees in actual work situations. Because real time detection of fatigue is not feasible at the present time, a better approach is to reduce the work-related inhibitors of sleep by making sure that work schedules allow sufficient sleep opportunity. Software is commercially available and in common use in some settings to “flag” fatigue-inducing schedules in workers (Moore-Ede et al., 2004). In the next section, we review organizational measures to reduce the impact of work on sleep duration and quality.

Organizational Interventions to Improve Schedule-Related Health and Safety

Worksite health promotion programs often target employee health risk behaviors (such as diet and exercise) to reduce cardiovascular risk, sickness absence, and disability (Parks & Steelman, 2008). Work schedules are often not examined as a source of morbidity. A robust worksite health program should conduct an exposure assessment of working hours as part of the health history and ongoing surveillance activities (Geiger-Brown & McPhaul, 2011). But addressing the work schedule in isolation will not reduce worker fatigue unless all aspects of fatigue risk are examined.

Occupational Screening for Sleep Disorders

The transportation industry is a leader in screening workers for sleep disorders in order to reduce accident risk (Hartenbaum et al., 2006). A large scale occupational sleep disorder screening program was successful in reducing injury rates among those with excessive sleepiness, with rates dropping by 30% after screening and a sleep hygiene educational intervention (Melamed & Oksenberg, 2002). In this study of 532 industrial workers (power plants, medical fabrication plants, heavy machinery repair), the odds of an occupational injury with excessive daytime sleepiness was twice that of those without sleepiness after controlling for age, sex, BMI, job tenure, type of factory, physical demands, and noise. Workers often have unrecognized sleep disorders, and generally do not seek medical attention. Lavie (2002) proposed that aggressive screening programs should be used to identify individuals with sleep-disordered breathing at the youngest age possible (similar to hypertension and diabetes screening) in order to prevent cardiovascular morbidity and mortality. In addition, shift workers with high levels of fatigue, who discount this as an unavoidable reaction to shift work, may actually have a sleep disorder (Hossain, Reinish, Kayumov, Bhuiya, & Shapiro, 2003). This is particularly true where the worker population is older or obese.

Shift Work Sleep Disorder

Nearly all shift workers have some sleepiness during the circadian low point of the night shift, and most cannot achieve adequate sleep during the day. Workers experiencing extreme shift work symptoms (sleepiness during the shift and daytime insomnia) have *Shift Work Sleep Disorder* (SWSD) (Box 14.1) (Barion & Zee, 2007), SWSD is estimated to affect 32% of night shift workers, and 26% of rotating shift workers based on one population-based sample (Drake, Roehrs, Richardson, Walsh, & Roth, 2004). Many workers accept difficulty sleeping during daytime hours and high levels of sleepiness during the night shift, thinking that this is a normal part of shift work. Most are not aware that there are treatments available for this physiologically based disorder. Risk for SWSD may be higher in older worker and females with social obligations (Sack et al., 2007). Also, workers who are exposed to bright light in the early morning may develop maladaptive phase shifting that reduces their ability to sleep in the daytime. Employers should provide accommodations under the Americans with Disabilities Act (ADA, Pub. L. No. 101-336, 104 Stat. 327 (1990) (codified as amended at 42 U.S.C. § 12101–12213)) to workers with SWSD by reducing night shift participation, allowing planned naps during the night shift and stimulant medication, and restructuring the work environment to increase ambient light. Occupational health departments should be instrumental in screening and detecting workers with this disorder, and working with the employer to tailor the job to improve the workers' health and safety as well as on-the-job performance.

Box 14.1. ICD-9 Criteria for Circadian Rhythm Sleep Disorder: Shift-Work Type (327.36)

1. Complaint of insomnia or excessive sleepiness that is temporarily associated with a recurring work schedule that overlaps the usual time for sleep.
2. Symptoms are associated with the shift work schedule over the course of at least 1 month.
3. Sleep log or actigraphy monitoring (with sleep diaries) for at least 7 days demonstrates disturbed circadian and sleep time misalignment.
4. Sleep disturbance is not better explained by another current sleep disorder, medical or neurological disorder, mental disorder, medication use, or substance use disorder.

Source: Center for Medicare and Medicaid Services, ICD-9 Manual

Shift Work and Long Work Hours Education for Workers

Guidance for coping with shift work and extended work hours often receives little attention during worker orientation programs, yet this has reduced fatigue in workers with adverse schedules. In a worksite intervention to prevent "occupational jet lag" for shift workers, sleep quality and quantity improved in the treatment group when sleep health education was provided in combination with exercise (Atlantis, Chow, Kirby, & Singh, 2006). Major industries, such as the Saturn automobile manufacturing company (Round-the-Clock-Systems, 2011) and Canadian Transport affiliated companies (Transport Canada, 2003), have instituted fatigue education programs for their workers The US National Transportation Safety Board (NTSB) cites fatigue as one of the major modifiable causes of accidents, and recommends worker education and safe scheduling as two important interventions to reduce accident risk (Rosekind, 2011). In fact, the NTSB has included fatigue-related factors on its list of "Most Wanted Safety Improvements" since 1990 (NTSB, 2011).

Creating Healthful Work Schedules

In 24/7 operations, there will always be a need for some workers to do shift work and to work with some level of cognitive impairment during the circadian low point. Most managers have not been trained in the principles of scheduling to avoid fatigue risk. However, fatigue risk management software can be used to model performance impairment based on specific work and rest schedules (Caldwell, Caldwell, & Schmidt, 2008). Managers can use this software to preplan work schedules, as well as to modify them "on the fly" to cover peak demands or worker absences. This software has been used since the mid 1990s in safety-sensitive industries such as rail, bus, chemical, nuclear, and offshore operations in the UK (Folkard, Lombardi, & Spencer, 2006), and for military, rail, and airline applications in the USA (Hursh et al., 2004) . The variables for fatigue prediction are as follows: (1) a cumulative component where patterns of work on previous shifts influence the current shift, (2) timing of work including start time, shift length, and time of day throughout the shift, and (3) the nature of the work (job intensity), as well as patterns of breaks taken during the shift (Folkard & Lombardi, 2006). In a US study where managers and dispatchers were trained in scheduling methods and fatigue risk software to reduce truck driver fatigue while still maintaining 24/7 h of service, fatigue risk scores (range 0–100, with higher score = more risk) fell significantly from 46.8 1 month prior to the intervention to 28.9 nine months after the intervention (Moore-Ede et al., 2004). A substantial change in overall patterns of work resulted from this intervention, with fewer accidents, lower cost of accidents, and lower insurance premiums for the company. The company maintained this program for several years after the intervention, supporting the contention that, once successful changes are made in organizations, they are generally sustained over time (Swerissen & Crisp, 2004). Managers sometimes fear workers' reactions to schedule modifications to reduce fatigue risk. However, in a study of 2,000 police officers where shift systems were experimentally altered to avoid compressed work schedules, officers preferred the healthier shift system to the compressed schedules that were thought to be favored, despite having two fewer days off per month (Kecklund et al., 2008).

Modifying Light Conditions During Night Shift

Dim lighting conditions are present in some workplaces during the night shift, and can increase workers' sleepiness during the circadian low period (usually between 3 and 5 a.m.) (Caldwell et al., 2008). Employers can provide brighter light during this time to improve workers' alertness (Santhi, Aeschbach, Horowitz, & Czeisler, 2008). This light provides a direct alerting effect, and also suppresses melatonin which can phase-shift the circadian rhythm (Cajochen et al., 2005). Night workers have used blue light in 10–15 min bursts every 3 h to sustain alertness during their workshift, and amber glasses to block blue light and promote sleep upon returning home (Boivin, Tremblay, & James, 2007; Boivin & James, 2005; Shechter, James, & Boivin, 2008). Light has also been used to

reduce decrements in alertness during the post-prandial dip in dayshift workers after lunch (Hayashi, Masuda, & Hori, 2003).

Planned Napping During Work Breaks

In the USA, napping during working hours is prohibited by most employers as it is thought of as "sleeping on the job"; however, many night-shift workers do nap covertly during breaks. Planned, but unsanctioned naps interfere with safe operations, with a recent example being air traffic controllers falling asleep on the job (Czeisler, C.A. (26 April, 2011). Unplanned napping also occurs when the biological drive to sleep overcomes the worker's ability to remain alert while on duty. It is unfortunate that napping is held in such low regard, as naps have been shown to be an effective way to increase alertness during shift work or extended work shifts (Ficca, Axelsson, Mollicone, Muto, & Vitiello, 2010). Both laboratory and workplace studies have confirmed (by EEG) that a brief 15–20 min nap during a workshift confers additional alertness, especially for workers with partial sleep deprivation or those working in monotonous tasks (Driskell & Mullen, 2005). A study of 12-h night shift workers' response times on a vigilance task revealed that, at the end of the first night shift, reaction times were quicker after a 20 min nap was taken between 1 and 3 a.m. (Purnell, Feyer, & Herbison, 2002). Because sleep inertia (i.e., grogginess upon awakening) can impair performance if the duration of napping is too long, naps ideally should last about 20 min. Excessive noise inhibits sleep initiation during planned napping; if employers create appropriate conditions for napping, it improves the outcome (Lenne, Dwyer, Triggs, Rajaratnam, & Redman, 2004). Most workers will decline to nap if work demands cannot be adequately covered during their absence.

Individual Worker Strategies to Improve Schedule-Related Health and Safety

Workers themselves can be proactive to manage their health and safety when working shifts, extended hours and early start times. These personal behaviors can reduce drowsiness and improve alertness.

Planned Caffeine and Stimulant Use

Caffeine is a universally used substance that helps workers to maintain alertness during shift work (Ker, Edwards, Felix, Blackhall, & Roberts, 2010). Night shift workers often drink caffeinated beverages throughout their shift in order to be alert enough to drive home. But, because the half-life of caffeine is about 4–5 h, this can cause premature awakening in the early afternoon before a full sleep period is achieved. The most commonly recommended strategy to avoid this is to drink 200–300 mg of a caffeinated beverage at 11 p.m. (e.g., 16 ounces of strong coffee), and then avoid caffeine for the rest of the night. More recently, Wyatt, Cajochen, Ritz-De-Cecco and Czeisler (2004) demonstrated a dosing regime that uses small intermittent doses of caffeine throughout the night to provide adequate and sustained stimulation without residual caffeine interfering with daytime sleep.

Sleep Timing

Because night shift workers usually revert to sleeping at night on their days off, their circadian systems can become dysregulated, creating poor sleep throughout the work schedule cycle. Eastman's extensive laboratory research on timing sleep to produce alertness during the night demonstrates that it is possible to improve nighttime performance in carefully controlled conditions. Her most recent study recommends that night shift workers adopt a compromise sleep position by remaining awake into the early morning hours (go to bed at 3 a.m.) on nights off, and then sleep during part of the day (arise at 12 noon) to avoid fully shifting their circadian system to increase night shift alertness (Smith, Fogg, & Eastman, 2009). Night shift workers should use blue-light blocking glasses in the morning to

avoid triggering the normal upswing in circadian waking pressure from bright morning light (Sasseville, Benhaberou-Brun, Fontaine, Charon, & Hebert, 2009).

Pharmacotherapy

There are several drugs that can be prescribed to promote either sleep or alertness for workers with SWSD. Hypnotics and melatonin can be used to induce and sustain sleep when the worker is unable to achieve adequate sleep independently. Stimulants are used to sustain alertness. Drugs are often prescribed as a first-line therapy by primary care providers without a full diagnostic assessment for sleep disorders; patients seen by sleep specialists are often patients who were unresponsive to medication from primary care settings. Drug treatment should not be a replacement for spending adequate time in bed.

Regulation of Work Hours: Governmental Regulation and Public Policy

Governments around the World have attempted to address some of the societal problems associated with work schedules and drowsiness as a matter of law and public policy, particularly where public and occupational health and safety are threatened (Jones, Lee, & Rajaratnam, 2010). One of the most common governmental actions has been the development, adoption, and implementation of hours of service (HOS) regulations to limit the number of work hours and to prescribe minimum rest periods for workers in particular occupational groups (Table 14.1). Many governments also have used their legal authority to regulate public health and safety by adopting broad regulatory schemes relating to occupational health and safety (OH&S) that place a general legal duty on employers to address drowsiness as a workplace safety hazard.

The USA

The principle legal authority protecting worker health and safety rights in the USA is the federal Occupational Safety and Health Act of 1970 (OSH Act; Pub. L. No. 91-596, 84 Stat. 1590), and the regulations promulgated under it that establish federal occupational safety and health standards (*see* 29 C.F.R. pts. 1900–2400). The OSH Act covers most employers and employees in the USA, including all of those in the private sector (*see* OSH Act § 3(5) (definition of "employer"), *codified at* 29 U.S.C. § 652(5); OSHA Workers website), and requires employers to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees" (OSH Act § 5 ("General Duty Clause"), *codified at* 29 U.S.C. § 654). In effect, the OSH Act provides workers with a right to working conditions that do not pose a risk of serious harm to their person and health. Enforcement of workplace safety and health regulations is administered by the federal Occupational Safety and Health Administration (OSHA, which is now part of the US Department of Labor). Under the regulatory scheme created by the OSH Act, States are free to address occupational safety or health issues for which OSHA has not promulgated federal standards; States also may work with OSHA to develop and enforce their own standards where OSHA has issued standards (OSH Act § 18, *codified at* 29 U.S.C. § 667).

To date, there are no formal OSHA federal standards relating to hours of service or to unusual or extended work shifts in any occupational group, despite requests from advocates to do so. For example, a group of health and safety advocates has petitioned OSHA to regulate work hours for resident physicians in US hospitals on two occasions over the past decade (Public Citizen et al.,

Table 14.1 Sample of Federal Hours of Service (HOS) Regulations in the USA

HOS regulation	Industry or profession regulated	Examples of types of workers covered	Promulgation year (oldest regulatory provision)
49 U.S.C. § 21103 and 49 C.F.R. pt. 228	Rail	Locomotive engineers Railroad signalmen	1907 (49 U.S.C. § 21103)
14 CFR §§ 121.465 to 121.525 and 135.261 to 135.273	Aviation	Airplane pilots Air crews	1964 (Various Provisions)
49 CFR pt. 395	Commercial Motor Carriers	Long-haul truck drivers Intercity bus drivers	1979 (§ 395.13–Drivers declared out of service)
46 U.S.C. § 8104 and 46 CFR §§ 15.705, 15.710, and 15.1111	Maritime Crews	Seamen Merchant marine officers	1983 (46 U.S.C. § 8104)
10 C.F.R. §§ 26.201 to 26.211	Nuclear Power Personnel	Nuclear power reactor operators	2008

2001, 2010). However, OSHA recently has provided guidance materials to educate workers in certain occupational groups about the health and safety hazards associated with unusual or extended work shifts (OSHA Safety and Health Guide; OSHA, Workers we can help.), and has signified that it is taking the issue of work schedules and occupational health and safety seriously. In his formal statement acknowledging receipt of the 2010 petition from Public Citizen and its allies, the US Assistant Secretary of Labor for Occupational Safety and Health acknowledged that:

> [t]he relationship of long hours, worker fatigue and safety is a concern beyond medical residents, since there is extensive evidence linking fatigue with operator error…. It is clear that long work hours can lead to tragic mistakes, endangering workers, patients and the public." (OSHA, Dr. David Michaels, 2010)

Other federal agencies in the USA appear to have already adopted this position (for quite some time in some cases), and have promulgated HOS regulations for workers in a number of industries and professions (Table 14.1) Furthermore, New York and Puerto Rico have promulgated HOS regulations for physicians in training at the State and Territory level, given the lack of federal HOS regulations for this occupational group (N.Y. COMP. CODES R. & REGS. tit. 10, § 405.4 and P.R. LAWS ANN., tit. 24, §§ 10005–10009).

European Working Time Directive

Europeans have paid more attention to work schedules as a quality of life issue than US employers. For example, the European Union (EU) has adopted a society-wide approach to addressing drowsiness in the work place as a matter of public policy by issuing the European Working Time Directive [EWTD; Directive 2003/88/EC of the European Parliament and of the Council (November 4, 2003), *repealing* Council Directive 93/104/EC (November 23, 1993)]. Instituted as a health and safety measure, the EWTD has changed working hours for citizens of EU Member States substantially by generally requiring all EU Member States to enact provisions limiting working time throughout all sectors of their respective economies (European Commission, 2010).

These provisions are to entitle all workers to work schedules that provide appropriate rest periods, including:

- A limit of 48 h of working time per week, including overtime (where "working time" is defined as "any period during which the worker is working, at the employer's disposal and carrying out his activity or duties, in accordance with national laws and/or practice")
- A minimum rest period of 11 continuous hours for every 24-h period (where "rest period" is defined as any period which is not "working time")
- A minimum rest period of 24 continuous hours for every 7-day period (in addition to the 11 h daily rest)
- Rest breaks during working time for shifts of 6 h or longer
- A minimum of 4 weeks of paid annual leave per year
- Restrictions on night work to an average of 8 h per 24-h periods and on heavy or dangerous work at night to 8 h in any 24-h period

The EWTD also provides night workers with a right to free regular health assessments and to transfer off of night duty when medically indicated. It also sets out special rules for working time in certain sectors (e.g., doctors in training, offshore workers, seagoing fishing workers, workers in urban passenger transport (Articles 17–21). Article 22 of the EWTD, however, allows EU Member States to "opt-out" of certain EWTD provisions restricting weekly working time under certain specified circumstances.

Organized Labor

Organized labor plays a significant role in decisions relating to work schedules and engages in a number of initiatives and activities to address the safety and health issues relating to long hours of work. For example, certain unions affiliated with the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO) formed the Overtime Work Group (now the Work Organization Work Group) in 2001 for the purposes of "gather[ing] and disseminat[ing] information on health and safety hazards associated with long work hours, develop[ing] materials for unions and their members to educate and assist them in addressing problems with excessive hours at work, draft[ing] model legislation, encourag[ing] research," and initiating other efforts to protect workers (Kojola, 2004). Many labor organizations have negotiated contract language in their collective bargaining agreements that place some limitations and restrictions on employers' ability to make working overtime hours mandatory, and to protect workers who refuse such hours (Kojola, 2004; AFL-CIO, 2002). In some cases, unionized workers have gone on strike over the issue of work schedules containing excessive hours and mandatory overtime. Such strikes in the past among certain health care workers (e.g., nurses, resident physicians) have resulted in some notable concessions from their hospital employers (Kojola, 2004; Lee, 2006).

Labor unions and other organizations also have been involved in a variety of governmental and legal activities relating to work schedules and excessive hours. For example, labor unions have been active in legislative efforts in the USA at the Federal and State levels relating to restrictions on mandatory overtime (Kojola, 2004). The Committee of Interns and Residents, a union affiliated with the Service Employees International Union (SEIU), has been one of the organizations to petition OSHA to regulate resident physician work hours in the USA (Public Citizen et al., 2001, 2010). In Canada, organized labor recently took legal action to bring about reforms in the work hours of resident physicians in Québec (FMRQ, 2011). The Québec Charter of Human Rights and Freedoms and the Canadian Charter of Rights and Freedoms were invoked to challenge certain extended work hour requirements for medical residents at a Montréal hospital under an existing collective agreement (McGill University Health Centre, 2011); FMRQ, 2011.

Finally, labor unions in the USA actively encourage and engage with government (viz., NIOSH) and academic researchers to "conduct scientific studies that deepen our understanding of the relationships between long work hours and worker health and safety and to identify effective intervention measures that protect workers." Of particular interest to organized labor is research on intervention and prevention efforts that are focused on "making changes in the workplace that reduce or eliminate exposure to hazards rather than at the level of the individual worker and his or her coping skills"; and do not "blame victims or discipline those who are injured or made sick" (Kojola, 2004).

It should be noted, however, that the interests of organized labor do not always align with the interests of advocates for healthy and safe work schedules. As a writer for the business travel blog on *The Economist* website noted when commenting on the recent controversy over sleeping air traffic controllers in the USA:

> [I]t's not always obvious whether labour, management or both are behind [drowsiness-inducing work schedules]…. On its face, [such scheduling] seems like the result of understaffing and of management cutting corners. But unions love overtime, so it's possible that labour was okay with this practice. Either way, let's all be glad that a few naps forced some major, necessary changes, and that no one was hurt. This could have been a lot worse. (NB, 2011)

These arguments could be framed as a workers' rights issue. Czeisler (2010) believes that adverse work schedules are unethical in safety-sensitive industries. He posits that employers often justify extended work hours by comparing schedules to the extremely onerous and unsafe physician-in-training work hours. The authors think that action is necessary at several levels. The provision of fatigue counter-measures and interventions should occur at the worksite, be evident in company policies, and at the level of industry regulation in order to prevent and mitigate the adverse health and safety consequences of work-related drowsiness and to promote worker sleep health. Such activities could be characterized as a meaningful response to the call for action of one Industrial Hygienist for the AFL-CIO:

> Organized labor will continue its efforts at the bargaining table to address issues of long hours of work, mandatory overtime and work organization through contract language with its employers. And we will remain involved in legislative efforts to resolve problems such as mandatory overtime in the health care industry. But dealing with individual employers and small sectors of our economy will not likely move the ball forward enough to address these problems for all workers who are impacted. To ultimately be successful, we will need to have broader public policy discussions and decisions over these matters. At this point in time, our colleagues in Europe and Canada are far ahead of us in this regard. They are examining issues of work organization and work–family balance, including long working hours, on a policy scale that far surpasses what we are doing in the United States (Kojola, 2004).

Summary and Conclusions

Adverse work schedules increase the risk for accidents, injuries, errors, acute health conditions and the development of chronic health problems. Work schedule characteristics such as early start times, shift work, and rotating shifts cause physiologic disruption in the body's homeostatic mechanisms. Adverse work schedules will continue to be a feature of employment worldwide, as some companies will always require continuous operations. Although employers cannot totally eliminate the impact of adverse work schedules, there are organizational interventions that can be implemented to mitigate risk. Employees must also maintain healthy behaviors, especially getting adequate sleep. As this is a societal issue, regulation could be improved to equal the playing field among employers and to protect workers against the risk of fatigue-induced injury and illness. Indeed, adverse work schedules affect nearly 1 in 5 workers in the USA (substantially larger proportion in some industry sectors), with the

burden falling disproportionately on low-wage employees. This chapter documents the effect of work schedules on increases in workplace accidents, drowsy driving, acute health conditions (e.g., infections, reproductive outcomes) as well as chronic diseases (e.g., cardiovascular disease, cancer). The consequences of working these adverse schedules can be serious, but are often not attributed to this risk exposure. For example, when a worker develops high blood pressure at age 35, he is unlikely to think "it must have been all that shift work I did for the past 15 years"; instead, he is more likely to think "I guess I'm not getting enough exercise and have gained a few pounds." The culture of individuality in the USA stresses personal responsibility for health, which is bolstered by public health campaigns that stress diet and exercise (but not sleep). Yet, most workers have little control over the types of schedules that are created by their employer, and thus, the more logical target for intervention is the employer.

There is a business case for preserving alertness and reducing drowsiness in workers. States can prosecute drivers who leave work drowsy and kill another driver in a motor vehicle crash under "reckless homicide" statutes (Jones et al., 2010). Moreover, the family members of victims in such cases have sued the employer on several occasions, arguing that the employer knew or should have known that their employee was too drowsy to drive based on their work schedule and failed to take preventative action (Robertson v. LeMaster, 301 S.E.2d 563 (W.Va. 1983); Faverty v. McDonald's Restaurants of Or., Inc., 892 P.2d 703 (Or. Ct. App. 1995), *appeal dismissed, petition for review dismissed*, 971 P.2d 407 (Or. 1998); Escoto v. Estate of Ambriz, 200 S.W.3d 716 (Tex. App. 2006), but *judgment reversed by* Nabors Drilling, USA, Inc. v. Escoto, 288 S.W.3d 401(Tex. 2009)) (Table 14.2). Moreover, the cost of workplace injuries is high for businesses that self-insure, and instituting fatigue-reducing schedules can reduce injuries as well as insurance costs (Moore-Ede et al., 2004).

Large employers who have active occupational health and safety departments already have adopted some elements of fatigue risk management program. Smaller employers are less aware of the need for such programs, and many are ill equipped to implement them. Small businesses account for about 45% of the non-Federal non-farm economy in the USA, and are projected to be a source of economic growth in the coming years (Popkin, 2001). There is a need to educate these employers, who are often operating on slim margins and may not have an awareness of occupational health and safety policies and practices.

Future Directions

Future research should focus on several areas. First, because adverse work schedules will continue to be a feature of work life for a substantial portion of the population, attention should be directed towards discovering strategies to help workers with these schedules to be safer. As was shown in this chapter, there are strategies known to be efficacious, but they need to be mainstreamed into the working culture. For example, it is accepted as "normal" for night shift workers to have extreme drowsiness on the drive home from work and, until workplace planned napping programs become a part of the work culture, this dangerous situation will continue. Workplace health promotion strategies should begin to emphasize sleep and safety, but must go beyond worker education and include the development and implementation of policies that ensure the opportunity for workers to achieve adequate rest. This must occur across industries where adverse work schedules are common, and must include motivated and resistant employers. Horrey et al. (2011) details other research needs, including identifying high risk populations and conditions for workplace sleepiness using stronger study designs and more objective measures of fatigue. In addition, he advocates for researchers to examine populations with chronic health conditions, and to consider interaction effects of various demographic and personality factors in fatigue research. As mathematical models of fatigue still have considerable unexplained

Table 14.2 Sample of Appellate Cases from US States Involving Lawsuits Against Employers of Drowsy Drivers

Case name	Citation	Summary of facts	Summary of decision	Subsequent judicial history
Robertson v. LeMaster	301 S.E.2d 563 (W.Va. 1983)	A 19 year-old railroad laborer fell asleep while driving home after being required to work for ~27 h without rest, resulting in a nonfatal crash with another vehicle	Ruling in which West Virginia's state supreme court declined to hold as a matter of West Virginia law that an employer's conduct in requiring its employee to work ~27 h and then "setting [the employee] loose upon the highway in an obviously exhausted condition" did not "create a foreseeable risk of harm to others which the [employer] had a duty to guard against"	The case was sent back to the trial court for further legal proceedings consistent with the state supreme court's opinion
Faverty v. McDonald's Restaurants of Or., Inc.	892 P.2d 703 (Or. Ct. App. 1995)	An 18 year-old employee of a fast-food restaurant fell asleep while driving home after working three shifts in a 24-h period and five nights during the preceding week, resulting in a crash with another vehicle that killed the employee and severely injured an occupant of the other vehicle	Ruling by an intermediate appeals court in Oregon that: • Upheld a trial court verdict for a plaintiff injured by the defendant corporation's fatigued employee driving home from work • Held that the defendant corporation knew or should have known that its employee was a hazard to himself and others when he drove home from his work place after working numerous hours	A subsequent appeal to Oregon's state supreme court ultimately was dismissed (971 P.2d 407 (Or. 1998)). [*N.B.*: This action does not necessarily mean that the Oregon state supreme court agreed with the outcome or legal reasoning behind the lower court's decision, nor does it mean that the state supreme court disagreed with the lower court's decision. Making such inferences from the state supreme court's action would be improper and invalid]
Escoto v. Estate of Ambriz	200 S.W.3d 716 (Tex. App. 2006)	A 19 year-old oil field worker driving home after a 12-hour night shift (6 p.m. to 6 a.m.) crashed into another vehicle, killing the worker and all 4 occupants of the other vehicle. During the ~4 months before the crash, the worker had been required by his employer to work 12-hour day shifts (6 a.m. to 6 p.m.) 1 week, take a week off, and then work 12-hour night shifts (6 p.m. to 6 a.m.) the following week	Case in which an intermediate appeals court in Texas ruled that: • An employer had a legal duty to an accident victim under Texas law because it was aware of the dangers of fatigue and knew that one of its employees was fatigued but "nonetheless permitted him to drive home to the foreseeable peril of himself and others" • The evidence adduced at trial "supports that [the employer] breached its duty by failing to act as a reasonably prudent employer in [the] same or similar circumstances" • The evidence adduced at trial was legally and factually sufficient to support a finding that the employer's conduct was "instrumental in causing its employee's fatigue and the subsequent accident in question"	The ruling in *Escoto* ultimately was reversed by Texas' state supreme court, which held that an employer had "no duty [under Texas law] to prevent injuries resulting from fatigue following an employee's shift-work schedule [or] to train its employees regarding the dangers of fatigue" (*Nabors Drilling, USA, Inc. v. Escoto*, 288 S.W.3d 401 (Tex. 2009))

Case name	Citation	Summary of facts	Summary of decision	Subsequent judicial history
Brewster v. Rush-Presbyterian-St. Luke's Med. Ctr.	836 N.E.2d 635 (Ill. App. 1 Dist. 2005)	A first-year resident physician at a hospital (i.e., hospital intern) fell asleep while driving home after a 36-hour work shift during which the resident worked (and thus was awake for) 34 of the 36 h scheduled, resulting in a crash with another vehicle that seriously injured the driver of the other vehicle	Ruling by an intermediate appeals court in Illinois holding in part that, under Illinois law, a hospital does not have a legal duty to a plaintiff "injured by an off-duty resident doctor allegedly suffering from sleep deprivation as a result of the hospital's policy on working hours"	The Illinois state supreme court declined to hear an appeal of this decision (844 N.E.2d 964 (Table) (Ill. 2006)). [*N.B.*: This action does not mean that the Illinois state supreme court agreed with the outcome or legal reasoning behind the lower court's decision, nor does it mean that the state supreme court disagreed with the lower court's decision. Making such inferences from the state supreme court's action would be improper and invalid]

variance, research should be directed towards identifying additional factors to account for these. Technological advances can be studied that can both predict and intervene when a fatigued worker is at risk. Finally, implementing fatigue risk management in organizations successfully is critical to reducing the burden of adverse work schedules on workers and the public at large.

In addition to studying workplaces, there needs to be a concerted effort to map out or examine systematically the current legal and policy landscape for protections against the occupational and public health and safety hazards posed by work-related sources of fatigue and drowsiness in the USA. There is a compelling public health and societal need for further work in this important area of public health law and policy. Once such a mapping effort is completed, it will be possible to investigate whether any gaps exist between governmental regulatory and enforcement activities, as well as to identify legal authorities and public policies where established fatigue and sleep knowledge is disregarded to the detriment of workers. The findings from such analyses potentially could allow legal professionals, researchers, legislators, policy-makers, workers, employers, and other stakeholders to consider thoughtful next steps to improve the health of the working population.

Acknowledgment The authors would like to thank Russell A. Sanna, PhD (Harvard Medical School, Division of Sleep Medicine) for providing the thematic inspiration for portions of this chapter.

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