Chapter 40. The Effects of Fatigue and Sleepiness on Nurse Performance and Patient Safety

Ann E. Rogers

Background

Although the words "fatigue" and "sleepiness" are often used interchangeably, they are distinct phenomena. Sleepiness refers to a tendency to fall asleep, whereas fatigue refers to an overwhelming sense of tiredness, lack of energy, and a feeling of exhaustion associated with impaired physical and/or cognitive functioning.[1] Sleepiness and fatigue often coexist as a consequence of sleep deprivation.

Even though fatigue can be due to a variety of causes (e.g., illness, a vigorous workout, or a period of prolonged concentration), this chapter will focus on the effects of fatigue associated with insufficient sleep (see Key Terms and Definitions). The impact of extended work shifts and the relationship of these work schedules to nurse and patient safety will also be explored. Several practices that show demonstrable potential for reducing the adverse effects of fatigue on patient safety will be reviewed at the end of the chapter.

Insufficient Sleep

Studies suggest that average sleep durations have decreased from 9 hours in 1910 to as little as 6.9 hours on workdays in 2002.[2–6] Objective measurements, however, suggest that mean sleep times may actually be somewhat lower than are typically reported in surveys. For example, 273 randomly selected middle-aged residents of San Diego (40 to 64 years) reported sleeping approximately 7 hours, an amount that appeared to correspond to their time in bed. Mean sleep times obtained from wrist actigraphy, however, revealed that participants slept on average 6.22 hours, approximately 43 minutes less than their subjective reports.[7]

Sleeping longer on weekends and nonworkdays is also common,[4, 6] suggesting that individuals are obtaining insufficient sleep on workdays, then attempting to "catch up" on weekends. Americans slept on average 36 minutes more on weekends in 2002,[4] which is somewhat longer than the 23 minutes reported by British adults.[6] American nurses who participated in a recent survey, however, obtained on average 84 minutes more sleep on nonworkdays than work days (8.2 hours on nonworkdays compared to 6.8 hours on workdays),[8] which is more than triple the amount reported by British adults and more than double that of other Americans.

Individuals working nights and rotating shifts rarely obtain optimal amounts of sleep. In fact, an early objective study showed that night shift workers obtain 1 to 4 hours less sleep than normal when they were working nights.[9] Sleep loss is cumulative and by the end of the workweek, the sleep debt (sleep loss) may be significant enough to impair decisionmaking, initiative, integration of information, planning and plan execution, and vigilance.[10, 11] The effects of sleep loss are insidious and until severe, are not usually recognized by the sleep-deprived individual.[12, 13]

Finally, it is not uncommon for nurses and other shift workers to acknowledge falling asleep when working nights.[8, 14, 15] Almost one-fifth of the nurses working permanent night shifts reported struggling to stay awake while taking care of a patient at least once during the previous month.[15] Another survey found that the occurrence of falling asleep during the night shift occurred at least once a week among 35.3 percent of the nurses who rotated shifts, 32.4 percent of the nurses who worked nights, and 20.7 percent of the day/evening shift nurses who worked occasional nights.[16] Objective recordings using ambulatory polysomnographic recorders and actigraphy have verified that nurses, air traffic controllers, and even commercial truck drivers regularly fall asleep for brief periods during the night shift.[17–19]

Effects of Insufficient Sleep

Although the exact amount of sleep needed by healthy adults has not been determined, the effects of insufficient sleep have been well documented. A review of the relevant literature over the past 15 years reveals that insufficient sleep (or partial sleep deprivation) has a variety of adverse effects. Despite the wide range of research methodologies (e.g., qualitative studies, surveys and clinical trials, instruments) and settings (e.g., field studies, and time-isolation laboratories, and sample sizes), the results are quite similar: insufficient sleep has been associated with cognitive problems, mood alterations, reduced job performance, reduced motivation, increased safety risks, and physiological changes. Results from laboratory studies of total sleep deprivation (one or more nights without sleep) were not included in this review, since the focus of this section is on insufficient sleep (partial sleep deprivation) and not on total sleep deprivation.

It is important to note that none of the several hundred studies reviewed for this paper showed *any* positive effects from sleep restriction in healthy adults. While it is true that one night of sleep deprivation can temporarily elevate mood in depressed patients,[20, 21] it has adverse effects on mood in healthy individuals of all ages,[22, 23] including nurses.[24] Depression increases,[25, 26] irritability increases,[27, 28] and people report feeling more stressed when sleep is restricted.[24] Extended sleep times, however, are not associated with improved mood or health and may be associated with poor health. Mortality rates were highest among subjects ages 30 to 100 years who slept 8 or more hours, and lowest among those who slept 7 hours sleep,[29] findings that were identical to those obtained a year later from a prospective study of 82,975 registered nurses (Nurses Health Study).[30]

Contrary to what one might expect, partially sleep-deprived older women (55 to 65 years) in one study suffered fewer ill effects when compared to younger women (20 to 30 years),[31] and sleep-deprived older drivers (52 to 63 years) of both genders performed better than sleep-deprived younger drivers (20 to 25 years).[32] An earlier study, however, reported that younger male drivers were more resistant to the adverse effects of sleep deprivation than older male drivers.[33]

Although some people are less impaired by insufficient sleep than others,[34] several studies have shown that failure to obtain adequate sleep is an important contributor to medical error.[25, 35–37] Although most studies have focused on measuring the effects of sleep deprivation on the performance of interns and resident physicians, sleep deprivation also has adverse effects on the performance of hospital staff nurses.[8] Using data from the first sample of nurses (n = 393) who participated in the Staff Nurse Fatigue and Patient Safety Study, Dawson and his colleagues (Dawson, personal communication, 2005) found a significant relationship between sleep in the prior 24 hours and the risk of making an error. Nurses who reported an error or near miss obtained significantly less sleep than nurses who did not report an error or near miss (6.3 ± 1.9 hours versus 6.8 ± 1.7 hours). Using techniques described in one of their papers,[38] researchers determined that there was a 3.4 percent chance of an error when nurses obtained 6 or fewer hours of sleep in the prior 24 hours and 12 or fewer hours of sleep in the prior 48 hours (Dawson, personal communication, 2005). Although a 3.4 percent risk of an error or near miss sounds insignificant, it would translate to a probability of 34 events per day in an average teaching hospital with 1,000 nursing shifts per day.

In addition to jeopardizing patient safety, nurses who fail to obtain adequate amounts of sleep are also risking their own health and safety. According to the National Center for Sleep Disorders Research and the National Highway Transportation Safety Administration Expert Panel on Driver Fatigue and Sleepiness,[39] sleep loss is the leading cause of drowsy driving and sleep-related vehicle crashes. Drowsy drivers have slower reaction times,[40] reduced vigilance,[41, 42] and information processing deficits,[40] which make it difficult to detect hazards and respond quickly and appropriately.[39] Laboratory studies have shown that moderate levels of prolonged wakefulness can produce performance impairments equivalent to or greater than levels of intoxication deemed unacceptable for driving, working, and/or operating dangerous equipment.[43, 44] Dawson and his colleagues[43, 44] were the first to report that prolonged periods of wakefulness (i.e., 20 to 25 hours without sleep) can produce performance decrements equivalent to a blood alcohol concentration of 0.01 percent, and numerous other studies have confirmed that prolonged wakefulness significantly impairs speed and accuracy, hand-eye coordination, decisionmaking, and memory.[45–49] Although numerous studies have shown that night shift workers report very high rates of drowsy driving and motor vehicle accidents when driving home after work,[50–52] the majority of research on drowsy driving among health care providers has focused on the dangers of resident physicians driving home after a night of being on-call.

There is also a growing body of evidence that sleep duration is (1) linked to metabolism and the regulation of appetite, and (2) decreased sleep times may be a contributing factor to the growing epidemic of obesity in this country. Several large-scale studies have shown dose-dependent relationships between sleep duration and obesity, with greater sleep deprivation associated with a higher risk of obesity.[53, 54] Glucose tolerance is altered by short-term sleep restriction,[55] and habitually short sleep durations have been shown to significantly increase the risk of developing diabetes in women.[56] Tightly controlled laboratory studies have also shown that short sleep durations, e.g., 4 hours per night, can result in alterations of hormones involved in the regulation of appetite (e.g., leptin, cortisol, and thyrotropin).[57]

Sleep is also believed to play a role in regulating immune function. Both human and animal studies have shown that immunological challenges such as vaccinations and both experimentally induced and spontaneous infections tend to increase sleep duration, often increasing the duration and intensity of slow-wave sleep (deep sleep) and decreasing REM sleep (rapid eye movement sleep or dream sleep).[58, 59] Even though studies evaluating the effects of sleep deprivation on immunity have shown a variety of effects,[60–65] no study has been able to link these changes in immune function with increased rates of infection or other adverse effects on health.

Extended Work Hours

Although the hazards associated with the prolonged hours worked by resident physicians and interns have been documented in numerous studies,[25, 65–68] limited attention has been paid to the hours worked by nurses or the effects of these hours on patient safety. Early studies tended to focus on nurse satisfaction with the new 12-hour shift schedule, only minimally addressing the increased risk of errors.[35] More recent studies, however, have shown that the 12-hour shifts favored by many nurses and frequent overtime are associated with difficulties staying awake on duty, reduced sleep times, and nearly triple the risk of making an error.[14, 69, 70]

Although the majority of hospital staff nurses (75 percent) now work 12-hour shifts, some nurses report being scheduled to work for periods as long as 20 consecutive hours.[14, 69] Data collected on 11,387 shifts revealed that nurses left work at the end of their scheduled shift less than once every six shifts (15.7 percent), and worked on average 49 to 55 minutes extra each shift they worked.[14, 69] Working overtime, whether at the end of a regularly scheduled shift (even an 8-hour shift) or working more than 40 hours in a week, was associated with a statistically significant increase in the risk of making an error.[14, 69] The most significant elevations in the risk of making an error occurred when nurses worked 12.5 hours or longer; the risk was unaffected by whether the nurse was scheduled to work 12.5 hours or more, volunteered to work longer than scheduled, or was mandated to work overtime.[14, 69]

A little over two-thirds of the nurses participating in the Staff Nurse Fatigue and Patient Safety Study reported struggling to stay awake on duty, and 20 percent reported actually falling asleep on duty.[14, 71] In fact, critical care nurses reported struggling to stay awake almost once every five shifts they worked. Not all of the difficulties remaining alert occurred at night (24:00–06:00); 479 episodes of drowsiness (40 percent) occurred between 6 a.m. and midnight, and 40 episodes (23 percent) of actually falling asleep on duty were reported between 6 a.m. and midnight.[14] Nurses working 12.5 hours or longer were significantly more likely to report difficulties remaining alert than nurses working fewer hours per day,[14] and they obtained on average 30 minutes less sleep.

Although the participants (n = 35) in Urgrovics and Wright's 1990 study[72] reported fewer difficulties driving home after switching to 12 hour shifts, at least two recent studies contradict their findings. All but two of the nurses (n = 45) who worked 12-hour night shifts in an intensive care unit of a large tertiary care center reported having at least one motor vehicle accident or near accident during the previous 12 months driving to or from work.[73] More recently, over half of the participants in the Staff Nurse Fatigue and Patient Safety Study (54 percent) reported struggling to stay awake driving home from work during the 28-day data-gathering period.[74] While difficulties remaining alert driving home were common (drowsy driving was reported approximately once every five shifts), critical care nurses reported difficulties remaining awake driving home after working 12.5 consecutive hours or more approximately once out every three shifts they worked. In fact, critical care nurses who worked 12-hour shifts had a 1.87 percent greater risk of fighting sleep on their drive home from work than nurses working traditional 8-hour shifts (95 percent confidence interval [CI] = 1.43–2.45, $P < 0.0001$).[74]

According to a recent report of the National Institute of Occupational Safety and Health (NIOSH),[75] working more than 40 hours per week (overtime), working extended shifts (more than 8 hours), and working both extended shifts and overtime can have adverse effects on worker health. Extended shifts have been associated with increased musculoskeletal injuries,[76] more cardiovascular symptoms,[77–79] the development of hypertension,[80] and higher risks for injury.[81–83] Working overtime has also been associated with poorer perceived health,[84, 85] increased neck and musculoskeletal discomfort,[76, 86, 87] increased risk for preterm birth,[88] diabetes,[89, 90] and cardiovascular disease,[91–93] as well as increased morbidity and mortality[94] and higher rates of accidents.[95, 96] Not all studies, however, suggest that overtime is associated with poorer perceived health,[97] increased risk of developing diabetes mellitus, or cardiovascular disease.[98]

Studies have shown that accident rates increase during extended periods of work,[96] with accident rates rising after 9 hours, doubling after 12 consecutive hours,[81, 83] and tripling by 16 consecutive hours of work.[82] Data from the National Transportation Safety Board aircraft accident investigations also show higher rates of error after 12 hours.[99] Other studies show no change in accident frequency or severity of accidents,[100, 101] while one study showed that workers on a 12-hour shift schedule had lower rates of injuries at work, but higher rates of more significant injuries away from work.[82] The combination of extended shifts and overtime, while rarely studied, has been associated with high rates of motor vehicle accidents or near misses in the prior year,[73] more musculoskeletal pain, and cardiovascular symptoms.[77]

Consecutive Shifts

Fatigue can be exacerbated with increased numbers of shifts worked without a day off,[102, 103] and working more than four consecutive 12-hour shifts is associated with excessive fatigue and longer recovery times.[104] Folkard and Tucker[83] also suggested that the accumulation of fatigue over successive work shifts might explain the rise in accident rates observed in their meta-analysis. On average, risk of an accident was approximately 2 percent higher on the second morning/day shift; 7 percent higher on the third morning/day shift, and 17 percent higher on the fourth morning/day shift than on the first shift. Accident risks also increased over successive night shifts (e.g., on average risk was 6 percent higher on the second night, 17 percent higher on the third night, and 36 percent higher on the fourth night) and were significantly higher than on day/morning shifts, a finding similar to that reported by Hanecke and colleagues several years earlier.[81]

Fatigue Countermeasures and Other Recommended Safety Practices

Fatigue-related problems are believed to cost the United States an estimated $18 billion dollars per year in lost productivity and accidents.[105] More than 1,500 fatalities, 100,000 crashes, and 76,000 injuries annually are attributed to fatigue-related drowsiness on the highway.[105] On-the-job performance also deteriorates: railroad signal and meter reading errors increase at night, minor errors occur more often in hospitals, and switchboard operators take longer to respond to phone calls.[106] Two significant nuclear power plant accidents (Three Mile Island and Chernobyl) and the environmentally disastrous grounding of an oil tanker (Exxon Valdez) occurred at night, during early morning hours when vigilance is at its lowest. In the case of the Exxon Valdez grounding, sleep deprivation was identified as one of the major causal factors of the grounding (the third mate had been awake 18 hours and the ship's master had not slept in the 36 hours prior to the accident).[107] According to a supplemental report,[108] sleep deprivation was a contributory, if not causal, factor in the poor decisions made the night before the launch of the Space Shuttle Challenger.

A variety of industries and professions have developed programs to reduce sleepiness-based errors under the aegis of "fatigue management."[109–111] These programs usually include an educational component [112–116] and sometimes include schedule alterations.[114, 117] Employees are usually given information about circadian rhythms, sleep hygiene measures, shift work and its adverse effects, and a variety of strategies that can be used to reduce fatigue (e.g., judicious use of caffeine and napping during night shifts).[118, 119] Managers may be urged to consider altering the starting times of shifts whenever possible to make schedules more compatible with circadian rhythms; to avoid scheduling employees to work more than two or three consecutive night shifts; and to provide adequate recovery time between shifts, especially when an employee is rotating off night shift. Hours of service regulations, where applicable, are also considered in the development of a fatigue management program.[119]

Only limited information about the efficacy of these programs is available to the public. Although several specialized fatigue countermeasures programs have been developed and tested by the U.S Coast Guard, the Crew Endurance Management System,[113] and the Commercial Mariner Endurance Management System,[112] information about the efficacy of these programs has not been disseminated. Private companies implementing Fatigue Countermeasures Programs consider their use to be proprietary information. In fact, the only paper describing the efficacy of a fatigue countermeasures program reported only equivocal results.[116]

Other Recommended Safety Practices

Rest breaks, napping, exercise, bright lights, and pharmacologic measures may be used to provide temporary relief from the symptoms of fatigue during the work shift. Although frequent short rests breaks are usually recommended for the prevention of fatigue, anecdotal information, collective bargaining agreements, and even research studies suggest that nurses are regularly sacrificing their breaks and meal periods to provide patient care.[120–126] In fact, a recent study revealed that hospital staff nurses were completely free of patient care responsibilities during a break or meal period less than half the shifts they worked (2,429 out of 5,221 shifts). There were 334 shifts (10 percent) in which nurses reported having no opportunity to sit down for a break or meal period. The rest of the time (2,249 out of 5,211 shifts) nurses reported having the time for a break or meal, but that they were not relieved of patient responsibilities during that time.[126] On average nurses reported having only 25.7 minutes break during their entire shift. Nurses working the longest hours were least likely to receive appropriate breaks (e.g., 10 minutes every 2 hours and a 30-minute meal period free of patient care responsibilities).

Studies have shown that short breaks not only improve performance and reduce subjective fatigue,[127–130] they are effective in controlling the accumulation of risk associated with prolonged task performance (e.g., 2 hours sustained work)[131, 132] and sleepiness.[129] Other studies however, have shown that rest breaks and tea breaks can decrease fatigue but not necessarily accident risk or errors.[126, 133]

Napping. Even though napping during breaks or meal periods is often prohibited, both laboratory and field studies suggest that naps (15 minutes to 3 hours) are quite effective in increasing alertness during extended work periods or at night.[134–139] Since few operational settings allow for long naps (e.g., 3 hours), most naps studied in operational settings are short. For example, 20-minute single naps during the first night shift improved the speed of responses on a vigilance task at the end of the shift,[134] and 26-minute in-seat naps have been shown to increase physiological alertness and psychomotor performance of airline pilots.[140] When pilots were allowed a nap during night flights, their performance improved by 34 percent, and physiologic alertness improved 54 percent compared to the no-nap condition.[140]

The alerting effects of naps are varied, with most studies suggesting that improvements in subjective alertness and performance are sustained for up to an hour or more postnap.[138, 139, 141] Longer naps tend to produce longer periods of alertness and improved performance.[142] Although some studies report sleep inertia, or a period of decreased alertness and performance immediately following a nap,[138, 139, 141] this effect was not seen in Driskell's meta-analysis.[142]

Stimulants. Caffeine is probably the most commonly used fatigue countermeasure.[143] Its effects have been studied alone,[144] as well as in combination with rest breaks, naps, and other stimulant medications.[145–147] Generally, caffeine's onset of action occurs approximately 15–30 minutes after ingestion and its effects last 3–4 hours. Although tolerance can develop, significant increases in alertness and performance can be obtained with 200 mg of caffeine (approximately the amount of caffeine in one to two cups of coffee), with positive effects occurring with doses ranging from 100 mg to 600 mg.[143, 145] Although caffeine alone improved alertness and performance during a laboratory study, the combination of napping and caffeine was more efficacious than just napping or just caffeine alone in a field study of evening and night shift workers.[146] Six hundred milligrams of caffeine was also as effective as 20 mg d-amphetamine and 400 mg modafinil in producing short-term performance and alertness during prolonged sleep loss.[148] Modafinil has also been shown to be effective in increasing alertness on laboratory measures of performance among workers diagnosed with shift work sleep disorder (see Table 1 for a description of the disorder),[149–151] but produced mixed results when evaluated during a randomized, double-blind cross-over study of sleep-deprived emergency room physicians. Even though modafinil improved some aspects of cognitive functioning and perceived alertness, participants had difficulties falling asleep when given an opportunity.[152] Although other compounds have been recommended (e.g., melatonin), their efficacy has not been established.[153, 154]

Bright light. Although a number of studies have shown that bright lighting in control rooms, work areas, and laboratory environments can increase alertness at night and facilitate entrainment to night shift work,[154–157] this strategy may not help nurses as much as other types of workers. Protocols typically involve exposure to bright lights (approximately 2,500 lux) or normal lighting (approximately 150 lux) while working at a desk for periods of 2 to 6 hours. No one has evaluated the efficacy of intermittent exposure to bright lights or the effects of alternating exposure to bright lights with the dim lighting typically found in patient rooms at night.

Exercise. Exercise typically produces increased subjective alertness and improved cognitive performance in both sleep-deprived and nonsleep-deprived subjects.[158, 159] Exercising for 10 minutes, however, produces only transient (30–50 minutes) increases in subjective alertness. In one study there were no effects on performance after exercise, but within 50 minutes there were signs of increased drowsiness on electroencephalogram (EEG) recordings.[160] As a result of this finding, the authors of the study caution that people who use exercise as an intervention for maintaining alertness during a period of sleep loss may end up sleepier than if they had not exercised.

Research Evidence

There is a very large, strong body of evidence showing that insufficient sleep has adverse effects on cognition, performance, and mood. These effects have been documented by at least two meta-analyses[22, 150] and several clinical trials,[32, 161, 162] as well as by studies using somewhat less robust designs including time series, cross-sectional, before-and-after designs, and noncomparative descriptive studies.[11, 30, 37, 163–167] The adverse effects of insufficient sleep have also been documented in a variety of settings ranging from tightly controlled laboratories[11, 32, 162, 163, 166] to field studies,[30, 37, 164–167] and in a variety of occupational groups.

The studies demonstrating a relationship between adverse effects on health and obtaining less than 7 hours sleep per night tend to use less robust designs (e.g., cross-sectional designs, time series designs, comparative and noncomparative descriptive designs), but they often include large numbers of participants. Although survey and cross-sectional designs may not be as rigorous as controlled clinical trials, the number of recent studies suggesting similar relationships between insufficient sleep, altered glucose metabolism,[56, 168] and increased risks of developing diabetes mellitus[54, 169] and obesity[53, 54] is powerful and convincing evidence that a relationship exists between these variables. Longer sleep durations (e.g., more than 8 to 9 hours per night) were also associated with greater risks of dying or developing a chronic illness such as DM or cardiovascular disease,[29, 56, 168] leading researchers to speculate that individuals who routinely obtain higher than normal amounts of sleep may have preexisting health problems.[29]

The evidence regarding shift duration, however, is less clear-cut. Although some studies suggest that reductions in the work hours of resident physicians and interns is associated with fewer errors,[35] other studies suggest that the implementation of work hour limitations has not decreased the number of adverse events.[169,170] Although there are numerous literature reviews,[171–173] descriptive and other comparative studies,[14, 25, 26, 69, 174–176] there are no meta-analyses and only one systematic review[177] focusing on the impact of work hours on medical errors or work performance. The strongest study, involving 20 critical care residents and interns and direct observation of errors, found that traditional schedules were associated with 35 percent more serious errors, and shortened workdays (16 hours) were associated with both fewer order-writing errors and diagnostic errors.[35] Unfortunately, this study has not been replicated outside of the critical care setting or at any other institution.

The evidence demonstrating a relationship between working long hours and adverse effects on health is stronger. Not only are there several large-scale studies documenting higher injury rates when people worked overtime or extended shifts,[82, 178, 179] there are several literature reviews[83, 170] and three meta-analyses examining the effects on worker health.[78, 79, 83]

Clinical trials that would provide more definitive answers to questions regarding shift duration and adverse health effects have not been done, nor are they likely to be done because of ethical issues.

Although more than 170,000 employees from a variety of industries (including aviation, rail, trucking, maritime, health care, petrochemical, nuclear energy, and law enforcement) have been exposed to fatigue countermeasures programs,[115] there is very limited information about their efficacy. Typical reports indicate that some aspects of a particular program were successful (e.g., employees slept longer at night,[180] napping improved alertness on duty,[129] and that participants used most of the suggested strategies),[116] but the reports rarely assess the efficacy of the program as a whole for improving alertness on the job and reducing errors. The only published study describing the outcomes of a fatigue countermeasures program for resident physicians involved a very small sample (n = 6) and produced mixed results.[116] Although participants reported increased subjective alertness after using the suggested strategies for a month, there were no improvements in their performance, mood, or the amount of sleep obtained when working the night shift.

There is strong evidence that short naps can improve alertness during night shifts and prolonged periods of wakefulness. Data obtained from several small clinical trials,[134, 138, 140, 146] and a meta-analysis[142] all support the use of this strategy for improving alertness at night. In addition, there are several small clinical trials that suggest a short daytime nap can improve alertness during the afternoon.[181–184]

The effects of rest breaks were more variable. Study designs evaluating the efficacy of rest breaks on performance and alertness also tended to be weaker, involving quasi-experimental designs[128, 130, 131, 133, 185] rather than randomized clinical trials[129] or meta-analyses. Given that almost all of the aforementioned studies were field studies conducted at actual worksites during regular workhours, the choice of somewhat less rigorous designs is understandable.

There is strong evidence that use of caffeine, either alone or in combination with a nap, can increase alertness. Although there are no meta-analyses evaluating the efficacy of caffeine, the utility of caffeine for increasing alertness has been demonstrated through numerous clinical trials,[144, 145, 147] and its widespread use by adults. (Mean caffeine consumption in the United States is estimated at 238 mg or slightly more than two cups of coffee per day per person.)[186] Other measures to increase alertness, such as bright lighting and exercise, either lack sufficient evidence or may not be practical for nurses.

Evidence-Based Practice Implications

Although studies have not always been able to document that the cognitive deficits associated with insufficient sleep lead to medical mishaps, there is enough evidence to suggest that insufficient sleep can have adverse effects on patient safety and the health of nurses. The effects, summarized in Table 1, provide the basis for the two recommendations in Table 2.

Table 1. Adverse Effects of Restricted Sleep on Patient Safety and the Health of Nurses

Sleep Duration in 24 Hour Period	Adverse Effects on Patient Safety	Adverse Effects on Health
< 7 hours	More likely to report struggling to stay awake during work shift[14]	Increased risk of developing cardiovascular disease and DM among nurses[187] Increased risk of becoming obese over a 10-year period[53]
≤ 6 hours	Risk of making an error is 3.4% during a work shift among nurses who slept ≤ 6 hours in 24 hours prior to shift (Dawson, personal communication)	Increased prevalence of DM and altered glucose metabolism[56, 168] Risk of obesity is 23% greater than subjects sleeping 7–9 hours[53]
< 5 hours	Increased subjective and objective sleepiness, and reduced performance on cognitive tasks[22, 161]	Increased risk of developing DM demonstrated in nurses[187] Risk of obesity is 50% greater than among subjects sleeping 7–9 hours[53]
≤ 4 hours		Altered levels of appetite-regulating hormones (leptin, cortisol, and thyrotropin)[57] Risk of obesity is 73% greater than among subjects sleeping 7–9 hours[53]

Table 2. Evidenced-Based Recommendations for Practice Related to Sleep Duration[32]

Recommendation	Practice Implication
Nurses need to obtain 7–8 hours sleep per night to protect both the health of their patients and their own health	Get 7 to 8 hours of sleep each day (24-hour period) before you go to work.
Younger nurses (e.g., those 20–30 years old) need to be particularly careful about obtaining sufficient sleep, since their mood and performance may be more adversely affected by insufficient sleep.	If you are younger than 30 years of age, adequate sleep is especially important for providing safe and high-quality patient care.

To implement these recommendations, many nurses will have to be willing to make substantial changes in their behavior. Despite their more sophisticated knowledge about health and illness, the sleep habits of nurses mirror those of other Americans. Only a little more than one-fourth of the participants in the Staff Nurse Fatigue and Patient Safety Study (27.2 percent) obtained at least 6 hours sleep prior to every shift they worked during the 28-day study period; more than one-quarter of the 11,387 shifts studied (29.1 percent) were worked by nurses who obtained less than 6 hours sleep, an amount that has been associated with higher risks of errors (Dawson, personal communication, 2005). Although few nurses would consider coming to work if they were legally drunk, the data suggest that many nurses are unaware of or disregard the equally serious risks associated with insufficient sleep.

Although it might be argued that family responsibilities prevented hospitals staff nurses from obtaining sufficient sleep, regression analysis has shown that this is not the case. Neither childcare nor elder care responsibilities were associated with reduced sleep times on workdays. Instead, longer work shifts, longer commutes, higher caffeine intakes, complaints of poor sleep, and older age (of the nurse) were associated with shorter sleep durations.[188] Childcare responsibilities, however, were associated with shorter sleep times on nonworkdays.

Several authorities have recommended that work shifts be limited to 12 hours in a 24-hour period and employees limited to working no more than 48 to 60 hours per week.[171, 173, 189, 190] Although 12-hour shifts are quite popular among nurses, most authorities do not recommend the use of 12-hour shifts unless there are sufficient rest breaks, there are adequate arrangements for coverage of absentees, overtime will not be added, and shift systems are designed to minimize the accumulation of fatigue.[173, 190, 191] Rosa[173] also recommends that 12-hour shifts not be adopted if there are staffing shortages, citing the dangers associated with an already fatigued worker covering part or all of a vacant shift.

In fact, legislation pending in the Massachusetts State legislature would (1) prohibit resident physicians from working more than 10 consecutive hours in all high-intensity settings, (e.g., emergency departments, intensive care units, etc.); (2) limit resident physician workhours to 18 consecutive hours in all other areas; (3) mandate 16 consecutive hours off after an 18-hour shift and require 10 consecutive hours off between all other work shifts; and (4) require all physicians, not just trainees, to notify patients before providing care if the physician has been awake 22 hours out of the prior 24 hours.[192] Although the workhours of most nurses will not be altered by this legislation, limiting the duration of nursing shifts and mandating sufficient rest periods between shifts would also be of benefit for nurses and the patients they care for.

Table 3. Evidenced-Based Practice Recommendations Related to Shift Duration and Number of Workhours During a Week

Recommendation	Practice Implication
Schedules that involve working 48 or 60 hours per week,[193] or working 7 consecutive 12-hour shifts in one week in order to have 7 consecutive days off the next week[194] are unacceptably risky,[83] and should be prohibited.	Do not work any more than 48 hours in a 7-day period.
The continued use of 12-hour shifts cannot be recommended given the current working conditions, including the almost daily need for nurses to stay beyond the end of their scheduled shift, the frequent absence of breaks during the workday, and the higher risk of errors associated with 12-hour shifts.[14, 69, 126]	Nurse managers should not schedule nurses for 12-hour shifts and nurses should not request 12-hours shifts.
If nurses insist on continuing to work 12-hour shifts, several measures should be taken to reduce the risks to patients and nurses. These steps include reducing the number of consecutive shifts to no more than three,[83, 104] providing adequate meal and rest breaks,[120, 195] revising schedules to ensure that nurses have at least 10–12 hours off between work shifts so that they have adequate time for sleep, commuting, and completing their domestic responsibilities, and requiring that nurses use their off-duty time to get sufficient sleep.	If you are scheduled to work a 12-hour shift, (1) do not work more than three shifts without a day off; (2) insist that provisions are made for sufficient staffing to ensure that you are able to be free of patient care responsibilities for 10 minutes every 2 hours and for 30 minutes to eat a meal; and (3) insist that you have at least 10–12 hours off between shifts so that you can obtain sufficient sleep.

The emphasis on maximizing opportunities for sleep is intentional. Because long workhours are often associated with insufficient sleep,[25, 36, 196] some authorities believe that fatigue on the job is more likely to be associated with a lack of sleep than the number of hours spent working.[191, 197] Workers who report high workloads, stressful workweeks, or who score higher on burnout indexes have shorter sleep times,[198, 199] as well as more arousals, greater sleep fragmentation, more wake time after sleep onset, lighter sleep, and less deep sleep.[200, 201] Fatigue and daytime sleepiness associated with stressful working conditions and burnout is believed to be a result of insufficient sleep, rather than a direct result of stressful working conditions or burnout.

Although employer support will be required to implement schedule changes, there are several strategies that nurses can adopt to improve their ability to remain alert throughout their entire shift. Even though the following three fatigue countermeasures were developed mainly for night shift workers, the first two recommendations are also appropriate for nurses working other shifts.

Practice Recommendations for Use of Caffeine

1. Caffeine should be used therapeutically. Caffeine should not be consumed on a regular basis or when alert. Instead, caffeine consumption should occur only at the beginning of a shift or about an hour before an anticipated decrease in alertness (e.g., between 3 a.m. and 5 a.m.). To reduce the possibility of insomnia, caffeine consumption should stop at least 3 hours before a planned bedtime.[202]

2. Nurses should be allowed to nap during their break and meal periods. Naps should be short, e.g., less than 45 minutes, to reduce the likelihood of awakening from deep sleep and

experiencing sleep inertia.[143] Some nurses may prefer to take a shorter nap, and have a 15-minute wake up period before they resume patient care.

3. Nurses, particularly those who start their shift at 11 p.m. or midnight, should consider napping prior to starting their shift. Not only are nurses who work at night required to be awake and vigilant when their body temperature is lowest and their sleep tendency is greatest, they are typically awake longer before the beginning of their shift than workers on other shifts.[203]

Table 4. Evidenced-Based Recommendations for Practice Related to Improving Alertness on the Job

Recommendation	Practice Implication
Caffeine should be used therapeutically. Caffeine should not be consumed on a regular basis or when alert. Instead, caffeine consumption should occur only at the beginning of a shift or about an hour before an anticipated decrease in alertness e.g., between 3 a.m. and 5 a.m. To reduce the possibility of insomnia, caffeine consumption should stop at least 3 hours before a planned bedtime	Do not consume caffeine outside of workhours. Consume caffeinated beverages only at the beginning of the shift or about an hour before an anticipated decrease in alertness, e.g., between 3 a.m. and 5 a.m. Avoid consuming caffeinated beverages at least 3 hours before bedtime.
Nurses should be allowed to nap during their break and meal periods. Naps should be short, e.g., less than 45 minutes, to reduce the likelihood of awakening from deep sleep and experiencing sleep inertia. Some nurses may prefer to take a shorter nap and have a 15-minute wake up period before they resume patient care	Use breaks and meal periods for a short nap, particularly during the night shift. Naps should be less than 45 minutes in duration. If you are somewhat sluggish when you first awaken, take a shorter nap so that you have at least a 15-minute wake up period before resuming patient care.
Nurses, particularly those who start their shift at 11 p.m. or midnight, should consider napping prior to starting their shift. Not only are nurses who work at night required to be awake and vigilant when their body temperature is lowest and their sleep tendency is greatest, they are typically awake longer before the beginning of their shift than workers on other shifts	If you work nights, especially if you start working at 11 p.m. or midnight, take a nap prior to starting your shift to help you remain alert during the early morning hours. Although it may be more difficult to schedule, taking a short nap before working a 12-hr night shift, would also help improve your alertness during the early morning hours.

Finally, nurses should realize that most people are not accurate judges of how impaired they are by fatigue or sleep loss.[204, 205] Few adults can perform at high levels for more than 12 consecutive hours or function adequately with less than 6 hours sleep. Figure 1 illustrates the risks associated with combining insufficient sleep with extended shifts and outlines strategies to reduce fatigue-related errors.

Figure 1. Risks Associated With Various Combinations of Sleep Duration, Shift Duration, and Shift Time, and Strategies To Mitigate the Effects of Insufficient Sleep and Extended Work Shifts

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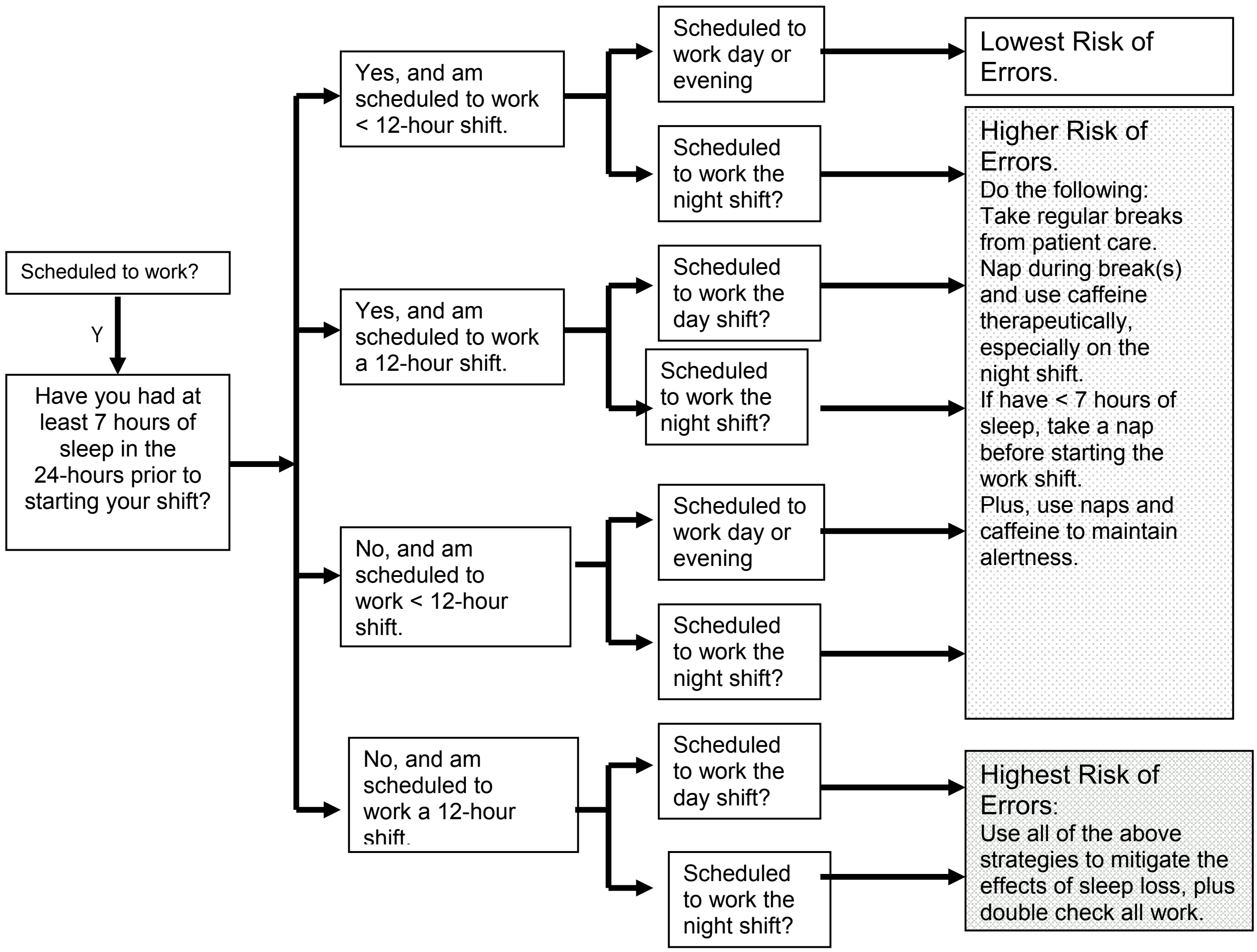

Research Implications

More research is needed to understand the effects of fatigue on patient safety. Controlled trials are needed to determine optimal work schedules in hospital settings and test fatigue countermeasures. Since night shifts cannot be eliminated, the efficacy of fatigue countermeasures, naps during break periods, therapeutic use of caffeine, and other measures should be tested in hospital environments. Since the use of naps and caffeine have been shown to increased alertness during prolonged sleep deprivation and during night shift work, these measures should also be evaluated to determine if they would be effective for increasing alertness on day and evening shifts.

Finally, there is no information about the sleep of nurses working outside of hospital environments, and only limited information about the workhours of nurses in nursing homes and extended-care facilities. Nor is there any information about the sleep and performance of nurses who work 24-hour shifts (e.g., nurse-midwives and some advanced practice nurses) or who are required to take call. These issues and others need to be examined to improve both the safety of patients and the nurses who care for them.

Although many questions remain unanswered, "We do know enough," according to L. G. Olson and A. Ambrogetti, "to end the worse abuses of the human sleep-wake cycle, and we need to see a shift by both hospital employers and the medical [nursing]* profession towards addressing this issue"[206] (p. 416). The service regulations written during the first two decades of the 20th century recognized that people cannot work for long periods of time each day without adequate time to sleep. Eighty years later, at the beginning of the 21st century, it is perhaps time to acknowledge that nurses cannot provide safe care when they are fatigued, have worked for more than 12 consecutive hours, and/or have not had at least 12 to 16 hours off between shifts.

* Material in brackets added by author.

Table 5. Critical Research Questions

Research Question	Research Goal	Possible Study Methods
What is the optimal schedule for minimizing fatigue among hospital staff nurses? For nurses working in long-term care facilities?	To evaluate different types of schedules to determine which is the most effective for minimizing fatigue among hospital staff nurses and nurses working in long-term care facilities.	Controlled clinical trials of schedules involving different shift durations, number of consecutive days off, and types of shifts, e.g., night versus day shift.
Will the risk of making an error decrease if shifts are shortened to ≤ 10 hours and/or nurses get at least 7 hours sleep?	To determine if shorter work durations and obtaining adequate amounts of sleep reduce the risk of making an error.	Clinical trial, with one group assigned to shorter shifts, the second group assigned to obtain at least 7 hours sleep, and the third group assigned to work shorter shifts and obtain at least 7 hours sleep.
Since most nurses and managers favor 12-hour shifts despite their well-recognized hazards, how can the culture of individual nursing units be changed to discourage their use?	To determine what factors favor the continued use of 12-hour shifts and how to alter those factors to make shorter shifts more acceptable to staff nurses and nurse managers.	Qualitative approaches, in combination with rating scales to assess unit culture and institutional commitment to improving patient safety.
What differentiates those nurses who always obtain at least 6 hours sleep prior to working from those who fail to get at least 6 hours sleep prior to working?	To identify the characteristics of nurses who are most likely to obtain the minimum amount of sleep necessary to provide care safely.	Correlation studies and regression models.
Will fatigue countermeasures, e.g., naps during break periods and therapeutic use of caffeine, increase the alertness of nurses working at night? Decrease the risk of making an error?	To evaluate the efficacy of fatigue countermeasures for increasing the alertness and decreasing the risk of errors when nurses work at night.	Clinical trial comparing the alertness and risk of errors in night shift nurses assigned to fatigue countermeasures group to those who are not assigned to the intervention group.
Will fatigue countermeasures, e.g., naps during break periods and therapeutic use of caffeine, increase the alertness of nurses working 12-hour shifts? Decrease the risk of making an error?	To evaluate the efficacy of fatigue countermeasures for increasing the alertness and decreasing the risk of errors when nurses work 12-hour shifts	Clinical trial comparing the alertness and risk of errors of nurses working 12-hours shifts assigned to fatigue countermeasures group to those who are not assigned to the intervention group.
Should nurse midwives and other advanced practice nurses be allowed to work 24-hour shifts?	To determine if 24-hour shifts worked by nurse midwives and other advanced practice nurses are safe.	Observational study using methodology similar to that used to evaluate the safety of 24-hr shifts worked by critical care residents.

Conclusion

The evidence is overwhelming that nurses who work longer than 12 consecutive hours or work when they have not obtained sufficient sleep are putting their patients' health at risk; risk damaging their own health; and if they drive home when they are drowsy, also put the health of the general public at risk. Nurses, nurse managers, nursing administrators, and policymakers need to work together to change the culture that not only allows, but often encourages nurses to work long hours without obtaining sufficient sleep.

Key Terms and Definitions

Table 6. Key Definitions

Term	Definition
Insufficient sleep	A condition that results from sleeping less than needed. Healthy adults who obtain enough sleep do not require an alarm clock to awaken them in the morning, do not have difficulties with remaining alert after lunch or during a boring lecture, and do not sleep in on weekends.
Wrist actigraphy	Wristwatch-sized instrument used to record frequency and amplitude of wrist movements. Used to distinguish sleep from waking states.
Sleep debt	The difference between the amount of sleep you need and the amount you obtained. The larger the sleep debt, the more likely you are to fall asleep during the daytime.
Polysomnographic recorders	Recording equipment used to record sleep. Equipment records electroencephalograms (EEG), electro-oculograms (EOG), and electro-myograms (EMG) needed for staging sleep.
Shift work sleep disorder	A sleep disorder effecting individuals who work at night. Individuals with this disorder have difficulty remaining awake during their work shift and have trouble sleeping after working at night, yet have no trouble sleeping at night or staying awake during the day on their days off.

Search Strategy

Relevant papers for this review were identified from three databases (MEDLINE,® CINHAL,® and PsychLit) using the period 1990–2006. Several older, classical works were also cited. Hand searches were also performed examining journals such as the *Journal of Sleep Research and Sleep.* Only those papers that focused on the effects of chronic partial or total sleep deprivation for a single night, extended work shifts, and strategies to reduce fatigue-related errors and accidents were included in this review. Search terms included "caffeine," "chronic partial sleep deprivation," "fatigue," "fatigue countermeasures," "extended work shifts," "napping," "overtime," "performance," "resident physicians," "registered nurses," "rest breaks," "sleep loss," "sleep restriction," "staff nurses," "total sleep deprivation," and "vigilance."

Author Affiliations

Ann E. Rogers, Ph.D., R.N., F.A.A.N., associate professor, University of Pennsylvania School of Nursing, and the Center for Sleep and Respiratory Neurobiology, University of Pennsylvania School of Medicine. E-mail: aerogers@nursing.upenn.edu.

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Evidence Table 1. Effects of Insufficient Sleep on Patient Safety and Health of Individuals

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Belenky 2003[161]	Chronic sleep restriction	Randomized controlled trial (2)	Randomized controlled trial (2) Vigilance, objective and subjective sleepiness (3)	69 healthy volunteers (16 women, 50 men) ages 24–62	Subjects' sleep restricted to 3 hr, 5 hr, 7 hr, or 9 hr/night for 7 nights	With mild to moderate sleep restriction (5–7 hr), performance initially declined then stabilized at levels below their baseline levels. With severe sleep restriction, performance continued to decline throughout the study period. There were no improvements in performance associated with increased sleep time (9 hr).
Harrison 1997[162]	One night's sleep loss	Randomized controlled trial (2)	Cross-over design (2), Verbal communication (3)	9 healthy college students		There was a significant reduction in word fluency, and subjects tended to become fixated within a particular semantic category. Speech was also more monotonic or flattened without appropriate intonation
Pilcher 1996[22]	Sleep loss	Meta-analysis (1)	Meta-analysis (1) Effects of sleep loss on cognition, motor performance, and mood (3)	19 studies and 1,932 participants		Sleep deprivation had more profound negative effects on mood than it did on cognition or motor performance. The effect sizes for partial sleep deprivation (≤ 5 hours sleep/night) on mood and cognitive function were larger than for long-term sleep deprivation 45 hours/week).

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Philibert 2005[150]	Sleep loss and cognitive function, memory and vigilance	Meta-analysis (1)	Meta-analysis (1) Effects of sleep loss among physicians on cognitive function, memory and vigilance (3)	60 studies published between 1971 and 2004 involving 959 physicians and 1,028 nonphysicians		Cognitive performance in physicians is affected by sleep deprivation. Smaller effect sizes in studies of physicians likely related to difficulty in controlling the exact number of hours sleep in field studies or the chronic sleep deprivation experienced by the "rested cohorts."
Phillip 2004[32]	One night's sleep loss	Randomized trial (2)	Cross-over design (2) Reaction time, subjective sleepiness and performance ratings (3)	10 younger (20–25 years) and 10 older (52–63 years) drivers		Reaction times were slower in older subjects without sleep deprivation; however, after sleep deprivation, the reaction times of older subjects remained unaffected, while the reaction times of younger subjects were significantly increased. Sleepiness and perception of performance were equally affected in both groups of subjects.
Ayas 2003 (a)[56]	Insufficient sleep	Time series (7)	Longitudinal study (3), self-reported sleep duration and risk of DM (1)	70,260 women ages 45–65 years who were enrolled in the Nurses Health Study		There was an elevated risk of developing DM among nurses who obtained less than 5 hours sleep/day or more than 9 hours sleep/day.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Gangwisch 2005[53]	Sleep restriction	Time series study (7)	Cross-sectional and longitudinal examination (4) of sleep duration and weight gain over a 10-year period (2)	Participants in the NHANES I study, 9,588 participants in the cross-sectional study and 6,981 participants in the longitudinal study		Subjects with sleep durations less than 7 hours at baseline (1982) were more likely to be obese 10 years later than subjects who obtained at least 7 hours sleep. Sleep durations greater than 7 hours were not consistently associated with either an increased or decreased risk of obesity.
Gottlieb 2005[168]	Chronic sleep restriction	Cross-sectional study (4)	Cross-sectional study (5) Usual sleep time, fasting glucose levels, blood glucose levels 2 hours glucose challenge (3)	Participants in the Sleep Heart Health Study (722 men and 764 women)		Sleep durations of ≤ 6 hours or > 9 hours were associated with increased prevalence of DM and impaired glucose tolerance
Kripke 2002[29]	Chronic sleep restriction	Cross-sectional study (4)	Survey (5) Participants were 30–100 years of age, sleep durations and morbidity and mortality rates over a 6-year period (1)	1.1 million participants from the American Cancer Society's Cancer Prevention II Study.		Mortality rates were highest among subjects who obtained ≥ 8-hr sleep or less than 3.5–4.5 hr. The lowest risks were found among those who obtained 7 hours sleep.
Singh 2005[54]	Sleep restriction	Cross-sectional study (4)	Survey (5), total sleep time in the 2 weeks prior to survey, and body mass index (BMI) (3)	3,158 randomly selected adults in the metropolitan area of Detroit, MI		Overall prevalence of obesity was 24.8% and significantly higher in those with lower amount s of sleep. After controlling for age, sex, loud snoring, hypertension, DM, arthritis, and alcohol intake, sleeping less than 6 hours greatly increased the risk of being obese.

Evidence Table 2. Extended Work Hours

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Arnedt 2005[174]	On-call schedules and performance	Nonrandomized trial (3)	Nonrandomized controlled trial (l3) 60-minute test battery consisting of sustained attention, vigilance, simulated driving performance, and self-reports of performance (3).	34 pediatric residents at a university hospital in the northeastern region of the U.S.	Residents tested in four conditions: (1) after a night of heavy call (on call every 4th to 5th night), (2) a night on a light call schedule (call is less frequent than heavy call), (3) after a night of light call and enough alcohol to obtain a blood alcohol level of 0.04–0.05, and (4) after a night of heavy call plus alcohol	Performance following a night of heavy call was quite similar to performance after drinking alcohol. Reaction times were slowed, errors of commission increased 40%, and lane variability and speed were significantly increased after a night of heavy call.
Fletcher 2004[169]	Number of hours worked	Systematic Review (11)	Literature review (6) Reviewed 7 studies between 1966 and 2004 related to reducing resident work hours. Outcomes included mortality, adverse events, and medication errors (1).			Research was not robust enough to reveal whether workhour limitations directly improve patient safety. None of studies involved clinical trials, and few used large databases or controlled for potential confounders.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Landrigan 2004[35]	Number of hours work	Nonrandomized trial (3)	Nonrandomized trial (3) Number of serious medical errors observed by trained observers in ICU (2), raters blinded to work schedules	20 critical care interns at large university teaching hospital	Traditional call scheduled with extended hours and every third night call, and a restricted schedule that reduced work shifts to 16 hours	Interns made 35.9% more serious medical errors during the traditional schedule than during the intervention schedule. Both the rate of serious medication errors and diagnostic errors were significantly increased during the traditional schedule compared to the intervention schedule.
Akerstedt 2002[178]	Number of hours worked, and overtime	Longitudinal, descriptive study (7)	Observational study with controls (4) Phone interviews, fatal occupational accidents (3)	47,860 Swedes interviewed over a 20-year period about issues related to work and health		There were 169 fatal occupational accidents. Predictors included male gender, difficulties sleeping in the past 2 weeks, and nonday work. Age, socio-economic status, overtime (>50 hr/week) or physically strenuous work did not increase the risk of a fatal occupational accident.
Dembe 2005[207]	Number of hours worked, overtime	Time series (7)	Survey (5), occurrence of injury (3)	10,793 Americans with a variety of occupations who participated in the National Longitudinal Survey of Youth between 1987 and 2000		Working a job with overtime was associated with a 61% higher injury rate compared to jobs without overtime. Working ≥12 hours per day was associated with a 37% increase in hazard rate, and 60 hr/week 23% increase in hazard rate. Injury rates increased in a dose-response fashion according to the number of hours per day (or week) that were worked. Injury rates were not affected by type of job or other factors such as gender.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Folkard 2003[83]	Work hours, shift work and safety	Meta-analysis (1)	Meta-analysis (1). Risks across different shifts, risks over successive shifts, risks over hours of duty, risk as a function of breaks (3)	26 studies		Risk of injury increases in a linear fashion across the shifts, with the lowest risk during the day shift and the highest risk at night. There was a slight increase in risk between 2 and 3 a.m., but effect was relatively small compared to substantial decrease in risk over most of night. Risks increased across successive shifts, e.g., risk was 6% higher on second night, 17% higher on 3rd night, and 36% higher on 4th night. Risks increased in exponential fashion after 8th hour of work, and during the 12th hour was double that during the first 8 hours. Risks of injury rose substantially between successive breaks, and that risk had doubled by the last 30-minute period before the next break. (This phenomenon occurred on all three shifts and during each 2-hour period between breaks.)
Sparks 2003[208]	Weekly workhours, ill health	Meta-analysis (1)	Meta-analysis (1) Weekly workhours, health problems (3)	21 studies		There was a mean correlation of 0.13 between weekly workhours and ill health.
Van der Hulst 2003[79]	Long work hours and health	Systematic literature review (1)	Systematic literature review (1) workhours, adverse health effects (3)	27 empirical studies		Long workhours were associated with adverse health effects (cardiovascular disease, DM, disability retirement, physiological changes, and health-related behavior).
Yang 2006[80]	Long workhours and hypertension	Cross-sectional study (4)	Survey (4), workhours/week and hypertension	24,205 working adults living in California		After controlling for age and other health and lifestyle factors, individuals working more than 50 hours/week had a 1.29 times the risk of developing hypertension than those working 15–39 hours.

Evidence Table 3. Fatigue Countermeasures

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Smith-Coggins 1997[116]	Maintenance of vigilance, fatigue countermeasures program	Nonrandomized controlled trial (3)	Nonrandomized controlled trial (3) Ambulatory polysomnography recordings during main sleep period, daily performance testing, and daily subjective ratings of sleep, mood, and intervention use (3) Tested on both day and night shifts.	6 emergency room physicians	Measures obtained at baseline, after a placebo intervention, and after the implementation of a fatigue countermeasures program	Increased subjective alertness reported after 1 month, but there were no improvements in performance, mood, or the amount of sleep obtained when working night shift.
Lilley 2002[133]	Fatigue, accidents and rest breaks	Noncomparative study (8)	Survey (5) Payment method, ethnicity, injury, fatigue, sleep duration, work duration, breaks and their duration (3)	367 logging and silviculture workers in New Zeeland		Presence or absence of breaks did not affect fatigue, but was associated with few injuries.
Neri 2002[129]	Maintenance of Vigilance, rest breaks	Randomized controlled trial (2)	Randomized controlled trial (2) Continuous recordings of EEG, subjective ratings of sleepiness, psychomotor vigilance testing (reaction time) (3)	28 pilots, flight simulator	Treatment group received 5 short breaks spaced hourly during flight, control group received 1 break in middle of simulated night flight	The short breaks reduced both objective and subjective sleepiness for at least 15 minutes postbreak and perhaps up to 25 minutes.
Rogers 2004[126]	Errors and rest breaks	Noncomparative study (8)	Survey (5) Daily reports of break duration, patient care responsibilities during break and meal periods, errors and near errors (3)	393 randomly selected full-time hospital staff nurses		No significant difference in number of errors reported by nurses who were relieved of patient care responsibilities during shift and those who were not. Mean duration of break and meal period during shift was 23.8 minutes. Shift duration did not effect duration of breaks and meal periods during the shift.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Tucker 2003[131]	Injuries and rest breaks	Noncomparative study (8)	Retospective analysis of accident data over a 3-year period (4), number of injuries in each 30-minute interval that preceded a break (every 2 hours) (3)	1,954 employees at an auto assembly plant in the UK		Risk of injury rose in each 30-minute period (n = 4) preceding each scheduled break, then decreased to baseline during the first 30-minute period after the break.
Driskell & Mullen, 2005[209]	Use of napping to improve performance and reduce fatigue	Meta-analysis (1)	Meta-analysis (1) Evaluated the effect of naps on performance, the effect of the nap duration, the effect of the postnap interval (3)	12 studies		Naps improved performance and reduced fatigue. There were no circadian effects on performance and fatigue.
Gillberg 1996[184]	Maintenance of vigilance, napping during work period	Randomized controlled trial (2)	Randomized controlled trial (2) Performance measures, reaction-time tests, and EEG/EOG recordings before, during, and after drive (3)	9 sleep-deprived truck drivers, driving simulator	Subjects assigned to one of three conditions: (1) day drive of 90 min, (2) night driving with 30-min rest period, and (3) night drive with 30-min nap	Effects on driving were small but significant, with a higher variability of sleep and lane positioning. Subjective and objective sleepiness were higher in the night driving conditions. Neither the nap nor the rest period affected performance or sleepiness.
Gillberg 1996[210]	Maintenance of vigilance, napping during daytime	Randomized controlled trial (2)	Randomized controlled trial (2) Cross-over repeated measures design. Karolinska Sleepiness Scale, visual performance task, and continuous EEG/EOG recordings (3)	8 healthy young males, laboratory setting	Sleep restricted to 4 hours at night, randomly assigned to either nap (20 min during mid-day) or no nap condition	Nap decreased subjective sleepiness, improved performance during test period 30 minutes after the nap.
Harma 1989[203]	Maintenance of vigilance, napping prior to shift	Noncomparative study (8)	Survey (5) Individual characteristics, short-term memory, alertness (3)	146 nurses and nursing assistants		Participants who took a nap prior to starting their night shift were less likely to report on-the-job fatigue.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Purnell 2002[134]	Maintenance of Vigilance, napping during night shift	Randomized controlled trial (2)	Randomized controlled trial (2), counterbalanced cross-over design, performance on neurobehavioral test battery, subjective fatigue, drowsiness driving home after a 12-hour night shift (3)	Worksite in New Zealand, 24 male aircraft maintenance engineers	During experimental week, subjects were given an opportunity to take a 20-minute nap at work between 1 and 3 a.m.; were not allowed opportunity to nap during control week.	20-minute nap significantly improved speed of response on vigilance test on first night shift, but not second night shift. Subjective fatigue ratings, level of sleepiness reported during drive home from work, or subsequent sleep duration and quality.
Rosekind 1994[140]	Maintenance of vigilance, napping during work shift	Randomized controlled trial (2)	Randomized controlled trial (2) vigilance performance testing, ambulatory physiological monitoring of sleepiness (3)	Regularly scheduled trans-Pacific airline flights	Intervention group allowed to take a 40-minute planned nap during cruise over water; control group not allowed a nap	Mean nap duration was 27 minutes. Fewer lapses in vigilance performance in nap group compared to no-nap group, fewer micro-sleep events (34 compared to 120 in the no-nap group), no micro-sleep events during last 30 minutes of flight or when landing compared to 27 micro-sleep events during the last 30 minutes of flight and landing from the no-nap group. Longer naps produced longer periods of alertness. Sleep inertia was not observed in the 1-hour period after the nap.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Sallinen 1998[138]	Maintenance of Vigilance, napping during night shift	Randomized controlled trial (2)	Randomized controlled trial (2), efficacy of naps during night shift evaluated using visual reaction times, subjective ratings of sleepiness, and physiological sleepiness (3)	14 experienced male shift workers, simulated work shift in laboratory	Subjects randomly assigned to take either a 30-minute or 50-minute nap at 1 a.m. or 4 a.m. Control condition was a shift without a nap.	Naps improved ability to respond to visual signals early in second half of night shift. Physiological sleepiness was improved by the nap at 1 a.m., but not the nap at 4 a.m. Subjective sleepiness somewhat decreased by the naps. Sleep inertia lasted approximately 10–15 minutes.
Bonnet 2005[211]	Maintenance of vigilance, sleep restriction, and use of stimulants	Systematic literature review (11)	High-quality systematic literature review (1) related to the safety and efficacy of five different stimulants	239 papers, most were double-blind clinical trials		Recommend caffeine as initial stimulant of choice due to its availability in multiple forms, widespread use, limited abuse potential, and little impact on sleep several hours later.
De Valck 2001[144]	Maintenance of vigilance, slow-release caffeine	Randomized controlled trial (2)	Randomized controlled trial (2) Cross-over design with sleep restricted subjects (4.5 hours of 7.5 hours time in bed) completed a 45-minute driving task, POMS, and Stanford Sleepiness Scale (3)	12 subjects ages 20–25 years, driving simulator	Subjects randomly assigned to take 300 mg sustained-release caffeine tablet or placebo after 4 hours sleep	Caffeine intake reduced lane drifting, speed deviations, and accident liability. Sleep loss produced significant impairments in driving ability.
De Valck 2003[147]	Maintenance of vigilance, slow-release caffeine, and a nap	Randomized controlled trial (2)	Randomized controlled trial (2) Cross-over design with sleep restricted subjects (4.5 hours of 7.5 hours time in bed) completed a 45-minute driving task, POMS, and Stanford Sleepiness Scale (3)	12 subjects ages 20–25 years, driving simulator	Subjects randomly assigned to take a 30-minute nap, 300 mg slow-release caffeine tablet, or placebo after 4 hours sleep	Both the 30-minute nap and caffeine were successful in counteracting driver sleepiness. Effect of slow-release caffeine lasted longer than the effects of the 30-min nap.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Gill 2006[152]	Maintenance of vigilance, modafinil	Randomized controlled trial (2)	Randomized controlled trial (2) Cognitive performance, subjective alertness on night shift (3)	25 emergency room physicians	Cross-over design used, all subjects randomly assigned to either modafinil or placebo group. After a 2-week washout period, received either placebo or modafinil.	Although modafinil improved subjective alertness and certain aspects of cognitive function, it made it more difficult fall asleep when arrived home.
Schweitzer 2006[146]	Maintenance of vigilance, napping, and caffeine	Randomized controlled trial (2)	Randomized controlled trial (2) tests the efficacy of napping, caffeine, and the combination of napping and caffeine in laboratory study. Cross-over design (2) for field portion of study. Outcomes included maintenance of wakefulness testing and psychomotor vigilance task (3)	Laboratory study 68 healthy individuals, field study, 53 shift workers (nights and evening shift)	Laboratory study included the following treatments: (1) an evening nap before the first 2 of 4 night shifts, plus placebo; (2) caffeine taken nightly; and (3) the combination of evening naps and caffeine. Field study tested subjects in both of the following conditions: (1) an evening nap prior to the first two of 4 night shifts, plus caffeine taken nightly; and (2) no placebo and no nap group.	Laboratory study—all interventions alone and in combination improved alertness and performance. The combination of napping and caffeine was more effective than individual interventions. Field study—napping plus caffeine improved alertness and performance.

Source	Safety Issued Related to Clinical Practice	Design Type	Study Design, Study Outcome Measures	Study Setting & Study Population	Study Intervention	Key Finding
Wesensten 2005[148]	Maintenance of vigilance, caffeine, dextroamphetamine and modafinil during prolonged sleep deprivation	Randomized trial (2)	Randomized trial (2) Performance testing, Stanford Sleepiness Scale, modified Maintenance of Wakefulness Test, and test of executive functioning	48 healthy young adults, laboratory	Subjects sleep deprived for 85 hour then given 600 mg caffeine, dextro-amphetamine 20 mg, modafinil 400 mg or placebo	Caffeine, dextroamphetamine, and modafinil were equally efficacious for restoring and maintaining cognitive function and alertness during 85 hours of sleep deprivation.
LeDuc 2000[160]	Maintenance of vigilance, exercise	Randomized trial (2)	Randomized trial (2), cognitive testing, subjective alertness, mood, performance testing, and maintenance of vigilance testing (3)	12 aviators	Subjects sleep deprived then assigned to the rest condition (10 minutes) or exercise condition	No beneficial effects from 10-minute rest. Exercise produced transient improvements in alertness (30–50 minutes), but after 50 minutes evidence of increased drowsiness on EEG.