Shift work generally is defined as work hours that are scheduled outside of daylight. Shift work disrupts the synchronous relationship between the body’s internal clock and the environment. The disruption often results in problems such as sleep disturbances, increased accidents and injuries, and social isolation. Physiologic effects include changes in rhythms of core temperature, various hormonal levels, immune functioning, and activity-rest cycles. Adaptation to shift work is promoted by reentrainment of the internally regulated functions and adjustment of activity-rest and social patterns. Nurses working various shifts can improve shift-work tolerance when they understand and adopt counter measures to reduce the feelings of jet lag. By learning how to adjust internal rhythms to the same phase as working time, nurses can improve daytime sleep and family functioning and reduce sleepiness and work-related errors. Modifying external factors such as the direction of the rotation pattern, the number of consecutive night shifts worked, and food and beverage intake patterns can help to reduce the negative health effects of shift work. Nurses can adopt counter measures such as power napping, eliminating overtime on 12-hour shifts, and completing challenging tasks before 4 am to reduce patient care errors.

At a Glance

✦ Shift work disrupts biologic rhythms that fluctuate with the light and dark cycle.
✦ Desynchronized rhythms alter nurses’ sleep-wake patterns, levels of alertness and sleepiness, and ability to perform demanding tasks.
✦ Patient safety is threatened when nurses work long and unpredictable hours, especially when the duration of prior waking increases beyond 17 hours.

Nurses need to clearly understand the implications of working various shifts and consider countermeasures to improve shift-work tolerance. Such measures may help to reduce problems related to shift work, including sleep disturbances, accidents, and injuries to nurses and patients. The most common sleep disturbances about 16.8% of full-time wage and salary workers and 24.6% of healthcare professionals, including RNs (Beers, 2000; Bureau of Labor Statistics, 2005). Shift workers most frequently cite the “nature of the job” (54.6%) as the reason for working alternative shifts (Bureau of Labor Statistics). Although no commonly accepted definition exists, shift work usually is classified as work hours that are scheduled outside daylight (6 am–6 pm) hours (Hughes & Stone, 2004). Shift-work start times and lengths vary and may include working part or all of the evening (2 pm–12 am) or night (9 pm–8 am) (Alward & Monk, 1993). Shift-work assignments are classified as permanent or rotating.

Since the 1960s, scientists have been examining the effect of working conditions such as air travel and shift work on biologic functions, activity, and rest. Because the body’s internal clock is cued by the light and dark cycle, shift work disrupts the synchronous relationship between the body’s internal clock system and the environment and has been linked to sleep disturbances (Drake, Roehrs, Richardson, Walsh, & Roth, 2004). The proportion of shift workers who report severely reduced sleep or alertness has been estimated to exceed 50% (Akerstedt, 2005). Furthermore, shift work and associated sleep disturbances are considered risk factors for human health (Kogi, 2005), injuries (Folkard, Lombardi, & Tucker, 2005), and medical consequences (Caruso, Lusk, & Gillespie, 2004; Folkard et al.; Rohr & Von Essen, 2003). Nurses, by virtue of their hospital and healthcare positions, work on shifts. As a result, nurses need to clearly understand the implications of working various shifts and consider countermeasures to improve shift-work tolerance. Such measures may help to reduce problems related to shift work, including sleep disturbances, accidents, and injuries to nurses and patients. The most common sleep disturbances...
disorder is insomnia, which is defined as repeated difficulty with sleep initiation, duration, consolidation, or quality that occurs despite adequate time and opportunity for sleep and results in some form of daytime impairment (American Academy of Sleep Medicine, 2005). The purpose of this article is to enhance nurses’ knowledge of biologic rhythms and increase understanding of shift-work adaptation and tolerance. Then, nurses can understand work-related sleep disturbances and the impact of shift work on their patients’ health and safety as well as their own.

Basis for Biologic Rhythms

Humans have evolved in a rhythmic environment. Evidence of environmental rhythms is widespread (e.g., seasons, tides, moon phases). The most prominent environmental rhythm is the light and dark cycle, which is based on the solar day and alters light intensity and ambient temperature over a 24-hour period. As a process of adaptation, humans have developed an internal clock system to maintain temporal stability. The system has external (exogenous) and internal (endogenous) rhythms and is under the influence of a master clock. The master clock, an autoregulatory genetic clock, is located in the hypothalamus and acts to regulate basic functions such as food intake and body temperature. External rhythms such as mealtimes and social activities are influenced by environmental changes and external stimuli and can be adjusted. Internal rhythms originate within an organism. Figure 1 lists the characteristics of the internal rhythms (Lanuza & Farr, 2003). Generally, external and internal rhythms parallel the more dominant environmental rhythm (Dijk & Lockley, 2002). When two or more rhythms are synchronized, the cycles are considered to be in phase. Of the internal rhythms, the circadian rhythm (i.e., about 24 hours) is the length of time most frequently studied in humans. For example, activity-rest and temperature rhythms are synchronized to the 24-hour light and dark cycle.

To maintain rhythm synchrony, the light and dark cycle and temporal cues such as mealtimes, noises, clocks, and exercise act to adjust the circadian system (Dijk & Lockley, 2002). Without external cues, internal rhythms can drift and last longer than the 24-hour period, thus disrupting parallel relationships. Therefore, temporal cues act to reset the body’s internal clock, maintain the 24-hour cycle, and preserve synchrony with the solar day.

Humans are diurnal, preferring to be active during the day and to rest at night. However, artificial lighting allows humans to be active and work in the dark, breaking the synchronous or in-phase relationship between activity-rest cycle and the light and dark cycle. When one or more cycles are out of phase, circadian desynchrony results, a condition associated with sleep disturbances, gastric complaints, poor performance, and fatigue. A similar phenomenon occurs with transcontinental air travel, which can lead to jet lag, a state of desynchrony, and disruption of the sleep-wake pattern, mealtimes, and daily activities (Rohr & Von Essen, 2003). Figure 2 lists the characteristics of desynchronized rhythms (Lanuza & Farr, 2003).

Physiologic Effects of Shift Work

Many physiologic rhythms fluctuate in preparation for activity or rest. Body temperature, cortisol, and melatonin levels change in preparation for waking or sleeping. For example, in anticipation of daytime activity, cortisol levels increase around 4 am and peak around 6 am (Lanuza & Farr, 2003). Core body temperature, which typically is coupled closely with activity rhythm, starts to increase after the minimum core temperature level is reached around 2–4 am, in anticipation of activity. Activity and core temperature peak at about 4 pm. Conversely, a rapid decline in core temperature normally occurs about two hours before sleep onset (Murphy & Campbell, 1997). Melatonin is the hormone believed to induce sleep in humans. Although core temperature and cortisol levels decrease with the onset of darkness, melatonin levels increase. Eight hours of uninterrupted sleep occur more easily when sleep begins about six hours before the minimum temperature is reached (Dijk & Lockley, 2002). Daytime sleep usually is shorter and fragmented when it coincides with increased body temperature.

Shift work and night work disrupt many intrinsic circadian cycles. For example, melatonin levels and growth hormone, which normally increase with darkness, are suppressed with night work (Hack, Lockley, Arendt, & Skene, 2005). As a result, shift workers experience more difficulty in sleeping anytime other than at night. A study of nurses (N = 635) during their scheduled work periods found that rotating shift workers and night nurses reported fewer hours of sleep than their counterparts who worked day or evening shifts. Only 29% of rotating nurses and 21% of night nurses reported sleeping for longer than seven hours compared to 39% of the day and evening nurses (Gold et al., 1992). Furthermore, nurses may overestimate the amount of sleep they actually get. Hobbs (2004) revealed that nurses’ actual sleep duration, using data collected from an actigraph, was less than their self-reported amount and less than the seven hours of sleep recommended for good health, which increases concern regarding sleep disturbances. Sleep disturbances related to shift work reportedly have been associated with a decreased number of natural killer cells and immune function (Irwin, 2002). The disruptions vary somewhat based on

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**Figure 1. Characteristics of Endogenous Circadian Rhythms**  
• The phase relationship is desynchronized between two or more temporally related rhythms.
• Loss of rhythm entrainment to the 24-hour day
• Physiological, cognitive, psychological, and behavioral effects
• Universal; could affect all people under certain conditions, including hospitalized patients, transmeridian jet travelers, and shift workers
• Can lead to negative physical and/or psychological effects

Figure 2. Characteristics of Transient and Spontaneous Desynchronized Rhythms


on individuals’ chronotype or preferred time for activity. Some individuals prefer the morning and others prefer the evening; their temperature and cortisol rhythms parallel individual activity patterns (Bailey & Heitkemper, 2001). Nurses need to understand biologic rhythms, the physiologic effects associated with shift work, and their individual chronotypes to take proactive steps to limit the effects of circadian rhythm disruption.

Tolerance of Shift Work

Tolerance of shift work varies among individuals and can be assessed by examining an individual’s health status and sleep habits as well as his or her social characteristics (Hughes & Stone, 2004). Chronotype also affects an individual’s tolerance of shift work. Preferring to be active in the morning may interfere with shift-work tolerance, whereas preferring evening activity may enhance shift-work adaptation and tolerance (Monk & Leng, 1986). Older age (i.e., mean age = 43.9 ± 6.8 years) has been identified as reducing performance compared to younger age (i.e., mean age = 21.2 ± 2.7 years) on simulated 12-hour shift rotations (Reid & Dawson, 2001).

Common unhealthy behaviors among workers who do not tolerate shift work include increased intake of caffeine, alcohol, sleeping medications, and over-the-counter medications for gastric acid secretion reduction and/or bowel products (Caruso et al., 2004). If unhealthy behaviors continue for an extended period of time, they may increase nurses’ risk of serious health problems. Evidence suggests that long hours and night work may be associated with an increased risk of preterm labor and pregnancy complications (Caruso et al.). Schernhammer et al. (2003) found that when female nurses work a rotating night shift at least three nights per month for 15 years or more, they are at increased risk for colorectal cancer. Social isolation, divorce, and substance abuse are signs of psychological ill health in shift workers that can lower health status (Michie & Williams, 2003).

Performance and Safety

Shift work impacts patient care and safety. The main factors influencing the level of alertness and performance of shift workers are the duration of prior waking or sleep and the phase of the circadian rhythm (Borbely, 1982). The level of alertness in particular is likely to be impaired as the duration of prior wakefulness lengthens (often by as much as 24 hours on the first night shift) or when trying to sleep during a time that is out of phase with normal circadian rhythms (i.e., daytime hours). When sleep is too brief in depth or duration, circadian rhythms become disrupted. Many negative effects may result, including decreased cognitive skills, impaired psychomotor skills, delayed reaction time, and decreased coordination (Lanuza & Farr, 2003). After 12 hours on duty, the risk of making a medication error or causing a needlestick can be twofold compared to the risk associated with an eight-hour shift (Institute of Medicine, 2004).

Safety is impaired when individuals struggle to stay awake during the second half of a shift, especially at night. Task performances show significant time of day variations, with worst performance occurring from 4–6 am, just after the minimum core body temperature is achieved (Rajaratnam & Arendt, 2001). Subjective alertness levels also are closely related to variations in task performance. One study compared the effect of blood-alcohol concentration (BAC) to the effect of hours of wakefulness on task performance. After 17–19 hours of sustained wakefulness, decreases in task performance were equal to or worse than those seen at a BAC of 0.05, and after 24–25 hours of wakefulness, decreases were equal to a BAC of 0.10—a level at or above the legal limit for driving (Rajaratnam & Arendt). Medication errors are one example of failure of attentiveness to task performance that may result in serious, life-threatening outcomes (Landrigan et al., 2004; Lee & Lipscomb, 2003). The Institute of Medicine (2004) has recommended that voluntary overtime by nurses be limited to promote safety.

Work duration, overtime, and the number of hours worked had significant effects on medication errors in a landmark study (Rogers, Hwang, Scott, Aiken, & Dinges, 2004). Nurses worked at least 12.5 consecutive hours on 39% of the 2,057 shifts that were reviewed in the study. The likelihood of making an error was found to increase with longer work hours and was three times higher when nurses worked shifts lasting 12.5 hours or longer (odds ratio = 3.29, p = 0.001). The study recommended that routine use of 12-hour shifts be curtailed and overtime be eliminated after 12-hour shifts.

Adaptation to Shift Work

Reentrainment is a process of adaptation in which internal rhythms shift (forward or backward) until the rhythms are in the same phase. Social adaptation can occur quickly; however, physiologic adaptation can take days or even weeks. Adaptation requires shift workers to alter or reverse their internal rhythms and may be easier for those who prefer the evening than those who prefer the morning. In theory, adaptation is greatest when internal rhythms are shifted to promote sleepiness during the daytime sleep period. However, family commitments and daily activities, which require nurses who work nights to be active in the morning, can hinder adaptation. Good shift-work adaptors have been found to have significantly better daytime sleep before a night shift, fewer social and family disruptions, and greater alertness during night shift than poor shift-work adaptors (Crowley,
Lee, Tseng, Fogg, & Eastman, 2004). Sleepiness and impaired performance occur toward the end of night shifts. Remaining active during the day prevents adaptation to a night-active and day-sleep cycle and acts to anchor the day-activity and night-rest rhythm to the light and dark cycle.

Shift workers need to adapt their weekly activity-rest patterns to a new work schedule. Research has suggested that even partial reentrainment is linked to improved performance and mood and better sleep. Cortisol peak levels reversed from 6 am–9 pm after working five night shifts; however, the change occurred only in those identified as good adaptors (Crowley et al., 2004). Nurses on rotating shifts had longer sleep duration when they worked only half of a night shift than did nurses working a full night shift (Watanabe et al., 2004). To enhance shift-work adaptation, counter measures are needed at work and in activity-rest schedules. Figures 3 and 4 list scientifically based countermeasures to improve sleep and circadian rhythmicity in permanent and rotating shift workers.

Light is the most influential external cue and acts to reset the internal clock system. Bright light (ocular) exposure can:

- Take responsibility for obtaining enough sleep to feel rested; seven to eight hours are recommended, but six hours are the minimum (National Sleep Foundation, 2005).
- Take a proactive role in establishing regular patterns of sleep, work, and leisure (Kahnoski, 2000).
- Establish a regular sleep schedule when working nights and on nights off.
- Use a bed only for sleep and sexual activity (Bootzin & Perlis, 1992).
- If sleep does not occur 15 minutes after going to bed, get up and try again later; repeat as needed (Bootzin & Perlis).
- Include a four-hour anchor sleep time during which sleep is scheduled whether on or off work. For example, after working, sleep from 8:30 am–4:30 pm, and on days off, sleep from 4:30 am–12:30 pm. The anchor sleep time is from 8:30 am–12:30 pm (Gold et al., 1992).
- Go to bed at a regular time (i.e., 4:30 am or 8:30 am) if you work nights.
- Establish a regular wake-up time (i.e., 12:30 pm or 4:30 pm) (Szuba et al., 2003).
- Wear dark glasses that block blue light when driving home after night work (Burgess et al., 2002).
- Seek exposure to bright light (sunlight is best) as soon as possible after waking (Burgess et al.).
- If needed and especially before the first night shift, power nap 30–90 minutes before leaving for work (Garbarino et al., 2002).

**Bedroom Environment (Morin & Espie, 2003)**
- Design the bedroom to make it suitable for day sleep.
- Maintain the room’s temperature from 65°F–70°F.
- Wear light bedclothes and use light bedcovers.
- Cover all windows with room-darkening or blackout shades.
- Turn around or off liquid crystal clock displays.
- Reduce all potentially disturbing noises in the bedroom (e.g., telephone, clock noises, pets) and wear earplugs or use white noise to block out environmental noises.
- Do not bring worries or stress into the bedroom.
- Develop a habit of a bedtime relaxation period before attempting to go to sleep; learn how to relax the body and mind before attempting to sleep.
- Select a relaxation method to use within an hour of going to bed (e.g., deep breathing, warm bath or shower, reading).

**Food, Drink, and Sedating and Stimulating Medications (Morin & Espie)**
- Avoid food, alcohol, and drinks that are high in caffeine at least six hours before going to bed.
- Stop smoking, but if smoking cigarettes or cigars or using chew, avoid nicotine before going to bed.
- Follow the diet and activity guidelines presented in www.MyPyramid.gov to maintain an ideal body weight. If overweight or obese, consider a plan to lose weight.
- Avoid eating a heavy meal three to four hours before going to bed; eat the biggest meal of the day after waking.
- Eat high-protein, light meals while at work and before going to bed.
- Limit fluid intake to 8 oz just before going to bed.
- If you awaken during the day, get up to use the bathroom and, if hungry, eat a light protein snack in a dim or dark environment, then return to bed.
- Discuss the use of over-the-counter melatonin with a primary care provider. It should be used only when planning to sleep for six to eight hours.
- Discuss the use of over-the-counter sleep medications with a primary care provider.
- Discuss the use of herbal remedies (e.g., valerian, lavender) with a primary care provider.

**Exercise**
- Establish a 30-minute period of time or longer for physical activity three to seven days per week after waking. Stop exercising three hours before bedtime.

**Family and Social Issues**
- Hang a sign on the bedroom door noting “day sleeper” as a reminder to family.
- Discuss individual needs for sleep with family and friends.
- Choose social activities wisely (i.e., avoid activities at the time sleep typically is scheduled).

**Figure 3. Tips for Improving Sleep and Circadian Rhythms of Permanent Shift Workers**
hasten adaptation and shift internal rhythms such as temperature and plasma melatonin (Honma et al., 1995; Park & Tokura, 1999). Shift workers need to understand the effect that light has on the circadian system and adaptation. Although the circadian system is sensitive to all light, it is most sensitive to shorter wavelength (i.e., 464–484 nanometers) blue light (Pauley, 2004). Blue light is present in sunlight and artificial light sources (fluorescent and halogen lights), and as little as 1 lux (i.e., light of the full moon) of blue light exposure at designated clock times (dusk and dawn) can reset the circadian system. Second, light levels at sunrise and sunset are known as skeletal periods; even a single exposure to simulated dawn conditions is effective in resetting the circadian clock (Dijk & Lockley, 2002). Nurses understand that exposure to changes in natural light levels helps to reduce hospitalized patients’ confusion and disorientation. The practice of opening blinds and drapes in the morning exposes patients and nurses to skeletal light levels, increasing alertness.

Nurses are exposed to sunlight while driving home after night work. Depending on the season, nurses working 12-hour night shifts (7 pm–7 am) may drive home from work at dawn. The exposure to light stimulates activity and alertness, and it also delays the body’s preparation for sleep. Night-shift nurses need to adopt counter measures, such as wearing sunglasses, to reduce or eliminate artificial and natural light exposure, specifically blue wavelength light, during skeletal periods. Doing so can enhance circadian adaptation and daytime sleep. Although nighttime light exposure can increase shift-work adaptation, it may have long-term consequences. Nighttime light exposure suppresses melatonin levels and has been linked to a higher incidence of breast cancer (Schernhammer et al., 2001).

Sounds can act to entrain or disrupt internal rhythms. Patterned noises such as clock chimes that occur at designated times can provide time-of-day cues, preventing adaptation to shift work. Similarly, disruptive noises from children, telephones, and pets can disturb daytime sleep and adaptation (Morin & Espie, 2003).

Factors Influenced by Shift Work

When scheduling eight-hour work shifts, nurses need to consider the direction of the rotation pattern and its effects on adaptation and sleep. Clockwise or forward shift rotation (i.e., days, evenings, and nights) has been suggested to improve sleep duration; however, the scheduling pattern has social implications. Nurses working forward-rotating shifts need to sleep the morning after their last night shift or on their first scheduled day off. As a result, the day off is lost to sleep. Counterclockwise or backward rotation (i.e., nights, evenings, and days) allows nurses to sleep at night after working the last day shift, resulting in more free time away from work. The rotation pattern has social benefits, but backward rotation reduces the time (less than eight hours) between shift changes, resulting in sleep disturbances. Permanent 12-hour day shifts are not designated as rotating shifts; however, nurses who work that shift also can sleep inadequately between shifts. A consistent trend exists in the risk of accidents over successive night shifts. Findings from pooled data from seven published studies indicate that, on average, the risk of an incident at work was 6% higher on the second night, 17% higher on the third night, and 36% higher on the fourth night shift (Folkard et al., 2005).

Nurses need to consider the effect of food intake and mealtimes on activity-rest rhythms. Night workers reportedly sleep through at least one daytime meal, altering caloric intake that can lead to sleep disturbances. Some night workers try to maintain a daytime meal schedule rather than aligning mealtimes with their work.
M.J. is a 26-year-old female newlywed of three months. She works 11 pm–7:30 am five days per week in an emergency room. She has worked her current shift for three years and never had problems being sleepy at work or while driving home. However, now that she is married, M.J. wants to spend more time with her husband, who works from 9 am–6:30 pm. Over the past 60 days, she has had two near-miss accidents and also pulled a back muscle during a routine patient transfer. Worried about being alert while driving home, M.J. drinks a cup of coffee around 5 am.

After work, she drives eastward to her home. Once at home, she eats breakfast (bacon, eggs, and toast) and visits with her husband until 8:45 am. At 9 am, M.J. goes into the bedroom and watches television until she falls asleep around 10 am. She generally sleeps until 1 pm, at which time she gets up to use the bathroom and eat a snack. She returns to bed at about 1:30 pm and sleeps until 4:30 pm. M.J. achieves about six hours of sleep, but it frequently is disrupted by outside noises (e.g., telephone, lawn mowers). Once awake, M.J. sits in the dark house, watching television and dozing. Around 5:30 pm, she starts making dinner. She eats dinner with her husband around 7 pm and watches television until 9 pm. Before work, M.J. tries to nap but worries that she will sleep through the alarm. Before leaving for work around 10:30 pm, she showers, drinks two cups of coffee, and eats a snack, such as cookies or cake. During her shift, she drinks cola or iced tea. M.J. used to exercise for 30 minutes after waking up but no longer has the time or energy. Wanting to spend more time with her husband and be active outdoors, M.J. goes to bed around midnight and gets up around 8 am on her days off.

Factors Leading to M.J.’s Sleep Disturbances
M.J.’s sleep quality and quantity are insufficient and may be affected by:

- Stress and anxiety
- Caffeine use
- Bedtime and length of sleep
- Lack of exercise
- Family and lifestyle needs
- A sleep period (anchor sleep) that is out of phase with her circadian cycle.

Recommended Lifestyle Changes

- Discuss her needs with her spouse, and develop a healthy lifestyle.
- Stop or eliminate caffeine intake at least six hours before sleep or nap periods.
- Wear sunglasses when driving home and avoid light exposure.
- Schedule two structured sleep periods to achieve seven hours or more of sleep; one period should be at least five hours or more and the second should be one to two hours.
- Move bedtime to 9 am on workdays, and use the bedroom for sleeping only.
- Schedule anchor sleep (6 am–1 pm) on days off.
- Set up a good sleep or napping environment with no television.
  - Block or turn off external lighting.
  - Maintain a cool temperature.
  - Use appropriate bedding and clothing.
  - Use quiet music or fans to block noise.
- Set an alarm clock for an evening nap.
- Nap around 9 pm or take a short power nap (< 30 minutes) during a break at work.
- Schedule an exercise period later in the evening to increase alertness at night or exercise early in the day at least three hours before the 9 pm nap (5 pm or 6 pm is best).

Counter Measures to Improve Tolerance to Shift Work

Multiple strategies can be used to improve shift-work tolerance and enhance safety. Hughes and Stone (2004) suggested the following four categories of techniques when adapting to shift work: Fight fatigue, work the shift that is tolerated best, establish support networks, and control the environment and individual activities. As society moves toward a 24-hour culture, people must make lifestyle choices that promote optimal biologic functioning. Figure 5 provides a case study, factors leading to sleep disturbances, and recommended lifestyle changes for successful adaptation to a permanent eight-hour night shift. The information available at www.sleepfoundation.org also can be used to successfully adapt to shift work. For health and safety, shift workers must know and use counter measures to adapt circadian rhythms to promote optimal performance.

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