Shiftwork and Working Hours

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The advent of modern industrial processes, the globalization of the economy, and the proliferation of information technology, among other factors, have contributed to the creation of a 24-hour society in recent times. As the demand for 24-hour availability of goods and services has risen over the past few decades, the prevalence of shiftwork has likewise increased. In the United States, approximately 20% of all nonagricultural workers experience some type of shiftwork, and 25% of these shiftworkers work at night (U.S. Congress, Office of Technology Assessment, 1991). Estimates for European workers are similar (Wedderburn, 1996).

Shiftwork is defined as any arrangement of daily working hours that differs from the standard daylight hours. Organizations that adopt shiftwork systems extend their hours of work past eight hours by using successive teams of workers. The nature of shift systems can vary widely along several dimensions, including the number and length of shifts, the presence or absence of night work, the direction and speed of the shift rotation (or whether the shift rotates or not), the length of the shift cycles, the start and stop times of each shift, and the number and placement of days off.

The scientific community has long maintained that individuals who regularly work atypical hours (i.e., shiftwork of some type) are at greater risk for physical and psychological impairment or disease than typical day workers (e.g., Costa, 1996; Costa, Folkard, & Harrington, 2000). This risk is assumed to originate from the physical and psychological stress that develops from work schedule-related disruptions of their biological functions, sleep, and social and family life. The risk is further exacerbated by extended hours of work beyond the standard 40-hour week, a trend that has also been increasing over the past several years (Costa et al., 2000).

In this chapter, we explore the relationships between shiftwork and health. We do not attempt to be comprehensive, but rather representative, in our review of the published research literature. First, we provide general background information on circadian rhythms to prepare the reader for the balance of the chapter. Second, we review the empirical literature on shiftwork and various types of health-related strains or outcomes. Third, we examine some of the factors (e.g., age, personality) that have been investigated in the search for the “shiftwork tolerant” individual. Fourth, we explore the various types of interventions that have been attempted to
enhance shiftwork effectiveness. Fifth, in light of our review, we summarize the research findings and then discuss implications for future research.

Theoretical Framework

Life on earth has evolved in an environment subject to regular and pronounced changes produced by planetary movements. The rotation of the earth on its own axis results in the 24-hour light/dark cycle, whereas its rotation around the sun gives rise to seasonal changes in light and temperature. During the process of evolution, these periodic changes have become internalized, and it is now widely accepted that living organisms possess a “body clock,” such that organisms do not merely respond to environmental changes but actually anticipate them.

Circadian Rhythms and the Internal Body Clock

The anticipation of environmental events is mediated by regular cyclic changes in body processes. In humans, the most pronounced of these are the approximately 24-hour “circadian” (“around a day”) rhythms that occur in almost all physiological measures (Minors & Waterhouse, 1981).

Evidence that these circadian rhythms are at least partially controlled by an internal, or “endogenous,” body clock comes from studies in which people have been isolated from their normal environmental time cues, or zeitgebers (from the German for “time givers”). In their pioneering studies, Aschoff and Wever (1962) isolated individuals from all environmental time cues in a temporal isolation unit for up to 19 days, and Siffre (1964) lived in an underground cave for two months. In both studies, people continued to wake up and go to sleep on a regular basis, but instead of doing so every 24 hours, they did so about every 25 hours. The circadian rhythms of other physiological measures, including body temperature and urinary electrolytes, typically showed an identical period to that of their sleep–wake cycle.

Approximately a third of the people who have subsequently been studied in this way, however, have spontaneously shown a rather different pattern of results. In these cases, the sleep–wake cycle and body temperature rhythms have become “internally desynchronized,” meaning that the temperature rhythm continues to run with an average period of about 25 hours, the sleep–wake cycle shows either a much shorter or a much longer period than either 25 or 24 hours (Wever, 1979). It is interesting to note that this phenomenon of “spontaneous internal desynchronization” occurs more frequently in older people and in those with higher neuroticism scores (Lund, 1974), topics we discuss later in this chapter.

Endogenous and Exogenous Components

At a more theoretical level, the fact that the temperature rhythm and sleep–wake cycle can run with distinctly different periods from one another suggests that they are independent. Moreover, under normal conditions, the body’s endogenous body temperature and plasma cortisol rhythms are synchronized and do so in a way that is a weaker correlate to external light exposure (and other stimulants) than body temperature and urination rhythms. Thus, the endogenous body clock model may be the fundamental rhythm for these processes.

These data also suggest that the effects of light are weaker on circadian rhythms in these circumstances. The endogenous body clock model may be disrupted by exposure to light.
suggests that the human "circadian system" comprises two, or perhaps more, underlying processes. The first of these is a relatively strong endogenous body clock that is dominant in controlling the circadian rhythm of body temperature (and of other measures, such as urinary potassium and plasma cortisol) and is relatively unaffected by external factors. The second is a weaker process that is more exogenous in nature (i.e., it is more prone to external influences) and is dominant in controlling the sleep-wake cycle (and other circadian rhythms, such as those in plasma growth hormone and urinary calcium). Some debate exists regarding whether this second process truly has a clock-like nature, but there seems to be general agreement that some circadian rhythms are dominantly controlled by the endogenous body clock, and others are more influenced by external factors.

These two processes are thought to be asymmetrically coupled, such that the endogenous clock exerts a considerably greater influence on the weaker process than vice versa. For example, internally desynchronized individuals show such a strong tendency to wake up at a particular point of the temperature rhythm, regardless of when they fell asleep, that their sleep periods can vary in duration from 4 to 16 hours (Czeisler, Weitzman, Moore-Ede, Zimmerman, & Kronauer, 1980). Therefore, sleep is likely to be disrupted unless the temperature rhythm has adjusted to any changes in the sleep-wake cycle.

Adjustment to Shiftwork

Under normal circumstances, both the endogenous body clock and the weaker exogenous process are entrained to a 24-hour period by strong natural zeitgebers, including the light-dark cycle. As a result, all circadian rhythms normally show a fixed-phase relationship to one another. For example, urinary adrenaline reaches a maximum around midday, and body temperature peaks at about 8.00 PM. Similarly, all other circadian rhythms reach their maxima at their appointed time, allowing us to fall asleep at night and wake up in the morning. The occasional late night may affect those rhythms controlled by the weaker process, but are less likely to upset the strong oscillator and, hence, our body temperature rhythm and the time at which we spontaneously wake up.

This inherent stability in the human circadian system, however, can pose problems if a mismatch arises between the internal timing system and external time cues. The simplest example of this occurs when people fly across time zones, because all the zeitgebers change, including the light-dark cycle. As a result, all circadian rhythms usually take more than a week to delay their timing by the appropriate amount (Wegmann & Klein, 1985). For the first few nights, this often results in people waking up in the early hours of the morning and being unable to resume sleep. The rhythms in other processes adjust at different rates, presumably depending on the degree to which they are controlled by the endogenous clock or the weaker exogenous process. As
a result, the normal phase relationship between rhythms breaks down and is only slowly reestablished as the various rhythms adjust to the new time zone. This internal dissociation between rhythms is thought to be responsible for the disorientation and general malaise typical of “jet lag.”

These feelings of jet lag are normally worse following an eastward flight, which requires an advancing of the body’s timing system, than following a westward one, which requires a delay. This “directional asymmetry” effect is related to the fact that the endogenous period of the circadian system is somewhat greater than 24 hours. Thus, in the absence of any zeitgebers, rhythms tend to delay rather than to advance, assisting adjustment to westward flights but inhibiting adjustment to eastward ones.

This directional asymmetry has implications for the design of shift systems. When shiftworkers go on the night shift, most environmental zeitgebers remain constant and discourage adjustment of the circadian system. The natural light–dark cycle, the clock time, and most social cues do not change while the timing of shiftworkers’ work can be delayed by up to 16 hours and that of their sleep by up to 12 hours. From what we know so far, it is clear that the adjustment of a shiftworker’s body clock to these changes is likely to be very slow, if indeed it occurs at all.

Review of Empirical Literature on Shiftwork and Health

In the previous section, we discuss how the experience of shiftwork, especially night work, provokes circadian disharmony, resulting in decreases in sleep quality and quantity. In the short-term, the effects of these deficits are quite obvious (e.g., increased fatigue, sleepiness), and, if unabated, they can presumably lead to more serious medical conditions. In this section, we discuss these short-term and chronic health effects of working shifts.

Sleep and Fatigue

Sleep is the primary human function disrupted by shiftwork. Many bodily processes, such as temperature, blood pressure, and heart rate, are at their lowest ebb at night; so it is not surprising that people who try to work at night and sleep during the day often report that they cannot do either very well. Shiftworkers who need to sleep during the day may have difficulty in falling asleep and remaining asleep because they are attempting sleep when they are at odds with their circadian rhythms. And because of work and personal demands, shiftworkers rarely achieve full adjustment to their shiftwork schedules.

The unfortunate outcome of shiftwork is that both the quality and quantity of shiftworkers’ sleep suffers (Costa, 1996). One almost immediate result is fatigue (Luna, French, & Mitcha, 1997; Tepas & Carvalhais, 1990). Severe sleep disturbances may develop over time and result in the development of chronic fatigue, anxiety, nervousness, and depression, any or all of which frequently demand medical intervention (Costa et al., 2000). Such effects relate, for example, to the workplace (e.g., Barr, 1992; Vann, 1992). However, our focus here is that shiftwork may contribute to accidents, such as those

Accidents

As we discuss in the introduction, circadian rhythm disturbances and injuries are already well documented in the research (Costa, 1996; Kripke, 1990; Paolino & colleagues, 1990). Kripke (1990) noted that “shift work is associated with injuries and accidents in most industries.”

Review of circadian rhythm disturbances and accidents has been carried out by Barrio and colleagues (1992; Vann, 1992). These accidents are well recognized in industry.

Shiftworkers have also been described as experiencing high levels of stress, which is not surprising, since their work is usually performed in a physically and emotionally demanding environment. In the workplace, the environment is often characterized by high levels of stress, which are known to be associated with accidents and mishaps.
effects are aggravated by long working hours, which accompany extended (e.g., 12-hour) shifts or multiple jobs or roles (e.g., the working mother). However, the primary concern with disrupted sleep and resultant fatigue is that it will culminate in the development of more serious conditions, such as serious injury or disease.

Accidents and Injuries

As we discussed in the previous section, shiftwork and the resulting biological dysfunction that often accompany it may culminate in serious errors and injury, especially on the night shift (Costa, 1996). Although some researchers have not found the expected increase in night-shift accidents (e.g., Barreto, Swerdlow, Smith, & Higgins, 1997), Folkard and his colleagues have demonstrated conclusively that when a priori risk is constant (i.e., work conditions are identical) across shifts, accidents and injuries occur more frequently at night (Folkard, Åkerstedt, Macdonald, Tucker, & Spencer, 2000; Smith, Folkard, & Poole, 1994). Similarly, the accidents and injuries that occur on the night shift are often more serious than those on the day shift (i.e., requiring prompt medical attention rather than first aid; Smith et al., 1994). Another related finding is that, relative to day workers, night workers are more frequently involved in automotive accidents while driving home after work (Monk, Folkard, & Wedderburn, 1996). Sleep deprivation, fatigue, and circadian malaise are the obvious culprits in most of these unfortunate incidents.

Research has also shown that accident and injury rates can vary according to the type of shift system (i.e., rotating or fixed or different hybrid [mixed] systems), although the nature and extent of these differences vary (e.g., Barreto et al., 1997; Barton, Smith, Totterell, Spelten, & Folkard, 1993). Selection of the best type of shift system is a complex issue, which has been debated by shiftwork researchers (Folkard, 1992; Wedderburn, 1992; Wilkinson, 1992). This topic will be discussed in some detail later in this chapter.

Shift-related differences in error or accident rates may reflect methodological confounds, such as the type of work performed and the workers' experience. Studies such as Smith et al. (1994) are rare in that these researchers were able to make comparisons across shifts that were identical in a priori risk. In contrast, supervision is usually decreased at night, and night shift workers tend to be less experienced than day workers (especially in the United States). True shift differences may also be masked by the fact that the day shift typically has the heaviest workload, whereas maintenance and repair activities are often reserved for the night shift (Costa et al., 2000; Smith et al., 1997); the type of work performed may also vary across different types of shift systems (Smith et al., 1997). Regardless of these issues, however, the potential risk for serious error and injuries on the night shift should not be underestimated. The infamous industrial mishaps in the nuclear facilities at Three Mile Island and Chernobyl, as well as the Challenger space shuttle disaster, all occurred during the night
shift. Shift schedules and fatigue were cited as major contributing factors to each incident (Price & Holley, 1990).

**Psychological–Emotional Disorders**

A common finding in shiftwork research is that psychological and emotional distress frequently accompanies shiftwork (e.g., Barton et al., 1993; Williamson, Gower, & Clarke, 1994), although the magnitude of the effects is sometimes low (e.g., Barton, 1994; Tucker, Barton, & Folkard, 1996). These findings are consistent with the psychological effects of shifting schedules and the resulting sleep disruption discussed previously.

Shiftworkers' psychological and emotional states are frequently assessed in empirical studies, although the physical disorders (e.g., gastrointestinal, cardiovascular) appear to have attracted the most attention. However, the psychological distress that often accompanies shiftwork from its onset may be the primary factor that provokes many (approximately 20 to 50%, depending on the data source) to leave shiftwork (Costa, 1996).

**Gastrointestinal Disorders**

Gastrointestinal disorders are the most prevalent health complaint associated with shift and night work (e.g., Angersbach et al., 1980; Vener, Szabo, & Moore, 1989). According to Costa et al. (2000), 20 to 75% of shift and night workers, compared to 10 to 25% of day workers, complain of irregular bowel movements and constipation, heartburn, gas, and appetite disturbances. Gastrointestinal complaints are commonly assessed in shiftwork studies, and most researchers report reliable effects, although the size of these effects is sometimes small (e.g., Barton et al., 1993). In many cases, these complaints eventually develop into chronic diseases, such as chronic gastritis and peptic ulcers (Costa, 1996).

Night work, not just shiftwork, appears to be the critical factor in the development of gastrointestinal disease (Angersbach et al., 1980). A review of 36 epidemiological studies, covering 50 years of data and 98,000 workers, indicated that disorders of the digestive tract were two to five times more common among shiftworkers who experienced night work than among day workers or shiftworkers who did not work at night (Costa, 1996). Tucker, Smith, Macdonald, and Folkard (2000) also reported that the development of digestive problems was associated with working longer shifts (i.e., 12 hours versus 8 hours) and relatively early shift changeovers (i.e., 6 AM vs. 7 AM).

Researchers have often speculated that gastrointestinal problems may be greater for shiftworkers because they have less access to healthy food than day workers (i.e., restaurants and stores are often closed between 12 and 6 AM), and their irregular hours encourage inconsistent dietary habits. However, the scant research that has addressed this issue (e.g., Lennernas, Hambraeus, & Akerstedt, 1994) found no differences in nutritional intake between shiftworkers and day workers.
between day and shiftworkers. Other factors, such as circadian disruption and sleep deficit, may be the culprits (Vener et al., 1989).

**Cardiovascular Disorders**

Despite years of debate, most researchers now acknowledge that a relationship between shiftwork and cardiovascular disease exists (e.g., Tucker et al., 1996). In an impressive longitudinal study spanning 15 years, Knutsson, Åkerstedt, Jonsson, and Orth-Gomer (1986) reported an increased risk of cardiovascular disease in shiftworkers. Specifically, as a group, shiftworkers demonstrated increased cardiovascular risk factors (e.g., smoking) and increased morbidity from cardiovascular disease as years in shiftwork increased. Occupations with a high percentage of shiftworkers are also associated with a greater risk of heart disease (Costa et al., 2000). In a recent meta-analysis of the epidemiological literature on shiftwork and heart disease, Boggild and Knutsson (1999) reported that shiftworkers have a 40% greater risk for cardiovascular mortality or morbidity than day workers.

Similar to our discussion on the origin of gastrointestinal disorders in shiftworkers, the etiology of cardiovascular disorders is unknown (Åkerstedt & Knutsson, 1997). The risk factors for cardiovascular disease are consistent with many of the problems associated with shiftwork, such as gastrointestinal symptoms, sleeping dysfunction, smoking, and poor working conditions (i.e., those found in many industrial environments). Shiftwork can also function as a stressor, thus exacerbating the stress response over time and resulting in increased blood pressure, heart rate, cholesterol, and alterations in glucose and lipid metabolism (Costa, 1996).

In a study of more than 2,000 Swedish men, Peter, Alfredsson, Knutsson, Siegrist, and Westerholm (1999) reported that, in addition to the direct effects of shiftwork on cardiovascular risk, psychosocial work factors in the form of effort–reward imbalance mediated the effects of shiftwork on cardiovascular risk. Therefore, the evidence to date strongly suggests that shiftwork is a contributing factor in the development of cardiovascular disease, but the specific etiology is complex and multifaceted.

**Women’s Reproductive Disorders**

The influence of night and shiftwork on women’s reproductive functions has been empirically investigated in several studies (Costa, 1996). Given that shiftwork disrupts periodic or cyclic functions, such as sleep and digestion, its negative effects on the female menstrual cycle are not surprising. In female shiftworkers, these effects include irregularities in cycle length or pattern (Hatch, Figa-Talamanca, & Salerno, 1999; Uehata & Sasakiwa, 1982), spontaneous abortions, and lower rates of pregnancies and deliveries (Nurminen, 1989). Shiftwork has also been associated with premature delivery and low birthweight (Nurminen, 1989).
In addition to coping with shiftwork, women frequently experience additional stress from domestic and childcare responsibilities. Female shiftworkers with children appear to be especially at risk, because research has shown that they have shorter and more frequently interrupted daytime sleep periods (Dekker & Tepas, 1990) and report greater tiredness than other groups of shiftworkers (Uehata & Sasakawa, 1982). However, some research has not found gender differences (Härma, 1993).

Review of Empirical Literature on Shiftwork Tolerance

In the previous section, we discussed the manner in which shiftwork directly affects women's reproductive health. Another way of expressing this idea is to say that gender moderates the shiftwork–strain relationship, such that shiftwork adversely influences reproductive functions. Other individual (e.g., age, personality), as well as situational (e.g., type of shift system) variables also moderate the shiftwork–health strain relationship. Often, however, these variables are treated analytically as predictors (main effects) rather than moderators (interactive effects). The criterion is generally operationalized as “shiftwork tolerance,” which is defined as the absence of the most common health-related complaints of shiftwork, such as sleep disturbances and gastrointestinal complaints (Härma, 1993). We examine each characteristic in turn as it relates to health or shiftwork tolerance.

Individual Factors

Researchers have investigated the relationships between several personal-level factors and the experience of shiftwork. We examine only those variables that have demonstrated the most consistent relationships.

Age. Over the age of 45 to 50, shiftworkers increasingly encounter difficulties in altering their sleep–wake cycles (Härma, 1993; Nachreiner, 1998). Specifically, with aging, people experience a decrease in slow wave (deep) sleep, an increase in stage 1 (light) sleep, and an increase in the number and length of arousals during sleep (Miles & Dement, 1980). The physiological effects of aging are also associated with a reduction in amplitude and a tendency toward internal desynchronization of circadian rhythms (Costa et al., 2000; Härma, 1993, 1996). Aging is also related to morning orientation, or the expressed preference for morning or early day activity (see next section), such that the circadian activity peak occurs almost two hours earlier in elderly relative to younger people (Lieberman, Wurtman, & Teicher, 1989). All of these changes in circadian functioning imply that shift changes and night work are inadvisable for shiftworkers over 50.

In addition, health problems increase with advancing age, and the effect of shiftwork generally is to increase that health risk or decrease shiftwork tolerance (Nachreiner, 1998; Tepas, Duchon, & Gersten, 1993) by further reducing performance. Researchers reporting the negative effects of shiftwork on workers' health have found this was true for both men and women, but the effect was more pronounced in women (Härma, 1993). Therefore, women who work more than 20 hours per week in shifts reported significantly lower ratings for health than did men in similar parts (Smith, Folkard, & Shepard, 1981).

Morning Orientation. Activity rhythms (morningness or eveningness of activity) are a good indicator for activities that are optimal during the morning or evening (Härma et al., 1978; Ritzen & Östlund, 1979).

Research demonstrates that morningness is related to the preference for early morning activity peaks (see Takahashi & Akerstedt, 1979). Morningness is especially important for morning shiftworkers. Weakly morning people (Bohle & Strotmann, 1990; Takahashi & Akerstedt, 1979) are more conflicted regarding the morning shift (Ritzen & Östlund, 1979).

The circadian activity profile (mornin-ness or evenin-ness) is related to the circadian activity rhythm–right or left or one’s ability to adjust to shiftwork schedules. Morningness is also related to morning orientation, or the expressed preference for morning or early day activity (see next section). This profile suggests that shift changes and night work are inadvisable for shiftworkers over 50.

There is a need for research that will help shiftworkers adjust better to their work schedules, particularly circadian rhythm and other factors in shiftwork.
by further disrupting circadian functions and sleep. An interesting finding reported by Oginska, Pokorski, and Oginski (1993) is that female shiftworkers' reports of subjective health improved after age 50, whereas the opposite was true for males. This gender difference may reflect the decreased childcare and domestic responsibilities of older women. Another study cited similar reasons for the increased alertness and decreased sleep difficulties reported by older female shiftworkers compared to their younger counterparts (Spelten, Totterdell, Barton, & Folkard, 1995).

Morningness and circadian type. Morningness (morning–evening orientation) is defined as the expressed preference for morning or evening activities; the guiding assumption is that people who express preferences for activities at the extremes of the 24-hour day (i.e., early morning or late evening), when feasible, behave in accord with those preferences (Horne & Ostberg, 1976; C. Smith, Reilly, & Midkiff, 1989).

Research has demonstrated that preference for early morning activity is related to phase advances (i.e., earlier circadian peaks), whereas preference for late evening activity is related to phase delays (i.e., later circadian peaks). Morning types are therefore thought to be especially suited to morning or early day shifts and evening types to evening or late-night shifts (see Tankova, Adan, & Buela-Casal, 1994). Morningness is also related to rigidity in sleep habits, or the inability to change sleep schedules, which is especially true for extreme morning types (Hildebrandt & Stratmann, 1979). However, empirical evidence indicates that morningness is only weakly to moderately related to health strains or shiftwork tolerance (e.g., Bohle & Tilley, 1989; Steele, Ma, Watson, & Thomas, 2000), but several conflicting studies do exist (e.g., Costa, Liewore, Casaletti, Gaffuri, & Folkard, 1989; Kaliterna, Vidacek, Prizmic, & Radojevic-Vidacek, 1995).

The notion of circadian type was created by Folkard, Monk, and Lobban (1979) to address other characteristics of circadian rhythms than phase (morningness). The construct rigidity–flexibility was developed to assess the stability of circadian rhythms, and the construct vigor–laguindity, the amplitude of the rhythms. Folkard et al. (1979) hypothesized that flexibility–rigidity, or the flexibility of one's sleeping habits, and vigor–laguinity, or one's ability to overcome drowsiness, are important contributors to adjustment to shiftwork; specifically, people with flexible- and low-amplitude rhythms should better adjust to the demand of shiftwork. Both the flexibility and vigor dimensions have been reported to relate to long-term tolerance to shiftwork (Costa et al., 1989; Vidacek, Kaliterna, & Radojevic-Vidacek, 1987). In fact, in Vidacek et al.'s (1987) prospective study, vigor was the best predictor of shiftwork tolerance after three years. More recent studies have also supported the relationship between flexibility and vigor and shiftwork tolerance (e.g., Steele et al., 2000).

These individual differences in circadian rhythms have helped researchers to understand why some people prefer, and presumably adapt better to, different shift schedules. However, the use of morningness or circadian-type measures as selection or placement instruments for night workers and shiftworkers would be premature because relevant validation
data are lacking, although they may be helpful in shiftwork counseling and education programs.

**Personality.** Researchers have investigated other individual differences as they relate to shiftwork tolerance. Introversion–extroversion is a well-known personality variable that, similar to morningness, has demonstrated relationships with circadian phase. Specifically, introverts have a somewhat earlier circadian phase (i.e., are more morning-oriented) than extroverts (Blake, 1967; Vidacek et al., 1987). Circadian adjustment to shift schedules also seems to occur faster in extroverts than introverts (Colquhoun & Condon, 1980).

Likewise, researchers have reported a relationship between neuroticism and shiftwork tolerance across several studies, such that shiftworkers who are very neurotic are less tolerant to shiftwork (e.g., Iskra-Golec, Marek, & Noworol, 1995). However, neuroticism does not appear to predict shiftwork tolerance (Kaliterna et al., 1995). Some evidence even suggests that neuroticism increases with exposure to shiftwork, and hence, behaves more like an outcome or strain measure than a moderator variable (Bohle & Tilley, 1989).

**Situational Factors: Shift System Characteristics**

The relative merits of different types of shift systems (i.e., Is there one best type of shift system?) have probably been debated more than any other issue in shiftwork research. The debate has often focused on the advantages and disadvantages of fixed versus rotating systems or different types of rotating systems (e.g., Folkard, 1992; Wedderburn, 1992; Wilkinson, 1992). Although the general consensus is that no best shift system exists, shiftwork researchers agree that some systems are definitely worse than others. To simplify this discussion, we examine each of the major components of shift systems (fixed versus rotating, length of rotation, direction of rotation, number of days off, number of night shifts, length of shift, weekly hours, annual hours, and overtime).

Regarding health effects, fixed shifts are certainly preferable for day or afternoon shifts because workers can easily maintain their diurnal orientation. However, shiftworkers on permanent night shifts rarely achieve adaptation to their hours of work because, on their rest days, they typically revert back to a diurnal (day) orientation to engage in social or family activities. So, in effect, permanent night workers create their own rotating shift because they must physiologically readapt to night work and day sleep after every rest period (Folkard, 1992).

Rotating shifts present a wide array of options. One of the most common rotating shifts is the weekly rotation, in which shiftworkers change their shift schedule every week. Unfortunately, the weekly rotating shift is also one of the worst from a circadian perspective: Just as the shiftworker’s body is beginning to adapt (i.e., the circadian rhythms are only partially inverted), the shift changes, and adaptation must begin again. (Adaptation to an 8-hour shift, a shift that changes every day, is relatively slow, and is likely not as severe as a 12-hour shift, which changes every other day). Studies have thus suggested that readaptation effects are not only for only 12-hour shifts (e.g., Folkard, 1992; Knauth, 1993).

The literature also stresses the importance of shift design (e.g., Folke and the adaptive capacity of workers to shift work, especially at the end of shift systems (e.g., Folkard, 1992). The design of shift systems and the duration of shifts are very important considerations. Shift systems are generally designed to be as efficient as possible, and managers often choose shift schedules that minimize costs. For example, the next shift system is often chosen to minimize the number of shifts needed or to minimize the number of shifts required to cover a particular work period. However, the design of shift systems must also take into account the physiological and psychological needs of workers. Shift systems that are too stringent or inflexible may lead to worker burnout and increased turnover. Therefore, shift systems must be designed with careful consideration of both productivity and worker well-being.
to an 8-hour change usually requires 10 to 14 days, if it occurs at all.) Very slowly rotating shifts (e.g., every 3 to 4 weeks) are acceptable, providing shiftworkers adapt to and maintain their current schedule (again, an unlikely assumption). When primarily considering circadian effects, most shiftwork researchers advocate the rapidly rotating shift (i.e., every 2 to 3 days). Such a rapid rotation limits the number of consecutive night shifts, thus permitting shiftworkers to retain a diurnal orientation. Therefore, no readaptation to a new shift is required, and night work must be endured for only a few days, thus circumventing chronic sleep deprivation (Folkard, 1992; Knauth, 1993).

The direction of the rotation is another shift characteristic that may influence the physiological adaptation to the shift schedule (see Knauth, 1993, for a review; Totterdell & Folkard, 1990). A shift system that progresses from morning to evening to night shift is a forward-rotating system because it rotates in a clockwise fashion (phase delay); a shift system that progresses from night to evening to morning shifts is a backward-rotating system because it rotates in a counterclockwise system (phase advance). The forward-rotating system is preferable physiologically because it complements the body's endogenous circadian rhythms, which have a cycle of slightly more than 24 hours. In other words, a forward-rotating system is equivalent to flying west, thus gaining time. The existing data favor the forward-rotating system's hypothesized superiority, especially in terms of less fatigue, higher alertness, and fewer sleep disturbances (e.g., Barton & Folkard, 1993; Tucker, Smith, Macdonald, & Folkard, 2000). However, too few studies have compared forward and backward rotating systems to permit any generalization (Tucker et al., 2000).

When designing shift schedules, the number of days off between shifts and the number of night shifts must be considered (Knauth, 1993). Sufficient time off between shifts is necessary to reduce sleep debt and fatigue and maintain well-being. After more than two to three days on the night shift, several days of leisure time may be needed to recuperate before the next shift (e.g., Tepas & Mahan, 1989; Totterdell, Spelen, Smith, Barton, & Folkard, 1995).

The effects of shift length, usually 8 versus 12 hours, have been debated without resolution. The 12-hour shift or compressed work week has been very popular in industry and health care because this type of compressed schedule permits longer blocks of free or leisure time. However, in 12-hour shifts, increased fatigue, particularly toward the end of the shift, is a major concern; if the shift involves night work, these effects can be exacerbated. Shiftwork researchers therefore recommend that 12-hour night shifts be limited to one or two consecutive nights. Longer shifts also permit longer exposure to environmental toxins, such as industrial by-products; most threshold values are based on an 8-hour working day, and the risk for a 12-hour day (longer exposure) is rarely unknown (Knauth, 1993).

Despite these limitations, empirical comparisons of the health- and sleep-related effects of 12-hour shift systems have generally been positive (e.g., Johnson & Sharit, 2001; Mitchell & Williamson, 2000; Williamson et al., 1994), with a few exceptions (e.g., Bourdouxhe et al., 1999). In a recent
review of the research evaluating shift length, Smith, Folkard, Tucker, and Macdonald (1998) also concluded that shiftworkers on 12-hour shifts, compared to those on 8-hour shifts, do not experience greater difficulties with sleep, health, and well-being, and may even show improvements. They cautioned, however, that several factors need to be taken into account in each case before adopting 12-hour systems. Specifically, older shiftworkers may be at greater risk for excessive fatigue and medical complaints. Shiftworkers who must perform physically demanding tasks, endure exposure to toxic substances, or cope with an accumulation of job-related stressors (e.g., noise) may also be at greater risk.

Excessive weekly hours, annual hours, and overtime are critical factors to consider in the workplace, especially for shiftworkers (Spurgeon, Harrington, & Cooper, 1997). In their meta-analyses on the effects of hours of work on health, Sparks, Cooper, Fried, and Shirom (1997) reported small, but significant, positive mean correlations between health symptoms, physiological and psychological health symptoms, and hours of work. The authors cautioned, however, that these correlations may be underestimates because of the degree of aggregation necessary to conduct the meta-analyses. For example, the physiological measures included mild (e.g., headaches) to serious health symptoms (e.g., myocardial infarction), some of which showed stronger relationships with hours of work than others. This issue has become especially salient with the popularity of 12-hour shifts, which afford shiftworkers sufficient free time to "moonlight" or obtain alternate employment; their schedule also permits them to "double-shift," or work two shifts if needed. The problems of excessive fatigue, sleep deficits, and overexposure to workplace toxins may become very serious in these situations, and the shiftworkers in question should be closely monitored.

**Interventions to Improve Shiftworkers' Health and Effectiveness**

The most common shiftwork intervention, manipulations or changes in shift system characteristics, has been discussed in some depth in a previous section and therefore is only briefly discussed here. Other attempts to improve the shiftworker's adaptation include the ingestion of pharmaceutical agents, exposure to bright lights, and education and counseling programs.

**Manipulations of Shift System Characteristics**

Because of the ongoing controversy regarding the optimal combination of shift system characteristics for health and well-being, shiftwork experts have explored this issue in some depth. Much of the research we discussed in the section on shift-system characteristics attempted to manipulate some aspect of a shift system to determine the effects of those changes. For many of these shift characteristic comparisons, researchers collected cross-sectional data and concluded that any health problems could be characterized by the shiftwork they had been involved in and postulated that the merits of 12-hour shifts outweighed the risks (In Press, 1998).

**Melatonin**

Probably the most promising and least controversial intervention is the administration of melatonin. Shiftworkers who experience fatigue, and whose melatonin levels are known to be lower than those of diurnal individuals, have been found to respond to melatonin, the major sleep driver that regulates the circadian rhythm (in the earliest stages of sleep, before the sleep cycle has been fully established). Because melatonin is produced and released as the body is transitioning to sleep, it is an excellent sleep aid. In addition, the physiological effects, most notably changes in body temperature, are known to have demarcated the normal sleep cycle (see Jones, 1997).

The use of melatonin is not always effective as a sleep aid. Melatonin has never been shown to have an effect on various over-the-counter sleep aids, and melatonin has been recommended for shiftworkers, with little data on its efficacy (see only unpublished case studies).

**Bright Light Therapy**

Another recommendation made by shiftworkers is the administration of bright light. Bright light has been theorized that it helps to regulate the body clock, and the shiftworker's time (say, about 500 lux for 30 minutes). The argument is that shiftworkers have a different internal clock, and therefore should experience improved mood and alertness (see Eastman, 1997). However, the evidence is mixed, and more research (e.g., Budman & Bursztein, 1995) is needed to determine the effectiveness of this treatment for shiftworkers. Another potential intervention is the use of a strict sleep schedule and circadian reset of melatonin to improve sleep and alertness.
sectional data at one point in time and compared these data, assuming that any health-related differences could be attributed to the different shift characteristics (e.g., Barton & Folkard, 1993). Few longitudinal studies have been published, although longitudinal research, with appropriate pre- and postassessments, has increased with the recent interest in the relative merits of 12-hour shift systems (e.g., Lowden, Kecklund, Axelsson, & Åkerstedt, 1998; Mitchell & Williamson, 2000).

**Melatonin**

Probably the most widely publicized shiftwork intervention involves the introduction of sleep aids to enhance on-shift adaptation. For decades, shiftworkers have used pharmacological aids to improve sleep, diminish fatigue, and enhance alertness, although long-term use of many of these drugs is not advisable because of potential side-effects (Walsh, 1990). Melatonin, the latest pharmacological sleep aid, seems to avoid the pitfalls of the earlier hypnotics. Melatonin is a pineal hormone that is present in humans and other species, and its purpose in the body is to initiate sleep. Because melatonin is a substance normally found in the body, administering it to control the onset of sleep does not introduce some of the negative effects experienced with other drugs. Numerous controlled clinical studies have demonstrated the efficacy and safety of melatonin in enhancing sleep and adaptation to new shift schedules or time zones (Arendt & Deacon, 1997).

The use of melatonin, however, is not without problems. For example, if taken at the wrong time of day, it may actually impair sleep and adaptation. Melatonin is not a controlled drug, so the purity (and therefore safety) of the various over-the-counter preparations is unknown. Interactions between melatonin and other drugs have also not been explored. Therefore, shiftworkers, who may need long-term use of melatonin, are advised to take it only under medical supervision (Arendt & Deacon, 1997).

**Bright Lights**

Another modern intervention to aid adaptation to shift changes is the administration of bright lights. More than 20 years ago, researchers discovered that exposure to very bright light (2500 lux; indoor illumination is about 500 lux) could suppress the normal nocturnal secretion of melatonin and therefore delay sleep and entrain human circadian rhythms (see Eastman, 1990, for a review of the early research). These effects have also been demonstrated in field settings with shiftworkers (e.g., Stewart, Hayes, & Eastman, 1995). Some results, however, have been mixed and inconsistent (e.g., Budnick, Lerman, & Nicovich, 1995). To achieve the desired effects, shiftworkers must follow, and their employing organizations must support, a strict schedule of exposure to bright light over time. The allocation of resources to achieve this outcome can be considerable, and therefore bright
light exposure has not achieved the popularity of over-the-counter melatonin to enhance adaptation to shift changes and night work.

Education and Counseling Programs

Education and counseling programs have been used to impart information that can aid adaptation to shiftwork. Programs or workshops that deliver mostly general information about shiftwork and its effects on human functioning, as well as recommendations for coping with these issues, have been reported, for example, for emergency room physicians (Smith-Coggins, Rosekind, Buccino, Dingess, & Moser, 1997). Smith-Coggins and colleagues devised a well-controlled study using both objective and subjective criteria to assess the effectiveness of the workshop they presented to a group of physicians. However, their results indicated that, although the physicians in the experimental group used the strategies they learned 85% of the time according to their log book entries, the intervention did not significantly improve the criteria (performance and mood).

The disappointing results in this well-controlled study support Tepas's (1993) argument that educational information alone is often not particularly helpful, and in some cases may actually be misleading or confusing. The workshop content usually has face validity but questionable criterion-related validity, or the assessment of the workshop material relative to its ability to change important criteria (e.g., sleep, mood; see Smith-Coggins et al., 1997). Tepas maintained that educational workshops are best used in the context of a larger effort to improve the existing shift schedule. Such a process was used by Sakai, Watanabe, and Kogi (1993); they used an educational program to aid them in analyzing, planning, and implementing an improved shift rotation schedule in a disabled persons' facility.

In a similar vein, Wedderburn and Schollars (1993) collected shiftworkers' opinions on guidelines for shiftworkers that were developed by a team of European shiftwork experts and published as the Bulletin of Shiftwork Topics No. 3. Six of the 24 guidelines focused on the personal level were supported by a majority of the shiftworkers (e.g., on shiftwork, “I avoid taking sleeping pills,” “I avoid alcohol before sleeping”) and six were opposed by a majority (e.g., when working nights, “I use earplugs in bed,” “I avoid eating fatty foods”). These types of guidelines often have been, in some form, incorporated into shiftwork legislation, which we discuss next.

Shiftwork Legislation

Shiftwork legislation has been developed by the European community to guard the health and safety of shiftworkers. For example, the International Labour Organisation (ILO) Night Work Convention (No. 171) and Recommendation (No. 178) concerning Night Work (1990) and the European Directive 93/104 deals with “certain aspects of the organisation of working time.” This document discusses specific measures for nightworkers, such as health

assessments of individual shiftworker intervals and workloads to allow for movement of personnel with similar reasons, characteristics, and time, and for reductions in hours per day. Portugal and Spain also have specific laws that cover shiftwork.

Interviews with individual shiftworkers for female health issues and safety concerns of the work environment. In these discussions, both the health and safety issues of shiftwork practices were discussed. The Occupational Safety and Health Administration (OSHA) has stated that shift work can be harmful to the health and well-being of shiftworkers, particularly during during the period between work and sleep.

Our goal is to provide a brief overview of shiftwork and its potential dangers as well as the current state of shiftwork legislation and health practices. Shiftwork can be harmful to the health and well-being of shiftworkers, particularly during the period between work and sleep.

The potential dangers of shiftwork vary depending on the nature of the work and the individual's ability to cope with its demands. On a personal level, addressing the dangers of shiftwork is to identify the potential risks and develop strategies to reduce them.
assessments before assignment to night work, reassessments at regular intervals, and reassessments in case of health complaints. Other issues include transferring workers out of night work and into day work for health reasons, limiting the average hours worked per week to 48, including overtime, and providing a minimum rest period of 11 hours per day and 24 hours per week. Several European countries (France, Germany, Austria, Portugal, the United Kingdom, and the Netherlands) have already passed laws that conform to this directive (Costa et al., 2000).

International regulations have also dealt with equality of treatment for female shiftworkers, consideration of job design factors, expanded health and safety measures, and participatory practices for introducing change in the workplace (Kogi, 1998; Kogi & Thurman, 1993). When treated as law, these directives and regulations should have a profound influence on the health of night and shiftworkers by limiting some of the most dangerous practices. Unfortunately, beyond the Occupational Health and Safety Act (OSHA) of 1971, which requires employers to provide a workplace “free from recognized hazards likely to cause death or serious physical harm to [their] employees,” no legislation has been specifically targeted toward night or shiftworkers in the United States.

**Conclusion**

Our goal in this chapter was to explore the relationships between shiftwork and health. The research evidence clearly indicates that the experience of shiftwork adversely affects sleep, promotes fatigue, and is associated with the occurrence of accidents and injuries. Shiftwork is also related to the development of psychological, gastrointestinal, cardiovascular, and women’s reproductive disorders. Although the data are largely not causal, the convergence of the evidence is strongly suggestive. To further complicate this issue, a number of individual (e.g., age, personality) and situational (e.g., amount of night work) characteristics may influence shiftworkers’ health. For example, a shiftworker over 50 who is on a fixed night shift is at greater health risk than younger shiftworkers who are on day or evening shifts. The most destructive component is the amount of night work, not simply shiftwork, and the impact of night work increases over time. A number of interventions, with varying degrees of success, have also been developed to ease the plight of shiftworkers (e.g., melatonin ingestion, educational and counseling programs).

The final report is distinctly negative: Shiftwork, and especially night work, which disrupts the human circadian system, is associated with increased health risk for minor and life-threatening disorders. Regardless of its impact on health, however, shiftwork will remain as a necessary way of structuring work because of the current and future demands of society. On a positive note, we have considerable knowledge at our disposal to address these issues. Therefore, our task as researchers and practitioners is to improve research and the tools (e.g., interventions) we develop from that research. Toward that end, we offer a few suggestions.
Because most shiftwork research is cross-sectional, researchers sample from a workforce in which an unknown number of shiftworkers have already transferred out of shiftwork for health or personal reasons. As a consequence, only the “successful” shiftworkers remain in shiftwork. The result is that researchers may greatly underestimate the negative impact of shiftwork (a sobering thought!); conversely, studies of former shiftworkers may overestimate the negative impact of shiftwork (Costa et al., 2000). This fact is important to recall when interpreting effect sizes in shiftwork research.

Another problem has been the lack of standardized measures to use in shiftwork research, which often makes comparisons across studies difficult. To address this issue, Barton et al., (1995) proposed a battery of self-report instruments, the Standard Shiftwork Index (SSI), to be used in shiftwork research. Some of the measures in this battery have been widely used in other areas of research (e.g., personality inventories) and some are fairly specific to shiftwork research (e.g., morningness scales). The authors considered such issues as scale length, ease of administration, and scale psychometric properties when developing the SSI. The scales fall into three areas: (a) general, contextual variables (e.g., timing and duration of shifts, workload); (b) outcomes or criteria (e.g., digestive symptoms, job satisfaction); (c) and modifiers or moderators (e.g., morningness, coping strategies).

Barton and her colleagues tested the SSI in large samples of nurses and industrial workers. Their results were used to generate a normative database, validity coefficients based on hypothesized relationships among the variables, and other psychometric data, such as scale-factor analyses. Over the past five years, various parts of the SSI have been used by shiftwork researchers (e.g., Tucker et al., 1996), and we strongly suggest that researchers consider using the battery in their future investigations.¹

Personal control is yet another important issue in shiftwork research and practice. Psychologists have long known that personal control and choice are critical to maintain psychological and physical health and well-being (e.g., Folkman, 1984). It is not surprising that shiftwork researchers have discovered that the opportunity to exert individual control over the selection of the hours or shift one works is important in achieving shiftwork tolerance (e.g., Barton, 1994; Barton et al., 1993). Therefore, individual choice or participation in the design of actual shift schedules should increase acceptance and positive attitudes toward the shift system (e.g., Sakai et al., 1993).

Knauth (1997) stated that “a ‘tailor-made’ shift system should be a compromise between the employer’s goals, the wishes of the employee, and ergonomic recommendations for the design of the shift systems.” According to Knauth, only management’s goals and ergonomic features have traditionally been considered when designing shift systems. However, if the new system is to achieve a high acceptance among shiftworkers, then a participatory process (i.e., their input) in the design and implementation of the new system is as necessary as the ergonomic features of the shift system. In

¹The SSI can be obtained by contacting Simon Folkard.
fact, shiftwork experts consider worker participation in the design and implementation of shift systems to be so universally appropriate that it has been incorporated into international shiftwork regulations and directives (Kogi, 1998).

Perhaps the most neglected topic, however, is the role extraorganizational factors play in shiftworkers' mental and physical health. Although the importance of extraorganizational and social factors has been discussed in previous reviews of shiftwork and health and shiftwork tolerance (e.g., Costa et al., 2000; Härma, 1996), studies on such topics are rare (e.g., Smith & Folkard, 1993). This dearth of research is surprising, given that the most frequent complaint of shiftworkers is that shiftwork interferes with their personal lives (e.g., Bohle & Tilley, 1998; Monk, 1989). On a more sobering note, Tepas et al. (1985) reported that divorces and separations were 50% more frequent in night workers than in other groups of workers.

In conclusion, decades of research indicate that shiftworkers are at greater health risk than comparable day workers. Using that knowledge, researchers have designed interventions to alleviate the risk. In the twenty-first century, our goals as applied researchers should be to improve and augment our research and the interventions developed from it.

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