Chapter 1

Summary, Policy Issues, and Options for Congressional Action

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Chapter 1

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Biological rhythms are changes in various physiological and behavioral functions of organisms that repeat at regular intervals and provide a framework of temporal organization for them. Biological rhythms in humans have cycles ranging from minutes to months; for example, stages of sleep and the release of a number of hormones in the body cycle with a rhythm measured in minutes, while the female menstrual cycle is measured in days (box 1-A). Cycles in synchrony with the 24-hour rotation of the Earth are probably the most widely studied. External factors that disturb the internal clock can produce deleterious effects. A common example is jet lag, the malaise associated with travel across time zones. In the case of jet lag, the effect is short-lived and the body readjusts relatively quickly to the local time at the new location. Work schedules outside the standard daytime hours can disrupt the biological rhythms of the body. This disturbance can continue unabated while other factors, such as sleep loss and social disruption, compound the deleterious effects. The results can be detrimental to some workers' health and ability to perform their jobs, which in turn can adversely affect their safety and that of society as a whole.

The term "shift work" is often applied to schedules that include nondaytime hours of work, but there is no consistent definition of the term. As used in this report, shift work refers to any nonstandard work schedule. It includes evening or night work; a rotating shift, in which hours change regularly (e.g., from day to evening to night); a split shift, in which a period of work is followed by a break and then a return to work; and extended duty hours, consisting of long periods of work (usually over 12 hours). This report focuses on the impact these schedules can have on the body's biological rhythms.

Diverse occupations require or involve 24-hour operations and use nonstandard work schedules. They include manufacturing industries (e.g., chemical, steel, paper), utilities (e.g., powerplants), protec-

Box 1-A—Biorhythms Are Not Biological Rhythms

The scientific study of the biological rhythms of the body should not be confused with the theory of biorhythms. No evidence exists to support the concept of biorhythms; in fact, scientific data refute their existence. Based on a theory first proposed by the German scientist Wilhelm Fliess in 1897 and popularized in the 1970s, biorhythm theory postulates that three cycles act in a concerted fashion to guide activity: a 23-day cycle that influences physical strength, endurance, energy, and physical confidence; a 28-day cycle that influences feelings, love, cooperation, and irritability; and a 33-day intellectual cycle that influences learning, memory, and creativity. According to biorhythm theory, these three cycles are linked to an individual's birth date and fluctuate in a constant fashion throughout his or her life. Each cycle has a high and a low point. By mapping the high and low points of the respective cycles and how they coincide or diverge, the theory states, performance can be charted, and critical days when performance can be expected to be highest or lowest can be predicted.

Although a theory that provides a system for predicting human behavior and scheduling activities has appeal, none of the contentions of biorhythm theory can be supported. No biological process with such a relationship to the calendar date of birth has ever been identified, nor have any studies attempting to validate biorhythms been able to do so. Thus, for example, attempts to validate the hypotheses using retrospective airplane crash reports and athletic scores have consistently failed. While there clearly are human biological rhythms with cycles that can be measured in days (the menstrual cycle being an example), there is no evidence for the existence of any of the three biorhythms, let alone any predictive interaction. Given its nonfactual basis, biorhythm theory is relegated to the realm of other popular pastimes, such as numerology, that can serve as a source of entertainment but have no substantive or predictive value.

SOURCE D.C. Holley, C.M. Winget, C.M. DeRoshia, et al., *Effects of Circadian Rhythm Phase Alteration on Physiological and Psychological Variables: Implications to Pilot Performance (Including a Partially Annotated Bibliography.),* NASA technical memorandum *TM-81277* (Moffet Field, CA: National Aeronautics and Space Administration March 1981).

tive and health services (e.g., police, fire and rescue, hospitals), transportation (e.g., airlines, railroads, trucking, shipping), major construction projects (e.g., darns, tunnels), military operations, and, increasingly, services (e.g., retail stores, financial institutions, entertainment and recreation, specialized services such as overnight deliveries).

At the Federal level, the Fair Labor Standards Act, which was enacted in 1938, established a standard 40-hour workweek. Various hours of service acts regulate maximum hours for a number of industries, notably transportation. Some States regulate hours of work, and collective bargaining agreements can specify hours and shift schedules.

The Federal Government has authority to regulate working conditions that endanger the safety and health of workers through the Occupational Safety and Health Administration (OSHA) of the Department of Labor or through individual Federal agencies that have the authority to regulate safety and health within their own jurisdictions. OSHA can impose standards and regulations on the workplace when scientifically valid research and empirical data indicate that conditions pose a significant risk of harm to workers. Interactions between biological rhythms and work schedules are examined through basic research on underlying biological mechanisms; applied research studying human responses to shift work in laboratory and field settings; statistical information on the occurrence of injuries, mishaps, deaths, and health problems in the workplace and the conditions under which they occur; and demographic information about populations working different schedules.

The effects of various work schedules on the health and safety of workers and the impact they could have on the public raise questions about possible Federal actions to regulate some work hours and schedules. These concerns are coupled, however, with questions regarding the extent of current knowledge about work schedules and their effects, namely:

- What types of schedules are being worked and by whom?
- What are the precise effects on the health, performance, and general well-being of workers who work nondaytime hours?
- What kinds of effects occur in what kinds of schedules?
- Who are the workers most likely to be affected?

What we envision as an internal clock is actually a group of neurons in the brain that control daily rhythms.

SOURCE: R.M. Coleman, *Awake at 3:00 a.m. by Choice or by Chance* (New York, NY: W.H. Freeman, 1986)."

- What factors contribute to any observed effects and to what degree?
- What are the implications of these effects for worker safety and the safety of the public?
- What interventions can be taken to alleviate or lessen deleterious effects?
- Most important, is enough known at this time to recommend specific 'guidelines or regulations?

This report discusses current theories and ideas pertaining to these questions and describes the latest efforts to answer them.

CIRCADIAN RHYTHMS

Many biological activities rise and fall in rhythmic patterns in humans, other animals, plants, and even single-celled organisms. This ability to keep track of time, apparently a basic part of life, is under genetic control. Geneticists have identified specific genes in simple organisms that are responsible for rhythmic cycles, and physiologists have identified a certain part of the mammalian brain that controls rhythms in more advanced organisms. Biological

Box 1-B--Cycles That Last From Minutes to Days

Circadian rhythms are a basic and well-recognized feature of human physiology and behavior. However, biological rhythms that repeat more or less frequently than every 24 hours are also fundamental to the body's function. In general, ultradian rhythms (those with a length of less than 24 hours) and infradian rhythms (those with a length greater than 24 hours) do not coincide with conspicuous environmental cues, and how they are generated is not well understood.

Sleep cycles were one of the first ultradian rhythms characterized in humans. A complete cycle of dreaming and nondreaming takes place about every 90 minutes. This finding prompted researchers to hypothesize that cycles of enhanced arousal followed by diminished activity typify both waking and sleeping periods. This theory of a basic rest-activity cycle has led to many studies of ultradian cycles in alertness-sleepiness, hunger, heart function, sexual excitement, urine formation, and other functions.

Hormones are also released in ultradian cycles. Many are secreted in a more or less regular pattern every few hours. More frequent cycles of release, every few minutes, have also been documented. Although the mechanisms of hormone secretion have not been uncovered, patterned release has been shown to be extremely important for proper functioning. For example, experiments have shown that, when replacing a deficient hormone, pulses of the hormone, not a continuous supply, are required for effectiveness. Also, abnormalities in the production cycle of hormones have been correlated with altered function. Although these cycles do not appear to be tightly coordinated, it is clear that ultradian rhythms with a cycle of 90 minutes, as well as with cycles of a few minutes to several hours, are a basic component of many human functions. How they are generated is unknown.

The most prominent infradian rhythm in humans is the menstrual cycle. Through a series of complex interactions between the brain and reproductive organs, an egg is released by an ovary approximately every 28 days, and the reproductive organs are prepared for possible fertilization. During each cycle, hormones are secreted in varying amounts, and the reproductive tract and breast tissue are altered. Other systems, such as those involved in immune function, may also be affected.

Although the menstrual cycle has long been recognized, how it is generated and how it interacts with other factors have not been completely detailed. It is clearly affected by circadian rhythms. For example, a peak in the secretion of luteinizing hormone, which triggers ovulation, usually occurs in the early morning hours. Also, phase shifts, such as those produced by transmeridian flight, may interfere with the menstrual cycle. The menstrual cycle may also have therapeutic implications. A recent study of the timing of breast cancer surgery in relationship to the menstrual cycle has found fewer recurrences and longer survival in patients whose surgery occurred near the middle of the menstrual cycle rather than during menstruation. That biological rhythms are often ignored is also indicated in this study: less than half of the records evaluated in the study recorded the time of the last menstrual period.

SOURCE: Office of Technology Assessment 1991.

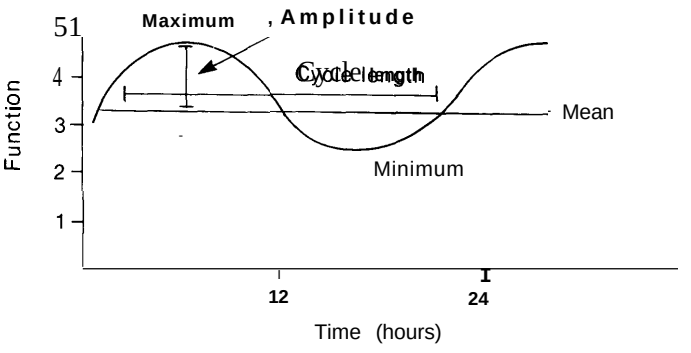
rhythms that repeat approximately every 24 hours are called circadian rhythms (box l-B) (figure l-l).

In humans, body temperature, the secretion of many hormones, the functioning of various organ systems (e.g., cardiovascular, pulmonary, renal) and the immune system, and sleep and wakefulness all exhibit circadian rhythms. In addition to these physiological activities, many psychological processes and mental functions that affect human performance exhibit circadian fluctuations. These include memory, reaction time, manual dexterity, and feelings of alertness. The implications of human circadian rhythms for shift workers form the **focus of this report (figure 1-2).**

When rhythms generated by the body are disrupted by changes in environmental cues, as they are in jet lag and in some work schedules, human function can be compromised until realignment is achieved. Patterns of sleep are disrupted, performance may be impaired, and a general feeling of malaise may prevail.

Circadian rhythms are generated by an internal clock, or pacemaker, that is located in a region of the brain called the suprachiasmatic nucleus. Circadian rhythms persist even in the absence of cues indicating the time or length of day, such as light and dark. In humans, as inmost species, light-dark cycles are very powerful entraining, or synchronizing, agents, while sleep-wake schedules

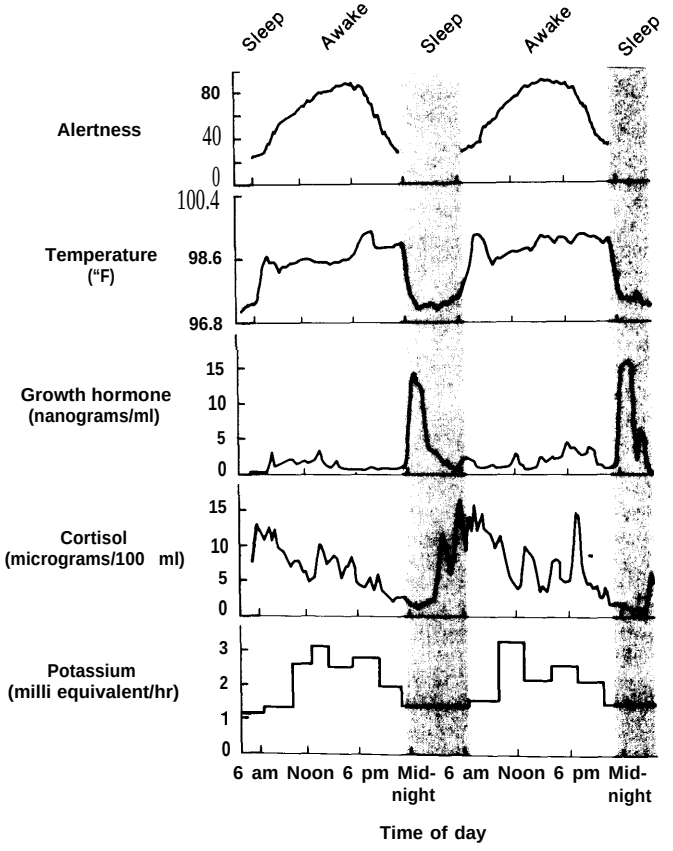
Figure I-I—Circadian Rhythm



Circadian rhythms have a single cycle length of approximately 24 hours. The amplitude, a measure of the degree of variation within a cycle, is the difference between the maximum value and the mean.

SOURCE: Office of Technology Assessment, 1991.

Figure 1-2—Circadian Timing of Various Functions



The timing of some functions that cycle with a circadian rhythm.

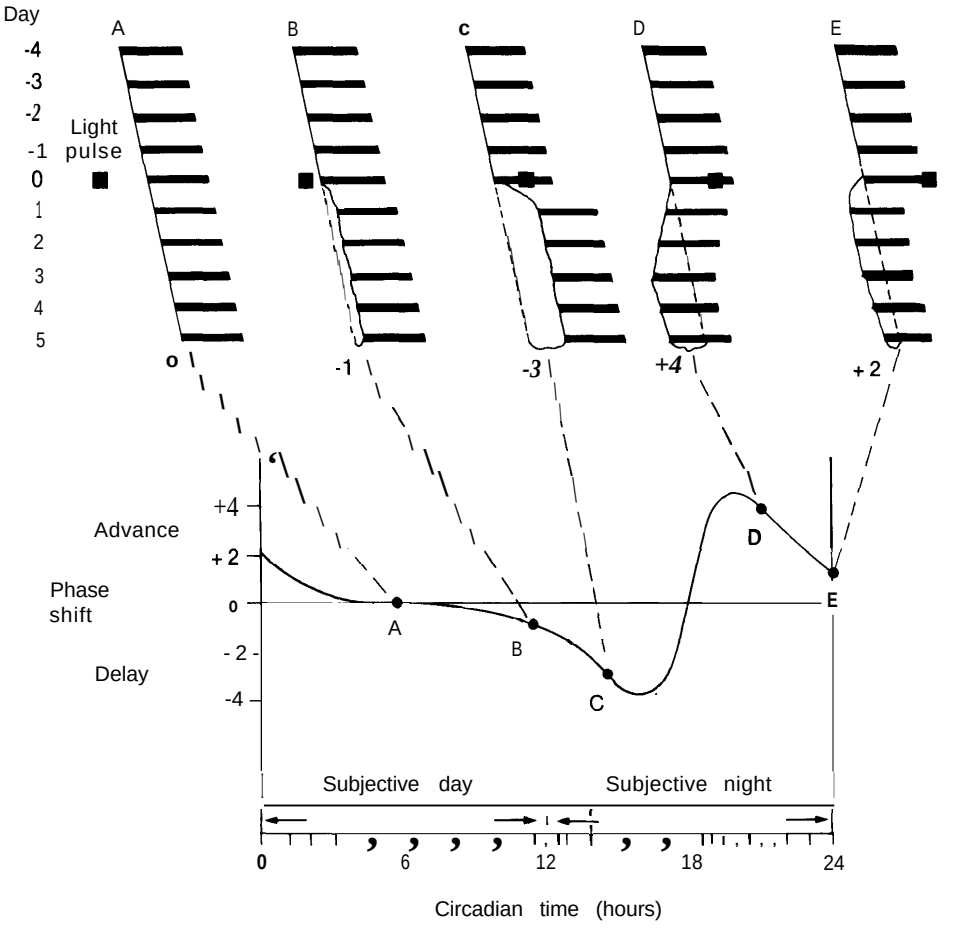
SOURCE: Adapted from R.M. Coleman, *Awake at* 3.00 *a.m. by Choice or by Chance (New York, NY:* W.H. Freeman, 1986).

and social cues may also synchronize human circadian rhythms. An entraining agent can reset, or phase shift, the internal clock; depending on when an organism is exposed to such an agent, circadian rhythms may be advanced, delayed, or not shifted at all (figure 1-3). When circadian rhythms are reset, the beginning and end of the cycle are shifted, but the length and progression of changes within it remain the same. The flexibility of a circadian rhythm in adjusting to different environmental cues will determine the degree to which the timing of the function controlled by that rhythm can be altered. In humans, this has direct implications for the ability of the body clock to readjust following changes in work schedules.

A standard schedule for most people is to awake in the morning and go to bed at night, some 15 to 17 hours later. The person who arises at 5 a.m. and the one who wakes 4 hours later both have 24-hour rhythms and spend the major part of their waking hours in the light and their sleeping hours in the dark, but they can have different phases. Some members of society have far different hours: a nurse or chemical worker who goes to work at midnight spends a major part of his or her waking hours in the dark and must sleep through daylight hours. In some situations, the work schedule changes in such a way that individuals will constantly be changing waking and sleeping times, and other functions that have a circadian rhythm will continually be readjusting to the new schedule.

While shift work may affect all circadian rhythms, its effect on performance rhythms and sleep-wake cycles are of particular concern. The timing of peaks in performance varies with the nature of the task, with peaks in many tasks (e.g., manual dexterity, simple recognition, reaction time) paralleling the peak in the circadian rhythm of body temperature. Also, sleep deprivation and sleepiness disrupt most types of performance. The timing and total amount of sleep are related to a person's environment and to other circadian rhythms, notably body temperature, with sleep occurring most readily when body temperature is low. When individuals are required to work at night, many types of performance can be affected, which can reflect both the effect of circadian rhythms and the lack of sleep. Thus, sleep deprivation, combined with the influence of the circadian pacemaker, can severely curtail performance at night.

Figure 1-3--Phase Response Curve



Experiments demonstrate that exposure to light at different points in a single circadian cycle variably shifts the internal pacemaker (A-E). The pulse of light given in mid-subjective day (A) has no effect, whereas the light pulses in late subjective day and early subjective night (B and C) delay circadian rhythms. Light pulses in late subjective night and early subjective day (D and E) advance circadian rhythms. In the lower panel, the direction and amount of phase shifts are plotted against the time of light pulses to obtain a phase response curve.

SOURCE: M.C. Moore-Ede, F.M. Sulzman, and C.A. Fuller, *The Clocks That Time Us* (Cambridge, MA: Harvard University Press, 1982).

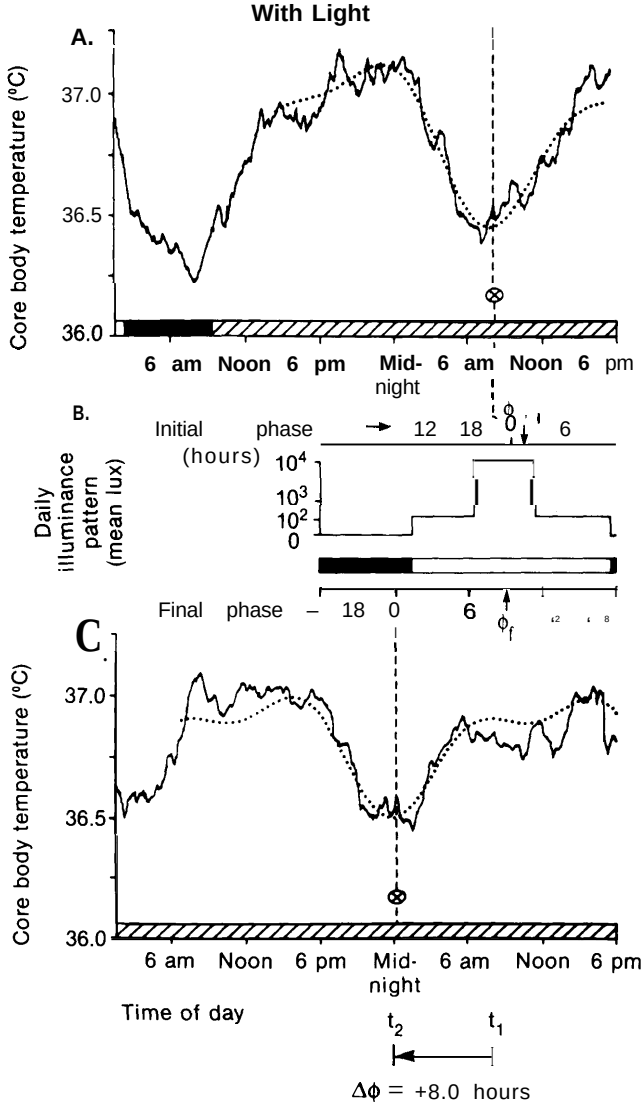
Other factors also alter circadian rhythms. For example, many physiological and behavioral functions, notably sleep, are altered with advancing age in humans. As a result, adjustment to shift work schedules and transmeridian flight is more difficult among older people (age 45 and above) and a considerable proportion of older people complain of sleep problems. In addition, the timing of sleep is very susceptible to circadian disruption; it is now recognized that some types of insomnia most likely result from circadian rhythm abnormalities.

There is great interest in the role the circadian system may play in some mood disorders. It is hypothesized that circadian rhythms are advanced, delayed, or the amplitude dampened in seasonal affective disorder (SAD), a mood disorder characterized by recurring autumn or winter depression which is alleviated in the springtime; however, SAD has not been proven to be a circadian rhythm disorder. Also, it has been observed that people suffering from nonseasonal depression may exhibit altered circadian patterns in physiological functions and that

their moods typically fluctuate daily, with improvement over the course of the day. These observations suggest a link between altered circadian rhythms and nonseasonal depression, although there is little direct evidence to support this hypothesis. Finally, some scientists are investigating the implications circadian rhythms have for the timing of surgery and the administration of drugs, in an effort to optimize their therapeutic effects.

Interest in manipulating the internal clock has grown with improved understanding of human circadian rhythms. Several agents show promise for manipulating circadian rhythms, and some are currently in use. Recent research indicates that light, especially bright light, is effective in shifting human circadian rhythms, although the mechanism is not well defined (figure 1-4). Researchers are investigating the capacity of melatonin, a hormone produced in the brain, to act as a circadian synchronizing agent in humans. Studies in animals suggest that administration of benzodiazepines, a class of hypnotic drug, affects the circadian system. It is not clear, however, whether the effect is due to direct action on the circadian clock or to the drug's ability to induce motor activity. Finally, there is some evidence that physical activity or arousal can synchronize the biological clock, but further experimentation is necessary to characterize this effect. The development or discovery of an agent that can manipulate the internal clock would be helpful in situations such as shift work, where a rapid realignment of the circadian system is desirable.

Figure 1-4—Resetting the Human Pacemaker With Light



The first graph (A) illustrates the original circadian rhythm of body temperature. Following exposure to bright light, as illustrated in B, the rhythm of body temperature was significantly shifted (C).

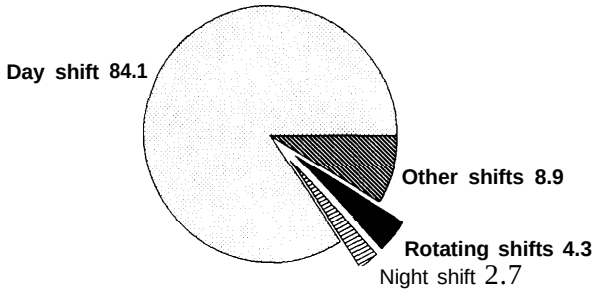
SOURCE: C.A. Czeisler, R.E. Kronauer, J.S. Allan, et al., "Bright Light induction of Strong (Type O) Resetting of the Human Circadian Pacemaker," Science 244:1328-1332, 1989.

PREVALENCE AND USE OF SHIFT WORK

Shift work is required in any modern, industrially developed country, and it is indisputably part of work in the United States. Understanding shift work and its impact on productivity, health, safety, and quality of life depends on information about its prevalence and use. The Office of Technology Assessment (OTA) finds that the Federal Government's collection of data pertaining to the prevalence and use of shift work has been inconsistent. This has precluded any accurate, thorough measure of the scope and nature of shift work in this country.

The most comprehensive data on the prevalence of shift work in the United States are based on the Current Population Survey (CPS), a household sample survey conducted monthly by the Bureau of the Census (in the U.S. Department of Commerce) for the Bureau of Labor Statistics (BLS) (in the U.S. Department of Labor). In this survey a set number of households are regularly asked a fixed list of employment questions. In May of each year between 1973 and 1980, a supplement was added to the CPS with questions on specific hours of employment, and in May 1980 data were collected for the first time on whether or not the principal job in the household was

Figure 1-5-Percentage of Shift Workers Among Full-Time Employees in the United States



SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review 109: 14-21, 1986.*

worked on a rotating shift. From 1980 through 1984, the CPS collected no information on work schedules. The next year, in May 1985, the supplement again included questions related to hours of work and work schedules. Since there have been no supplements since 1985 that include shift work questions, the 1985 data provide the most recent estimates available. These data indicate that approximately one in five Americans—20 million people—is a shift worker. Approximately 2.0 million individuals are night workers, and another 3.1 million people work rotating shifts, which may involve night work. The remaining individuals work other types of nonstandard work schedules, such as split shifts or evening hours. In 1991 another supplement was added to the CPS.

A more recent and comprehensive national source of data on shift work is the 1987-88 *National Survey of Families and Households*, conducted by the Center for Demography and Ecology at the University of Wisconsin. This survey asked the most detailed questions on work schedules of any national survey to date, including the hours work began and ended each day of the week and shift rotation. Although no analysis of the shift work data has been completed yet, preliminary results on prevalence are consistent with the May 1985 CPS findings.

Shift Work in Various Employment Sectors

Many occupations and industries use shift work; in fact, 15.9 percent of all full-time workers are engaged in shift work (figure 1-5). The factors that lead to shift work vary considerably from sector to sector.

Reasons for adopting shift work schedules include the following:

- an extended period of time required to complete a particular job or process;
- a constant need or extended demand for services;
- economic factors (e.g., expense of capital investment, concerns about competitiveness); and
- technological advances.

From 1979 to 1984, capital-intensive industries and continuous-process operations had as many as 50 percent of employees working evening or night shifts. In contrast, less than 3 percent of workers in labor-intensive industries are scheduled for an evening or night shift (table l-l).

Shift work is also prevalent in transportation occupations and industries, including trucking, airlines, railroads, and shipping. Among those employed by public utilities and transportation industries, 20.6 percent are shift workers; 25.5 percent of full-time motor vehicle operators are shift workers, half of them on night or rotating shifts. While many transportation sectors are governed by hours of service regulations, those regulations do not preclude night work, shifts exceeding 8 hours in length, or erratic scheduling.

Round-the-clock operations are also demanded by various service industries, a significant and growing sector of the U.S. economy. More than 38 percent of persons employed full-time in service occupations are shift workers, compared to the average of 15.9 percent of all full-time employed persons. Some subgroups of the service sector exhibit an extremely high prevalence of shift work. For example, 60.8 percent of full-time protective service workers (e.g., police and firefighters) are employed during nonstandard hours. Among workers in other service industries, those employed in eating and drinking establishments (47.6 percent) and in entertainment and recreation (33.4 percent) are especially likely to be shift workers.

Technological advances--office automation and the increased importance of global communication and interaction-provided powerful incentives for the addition of a second and third shift. BLS reported that between 1978 and 1985 the number of clerical personnel working at night increased three times faster than the number of all other night workers.

Table I-l—Shift Work in Various Employment Sectors

Occupation or industry	Total workers employed (thousands)	Standard work schedule (percent)	Shill work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Occupation						
Managerial and professional specialty	18,944	91.4	2.0	1.2	2.7	8.6
Executive, administrative, and managerial	9,079	92.6	1.8	0.8	2.6	7.4
Professional specialty	9,866	90.3	2.3	1.5	2.8	9.7
Health-diagnosing occupations	212	77.6	1.7	—	13.6	22.4
Health assessment and treating occupations	1,257	68.7	8.3	8.3	12.1	31.3
Technical, sales, and administrative support	21,961	88.3	4.2	2.1	3.5	11.7
Technicians and related support	2,548	84.5	6.5	3.3	4.6	15.5
Health technologists and technicians	761	70.1	12.5	9.0	7.6	29.9
Sales occupations	6,730	82.8	4.1	2.2	6.9	17.2
Supervisors	1,957	84.0	2.8	2.1	7.4	16.0
Salesworkers, retail and personal services	2,400	72.3	8.3	3.6	11.5	27.7
Administrative support, including clerical	12,684	92.0	3.7	1.7	1.6	8.0
Computer equipment operators	673	81.2	11,0	2.7	4.1	18.8
Mail and message distributing	613	76.2	12.7	9.1	0.4	23.8
Service occupations	7,268	61.6	16.9	6.1	8.7	38.4
Private household	275	83.0	7.3	1.9	—	17.0
Protective service	1,286	39.2	19.8	7.2	23.8	60.8
Service, except private household and protective	5,707	65.6	16.7	6.1	5.7	34.4
Food service	2,194	56.9	21.2	5.3	8.2	43.1
Health service	1,076	63.9	14.8	10.3	6.8	36.1
Cleaning and building service	1,719	74.4	16.1	5.4	1.7	25.6
Personal service	718	73.9	7.5	3.7	6.2	26.1
Precision production, craft, and repair	10,477	87.0	6.3	2.2	3.7	13.0
Mechanics and repairers	3,582	87.3	6.0	2.3	3.6	12.7
Construction trades	3,282	94.1	3.4	1.0	1.2	5.9
Other precision production, craft, and repair	3,614	80.3	9.3	3.2	6.1	19.7
Operators, fabricators, and laborers	13,326	76.3	10.5	4.6	6.2	23.7
Machine operators, assemblers, and inspectors	6,748	76.3	13.2	3.7	6.2	23.7
Transportation and material-moving occupations	3,448	73.8	5.8	6.0	7.4	26.2
Motor vehicle operators	2,392	74.5	4.3	6.9	5.9	25.5
Handlers, equipment cleaners, helpers, and laborers	3,130	78.9	9.9	5.2	4.9	21.1
Farming, forestry, and fishing	1,418	89.9	1.5	1.4	0.7	10.1
Industry						
Private sector	60,127	83.5	6.6	2.9	4.4	16.5
Goods-producing industries	24,626	85.0	7.4	2.6	3.9	15.0
Agriculture	1,154	89.4	0.9	2.2	0.2	10.6
Mining	885	78.1	6.0	1.6	12.1	21.9
Construction	4,279	97.5	1.3	0.4	0.4	2.5
Manufacturing	18,309	82.1	9.3	3.2	4.5	17.9
Durable goods	11,277	84.0	10.0	2.5	2.8	16.0
Nondurable goods	7,033	79.1	8.2	4.4	7.2	20.9
Service-producing industries	35,501	82.4	6.1	3.0	4.8	17.6

Table I-l-Shift Work in Various Employment Sectors--Continued

Occupation or industry	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Transportation and public utilities	4,958	79.4	6.1	3.5	6.4	20.6
Wholesale trade	3,222	91.9	2.9	2.1	0.9	8.1
Retail trade	9,111	73.7	9.1	3.7	8.6	26.3
Eating and drinking places	2,242	52.4	21.0	5.3	12.5	47.6
Finance, insurance, and real estate	5,003	93.9	1.9	1.0	1.1	6.1
Services	13,207	82.9	6.4	3.3	3.9	17.1
Private household	345	80.8	7.3	1.5	0.7	19.2
Business and repair	3,242	87.4	5.8	2.4	3.1	12.6
Personal, except private household	1,379	74.0	10.1	3.8	6.6	26.0
Entertainment and recreation	529	66.6	13.8	2.2	7.3	33.4
Professional services	7,682	83.8	5.4	3.7	3.6	16.2
Hospitals	2,303	73.0	10.5	6.6	8.5	27.0
Public sector	13,268	87.2	4.6	2.0	3.7	12.8
Federal Government	2,901	86.2	6.1	3.4	2.8	13.8
State government	3,320	88.2	4.3	2.3	3.0	11.8
Local government	7,047	87.1	4.2	1.3	4.5	12.9

SOURCE: E.F. Mellor, "Shift Work and Flexitime: How Prevalent Are They?" *Monthly Labor Review* 109:14-21, 19S6.

Night work among technical and professional office personnel has increased 36 percent during this time period.

Who Are Shift Workers?

A higher percentage of young men, single men, and black men are shift workers, Approximately 22.6 percent of black men employed full-time are shift workers, versus 17.3 percent of white men employed full-time. Among all men employed full-time, 27.4 percent of those between the ages of 16 and 19 do not work a regular daytime schedule, compared to 14.6 percent of men age 45 and older. Among all men employed full-time, 21.1 percent of single men and 16.5 percent of married men work nonstandard hours. Although young, single, and black men are more likely to be shift workers, older, married, and white men, being the majority of full-time workers, form the majority of shift workers (table 1-2).

Differences in shift work prevalence by sex depend on whether Ml-time or part-time work is considered. Considering only full-time wage and salary earners age 16 and over, the BLS reports that 17.8 percent of men and 13.0 percent of women are shift workers. Men are more likely than women to be working night, miscellaneous, and rotating shifts, whereas women are more likely than men to work the evening shift. While men are more likely than women to be shift workers, shift work is highly prevalent among women in some employment sectors, particularly nursing and other health services.

One-fourth of all dual-earner couples without children and one-third of all dual-earner couples with children include at least one spouse who works a nonstandard shift. Moreover, shift work is especially high among married couples with young children. One study estimated that about 50 percent of all young couples with children under the age of 5 in the United States include at least one spouse who works nonstandard hours. Also, the prevalence of shift work is considerably higher among unmarried parents. Both young dual-earner parents and unmarried employed mothers are especially likely to be working nonstandard hours.

The reasons individuals work nonstandard hours vary and include both voluntary and involuntary factors. Voluntary reasons include better child-care arrangements, better pay, better arrangements for care of other family members, and more opportunity for education. Involuntary reasons include the inability to get any other job and the schedule being a requirement of the job. A survey by the BLS reported that only 28 percent of persons working nonstandard hours did so voluntarily; 72 percent

Table 1-2—Demographic Profile of Shift Workers

Characteristic	Total workers employed (thousands)	Standard work schedule (percent)	Shift work (percent)			
			Evening shift	Night shift	Rotating shift	Total
Age						
Men, 16 years and over	43,779	82.2	6.8	3.0	4.9	17.8
16 to 19	1,139	72.6	11.8	4.7	7.0	27.4
20 to 24	5,567	80.0	8.5	3.5	5.0	20.0
25 to 34	14,281	80.0	7.8	3.3	5.6	20.0
35 to 44	10,630	83.6	5.7	2.7	5.0	16.4
45 to 54	7,094	85.4	5.3	2.7	3.9	14.6
55 to 64	4,594	85.5	5.6	2.1	3.8	14.5
65 And over	474	85.4	2.8	2.5	4.0	14.6
Women,16y ears and over	29,616	87.0	5.5	2.3	3.3	13.0
16 to 19	777	71.1	12.8	4.0	9.4	28.9
20 to 24	4,346	84.0	6.7	2.0	5.1	16.0
25 to 34	9,510	87.5	5.3	2.2	3.3	12.5
35 to 44	7,080	88.9	4.8	2.3	2.2	11.1
45 to 54	4,753	88.4	4.6	2.2	2.8	11.6
55 to 64	2,838	87.3	5.3	2.6	3.2	12.7
65 And over	311	85.8	7.3	3.8	—	14.2
Total,16 years and over	73,395	84.1	6.3	2.7	4.3	15.9
Race and Hispanic origin						
White	63,523	84.7	5.8	2.6	4.3	15.3
Men	38,588	82.7	6.3	2.9	5.0	17.3
Women	24,935	87.8	5.0	2.1	3.3	12.3
Black	7,847	80.1	9.8	3.5	4.3	19.9
Men	4,054	77.4	10.6	3.7	5.3	22.6
Women	3,793	83.0	8.9	3.2	3.2	17.0
Hispanic origin	4,911	84.6	7.1	2.5	3.3	15.4
Men	3,184	82.3	7.7	2.8	4.0	17.7
Women	1,727	88.8	5.8	1.9	2.0	11.2
Marital status						
Men						
Single, never married	9,703	78.9	9.3	3.6	5.0	21.1
Married, spouse present	29,666	83.5	5.7	2.7	5.1	16.5
Widowed, divorced, or separated	4,410	80.4	8.5	3.6	4.0	19.6
Women						
Single, never married	7,109	83.6	6.8	2.3	5.2	16.4
Married, spouse present	15,679	89.9	4.3	1.9	2.3	10.1
Widowed,divorced, or separated	6,828	83.7	7.0	3.3	3.6	16.3

SOURCE: E.F. Mellor, "Shift Work and Flexitime: HowPrevalentAre They?" *Monthly Labor Review* 109:14-21 ,19SS.

did so involuntarily, and 9 out of 10 of the latter said the schedule was a requirement of the job.

Shift Work Schedules

Several hundred shift routines are in place in the United States, but data characterizing specific shift work schedules in various occupations and industries in the United States have not been collected by the Federal Government, labor representatives, or industry. The absence of these data, coupled with sparse demographic information about the populations of workers involved, severely handicaps the study of the health, performance,and social effects of shift work,as well as changes in trends concerning the use of shift work.

The most common work schedule in the United States, especially in the manufacturing sector, is 8 hours a day, 5 days a week on a single shift, followed by 2 days off. Shift work schedules can be used to cover 7 days a week of continuous operation, with shift lengths ranging from 8 to 12 hours.Shifts may be fixed, partially fixed, or rotating. Shift rotation-that is, the time a worker spends on one shift before moving to another-may be rapid (3 days) or gradual (4weeks),and it may move forward

Box 1-C—The Compressed Workweek

The compressed workweek (CWW) refers to a schedule in which employees work approximately 40 hours in fewer than 5 days. A variety of schedules, with a variety of rationales, can be said to constitute a CWW. Typically, work is performed 10 or 12 hours per day, 3 or 4 days per week, and 3 or 4 days per week are free. Other possibilities include a long break schedule; for example a schedule of 12-hour shifts may employ a sequence of 4 days on duty, 7 days off duty, 4 days on, 3 days off, 3 days on, 1 day off, 3 days on, and 3 days off. As with all types of shift work, national data on the prevalence of specific CWW schedules are not available,

The CWW with 12-hour shifts appears to be common in the chemical industry (including petrochemical), the petroleum industry, offshore oil rigs, and ministeel industries. Other types of employment that could adopt the CWW include the paper industry, other manufacturing processes, utility industries (including nuclear powerplants), nursing and other health fields, clerical work, administrative work, technical maintenance, and computer operations.

Information derived from management and employee comments, limited psychological testing, and performance and safety records has highlighted some of the advantages and disadvantages of the CWW. In general, the CWW appears to increase worker satisfaction because it allows more days and weekends off. For example, in one plant, conversion to a CWW schedule with 12-hour shifts reduced the number of days on the job each year from 273 to 182. Also, when the CWW has 12-hour rotating shifts, fewer consecutive days are spent on the night shift and there is more time to recuperate than with 8-hour shifts 5 days a week. This may lessen the fatigue associated with rotating shifts and night work. While more days off may improve employee satisfaction, concerns about increased moonlighting have been voiced and have been documented in one case. In general, however, studies have failed to document an increase in moonlighting.

Data have suggested that not all employees endorse the CWW. Family responsibilities and previous work experience appear to influence preference for the CWW. One study estimated that 28 percent of work sites adopting a CWW will revert to the standard 8-hour day, 5-day week schedule, A few studies have indicated that women, especially those with young children, and older employees may be less satisfied with a CWW.

The use of the CWW, especially with two 12-hour shifts replacing three 8-hour shifts, may be more cost-effective for employers, since the number of shift changes is decreased (shift changes are the least productive time in an operation), Absenteeism also appears to be diminished when the CWW is adopted. Replacement of absent employees, however, may be more difficult with this schedule, since one common way of replacing an absent employee is holding over another from a previous shift, which is ill-advised for shifts of 12 hours.

Concerns over performance and safety have been voiced in relation to the CWW, although few studies have analyzed this issue. It has been suggested that fewer errors and accidents occur and productivity improves on CWW schedules. Other studies suggest that a 12-hour day, 4-day week produces more fatigue and poorer sleep and psychomotor performance than an 8-hour day, 5-day week.

Administrative problems may arise from the use of the 12-hour shift and the CWW. Since laws and regulations regarding hours of work are generally based on the 8-hour day and 40-hour workweek, computation of hourly wage and vacation time must be adjusted. Similarly, since exposure limits to noise, chemicals, and heat are generally based on the 8-hour day, they may need to be recalculated.

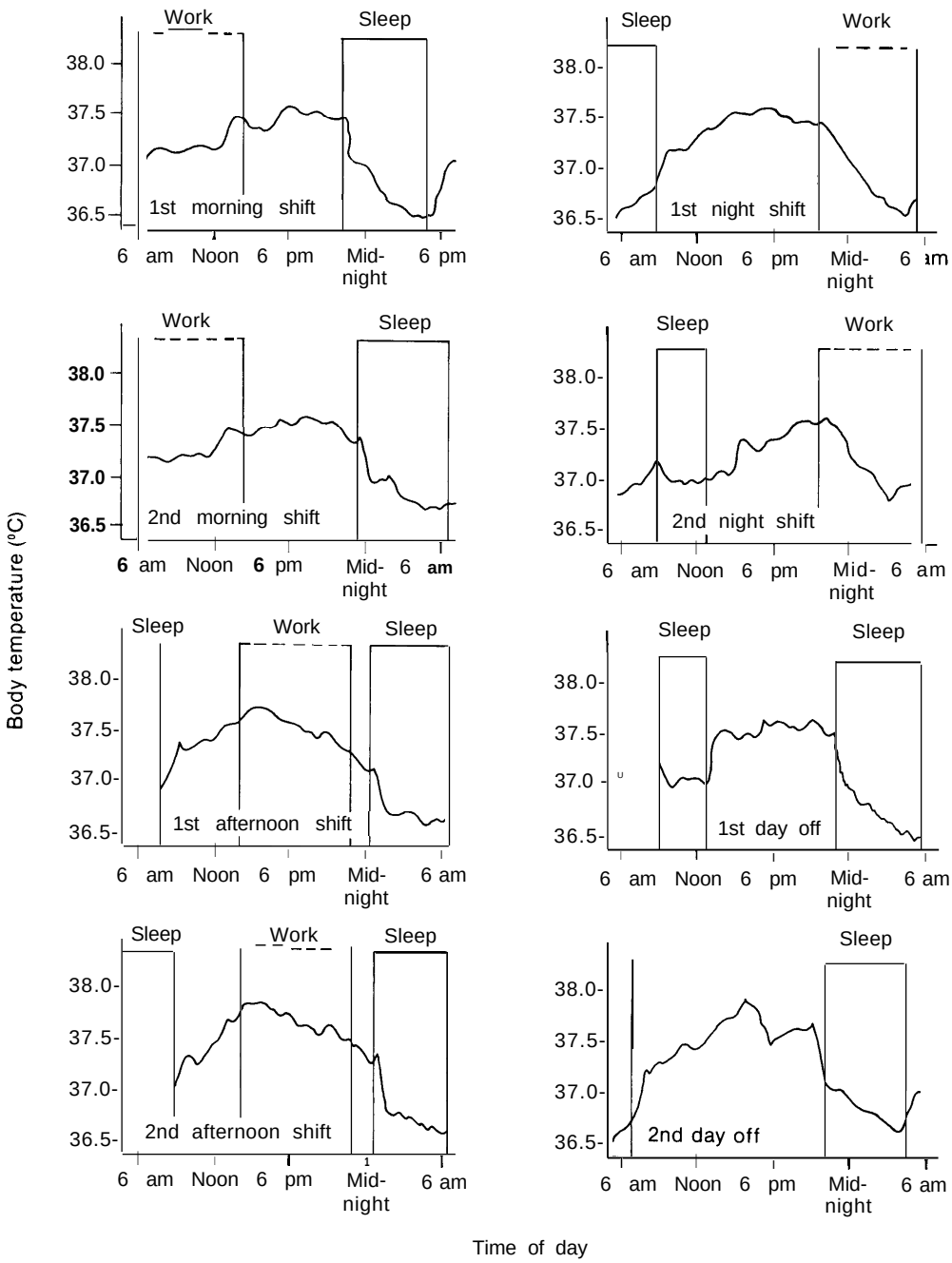
SOURCE: Office of Technology Assessment 1991.

(day, evening, night) or backward (day, night, evening). Other types of scheduling, such as the compressed workweek (in which employees work approximately 40 hours in fewer than 5 days) and irregular scheduling (in which scheduled work shifts are variable and erratic), also exist. Compressed workweeks are used in the chemical and petroleum industries and are becoming more common in other employment sectors (box l-C); irregular schedules are used in some employment sectors, including the transportation and manufacturing industries.

BIOLOGICAL RHYTHMS AND WORK SCHEDULES

Any work schedule that requires people to work when they would normally be sleeping (and sleeping when they would normally be awake) will conflict with the workers' circadian cycles and can cause disruption in circadian rhythms. These include irregular or rotating shift schedules, which cause workers to change constantly the hours that they work, or extended duty hours, which require them to

Figure 1-6-Relationship of Body Temperature, Work, and Sleep in a Rapidly Rotating Schedule



Graphs showing average body temperature of four workers on a 2-2-2 rotating shift system. On the night shift, the low point of body temperature coincides with the work period.

SOURCE: S. Folkard, D.S. Minors, and J.M. Waterhouse, "Chronobiology and Shift Work: Current Issues and Trends," *Chronobiologia* **12:31-54, *1985.***

work for extended periods of time. In these situations, the physiological changes caused by circadian rhythm disruption often interact with other stressors associated with work schedules (i.e., fatigue, sleep deprivation, and social or domestic stress) to compound the effects on the health, performance, and safety of the worker.

Effects of Work Schedules

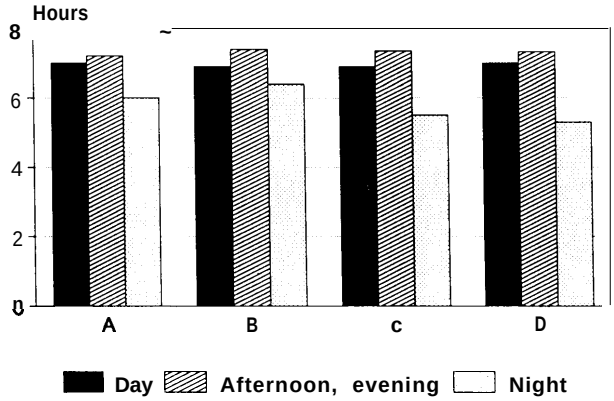
Human beings are naturally diurnal creatures, whose internal clocks are geared toward active wakefulness during the day and sleep at night. Most of society reflects this pattern. Normal work hours end in the late afternoon, and social activities, as well as the evening meal, usually a time for family conversation, follow. The shift worker, who goes to work or tries to sleep at that time, misses these activities. Shift workers end up fighting the diurnal trends and social attitudes that surround them. This creates three sources of stress:

. disruption of circadian rhythms;
. sleep disruption and fatigue; and
. social and domestic disturbances.

How much stress is placed on the worker by each of these sources varies, depending on the nature of the work situation and the schedule employed. The impact of these stressors and their resultant consequences may, in some individuals and some situations, lead to difficulties in coping with a work schedule. Indeed, some experts assert that shift workers never adjust to the stress associated with this work. However, there is great variability among people in their ability to adjust to shift work, with some individuals suffering few, if any, problems, and others finding certain work schedules intolerable. As a result, for some people shift work is an inconvenience, while for others it can have major adverse consequences. It should be borne in mind, however, that even those individuals who appear to adjust well to shift work may experience negative effects on factors such as performance or safety.

Work schedules can require an individual to be awake and active at an inappropriate time during the circadian cycle and can result in a state in which an individual's circadian rhythms are out of synchrony (figure 1-6). An inappropriately phased circadian system is in a state of disharmony akin to that of a symphony orchestra without a conductor. That disharmony can result in feelings of malaise and

Figure 1-7--Length of Sleep of Permanent and Rotating Shift Workers



Average sleep lengths on different shifts for two samples of permanent (A,B) and rotating (C,D) shift workers. Rotating shift workers on the night shift had the shortest average sleep lengths.

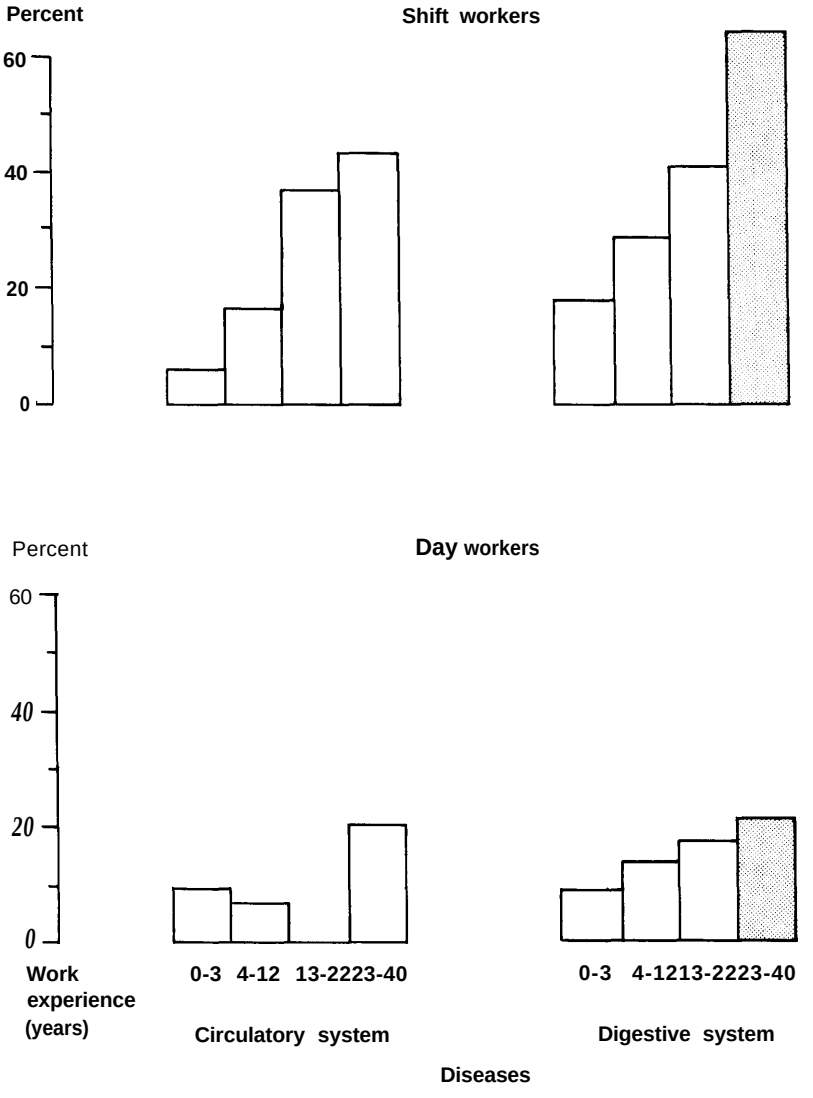
SOURCE: M. Colligan and D. Tepas, "The Stress of Hours of Work," ***American Industrial Hygiene Association Journal 47 S66%95, 1966.***

fatigue, disrupted sleep, and attempts to perform certain tasks at a less than optimal time in the circadian cycle. The degree to which individuals are affected by circadian disruption varies, with some people being better able to tolerate circadian desynchronization than others.

Another prominent effect of work schedules, especially those that require night work, is sleepiness and fatigue (figure 1-7). One of the most common complaints among shift workers is the inability to sleep as long as necessary during the day, because of both internal factors, such as a desynchronized circadian system, and external factors, such as daylight, a noisy environment, and family and social demands. The net effect of these disruptions of sleep is often a state of chronic fatigue and sleepiness referred to as sleep debt. There is some variability among individuals in their ability to sleep, and persons who find it easier to sleep at odd times may adjust more readily to sleep disruptions caused by work schedules.

Finally, work schedules may induce stress by preventing workers from fulfilling family responsibilities and putting them out of synchrony with the rest of society. Social companionship, parenting, and sexual partner roles can all be compromised by work schedules, and carrying their domestic work-

Figure 1-8-Prevalence of Disease in Shift Workers and Day Workers



Percent of shift workers and day workers at an oil refinery, subdivided into groups according to work experience, suffering from circulatory and digestive diseases. Shaded bar indicates that there was a statistically significant difference between the shift workers and day workers.

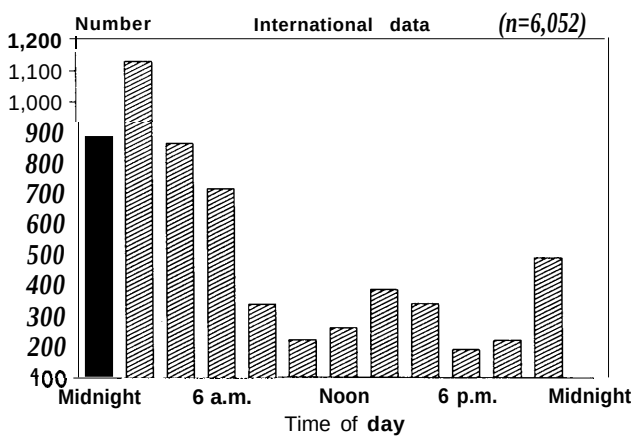
SOURCE: Adapted from M. Keller, "Health Risks Related to Shift Work: An Example of Time Contingent Effects of Long-Term Stress," *International Archives of Occupational and* Environmental Health 53:59-75, 1983.

load is a major source of difficulty for women workers. Shift workers commonly feel alienated from the community because they are unable to attend evening or weekend educational, sports, religious, or recreational events and are unable to take advantage of community benefits.

These stressors can have a variety of consequences, including decreased well-being, chronic malaise, and poor sleep; increased gastrointestinal distress; and, perhaps, increased risk of cardiovascular disease and negative reproductive outcomes such as babies with low birth weight and preterm births (figure 1-8). While there has not been extensive research in the area, there is some evidence that decrements in performance occur as a result of nonstandard hours and that a number of factors besides circadian desynchronization contribute to them, notably sleep deprivation and fatigue. Information about how shift-work-induced performance decrements could affect productivity has not been collected.

The implications of shift work for safety have not been examined thoroughly. Work schedules may affect not only the worker's safety, but the public's safety as well. Existing studies show that time-of-day effects and sleep loss and fatigue can contribute to transportation mishaps (figure 1-9), but the amount of information regarding their effects on rates of injury and mishap in other work settings is too sparse for any conclusions to be drawn. Additional data on the frequency, nature, and magnitude of such incidents are needed before measures to prevent them can be designed.

Figure 1-9-Fatigue-Related Vehicular Accidents



The distribution, by time of day, of 6,052 vehicular accidents that were judged by investigators to be fatigue-related.

SOURCE: M.M. Mittler, M.A. Carskadon, C.A. Czeisler, et al., "Catastrophes, Sleep, and Public Policy: Consensus Report," *Sleep* 11 :100-109, 1988.

Interventions

A number of interventions to counteract the circadian desynchronization, sleep disturbances, and social disruption associated with shift work are being examined, but additional research is needed to understand the mechanisms at work in specific situations and to determine the effectiveness of these interventions.

While the most direct intervention is to devise less disruptive schedules, determiningg what is the best schedule is difficult. For example, the least disruptive schedule from a circadian perspective may not be optimal in terms of sleep and fatigue, or a schedule that tries to avoid sleep loss effects may create hardships for the worker in the social and domestic arenas. The "best" schedule varies from setting to setting, and the nature of a given job may dictate what is optimal. From a strictly circadian perspective, fixed shifts and shifts that rotate in a clockwise direction (mornings, evenings, nights) are probably the least disruptive; however, permanent night workers often suffer from chronic sleep disturbances, and the placement of shifts in a clockwise rotating schedule may provide less opportunity to prepare for and recover from the night shift. Expert opinion is divided as to whether a fast (1 to 3 days) or slow rotation (2 weeks or longer) is best, and it may be that consideration of the type of task to be performed (e.g., a simple repetitive task vs. one requiring memory) would be helpful to determine speed of rotation. One of the most popular rotation frequencies is 1 week. It is also one of the most problematic. One week is long enough to incur sleep deprivation but not long enough to allow for complete circadian readjustment, so the avoidance of weekly rotating schedules maybe preferable from a circadian perspective. Furthermore, extended duty schedules that result in sleep loss and fatigue should be avoided.

Some interventions are designed to facilitate the process of adjustment to shift work. There is some evidence that bright light can help the circadian system adjust to work schedules, and medications that directly affect the circadian system or counteract the effects of fatigue and sleep problems are also being investigated. No drugs have yet been conclusively shown to have a direct effect on circadian rhythms. While certain compounds are helpful in inducing sleep (i.e., short-acting hypnotics, tryptophan, antihistamines) or maintaining alertness (i.e., amphetamines, caffeine), all have characteristics that prohibit regular use. The use of sleep and napping strategies to optimize a worker's ability to obtain adequate sleep is another area of investigation. Napping before a period of extended work is helpful in improving performance during the work period and can help workers on rotating shifts to supplement their sleep periods.

Other possible interventions include monitoring systems to detect when individuals may pose a risk to themselves or others because their performance is impaired. These can take the form of specific tests administered to workers on the job to determine if their performance on a task is suboptimal and systems that provide real-time, on-the-job feedback

to the worker. Finally, educational programs that provide workers with information and strategies to deal with the problems they may face and ease some of the consequences of shift work are an important area of intervention research.

Research Needs

All conclusions and inferences about the effects of shift work are based on limited data. In the first place, the effects of work schedules are complex and often difficult to study. In the second place, OTA finds that studies of shift work have received little support in this country. Three basic types of studies have been used to examine the effects of shift work: field studies, in which subjects are studied in their actual work environment; survey studies, in which workers answer interview questions; and laboratory studies, in which the work situation is simulated in a controlled setting. There is a pressing need for research into how to apply basic knowledge about circadian rhythms and other factors in shift work to studies of the workplace. Research is needed to explain the various effects of work schedules, the variables that contribute to difficulties in adjusting to shift work, and interventions that could be used to counteract them. In addition, there is a compelling need for more studies of the interaction between work schedules and safety in the workplace. Crucial to this endeavor is more thorough collection of workplace data regarding hours of work and the occurrence of on-the-job accidents. The major mechanism for collection of data related to workplace injuries and mishaps in the United States is the BLS. Currently, the data being gathered by the BLS provide no information that could help in assessing the impact of shift work on employee safety and health.

LEGAL AND REGULATORY ISSUES

Current Regulation

Some Federal regulations on work hours are included in statutes and can be modified only by legislative action. In other instances, legislation delegates regulatory responsibility to an administrative agency which then promulgates requirements. Many existing regulations came about as a result of concern for public safety, notably within the transportation industry. In every case, existing regulations are concerned with total work hours in a freed period of time, without specifically addressing shift changes or regulation of proportion of day and night work. There is also a substantial body of State regulation in the area of employee hours and conditions of work, some of which relates directly or indirectly to work scheduling.

The Hours of Service Act, which regulates work hours within the railroad industry, is an example of a statute that imposed specific requirements. First enacted in 1907, and enforced by the Federal Railroad Administration, it limits work hours for railroad employees and provides for penalties for violators. The Fair Labor Standards Act of 1938, which mandates a minimum wage for employees and requires that employers pay an overtime premium for time worked in excess of 40 hours a week, may influence work schedules indirectly. It also limits the hours that may be worked by children under 16.

The remainder of the current Federal regulation of work hours takes the form of requirements imposed by individual agencies, mostly within the Department of Transportation. Hours of service regulations are imposed by the Federal Highway Administration on truck and bus drivers, by the Federal Aviation Administration on airline crews and dispatchers, and by the Coast Guard on maritime crews. All of these regulations specify maximum permissible hours of service, and each contains details related to such issues as minimum rest periods, methods for recording hours of service, and penalties for violations. The Nuclear Regulatory Commission (NRC) has issued a policy statement concerning maximum work hours for licensed nuclear powerplant personnel. However, NRC policy statements are only enforceable if a plant voluntarily incorporates them into its technical specifications as part of the NRC licensing procedure.

Areas of Potential Regulatory Action

Action related to work hours could take two forms: the enactment of new (or amended) legislation covering work schedules or the promulgation of new regulations under existing statutory authority. With respect to the enactment of new Federal legislation, there is no serious question regarding the power and authority of Congress to take legislative action to regulate work hours. State legislatures also have authority to regulate economic matters, within

the boundaries of both Federal and State constitutional limits.

The most likely source of authority to regulate work schedules would be safety and health statutes. Some of these deal specifically with occupational safety and health, notably the Occupational Safety and Health Act, which is implemented by OSHA. With a few exceptions, the act covers all private employees, and employers are obligated to comply both with the occupational safety and health standards issued by OSHA and with the general duty clause of the act. The general duty clause requires that an employer provide employees with a workplace "free from recognized hazards likely to cause death or serious physical harm. " If OSHA were to determine that certain hours of work pose a safety or health hazard to employees, it could issue a specific standard, in accordance with the statutory procedures, or regulate it under the general duty clause. Standards and the general duty clause are enforced through workplace inspections, citations, and penalties. However, standards define employer obligations, while under the general duty clause, the employer's obligation is established on a case-by-case basis. Thus, regulation under the general duty clause would likely lead to less effective compliance and would be more burdensome for the agency. The Federal Mine Safety Act of 1977 empowers the Mine Safety and Health Administration to issue ''mandatory health and safety standards for the protection of life and the prevention of injury in coal and other mines. It could regulate hours of work in mines in a reamer analogous to that of OSHA in other industries.

Department of Transportation agencies have the statutory authority to regulate work hours (existing hours of service regulations), as do some other Federal agencies. The Railroad Safety Act of 1970 is designed to protect railroad employees, passengers, and members of the public who may be affected by railroad operations. Under the Energy Reorganization and Development Act the NRC has authority to issue regulations governing nuclear materials in order to protect health or to minimize danger to life or property. This could provide sufficient authority for the agency to regulate work schedules of covered employees.

The Labor-Management Relations Act regulates hours of work indirectly, by giving employees the right to bargain collectively and to enter into collective bargaining agreements. Under the act, the employer and the union must bargain in good faith; failure to do so is an unfair labor practice. The parties are obligated to bargain only in certain areas, including hours of employment.

CONCLUSIONS

There have been significant advances in the description and understanding of biological rhythms during the last decade. Basic research has delineated many physiological and cognitive functions that fluctuate in cycles, with circadian rhythms being the most thoroughly characterized. Further research is needed, however, into the mechanisms controlling biological rhythms, the role they may play in conditions such as aging and mental disorders, the implications of biological rhythms for clinical pharmacology and medicine, and the testing of interventions to manipulate them.

There have not been equivalent advances in the application of biological rhythm research to the workplace. Available data indicate that the biological rhythm disruption associated with nonstandard work schedules can, in conjunction with other factors, adversely affect the health and safety of workers. But there are significant gaps in the base of knowledge related to the precise nature of the effects that occur, the factors that influence individuals' susceptibility to them, and the prevalence and magnitude of such effects. Additional research and collection of statistical data on the workplace are needed in these areas.

Shift work is necessary in a modern, technological society. An understanding of its effects on workers is essential in designing work schedules with the least negative impact on the worker and society, in developing interventions to alleviate the problems workers encounter, and in directing the guidance and regulation of work hours and work schedules.

CASE STUDIES

To highlight the variety of settings in which shift work can be found, OTA has selected three case studies for closer examination. Each represents an area of employment in which nonstandard work hours may affect the public welfare as well as the individual worker.

Nuclear Powerplant Control Room Operators

Control room operators continuously monitor all indicators in the control room of a nuclear utility and oversee the operations of all of its components. These monitoring tasks require low-level sustained vigilance, which could be degraded by the effects of nonstandard work hours. Typically, powerplant control room operators work either an 8- or 12-hour per day rotating shift schedule.

The NRC licenses all nuclear powerplants and has authority over them. It has issued policy statements providing guidance on total working hours and maximum consecutive hours of work for nuclear powerplant operators. Although NRC policy statements are not enforceable per se, if a plant chooses to incorporate them into its technical specifications or administrative procedures, it must then follow those policies. To date, 77 of the 111 nuclear powerplants licensed by the NRC have incorporated the policy statements regarding work hours into their technical specifications. The NRC provides no guidance or policy regarding the specific design of work schedules. A panel convened under contract to the NRC has made recommendations, but no action has been taken on them to date, and they remain under consideration by the NRC.

Although the primary responsibility for monitoring employees on the job rests with the management of the utility that operates the powerplant, the NRC maintains resident inspectors at all plants as a means of monitoring compliance with regulations. If an inspector observes that individuals are not performing their duties adequately, he or she notifies the appropriate supervisor. Beyond the supervision provided by the utility management and the observational oversight of the NRC resident inspectors, the NRC has set forth no specific guidelines or regulations for monitoring control room operators for performance deficiencies related to sleepiness, fatigue, or disrupted biological rhythms. The Commission has instituted regulations regarding fitness for duty which are intended to ensure that all operators and plant personnel are reliable, trustworthy, and not under the influence of any substance (legal or illegal), or mentally or physically impaired from any cause, that would affect their ability to safely and competently perform their duties. Currently, this program is designed only to detect individuals using legal or illegal substances. If deemed necessary or desirable, it could be modified to include monitoring for decrements in performance caused by sleepiness, fatigue, or circadian desynchronization.

Registered Nurses and Resident Physicians

Registered Nurses

Registered nursing, the largest health care profession, is a predominantly woman's profession. The preponderance of women in nursing makes it difficult to generalize from studies of shift work in industries that employ primarily men. Shift work is a common part of nurses' lives, but there are no national data about the prevalence of shift work in nursing; few studies of the short- or long-term consequences of shift work for nurses' family and social life, health, and work performance; and few studies of the impact of different shift schedules on the quality of patient care. The information that is available indicates that a sizable proportion of registered nurses work some nondaytime hours and that shift work and the perceived lack of control over scheduling are important factors in nurses' job dissatisfaction and job turnover. Nurses typically work five 8-hour shifts per week on either a fixed or rotating basis, although other schedules are sometimes used. Higher hourly wages for evening and night shifts are common.

A study of nurses found that rotating shift work was associated with more digestive problems, more tension and stress, higher rates of injury, and disruptions in family and social life. As with shift workers in general, sleep disturbances are common among nurses working nondaytime hours. Some studies have found that nurses on rotating shifts take more sick days and rate themselves lower on job performance. Very little research has been conducted on the relationship between shift work and quality of patient care by nurses. What research has been conducted suggests two means by which shift patterns might affect quality of nursing care. First, patterns that are more compatible with circadian rhythms could result in less fatigue and increased alertness on the job. Second, shift work patterns that are more satisfying to nurses could result in greater nurse retention, unit cohesiveness, and continuity of care across shifts.

More research is needed on various shift work issues related to nursing, including the impact of changes in the health care system on workload, shift work, job stress, and related issues. Hospital nurses today must cope with decreased length of patient

stay and increased severity of disease as a result of prospective reimbursement of hospitals. These factors may exacerbate work stress and health problems in general, independent of shift work, or they may interact with shift work to produce extremely high stress levels among those nurses working undesirable shifts and confronting patients who require more intensive nursing care.

Resident Physicians

Medical resident training has a long-standing tradition of extended duty hours, often including on-call periods of 24 hours or more. The major rationale for these schedules has been to provide continuity of care by observing and treating the patient over an extended period. Traditionally, the possible negative consequences of these schedules, such as fatigue and sleepiness, which could have a detrimental impact on resident performance and quality of life, have received minimal attention. Recently, however, consideration of these consequences has increased, partially as a result of an incident in 1984 in which a young woman died while being treated at a hospital in New York. An investigation found that of the five factors contributing to her death, one was that the resident who treated her had been on duty for an extended period of time (the other four were related to the level of supervision of the residents and other treatment-related issues). In response to this incident, the State of New York enacted regulations that limit the hours of work of hospital house staff. Implementation of these regulations has had a high financial cost, increasing New York State's health department budget by 3 percent.

Length of resident hours has traditionally been the concern of the Accreditation Council for Graduate Medical Education (ACGME). Within the past few years, ACGME has moved to revise its requirements for working hours and supervision of residents by having its Residency Review Committees (RRCs), which oversee the various medical-surgical specialties, introduce new standards. The responses of the RRCs ranged from specific (emergency medicine: no more than 60 hours per week with 12-hour shifts), to general (thoracic surgery: responsibility of program director to ensure reasonable in-house duty hours), to no response (general surgery and psychiatry). These revisions were made during 1988-89 and took effect in the summer of 1989.

Information regarding the effects of extended duty hours on residents and their patients is meager. While anecdotal evidence supports the idea that sleep deprivation associated with resident on-call schedules can affect patient care, the studies that have been conducted are equivocal. It is reported that extended duty hours prolong the time it takes to perform tasks but have no effect on the quality of performance. There is even less information available on the contribution long hours can make to health and family interactions.

The debate over the necessity for extended duty hours for medical residents remains unresolved. Until more information is gathered, a determination of what will best serve the needs of the doctors and the patients they care for cannot be made.

The Military

Many military situations demand that personnel engage in duty schedules that can lead to circadian rhythm disruption, sleep loss, and other stressors. The operational situation surrounding an activity determines the tempo at which tasks are to be performed and the nature of the stressors associated with job performance. A task performed during routine operations or in training, for example, is very different when performed under actual or simulated combat conditions. Usually, activities that occur in conjunction with combat or training for combat are marked by an increased tempo and sustained hours of duty. Since sustained operations requiring prolonged performance are integral to modern military operations, some of the most salient problems encountered are sleepiness and fatigue. Military tasks that could be affected include vigilance tasks, which require concentrated attention and alertness (e.g., electronic tracking and surveillance, sentries); operation and control of vehicles (e.g., aircraft, mobile weapons systems, boats); maintenance, preparation, and operation of equipment (e.g., weapons systems, communication systems); and command and control activities.

Few specific military regulations or guidelines relate to hours of service and scheduling, although all services do regulate flight operations. These regulations specify maximum allowable hours of flight duty and may include stipulations regarding transmeridian flight, minimum necessary rest periods, and the scheduling of flight operations. The Navy has specific guidelines, which have been used

for centuries, for the scheduling of watches on board ships. They require that personnel standing watch constantly vary their hours of activity and sleep, which results in a constant state of circadian desynchronization. Beyond these regulations and guidelines, decisions regarding hours of duty and work schedules for military personnel are generally left up to commanding officers, who base their decisions on their knowledge of mission requirements and on the condition and limitations of their personnel.

POLICY ISSUES AND OPTIONS FOR CONGRESSIONAL ACTION

OTA has found that the significant progress made in recent years in the understanding of biological rhythms has not been matched by comparable advances in the understanding of biological rhythm disruption and its interaction with other factors in shift work. The limited information from research aimed at applying basic information about biological rhythms to work settings indicates that problems can arise as a result of nonstandard work schedules and that these problems affect the health, well-being, and safety of workers, and in some instances the public's safety. However, further clarification and definition are needed to determine the precise nature, prevalence, and magnitude of such problems. It is clear that for some workers nonstandard work hours impose a hardship that needs to be recognized and addressed. Three policy issues related to biological rhythms and work schedules were identified in the course of this assessment:

- the level of the Federal research effort in this area;
- the adequacy of Federal mechanisms for collecting workplace safety data related to hours of work; and
- the role of Congress in ensuring the well-being of men and women who work nonstandard hours.

Associated with each policy issue are several options for congressional action. Some of the options involve direct action. Others involve congressional oversight or direction of the executive branch. The order in which the options are presented does not imply any priority. Moreover, the options are not, for the most part, mutually exclusive; adopting one does not necessarily disqualify others within the same category or in any other category. Implementation of a combination of options might produce the most desirable effects. It is also important to keep in mind that changes in one area may have repercussions in other areas.

Issue 1: Is the current Federal research effort on the effects of work schedules and the mechanisms for collecting information on work schedules adequate?

Various Federal departments and agencies direct and fund intramural and extramural research programs about biological rhythms and the effects of work hours. Some programs are dedicated to basic research related to biological rhythms, while others are concerned with workplace issues. Many, especially those devoted to applied research in the workplace, are limited in scope and are minimally funded. Often, these programs focus on settings directly related to the funding agency (e.g., the Federal Railroad Administration conducts research on railroad operations, the Department of Defense studies military operations, etc.). Although the information derived from such studies may be applicable to other situations, few programs are devoted to studying general issues related to work schedules. The National Institute of Occupational Safety and Health (NIOSH) in the Department of Health and Human Services is an appropriate agency to fund and conduct such research, but only a small component of its research effort is devoted to this area. Moreover, NIOSH itself is a relatively small agency, and it may be unable to expand research in any area without an overall increase in size.

The Bureau of Labor Statistics (BLS) is responsible for the collection of workplace data. Its collection of data on the demographics, prevalence, and use of shift work is sporadic and inconsistent. The last collection of any such data was in 1985, with another scheduled for 1991.

Option I: Take no action.

If Congress takes no action, the Federal research effort on the effects of work hours will continue at its current pace and extent. Information from basic research on biological rhythms and other pertinent factors will continue to be gathered, while research applying that knowledge to studies in the workplace will remain limited. Statistical data that would facilitate and augment this research will continue to be gathered in a nonsystematic fashion. Taking no

action will forestall the gathering of information about the precise effects of various work schedules on workers-information that is needed to better understand what effects occur, to develop interventions that will help workers cope with these schedules and to steer guidance and regulation related to the design of work schedules.

Option 2: Create a Federal interagency task force to guide research efforts.

Congress could direct the establishment of an interagency coordinating group to ensure maximum use of U.S. research resources. Given the cross-agency nature of issues related to hours of work, the Committee for Health and Life Sciences of the Federal Coordinating Council for Science, Engineering, and Technology under the auspices of the Office of Science and Technology Policy is an appropriate body to assume this role. The Committee could coordinate research efforts across Federal agencies and set priorities for research. This would expedite the transfer of information from basic research to applied settings. The Committee could also set priorities for the collection of statistical data on the workplace by pertinent Federal agencies, which would facilitate research.

Option 3: Convene a national commission of nongovernmental experts on biological rhythms, work schedules, and their effects.

Congress could direct that a national commission of nongovernmental experts be established to provide guidelines for research priorities and directions. Since the guidance provided by such a commission would affect several Federal agencies and departments, the commission could be directed to submit its findings to the Federal Coordinating Council for Science, Engineering, and Technology within the Office of Science and Technology Policy to ensure the widest possible dissemination of its recommendations. The findings and recommendations of this commission could be used to coordinate and direct research efforts in this area.

Option 4: Direct the Bureau of Labor Statistics to expand the scope of its collection of data related to work schedules and hours worked.

Congress could direct the BLS to increase the consistency and scope of its collection of data related to hours of work. This could include information regarding the types of schedules being used in various industries and occupations and the demographics of the populations involved. Such data could be collected at regular intervals to ensure an up-to-date database. Before initiating this effort, representatives from the BLS could meet with representatives from the Occupational Safety and Health Administration (OSHA) (in the Department of Labor), NIOSH, and other pertinent agencies to determine what information is needed and the best format for its collection. These data would provide a clearer picture of the nature and extent of work schedules being used in the United States and the people who work them. If Congress takes this action, it will ensure the availability of pertinent information regarding the use of work schedules.

Option 5: Expand intramural and extramural research programs at the appropriate agencies and departments.

Congress could increase Federal research on the impact of work schedules on workers. This could include directing the pertinent Federal agencies to expand existing research programs and to develop new programs, as well as increasing appropriations of funds to support these efforts. Programs examining general issues related to hours of work could be carried out by agencies within the Department of Health and Human Services, notably NIOSH, and the Department of Labor, while industry-specific studies could be conducted by appropriate agencies, such as the agencies of the Department of Transportation and the Department of Defense.

OTA concludes that available information fails to answer questions about possible impacts of shift work on health and safety and provides very little information about possible interventions to alleviate any effects. While those answers and that information can be obtained, to do so in a timely reamer will require increases in research support.

Issue 2: Are current Federal mechanisms for the collection of workplace safety statistics adequate?

BLS is the collector of workplace data related to injuries and mishaps. Currently, BLS forms for reportable injuries and illnesses include no questions regarding time of day, hours of work, or work schedules associated with an incident. OSHA may record information on time of day and hours of work

in its investigations of workplace fatalities and catastrophic incidents in which five or more people are injured or substantial damage to property occurs. The National Transportation Safety Board routinely collects information regarding the role that hours of work might play in mishaps. Other Federal agencies and departments may examine the role of work hours when investigating incidents that occur within their domains. This information is used to help determine the cause of an event and is available to investigators who want to examine possible contributing factors in various types of work-related incidents.

Option 1: Take no action.

Workplace safety statistics will continue to be collected in the current fashion if Congress chooses to take no action. The data currently being collected by the BLS provide no information that could facilitate the assessment of the impact of work hours on employee and public safety, and the data collected by other agencies mayor may not do so. Lack of this information makes it difficult to determine the frequency and severity of effects various work schedules can have on employee---and public—safety in different settings and occupations.

Option 2: Direct that the Bureau of Labor Statistics increase its collection of workplace data.

Congress could direct the BLS to gather information on work schedules and hours of work in its collection of data related to occupational injuries and illnesses. Since including this information on the BLS log sheets would increase the amount and complexity of information an employer would have to provide following a workplace incident, the BLS could first assess the feasibility and best method of obtaining such data. This information could include the time of day an incident occurred, the schedule being worked by the individual involved, and how many hours the person had worked previously. The resulting database could be analyzed to clarify the relationship between hours of work and workplace accidents and illnesses. In addition, the BLS could conduct targeted studies through its work injury report activity to describe relationships between work schedules and injuries.

Option 3: Direct the Occupational Safety and Health Administration and other agencies that collect workplace safety information to record information on hours of work related to safety incidents.

Congress could direct Federal agencies and departments that are involved in investigating safety-related incidents to routinely collect information related to work schedules and hours of work. This action would guarantee the availability of information that would make it possible to assess the contribution of work hours to the occurrence of accidents in various work settings and occupations.

Issue 3: Should Congress take steps to ensure the well-being of workers engaged in nonstandard hours of work?

Shift workers are exposed to a variety of circumstances and conditions not associated with standard daytime schedules. While much information is still needed, it is clear that nonstandard work hours can have a variety of effects on some workers. Gastrointestinal complaints, difficulty sleeping, and disruptions in family and social life are common and may affect the performance, well-being, and safety of the worker—and, by extension, the public. While there are some actions that can be taken to assist workers in coping with some of these conditions and to lessen their impact, there is currently little awareness of them, either in government or in private institutions. While concerns raised by nonstandard hours of work do receive some Federal attention within specific domains, the extent of activity in this area is narrow and inconsistent.

Option 1: Take no action.

If no action is taken, the recognition and awareness by government and private institutions of the impact of nonstandard work schedules will remain at its current level. Most shift workers will have little, if any, information to help them adjust to their work schedules and few resources to assist them with problems they may encounter. Furthermore, employers may not be aware of interventions to reduce the impact of the problems posed by shift work. Recognition by Federal agencies of the effects nonstandard work hours can cause and the importance these agencies place on monitoring and responding to them will continue to be low.

Option 2: Encourage the development of educational programs and support services for workers.

Congress could direct the Public Health Service, in the Department of Health and Human Services, and other Federal agencies to develop programs to educate shift workers about the demands and stressors they may encounter as a result of their work schedules. Congress could also provide incentives to private industry to do likewise. These programs could tell workers and their families about actions, such as sleep and dietary strategies, they can take to lessen some of the negative effects that may occur. Congress could also encourage the development of support services in the workplace, such as counseling and guidance programs, that would be available for workers encountering difficulties associated with their work schedules.

Option 3: Direct the Occupational Safety and Health Administration to determine whether the issuing of standards related to hours of work and scheduling is warranted.

Under the Occupational Safety and Health Act, OSHA may issue standards related to safety or health risks that exist in the workplace. OSHA issues standards once it determines there is sufficient evidence that a hazard exists. Congress could direct OSHA to evaluate the latest research on work hours to determine if there is sufficient information regarding health and safety impacts to guide the development of standards related to shift work. Available information regarding the effects work schedules can have on the health and performance of workers, their prevalence, and how they impinge on safety would have to be considered. This evaluation could involve Federal, State, and industry officials, researchers, and representatives of labor organizations. In addition, Congress could direct OSHA to keep up-to-date on progress in this field and to take any action that might be warranted by new developments and findings.

Option 4: Direct Federal agencies with authority over health and safety to review current regulations and determine whether they adequately address concerns raised by nonstandard work hours.

A number of Federal agencies have the authority to regulate health and safety requirements within their jurisdiction. Many of these agencies currently have hours of service requirements regulating certain aspects of work schedules. Congress could direct these agencies to review their current regulations to ensure that they are consistent with, and incorporate the results of, the latest research on shift work and its effects on health and safety. This would also require pertinent agencies to increase their surveillance and collection of data regarding the impact of shift work on worker health and safety in their domains.

Option 5: Encourage labor and management to include provisions regarding the safety and needs of shift workers in collective bargaining agreements.

As part of the good-faith bargaining conducted under the Labor-Management Relations Act, agreements regarding scheduling and hours of work are often struck between labor and management. Congress could encourage labor and management representatives to include in their deliberations safety and health concerns that some work schedules raise and the special requirements and needs of workers exposed to nonstandard hours. While neither labor nor management is under any obligation to respond to congressional interests, taking this action would indicate Congress' concern about the matter.

*Option 6: Direct that measures be taken to further ensure individual and public safety in **settings** where nonstandard work hours are in effect.*

Nonstandard work hours are often associated with safety concerns. Congress could direct the Department of Labor and other agencies to increase efforts to ensure that threats to worker and public safety are being adequately addressed. This could include increased surveillance of compliance with existing regulations regarding hours of work and investigation into the development of devices and interventions that can lessen hazards.