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Extended workshifts and excessive fatigue

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SUMMARY Studies of overtime have pointed to fatigue as a potential factor producing, for example, a three-fold increase in accident rate after 16 h of work, increases in back injuries, hospital outbreaks of bacterial infection, or nuclear-power plant safety compromises. Fatigue has been measured more directly in studies of scheduled long workshifts, where performance decrements in both work-related tasks and laboratory-type behavioural tests have been observed, and significant loss of sleep and increases in subjective sleepiness have been reported. Analyses of accidents or injuries during scheduled extended workshifts, however, have produced equivocal results. Factors which could compound the fatiguing effects of extended workshifts, such as workload, noise, chemical exposure, or duties and responsibilities outside of the workplace, rarely have been studied systematically. It is concluded that extended workshift schedules should be instituted cautiously and evaluated carefully, with appropriate attention given to staffing levels, workload, job rotation, environmental exposures, emergency contingencies, rest breaks, commuting time, and social or domestic responsibilities.

KEYWORDS accidents, long work hours, overtime, performance decrements, sleep loss, work scheduling.

INTRODUCTION

Socio-economic developments in industrialized countries over the past two decades have produced a trend toward increasing use of workdays or workshifts longer than the typical 8 h. Some schedules compress the workweek by completing a 36–48 h week in 3 or 4 days instead of 5. Other situations require frequent bouts of overtime work because of impending deadlines (e.g. in construction), understaffing (e.g. in nursing), or emergency contingencies (e.g. in firefighting). Other industries, such as shipping, mining, or oil drilling, formally schedule long periods of work, followed by long rest periods, because the difficulty with travel to a remote site makes frequent staff turnover impractical. The degree to which the jobs in any of these contexts can be performed safely and efficiently has been the subject of considerable debate. In Europe, such debate has intensified recently as a current directive on working time proposes, with some exceptions, a minimum daily rest period of 11 consecutive hours, and a maximum of 8 h of night work (Harrington 1994). The concern of this directive, and the debate in general, is the avoidance of excessive fatigue and the possible risks of accident and injury in the short term, or deterioration of health in the long term. The purpose of this review is to characterize the state of knowledge on long work hours and their association with fatigue, and point to some factors which might produce fatigue or deterioration of performance and alertness in the worker. Studies of extended workshifts can be divided roughly into those concerned with scheduled long workshifts, such as the 10- or 12-h shifts used in compressed workweeks, and those concerned with unscheduled or sporadic long workshifts, which collectively can be termed as overtime.

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OVERTIME

Survey and questionnaire studies have associated overtime mostly with health outcomes or with outcomes which are both health- and safety-related. Overtime has been associated least with outcomes which are primarily within the domain of safety, such as accidents or acute traumatic injuries. An exception is a recent analysis of a national occupational-injury database where a constant accident/injury rate was observed through nine consecutive hours of work, followed by a progressive increase to three times that rate at 16 h of work (Åkerstedt 1994). That report is preliminary, however, so it is not clear whether those rates

are associated with overtime vs. scheduled extended shifts, or whether the effects are concentrated in specific occupations or industries.

In the health or health/safety domain, overtime has been associated with lower self-ratings of health status (Broadbent *et al.* 1985), lower birth weight or gestational age in children of women working overtime (Marbury 1992), and increased presence of corticosteroids (in women) possibly indicative of a stress response (Härenstam and Theorell 1990; Lundberg and Palm 1989). Increased triglycerides and cholesterol (risk factors for cardiovascular disease) were observed in construction managers who frequently worked overtime (Sutherland and Davidson 1993). This group also reported higher levels of job dissatisfaction and poor psychological health. Frequent overtime work was associated with heavy and problem-drinking in men (Kawakami *et al.* 1993), higher suicide rates in both men and women (Starrin *et al.* 1990), and cardiovascular mortality in women (Starrin *et al.* 1990). In all of these studies, the possibility of a role for fatigue as one of the underlying factors producing health compromises at least should be considered, but such a possibility is highly speculative given that no attempt was made to measure fatigue.

A few reports raise the possibility of a more direct role of fatigue from working overtime. In a case-control study, overtime was identified as a risk factor for occupational low back injury in mail handlers (Daltroy *et al.* 1991), while another study reported that complaints of low back pain were more frequent in those who worked less overtime (Svensson and Andersson 1983). In the latter study, the authors suggested that workers with low back pain had limited their working hours because of their condition.

Two reports identified increased staff overtime as a factor contributing to separate outbreaks of *Stahpylococcus aureus* infection in hospitals (Arnow *et al.* 1982; Russell *et al.* 1983). In both incidents, an unanticipated combination of high patient load and understaffing resulted in extensive use of overtime to meet demands for patient care and treatment. The infectious outbreaks associated with these periods of overtime were attributed by the investigators both to time pressure from the high patient load, and to high levels of fatigue from long work hours, which resulted in inadequate compliance with aseptic practices (i.e. skipping steps or rushing through procedures). While perceived time pressure or fatigue levels were not assessed directly in these studies, the fatigue interpretations given by the authors are consistent with our laboratory study demonstrating increased errors and faster response times (a speed-accuracy tradeoff) in an externally-paced reasoning task during 12-h work days compared to rest days (Rosa and Colligan 1988).

Operator fatigue from working overtime was also suggested as a factor that is detrimental to safety performance in nuclear-power plants (Baker *et al.* 1994). In a plant-level analysis of operator, technical, and maintenance staff overtime, safety incidents were associated most strongly with operator average annual overtime, which ranged from 300 to 1200 h. These results were attributed to operator fatigue, rather than overall plant inefficiency, because no strong association was observed between safety incidents and technical staff or maintenance staff overtime.

Worksite studies taking behavioural measures of fatigue (e.g. performance tests or self-report scales) in association with overtime are rare. In a cohort study of automotive industry workers, however, recent experience with overtime was associated with poorer performance on neuropsychological tests, such as trailmaking and card sorting, which are sensitive to fatigue-related deficits in attention or cognitive function (Proctor 1992).

In summary, cross-sectional studies have associated overtime work with a handful of health and safety outcomes which may be related to fatigue. In most of these studies, it was recognized that the fatigue effects of overtime occurred in combination with other personal, occupational, or organizational factors and that, because of the cross-sectional designs, clear directions of causality could not be determined. The putative role of sleep loss, excessive fatigue, or their combination, usually was not explicit. Only one study attempted to quantify fatigue deficits using behavioural measures. No studies were identified which were able to prospectively measure safety- or health-related effects of overtime. The irregular and often unscheduled nature of overtime work, however, would make such a study difficult to conduct.

SCHEDULED EXTENDED WORKSHIFTS

Surveys of on-the-job fatigue effects of scheduled extended workshifts have considered efficiency and productivity, accidents, absenteeism, and subjective reports. Regardless of the outcome variables tested, there are no consistent trends. With respect to productivity, there were, for example, equal numbers of oil refineries reporting increases, decreases, or no change after the introduction of 12-h shifts (Campbell 1980). Nevertheless, a major US electronics manufacturer and a majority of US government sites abandoned long workshifts because of reductions in productivity (Tepas and Tepas 1981). Studies of absenteeism have also produced equivocal results (Campbell 1980), as have surveys of accidents and injuries. No change in accident frequency or severity, for example, was observed in 57 oil refineries, an increase was observed in five refineries, and a decrease was observed in eight refineries (Campbell 1980). Another study reported no increases in accidents, or in violations of occupational health and safety regulations, in a sample of 50 oil refineries (Northrup *et al.* 1979). The adequacy of the survey approach used in these studies is open to question, however, as the investigators reported only managers' impressions in response to brief, general questions to determine the frequency of accidents or safety violations. Since the cause of most of these incidents involve a multiplicity of factors, a more fine-grained analysis than that gained from one or two brief questions is required to

determine the contributory role of long workshifts. Such an approach was used in a long-term study of accidents over 10-y periods of 8-h and 12-h shifts in a yarn manufacturer (Laundry and Lees 1991). In that study, lower rates of the most minor injuries on the job, but higher rates of more major injuries off the job, occurred during the 10-y period of 12-h shifts.

Despite the fact that some studies of scheduled extended workshifts have reported little or no effect on gross indices of health and safety, there still are persistent concerns about excessive fatigue. Such concerns were given as a primary reason for not adopting the compressed workweek by 800 members of the American Management Association (Wheeler *et al.* 1972). In Singapore, 12-h shift systems in several industries were abandoned because of their adverse impact on worker health and social life (Kogi *et al.* 1989). The reported health factors associated with fatigue included insufficient sleep and weight loss, while other factors potentially associated with fatigue included lower productivity, high turnover, and more frequent part-time work on off-duty days. Even among industries using long workshifts, the subjective impression of increased fatigue is acknowledged. Studies have shown that the primary source of worker dissatisfaction with compressed workweeks was increased fatigue (Hodge and Tellier 1975). Despite the fatigue, however, employees generally were more satisfied with the compressed schedule.

Attempts at more direct assessments of fatigue have analysed job factors or administered laboratory-type performance tests and self-report scales. With a standard nursing-care job analysis, Mills *et al.* (1983) concluded that 12-h shifts had no adverse impact. Todd *et al.* (1989), on the other hand, concluded that overall nursing care was adversely affected by 12-h shifts, while direct physical care was not affected. Reid *et al.* (1993), however, reported that nurses' direct care time with patients was reduced on 12-h shifts as more unscheduled rest breaks were taken. In his analysis of truck-driver accidents, Hamelin (1987) reported that accident risk was particularly high after 11 h of work, especially if work occurred at night.

Behavioural assessment of extended workshifts with standard performance tasks and self-report scales have indicated some improvements and some decrements associated with these shifts. Volle *et al.* (1979) reported decreased grip strength and decreased critical flicker fusion frequency in a factory on 10-hour shifts compared to a similar factory on 8-h shifts. Peacock *et al.* (1983) reported increased sleep, improved subjective alertness and cardiovascular fitness in police officers after a switch from 8-h to 12-h shifts, and no effect on critical flicker-fusion frequency or grammatical reasoning performance. Mills *et al.* (1983) reported increased subjective fatigue in nurses across a 12-h shift, and more frequent errors in a grammatical reasoning task and a medical record reviewing task. Daniel and Potasova (1989) concluded that chemical workers on 12-h shifts performed more poorly on reasoning, visual search, reaction time and tapping tasks when compared to 8-h shift workers. They suggested, however, that differences in the capabilities of the workers selected for each shift system contributed to these results.

The United States National Institute for Occupational Safety and Health has conducted two worksite evaluations of extended workshifts using standard performance tests and self-report scales. In the authors' first study (Rosa *et al.* 1989), decreased reaction time and grammatical reasoning performance and increased subjective fatigue were observed after 7 months of 12-h shifts as compared to the previous 8-h shift schedule. Daily sleep logs indicated a 1-h sleep debt by the end of the 12-h/3–4 day workweek. Performance did not deteriorate across the workweek, however, indicating that the shorter workweek compensated somewhat for the longer workshift. After 3.5 y on the 12-h shift schedule, declines in alertness with time on-shift and reductions in total sleep time were still apparent, and few improvements were observed relative to the 7-month test phase (Rosa 1991). In a second worksite study at a natural gas utility, there were decrements in reaction time performance and subjective alertness 10 months after the change to the 12-h shift schedule (Rosa and Bonnet 1993). There were also reductions in sleep across the workweek which were most apparent on 12-h night shifts. The declines in alertness observed in the authors' studies were most apparent at night when lowered circadian arousal added to fatigue resulting from hours of work (see also Hamelin 1987).

TWO SPECIAL CASES OF LONG WORK HOURS

The 'on-call' schedules of hospital-resident physicians in training and the part-time work of adolescents who also attend school constitute two special cases of long work hours which do not fit neatly into the overtime or scheduled extend workshift categories. The average 80-h workweek of resident physicians has received substantial study over the last three decades because the potential for functional impairment from the combination of long work hours and sleep deprivation might compromise patient care. Behavioural studies of resident physician fatigue, however, have met with equivocal results. Several of these studies have been reviewed recently and tabulated in detail by Leung and Becker (1992). These authors attribute the lack of consistent results to three methodological domains including differences in test methodology, variations in the definition of sleep deprivation, and failures to distinguish between acute and chronic sleep loss. With respect to differences in test methodology, some studies used standard neuropsychological or laboratory performance tests, other studies used work-related tasks, and a third set of studies used medical examination results. Definitions of experimental (sleep-deprived) and control (rested) conditions by different studies varied by several hours. Deaconson *et al.* (1988), for example, defined sleep-deprived subjects as those receiving

less than 4 h of sleep and control subjects as those receiving more than 4 h of sleep in the 24 h prior to testing. Rubin *et al.* (1991), on the other hand, defined the sleep deprivation condition as less than 2 h of sleep and the rested condition as more than 6 h of sleep in the previous 33 hours. Many studies did not define the rested condition at all. While some attempt was made to define acute sleep loss in the previous 24–48 h, little effort was made to quantify chronic sleep debt or circadian-rhythm disruptions which may have accumulated over several days. In addition to the methodological concerns highlighted by Leung and Becker (1992), the consecutive number of hours worked (as opposed to simply resting at the hospital) was considered rarely, which may have contributed further to the variable results. A notable exception concerning work hours is an early study by Wilkinson *et al.* (1975), who reported that greater numbers of hours worked within the on-call duty period were associated with lower self-reported levels of work efficiency. Despite a failure to observe fatigue or sleep-loss effects in some studies, the number of studies observing such effects has prompted recent review and revision of resident physician work schedules, both within hospital systems and at the government or professional-association level (American College of Physicians 1989; Leung and Becker 1992; Scott 1992).

A second special case of long work hours involves adolescents engaged in part-time employment. If the primary 'job' of adolescents is schoolwork (in the USA, approximately 35 h of school attendance plus homework), then any additional employment can be construed as within the domain of extended work hours. Based on a survey of over 3900 students, Steinberg and Dornbusch (1991) reported that approximately half had part-time employment, and that half of those employed worked more than 20 h per week. Increasing hours of employment was associated with poorer school performance, higher psychological stress, more frequent substance abuse, and reduced parental supervision. Those students working the most hours tended to obtain the least sleep and were the most sleepy during the day based both on electroencephalographic assessment (the Multiple Sleep Latency Test), and on subjective reports of intrusive sleepiness while driving or frequent inattention during class (Carskadon 1989/90; Carskadon 1990). From these studies, it can be asserted that schoolwork plus 20 or more hours of employment places a significant number of students at acute risk of accident or injury (from sleepiness, possibly combined with substance use), and also presents a developmental disadvantage because of poor school performance (if they attend school at all) and increased stress.

FACTORS PRODUCING FATIGUE

A multitude of factors can contribute to the level of fatigue or performance efficiency observed during extended workshifts. These factors can be divided roughly into those related to work-rest scheduling, job tasks and workload, the environment (both within and around the workplace), and social/domestic demands and support. Of these factors, only work-rest scheduling has been examined with any frequency and only in its broadest terms, i.e. considering such parameters as number of hours worked, day work vs. night work, number of consecutive days worked, or opportunity for sleep/recovery. When increased fatigue is observed, as in our own worksite studies, then fatigue, sleepiness, or performance loss, will increase with number of hours worked. This effect will be higher on night shift compared to day shift and may be compounded by partial sleep deprivation, but may be tempered by a shorter workweek.

Virtually no worksite research has compared different job tasks or workloads under the same extended workshift schedules, and environmental or social elements have been recognized but not studied systematically in terms of how they might affect fatigue (see Carskadon 1989/90, for an exception). With respect to job tasks, it appears that scheduled extended workshifts have been applied most frequently in jobs that are sedentary, automated, or require relatively more cognitive as opposed to physical activity (e.g. control room monitoring, computer operations). Almost no studies have examined extended workshifts in jobs with high physical workloads. One notable exception is a study of 12-h workshifts in underground mining where the associated fatigue was judged to be no different from that seen on 8-h shifts. That study was conducted at a remote mine site where the workers stayed at the site for several days (Duchon *et al.* 1994). Such a practice also occurs on off-shore oil rigs using extended workshifts. Environmental factors and support systems are quite different in those situations because non-work activities are restricted (e.g. prohibition of alcohol, no access to a second job) and food and housing needs are provided at the site (Parkes 1994).

In addition to physical workload, other job factors can affect fatigue observed on long workshifts. Job pacing, for example, has been examined only rarely although worker-paced jobs afford, and externally-paced jobs forbid the opportunity for unscheduled rest breaks to reduce fatigue (Reid *et al.* 1993).

Environmental and social effects have been recognized but not studied systematically. As mentioned above, if workers are separated from the demands and distractions of home and community then long workshifts might be manageable. Such observations lead to questions about the compounding fatigue effects of a long commuting time in heavy traffic, or the fatigue effects of a high domestic workload, such as in the care of small children. For example, if the individual working long shifts is the primary caretaker in the home, then that person's own rest and recovery may be sacrificed for the needs of the children.

Other environmental exposures on the job can affect fatigue but there are few standards for work periods longer than 8 h. Chemical solvents cause drowsiness (Dick 1988),

and noise, vibration, or heat may produce performance decrements (Hockey 1983, reviews), yet little is known about the influence of an additional 2–4 h of daily exposure to any of these agents.

CONCLUSION

In conclusion, research demonstrating increased fatigue with long workshifts, and a lack of substantial research on other factors which may modulate fatigue, indicates that schedules requiring long workshifts should be instituted with caution. If such schedules are used they should be evaluated carefully. While many jobs allow a wide margin of error, any situation where increased fatigue, decreased sleep, or performance loss can be demonstrated is a situation where the margin for error is reduced, albeit by some unknown amount.

If experts in a certain occupation or industry already consider a job to be dangerous on an 8-h shift, then extended workshifts probably should be avoided. When extended workshifts are used, it is conservative to assume *a priori* that the margin for error will be reduced and contingency plans should be devised accordingly. A primary concern is having sufficient personnel to cover all working hours, because an individual required to work an additional 6–12 h overtime following their usual 12-h shift may push fatigue past acceptable limits.

In addition, workloads should be distributed to account for critical time periods when fatigue is assumed to be high. From our own studies, the final 4 h of a 12-h night shift was identified as a critical time because the fatigue from extra hours of work combines with the circadian low-point in arousal to produce the highest amount of subjective sleepiness and fatigue, and the lowest efficiency in performance.

Where demand permits, breaks should be distributed liberally throughout the shift to provide temporary recovery from the task at hand. Job rotation also becomes more critical as repetitive work, or long, monotonous tasks can induce boredom and loss of attention. The risk of fatigue-related mishaps off the job must also be anticipated because institutionalized safety procedures at the worksite will be absent. A critical time in this regard is the commute to and from the worksite as excessive fatigue can compromise the quick response time occasionally needed to drive in dense urban traffic, and also increase the potential for drowsiness during long monotonous drives in unpopulated areas.

Studies of long workshifts at remote worksites point to the influence of domestic obligations adding to work-related fatigue. Especially when children are involved, day-to-day home duties may not change just because additional hours are worked each day. Therefore, if a substantial number of single parents of small children comprise the workforce, then use of long workshifts may not be advisable.

Beyond the initial anticipation and rectification of factors which may exacerbate extended workshift fatigue, periodic quantitative evaluation of the work schedule is strongly advised for continued prevention of undue risk. Evaluation efforts should extend beyond the initial 'honeymoon' or 'Hawthorne' period, when the mere act of change is viewed positively, into the time of potential complacency when a relaxed state of vigilance could allow problems to arise.

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