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Review Article

Extended Work Periods*

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Abstract: A literature review of 105 studies on the effects of extended daily working hours was conducted. Potential negative effects of extended working hours are discussed: More accidents on the job; more accidents off the job; reduced duration and quality of sleep due to moonlighting; sleepiness; reduced alertness; fatigue; adverse effects on performance; prolonged toxic exposure; adverse effects on health; increased absenteeism; problems communicating with managers; and problems while driving home. Potential positive effects of extended working hours are discussed: Less travel time and costs; more time for the family, social life, and domestic duties; increased satisfaction with working hours; fewer handovers; and less overtime. No firm conclusions can be drawn because of the partly contradictory results and the methodological problems of many studies. However, caution is advised when considering the introduction of extended work shifts, particularly where public safety is at stake. A checklist is provided (concerning work load, breaks, staffing level, systematic assessments of health and safety factors) to support decisions for or against the use of extended work shifts.

Key words: Shift work, Working hours, Shift length, 12-hour-shift, Extended work periods

Introduction

Many researchers who have studied extended working hours are very concerned about adverse effects of extended work shifts. The term "extended work periods" signifies shifts longer than 8 hours, such as 9, 10, 11 or 12-h day, morning, evening or night shifts. In general, these are combined with "compressed work weeks", i.e. longer hours worked per day but fewer days worked per week.

However, in some cases 7 d of 12-h shifts have to be worked. These extreme cases are not considered in this review because it is evident that they may be detrimental to health. (see, for instance, the review by Rädiker *et al*., 2005)[1] who carried out a secondary analysis of a European survey and found a high correlation between the number of weekly working hours and the incidence of health complaints.

The present review is based on 105 relevant English or German articles and books (including the proceedings of all 16 "International Symposia on Night and Shiftwork" from 1969 to 2003) collected by the author from 1970 to 2005.

Extended working hours may have positive as well as negative effects (Fig. 1).

Potential Negative Effects of Extended Working Hours

Accidents on the job

As shown in Table 1, results of different studies showed some inconsistencies: 9 reported long work hours were associated with more accidents, whereas 5 were not significant, and 4 reported that long work hours were associated with fewer accidents. Differences in study methods may have contributed towards inconsistencies in the results reported; thus, the studies by Northrup *et al*. (1979)[2] and Campbell (1980)[3] were based exclusively on interviews with managers.

Analysing the last four studies in column one (Table 1), Folkard *et al*. (2005)[4] estimated the risk across the work shift, from hour 1 to hour 16 at work. For example, they

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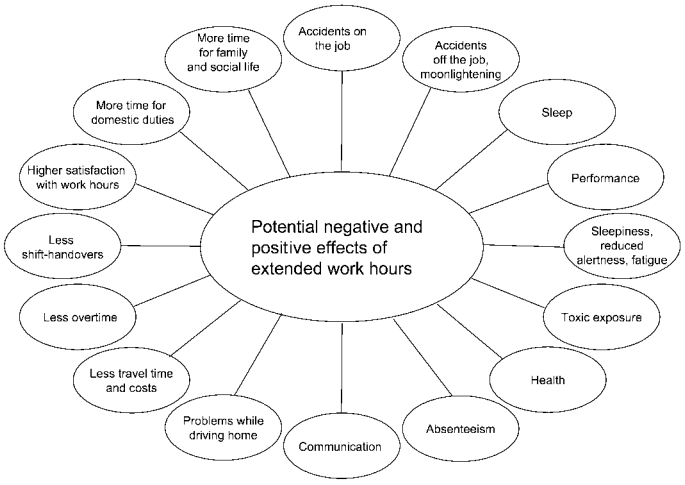

Fig. 1. Potential negative and positive effects of extended work hours.

Table 1. Risk of accidents and injuries dependent on the length of the shift

Higher risk for shifts longer than 8 hours	No difference of risk 8-h vs. 12-h	Lower risk for shifts longer than 8-hours
-Hettinger 1970	-Wilson and Rose 1978	-Campbell 1980 (8 companies)
-Campbell 1980 (5 companies)	-Northrup *et al*. 1979	-Laundry and Lees 1991
-Hamelin 1987	-Campbell 1980 (57 companies)	-Aguirre *et al*. 2000
-Hunting and Weeks 1992	-Smiley and Moray 1989	-Smith *et al*. 2005
-Cohen and Lin 1991	-Pollock *et al*. 1994	
-Åkerstedt 1995		
-Folkard 1996		
-Haenecke *et al*. 1998		
-Nachreiner 2001		

Mixed results within the study of Campbell 1980

estimated 'that relative to 8-h shifts, 10-h shifts are associated with a 13% increased risk and 12-h shifts with a 27% increased risk' (p. 21) (Fig. 2).

Accidents off the job, moonlighting

Laundry and Lees (1991)[5] found higher rates of relatively severe injuries off the job on extended shifts as compared with 8-hour shifts. Angersbach *et al*. (1980)[6] as well as Jozef (1990)[7] observed increased accident rates (non-significant) off the job, which might be due e.g. to moonlighting. Portela *et al*. (2004)[8] provides some evidence for moonlighting with extended shifts, finding 64% of nurses on 12-h night-shifts and 45% on 12-h day-shifts had a second job.

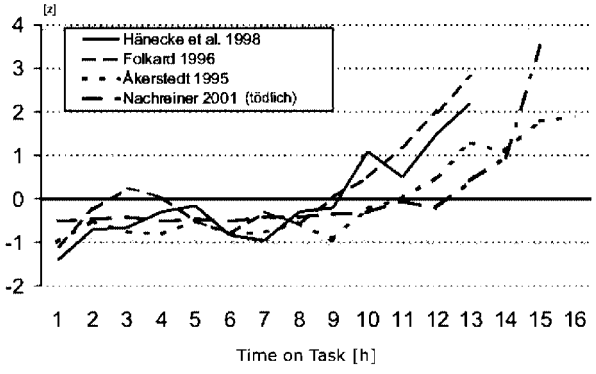

Fig. 2. Accident risk as a function of time on task for 4 studies using aggregated data (Nachreiner, 2001).

Reduced duration and quality of sleep

Table 2 summarizes 21 studies that used different methods

Table 2. Effects of extended shifts on duration or quality of sleep

"Worse" sleep in shifts longer than 8-h	No difference 8-h vs. longer shifts	"Better" sleep in shifts longer than 8-h
-Kogi *et al*. 1989	-Wallace and Levens 1994	-Peacock *et al*. 1983
-Rosa *et al*. 1989	-Smith *et al*. 1998b	-Jaffe *et al*. 1994
-Moors 1990	-Axelsson *et al*. 1998	-Axelsson *et al*. 1998
-Rosa and Bonnet 1993	-Aguirre *et al*. 2000	-Lowden *et al*. 1998
-Axelsson *et al*. 1998	-Heslegrave *et al*. 2000a, b	-Tucker *et al*. 1998
-Tucker *et al*. 1998	-Dahlgren and Akerstedt 2005	-Aguirre *et al*. 2000
-Aguirre *et al*. 2000		-Heslegrave *et al*. 2000a
-Heslegrave *et al*. 2000a		-Smith *et al*. 2005
-Kecklund *et al*. 2001		
-Dahlgren *et al*. 2003a		
-Ekstedt *et al*. 2003		
-Härmä *et al*. 2003		
-Di Milia 2003		

Mixed results within the following studies: Axelsson *et al*., 1998; Tucker *et al*., 1998; Aguirre *et al*., 2000; Heslegrave *et al*., 2000a

to measure sleep, e.g. sleep diaries, actigraph, or questionnaires (hardcopy or palm-size computer).

In many studies, the comparability of groups or shift systems was not assured. Thus, for instance, Aguirre *et al*. (2000)[9] assumed that changes in sleep duration after a change from an 8-h shift to a 12-h shift schedule are related more to the starting times of the shifts than their duration. Sleep duration was shorter with a 12-h day shift (6 a.m. to 6 p.m.) than an 8-h day shift (7 a.m. to 3 p.m.). Conversely, a 12-h night shift (6 p.m. to 6 a.m.) resulted in longer sleep duration than an 8-h night shift (11 p.m. to 7 a.m.).

With the help of time-budget studies, we observed that the sleeping behaviour of 8-h and 12-h shift workers on night shifts is different (Fig. 3). On the evening before a night shift, fewer 8-h shift workers would take a nap than 12-h shift workers which may be interpreted as more need for recovery or simply as a better coping strategy on the part of the 12-h shift workers.

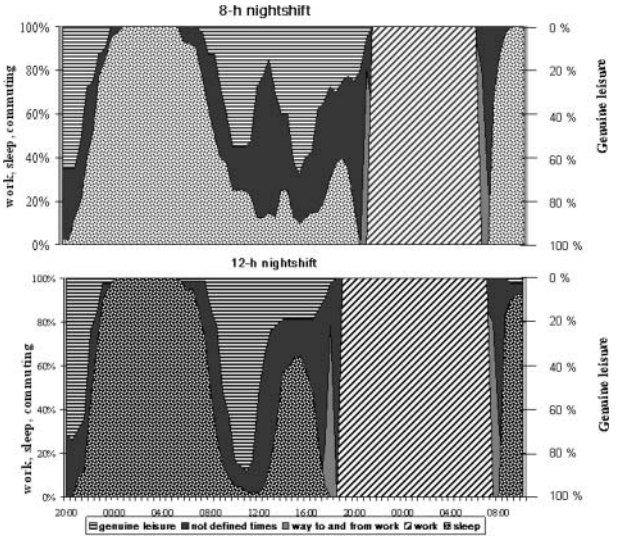

Fig. 3. Timebudget studies in 8-h and 12-h shiftsystems (Knauth *et al.*, 1975).

Sleepiness, reduced alertness, fatigue

Many shiftwork researchers express their concern about excessive fatigue in long work shifts. Such a concern was also the primary reason given by about 800 members of the American Management Association for not adopting the compressed workweek (Wheeler *et al*., 1972[10]). According to Ong and Kogi (1990)[11], a large multinational electronics factory abandoned 12-h shifts after 2 months and reverted to the 8-h shift system owing to worker complaints of tiredness and difficulty in concentrating.

The compilation of 38 studies in Table 3 should be viewed with some caution. First, the underlying concepts of fatigue and sleepiness are different (Pigeon *et al*., 2003[12]). Second, as demonstrated by the three-process model of Åkerstedt (1995)[13] and Åkerstedt and Folkard (1997)[14], alertness deficits, for instance, are caused not only by the length of a shift but also by

- working hours shifting within the circadian phase;
- more time being spent awake, and by
- reduced sleep length.

An important factor for the magnitude of fatigue is workload. In air traffic controllers, a combination of high

Table 3. Effects of extended shifts on sleepiness, fatigue or alertness

"Worse" in shifts longer than 8-h	No difference 8-h vs. longer shifts	"Better" in shifts longer than 8-h
-Kogi *et al*. 1975	-Fields and Loveridge 1988	-Peacock *et al*. 1983
-Hodge and Tellier 1975	-Wallace *et al*. 1990	-Williamson *et al*. 1994
-Mills *et al*. 1983	-Washburn 1991	-Smith *et al*. 2005
-Rosa *et al*. 1985	-Duchon *et al*. 1994	
-Colligan and Tepas 1986	-Feyer and Williamsson 1995	
-Rosa *et al*. 1989	-Tucker *et al*. 1998	
-Moors 1990	-Axelsson *et al*. 1998	
-Daniel 1990	-Smith *et al*. 1998b	
-Ong et Kogi 1990	-Aguirre *et al*. 2000	
-Rosa 1991	-Dahlgren *et al*. 2003b	
-Rosa and Bonnet 1993		
-Baker *et al*. 1994		
-Wallace and Greenwood 1995		
-Smith *et al*. 1995		
-Tucker *et al*. 1996		
-Sammel *et al*. 1999		
-Mori *et al*. 2000		
-Spencer *et al*. 2000		
-Fischer *et al*. 2000		
-Heslegrave *et al*. 2000		
-Kecklund *et al*. 2001		
-Son *et al*. 2003		
-Dahlgren *et al*. 2003a		
-Sallinen *et al*. 2005		
-Dahlgren and Akerstedt 2005		
-Turner *et al*. 2005		

Mixed results within the following study: Dahlgren *et al*. 2003a

workload and longer working hours resulted in a significant increase in fatigue as shown in Fig. 4. Fatigue increased from 3–4 h to 5–6 h ($p<0.05$), to 6–7 h ($p<0.01$) and to greater than 7 h ($p<0.01$).

Feyer and Williamsson (1995)[15], who studied professional drivers, found that working longest hours was not necessarily associated with reporting greatest fatigue. They offered two possible explanations:

- self-selection of the group of drivers working longer hours;
- better strategies to manage fatigue, i.e. scheduling rest periods to coincide with periods of fatigue.

To sum up, no clear conclusions regarding sleepiness, reduced alertness or fatigue can be drawn because of methodological and conceptual limitations.

Adverse effects on performance

Table 4 shows a very rough overview of 30 studies. In most studies, either the design or the methods used are open to criticism, e.g.

- Some results are based on interviews alone.
- Pilot and reference groups are frequently not comparable with respect to physical or mental work demand, work environment, timing of shifts, breaks, commuting time, age structure, etc.

Rosa conducted two well-designed work-site studies including a follow-up study of the first company. Figure 5 shows that single auditory reaction time and subjective sleepiness increased among night-shift workers after the change from the 8-h to the 12-h shift system (Rosa and Bonnet, 1993[16]). In the first work-site study, even after 3.5 yr on a 12-h shift schedule, declines in performance and alertness with increasing shift length were still apparent (Rosa, 1991[17]).

Prolonged toxic exposure

We know very little about toxic exposure on the job and toxic clearance off the job under conditions of extended shift length (Bolt and Rutenfranz, 1988[18]).

Chemicals that are not quickly eliminated from the body may accumulate during successive extended shifts. Having

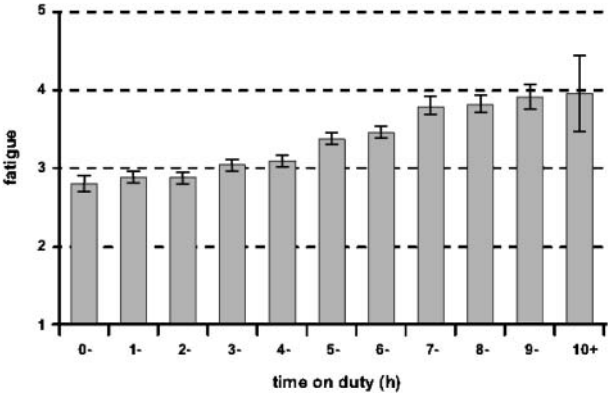

Fig. 4. The effect of time on duty on fatigue (Spencer *et al.*, 2000).

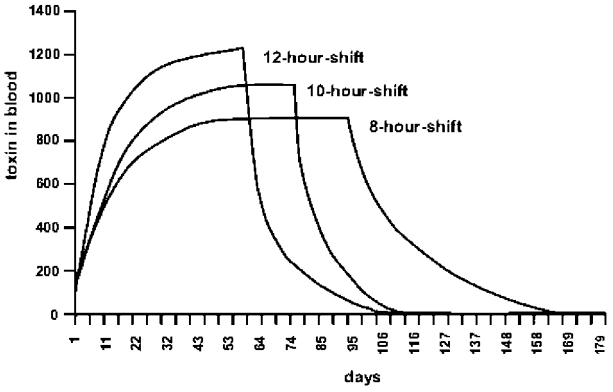

Fig. 6. Simulated effects of a prolongation of the daily occupational exposure (half live= 168h) (Jung *et al.*, 1998).

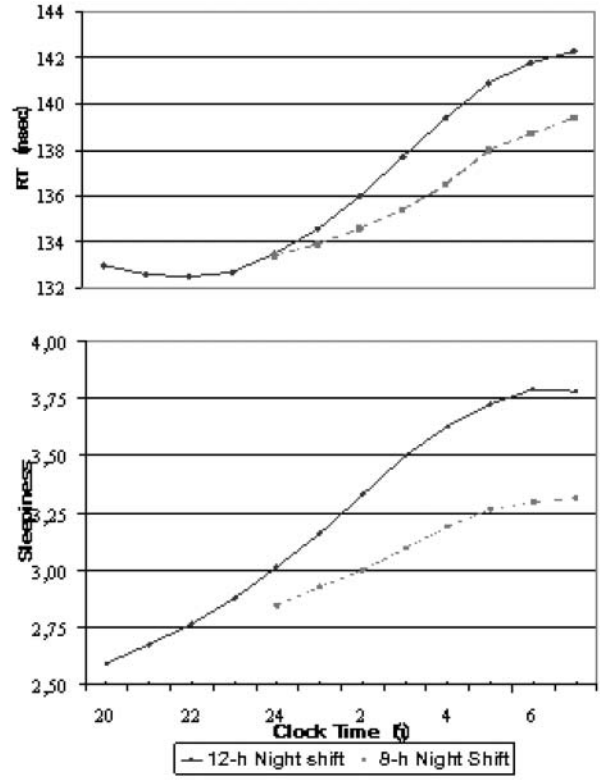

Fig. 5. Multiple regression predictive functions for simple auditory reaction time and subjective sleepiness for 8-h and 12-h night shifts (Rosa and Bonnet, 1993).

calculated the effect of extended shifts on the toxicity of workplace toxins with the aid of models, Jung *et al.* (1998)[19] concluded that the prolongation of daily or weekly occupational exposure essentially influences the toxicity of substances with medium half-lives (10–1,000 h). Figure 6 shows an example of the simulated effects of 8, 10, and 12-h shifts on blood toxin levels. There is a quicker accumulation of toxins in blood in extended shifts compared to 8-h shifts.

Kieswetter *et al.* (2000)[20] studied the combined effects of workplace chemicals and shift work in 8-h shift workers. Although protective clothing was worn at high exposure rates, additive effects could be shown. Therefore, they concluded that under certain conditions, 'a lengthening (up to 10 or 12 h) and a compression of the working hours cannot be recommended' (p. 167).

Adverse effects on health

The health effects of extended working hours are not clear. In some studies, 12-h shift workers reported more adverse health consequences than 8-h shift workers (e.g. Ong and Kogi, 1990[11]; Daniel, 1990[21]; Kundi *et al.*, 1995[22]; Spurgeon *et al.*, 1997[23]). Other studies failed to find such differences or even found better subjective health in 12-h shift workers (Frese and Semmer, 1986[24]; Lees and Laundry, 1989[25]; Nachreiner *et al.*, 1975[26]; Chan *et al.* 1993[27]; Williamson *et al.*, 1994[28]). However, most studies have methodological problems concerning, for instance, the comparability of the groups and working conditions studied or missing control for potential confounders (Van der Hulst, 2003[29]).

Furthermore, 12-h workers have more days off, and it is rather unlikely for them to report sick on off days. Finally, most studies rely on subjective assessments of health, and there are not many longitudinal studies. Angersbach *et al.* (1980)[6] conducted a retrospective cohort study of 8-h and 12-h shift workers based on medical data. As shown in Fig. 7, differences between 8-h and 12-h shift workers developed only after about 7 yr.

Absenteeism

The results of the following studies comparing absenteeism in 8-h and 12-h shift systems are inconclusive. Nachreiner

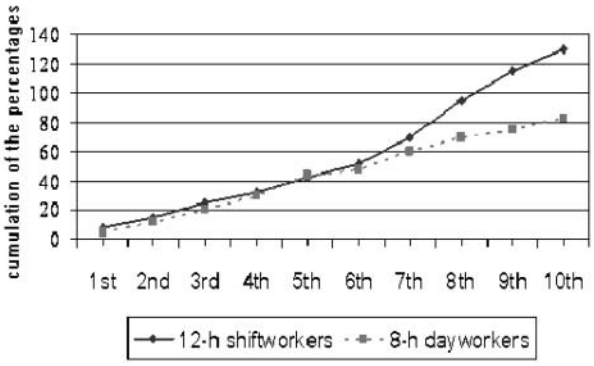

Fig. 7. Cumulative morbidity of falling ill the first time (within study period) due to gastrointestinal disease (Angersbach *et al.*, 1980).

et al. (1975)[26] and Jozef (1990)[7] found no significant differences in absenteeism.

Baker *et al.* (2001)[30] compared absenteeism rates in shift systems which changed first from a backward-rotating 8-h/7-d roster to a 12-h/7-d roster and then to a 12-h/5-d roster. A significant increase in absenteeism relating to the last-named change was found only in the coal-treatment plant. The authors suggest that this increase was caused, among other things, by the amount of overtime done.

On the other hand "it may be the case that any decrease in absenteeism found on a 12 h regime is an artefact of having fewer workdays to be absent from" (Smith *et al.*, 1998a[31], p. 225).

Problems concerning communication with managers

Smith *et al.* (1998b)[32] studied the change from an 8-h shift to a 12-h shift. The reduction in overtime combined with fewer overlapping hours spent at work alongside day-time management and day workers was reported as giving rise to communication difficulties. One manager said 'they don't seem to ever be here with the new roster' (p. 59). Northrup *et al.* (1979, p. 323)[2] report that with 12-h shifts "production workers' hours in the plant coincide with management's only five days each month. The opportunity for contact, then, was decreased by 50%." Therefore there was a need for heavier reliance on written communications.

Wilson and Rose (1978)[33] report communication problems between shiftworkers and management after three or four days away from work. Lewis and Swaim (1986)[34] mention an impairment in shift handovers after a block of seven rest days on the 12-h system compared with four rest days on the 8-h system. There might be a greater need for work reorientation on return from long breaks (Northrup *et al.*, 1979[2]; Smith *et al.*, 1998[31]).

Problems while driving home

Extended working hours might make driving home after the shift more difficult and dangerous. Heslegrave *et al.* (2000)[35] studied workers in a nuclear power facility who changed from 9 to 12.5-h shifts. Although most of the workers lived within 30 min of the workplace, commuting on both 12.5-h night and 12.5-h day shifts presented more problems compared to the old shift system: While in the new shift system commuting was significantly more risky at night than during the day, 25% of workers reported falling asleep in the last year during day-shift commuting compared to 41% for night-shift commuting. 12.5-h shifts resulted in significantly more workers experiencing lapses in attention while driving, falling asleep behind the wheel, and near-accidents compared to 9-h shifts.

Di Milia and Tepas (2005)[36] compared three groups of drivers: rotating shiftworkers (SW) who were employed mostly on 12.5 h shifts, long day workers (LDW), who worked 10–12.5 h shifts, and standard day workers (SWD), mostly working 8 h shifts. The last group (SDW) reported the least sleepiness when driving home. Driving home following night shift (SW) was linked with the highest levels of sleepiness and frequencies of falling asleep at the wheel.

Perera (1987)[37] also reported problems of tiredness and drowsiness in workers travelling home after double shifts ("three workers who performed two double shifts did 62 h each while two others who did three double shifts worked 70 1/2 h each in the study week", p. 245). In a study by Duchon *et al.* (1992)[38], mine workers on 12-h shifts were expected to stay at the mine throughout their 4-d shift work due to the remote location of the mine. This had a beneficial effect on sleep and rest between shifts as well as eliminated risks associated with driving home after long shifts.

Potential Positive Effects of Extended Working Hours

Despite all the potential negative effects of extended working hours discussed above, many shift workers like 12-h shift systems because they have more days off than 8-h workers: Shift workers on a 12-h system will typically work only two-thirds of the number of days per year as those on an 8-h schedule.

Figure 1 lists some potential positive effects of extended working hours.

Less travel time and costs

12-h workers travel less than 8-h workers to attain the same weekly working time, which also means, of course,

less travel costs, less energy consumption and less air pollution.

More time for family and social life

As 12-h shift workers have more time off than 8-h shift workers, this additional leisure time may be used for various leisure activities. In Fig. 8 eight-hour shiftworkers complained much more than 12-h shiftworkers about not having enough time for leisure activities. Table 5 shows that most of the 10 studies observed more positive effects of 12-h shifts on family and social life. According to Taylor *et al.* (1997)[39], advantages to family life are positively related to psychological health and, to a lesser extent, to physical health. In contrast to most authors listed in Table 5, Kundi *et al.* (1995)[22] studied nurses working 12 and 8-h shifts, finding that both schedules seemed to interfere with family responsibilities and leisure activities. In nurses working 12-h shifts, Kundi *et al.* (1995)[22] found that, compared to nurses working 8-h shifts, stronger relationship existed between both their subjective health state and their rating of expected schedule-related adverse health effects on the one hand and the amount of expected adverse social and leisure-time effects on the other hand. Although the potential value of free time as compared to 8-h schedules was greater, it might be diminished by an increased need for compensation and recuperation, and the effect of the remaining free time might be as low as that of an 8-h schedule (pp. 138, 139).

More time for domestic duties

In a study of Makowiec-Dabrowska and Krawczyk-Adamus (2000)[40], nurses had more time for domestic duties in 12-h compared to 8-h shift systems. However, only domestic duties which are not bound to a particular time of day or a particular day of the week are facilitated by the longer leisure hours of 12-h shiftworkers. Tucker and Rutherford (2003)[41] studied factors moderating the impact of long working hours on well-being. Respondents reporting higher levels of interference between hours worked and life outside (performing household duties, non-domestic chores, leisure activities, etc.) showed a significant positive association between the number of hours worked and cold/flu. By way of contrast, those with lower levels of interference reported negative associations.

Increased satisfaction with working hours

In most studies, 12-h shift workers were more satisfied with their working-time arrangements than 8-h shift workers or after the change from an 8-h to a 12-h shift system (e.g. Nachreiner and Rutenfranz, 1975[42]; Wilson and Rose, 1978[33]; Mills *et al.*, 1983[43], Smith *et al.*, 1998a[31]; Daniel, 1987[44]; Lowden *et al.*, 1998[45]; Aguirre *et al.*, 2000[9]). The subjective perception of the advantages of more time for one's family and social life seems to outweigh all potential adverse effects of 12-h shift systems. However in the study of Northrup *et al.* (1979)[2], the older workers seemed to be "somewhat less fervent in their support" of the 12-h shift system.

Fewer shift handovers

In general, patients in hospital prefer 12-h nursing shifts because handovers are fewer than with 8-h shifts, i.e. they see the same nurse longer than an 8-h shift nurse. However, Reid *et al.* (1993)[46] found a significant reduction in the amount of direct patient care under the 12-h shifts compared to the 8-h shifts.

Furthermore, the decrease in the number of shift changeovers may reduce the margins for error with better continuity of communication between those starting and those finishing work. In a study of Wilson and Rose (1978)[33], the 12-h shift allowed operators to make equipment ready for the maintenance crew and pay more attention to repair or serving because the same crew had to restart the equipment.

Less overtime

In some companies, the change from an 8-h to a 12-h shift system is accompanied by a reduction in overtime. In other companies with a 12-h shift system, overtime is required by the managers and accepted by the workers because of the bonus for overtime. However, from an ergonomic point of view, combining a 12-h shift system with overtime is not to be recommended. Spurgeon et al. (1997)[23] reviewed studies on overtime at normal working days (i.e. no shiftwork) and conclude "Viewed from a health and safety perspective it is clear that excessive overtime working is not without risk" (p.374). Baker *et al.* (2001)[30] studied the effects of a roster schedule change from 8-h to 12-h shifts on health and safety in a mining operation. In two sectors (mining and coal treatment plant), no significant negative effects of the 12-h pattern were found. However, when unregulated and excessive overtime was introduced in a third sector (maintenance), the absenteeism rate significantly increased. Therefore, 'less overtime' is not always a valid argument for a 12-h system.

Conclusions

As indicated in Table 6, there are methodological problems in many of the studies cited. Because of the partly contradictory

results and the methodological problems of many studies, no firm conclusion can be drawn from the studies reviewed. However, caution is advised when considering the introduction of extended work shifts, particularly where public safety is at stake. Only with appropriate planning, structuring and proper allowance for rest, health and safety concerns may extended work shifts be considered acceptable. The following checklist may support decisions for or against the use of extended work shifts:

a) Is the nature of the work and the workload suitable for extended work hours and the individuals' resources? When the physical work demands (e.g. static muscular work, lifting and carrying heavy weights, poor work postures) are too great, the work environment is strenuous and dangerous or the work organisation is poor (e.g. need for a fast work pace) it is not advisable to consider extended work shifts.

b) Are adequate rest breaks allowed? The heavier the work, the more time is needed for recovering. This need increases with age and the hardness of the work.

c) Is the whole working time arrangement designed to minimize the accumulation of fatigue? Many 12-h shifts in a row, for instance, are unfavourable (for more details concerning ergonomic recommendations for the design of shift systems, see Knauth and Hornberger (2003)[47].

d) Are staffing levels sufficient to cover absenteeism of colleagues? If this is not the case, a combination of extended shifts and overtime (on schedule off days) will probably occur.

e) Is exposure to toxic chemicals limited? Although our knowledge is very limited, it seems to be advisable not to change from 8-h to 12-h shift systems if the toxic exposure is already near to the published threshold value.

f) Can workers recover completely after work? Ong and Kogi (1990[11], p. 424) report that "the hot tropical climate and noisy dwelling units of Singapore were not conductive to sound sleep for shift workers who needed to sleep in the daytime". Such circumstances increased fatigue and affected productivity on the 12-h shift the next day. If female workers have to take care of children, their household, or sick relatives after a 12-h shift, the double burden may be far too high. The effects of regular moonlightning on days off in 12-h shift systems are difficult to assess but may be dangerous to health.

g) Does the company have systematic assessments of health and safety factors to identify early signs of adverse effects of extended work shifts?

h) Does the country in which the company is situated expect an ageing workforce? The demographic change with an ageing workforce may aggravate the problems of extended work periods (e.g. Jozef, 1990[7]; Conrad-Betschart, 1990[48]).

Further studies will be needed, especially well-controlled longitudinal studies on the effects of extended work shifts.

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