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Compressed working weeks

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Preface

An intensification of competitive pressures, brought about in part by globalization and facilitated by advances in technology, is driving companies to tailor working time ever more closely to the demands of the market. For individual workers, what we are seeing is, broadly viewed, a move away from workers actually working the "normal" or "standard" working hours established in law, and towards a greater diversity in the hours that are actually being worked. At the same time, the move towards a 24-hour-a-day, seven-day-a-week economy is also resulting in another kind of diversification in working time: an increasing diversification in the scheduling of *when* work is performed. As more and more businesses extend their hours of operation or even establish 24-hour continuous operations, we are seeing an increasing proportion of workers who are working on shifts, in the evenings, at night and on weekends.

The diversification in working time that is occurring offers both challenges as well as important opportunities for improving existing working time arrangements. One particularly important trend has been the rise of *compressed workweeks*: working time arrangements in which a set number of hours is "compressed" into fewer but longer shifts — for example, 40 hours worked in four ten-hour days instead of five eight-hour days. Compressed workweeks typically result in improved productivity for firms, and they are also popular with workers because they often result in more consecutive days off between shift cycles and a better fit between work and personal life. Nevertheless, compressed workweeks also have the potential to have negative effects on the safety, health and well-being of the workforce. For example, if compressing the workweek results in long daily shifts — as with a 48-hour workweek that is worked in only four 12-hour days — there will be greater potential risks to workers' health and safety.

This study provides a comprehensive review of the current state of knowledge regarding the effects of compressed working weeks on a broad range of outcomes, including: productivity and job performance; absenteeism and turnover; sleep and recovery periods; safety in the workplace; occupational health; and workers' job satisfaction, attitudes, and preferences. The paper also considers a variety of factors that can affect these outcomes, including potential differences between industrialized and developing countries. It concludes that, while there are clearly increased risks to health and safety associated with compressed workweeks, even with the use of longer (e.g. 12-hour) shifts these potential risks can often be reduced considerably if these shifts are properly structured and include adequate rest periods. Towards that objective, the paper also provides a set of practical recommendations regarding how to implement compressed workweeks to counter fatigue and improve performance.

The sweeping diversification in working time arrangements — such as the increasing use of compressed workweeks — poses a number of challenges to decent work as it applies to working time. Nevertheless, the rise of arrangements such as compressed workweeks also offer new opportunities for simultaneously meeting the needs of both workers and employers. It is hoped that this study will assist them, with the support of governments, to seize these opportunities and create "win-win" solutions.

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Executive summary

Compressed working weeks (CWWs) involve reducing the overall length of the working week, while retaining the same average number of hours worked per week. This is most commonly achieved by compressing the working week into fewer longer shifts. It may also be achieved by incorporating short intervals between the end of one shift and the start of the next — so called "quick returns". CWWs are often very popular with the workforce because of the associated benefits. These include extended rest breaks between shift cycles, reduced commuting time, and a better fit between the work schedule and life outside work. However, researchers have expressed concerns regarding the effects of CWWs on fatigue and alertness on-shift. For example, studies have identified heightened fatigue levels towards the end of extended shifts and also following quick returns. Moreover, the adoption of CWWs may have other consequences, such as chronic health effects and changes in organizational functioning.

The popularity of CWWs means that care must be taken when interpreting self-reports of well-being, fatigue, safety, etc. The very popularity of CWWs may lead to the under-reporting of problems. Researchers must also be careful to ensure that any differences that they observe in shiftworkers' health and well-being is a consequence of compressing the working week and not a consequence of other factors that vary systematically with comparison of shift systems, e.g. management practice, work demands, shiftworkers' characteristics, etc.

Many of the problems that shiftworkers experience are thought to result from disruption of sleep. There is mixed evidence about the impact of CWWs on sleep. Several studies suggest overall improvements in sleep with the move from eight- to 12-hour shifts. This seems to be because the latter often allow for a greater number of normal nights of sleep over the shift cycle. However, some studies have identified decrements in sleep, particularly associated with 12-hour night shifts. CWW schedules should try to incorporate change-overs timed so as to optimize sleep for workers coming onto, and going off, shift. They should also avoid quick returns. Taken as a whole, the evidence suggests that a well-designed CWW should not lead to *chronic* sleep deprivation, so long as the job is not too demanding. However, there may also be problems of *acute* fatigue at certain points within the shift cycle. In particular, several studies have identified heightened levels of fatigue towards the end of 12-hour shifts. Such increases in fatigue may be greater in high-demand environments. While there is some limited evidence that a change from eight- to 10-hour shifts may be less problematic, further research is needed on this form of CWW. There is also evidence (albeit limited) of heightened fatigue following quick returns. The acute fatigue effects of extended shifts and quick returns appear to stem largely from the impact of the CWW schedules on sleep taken prior to particular shifts. Therefore the design of CWW schedules should aim to minimize the disruption of sleep, and also to optimize recovery, both during and between shifts.

There is little consistent evidence from industrial settings that a CWW harms job performance or productivity. However, there is some suggestion that it may impair job performance in certain occupational settings (e.g. nurses). Twelve-hour shifts can lead to improved shift handovers. However, some workers on CWWs may have greater problems readjusting to, and reacquainting themselves with, the work environment on the first shift back after an extended period of rest. Similarly, there is little direct evidence of a link between CWWs and increased accident risk. However, a growing body of evidence suggests that particular features of CWW schedules (e.g. extended shifts, quick returns) may be associated with increased risk in at least some situations. Further research is needed to understand the way in which shift system features (e.g. shift length, shift sequence, distribution of rest breaks) interact to determine the way in which risk varies during a shift and over a sequence of shifts.

There is relatively little evidence to suggest that CWWs negatively affect long-term health, and some evidence shows that health outcomes are improved. However, it seems likely that such relatively benign effects are dependent upon a well-designed schedule that involves rapidly rotating 12-hour shifts. Negative health outcomes are most likely to be associated with extended shifts in combination with either high workloads or regular overtime working.

There is little evidence that CWWs affect absenteeism rates, while limited evidence suggests that they improve rates of staff turnover. The way in which CWW schedules are implemented and subsequently managed will be crucial to the impact of the new schedule. Participatory approaches to shift system design increase the chances of successful implementation. Individual difference factors, such as gender, domestic circumstances and age, will also play a crucial role. However, evidence on the precise role of many such factors is currently lacking. CWW schedules carry significant risks associated with overtime working and moonlighting. Overtime must be carefully managed and, where appropriate, restricted, in order to avoid the build up of fatigue and to ensure adequate recovery. The extended rest breaks of CWW schedules provide additional opportunity for moonlighting, which is likely to result in workers experiencing heightened levels of fatigue both on and off shift. While there is limited evidence that CWWs involving very long shifts (e.g. 16-hours) may be feasible in some circumstances for some individuals, their use cannot be recommended until further evidence is available regarding their impact on safety and long-term health. There is an urgent need for research into the impact of CWWs in developing countries. In the absence of direct evidence, it is anticipated that particular problems may arise in relation to inadequate recovery between shifts, moonlighting, work/non-work conflict and the possible effects of CWWs on female industrial workers.

The review concludes with a set of guidelines for the design and implementation of CWWs, together with recommendations for future research.

1. Introduction

Many studies have highlighted the positive impact of compressing the working week into fewer longer shifts, e.g. changing from a system of eight-hour shifts to one comprising 12-hour shifts. In such a system, the average number of hours worked per week remains the same, but the number of rest days per week increases. In particular, many studies have shown that employees value the extended time away from work, reduced commuting and other benefits associated with compressed working weeks (CWWs). Their very popularity makes them attractive to employers who are looking for ways to improve employee satisfaction, motivation, stress and general well-being. Moreover, CWWs have the potential to improve organizational efficiency. For example, 12-hour shifts can lead to improved communications at shift handover. Thus CWWs have become increasingly prevalent in a range of occupational settings. However, in the face of this surge in popularity of CWWs, a number of researchers have raised concerns regarding the potential negative consequences of CWWs. For example, several authors have highlighted reports of heightened fatigue levels, particularly in the last few hours of extended shifts. Such reports have obvious implications for safety and performance. Nevertheless, the widespread popularity of CWWs means that any arguments against their implementation need to be firmly grounded in empirical evidence if such recommendations are to be taken seriously by employees and employers alike.

1.1 Definitions

As a first step in considering the impact of CWWs, a clear definition of the term needs to be established. This presents us with our first problem. Conventionally, the term CWW is associated with the rearrangement of working time into fewer longer shifts. For example, Tepas (1985) defines CWW as:

> "Any system of fixed working hours more than 8 hours in length which results in a workweek of less than 5 full days of work a week. Examples: 4 days at 10 per day; 3 days at 12 hours per day" (p. 148).

However, it is possible to compress the working week without changing the length of individual shifts. This is achieved by reducing the amount of rest between shifts within a cycle. Short intervals between the end of one shift and the start of the next, so called "quick-returns", are commonly associated with "rapidly backward rotating" shift systems. A "rapidly rotating" system is one in which the change from one type of shift to the next happens relatively frequently, e.g. every two or three shifts. On the other hand, a "slowly rotating" system might involve changing from one type of shift to the next only once a week, or even less frequently. A "backward rotating" system is one in which the change from one type of shift (e.g. afternoon shifts) to the next (e.g. morning shifts) involves moving the start of the shift "backwards in time", i.e. anti-clockwise. Thus, for example, an eight-hour shift system that involves working a sequence of two afternoon shifts (starting at 14:00), followed by two morning shifts (starting at 06:00) and then a single night shift (finishing at 06:00 on the fifth day) compresses a 40-hour working week into a total of 88 hours. This results in an 80-hour weekend. By comparison, a schedule of five consecutive morning shifts gives 64 hours off at the weekend; the equivalent forward rotating schedule (i.e. two mornings, followed by two afternoons, followed by a single night shift) gives just 48 hours off at the weekend. The reduction in the overall length of the working week is achieved by incorporating two quick returns of just eight hours between the second afternoon and the first morning shift, and between the second morning shift and the night shift.

As we shall see, there is relatively little research on the impact of quick returns. Hence there is no established threshold for determining what constitutes an adequate interval between the end of one shift and the start of another. For the purposes of this review, an interval of less than ten hours will be considered as a quick return. However, it should be noted that this is an arbitrary and expedient threshold, rather than one based on empirical evidence. Therefore, while Tepas' definition describes the majority of CWW systems that will be considered in this review, the following supplementary definition will apply for the purposes of the review:

> Alternatively, any system which incorporates "quick returns", i.e. intervals of less than ten hours between shifts.

1.2 Prevalence of CWWs

There appears to be relatively little recently published evidence regarding the extent of CWW schedules. Among the exceptions to this rule are two studies that report prevalence rates in the United Kingdom. The most recent was a survey of 2,000 employees in a representative range of industries, published by the UK Department of Trade and Industry (Stevens et al, 2004). It was reported that CWW arrangements were available to 30 per cent of employees surveyed. This suggested an increase over the 23 per cent reported in the base-line study conducted three years earlier (Hogarth et al, 2000), although the difference may have been due to variations in the question formats in the two surveys. It is notable that the second survey was conducted shortly after the enactment of new legislation intended to promote family-friendly flexible working practices. CWW was more prevalent in large organizations (over 250 employees) than in medium-sized organizations (25-99 employees).

Of those to whom CWW arrangements were available, the take-up rate was 36 per cent (i.e. 11 per cent of the total sample). This reflected an increase compared to the earlier survey (6 pr cent of the total sample). Among those who reported that CWW was not available to them, 34 per cent said that they wished to work compressed workweeks. Full-time employees were more likely to express an interest than part-time employees (37 per cent and 26 per cent, respectively), and a higher proportion of managers and professionals said they would like to work CWWs than those in sales and service occupations (39 per cent and 26 per cent, respectively). Demand did not change substantially between the two surveys. Compared to other forms of flexible working (e.g. reduced hours for a limited period, part-time working, jobsharing), CWWs were less likely to be available, but were more likely to be taken up if they were available, and more likely to be desired if they were not available. Of those who did not have the option of CWWs, 35 per cent said it would be feasible for them to work in this way, with the largest proportions observed among those in large workplaces (42 per cent) and in clerical and skilled manual occupations (40 per cent). Employees in small organizations (under 25 employees) and those working in services and sales were less optimistic about the feasibility of CWWs working (33 per cent and 27 per cent, respectively).

1.3 Rest and recovery

Signs of fatigue are mostly experienced during or after a day's work. This need not be a problem if enough time is allowed to recover between two periods of work. Thus time seems to be the crucial variable in recovery from occupationally exerted efforts (Sluiter et al., 1999). The features of CWWs (e.g. extended shift length, quick returns) are intrinsically linked to the issue of recovery. A number of studies have examined the effects of different distributions of rest days within CWW systems (e.g. '2 on – 2 off' vs. '4 on – 4 off'; Tucker et al., 1999) and the length of rest periods between shifts (quick returns; e.g. Barton and Folkard, 1993; Tucker et al., 2000; Axlesson et al., 2004). They indicate that schedules that restrict recovery during a sequence of shifts result in workers being less alert when on shift. A less commonly researched issue is the distribution of rest breaks within shifts. Indeed, there are no studies that the author is aware of that directly examine intra-shift rest breaks in relation to CWWs. However, a recent study suggests that intra-shift rest schedules may be an important influence on the successful implementation of shift systems (Tucker et al., 2003).

1.4 CWWs and fatigue

It is widely believed that many of the health and safety problems of shiftworkers are linked to fatigue. However, it is very difficult to conclusively demonstrate firm causal links. This is particularly the case in relation to chronic health effects that may only be manifested after years of exposure.

Heightened fatigue is likely to occur when effort is sustained over a prolonged period. Thus, for example, fatigue may increase when the length of a shift is extended from eight to 12 hours. Fatigue is also likely when there is insufficient opportunity for recovery between shifts. This may happen when the schedule features quick returns. Fatigue is also a likely consequence of inadequate sleep between shifts, i.e. short sleeps and/or disturbed sleep. Shiftworkers' sleep is greatly influenced by the timing and sequence of their shifts. Quick returns are just one aspect of a shift schedule that may result in inadequate sleep. Other features, such as nightworking, are also associated with inadequate sleep. CWW schedules may feature any or all of these fatigue factors. Their combined effects are likely to have an especially marked impact upon the individual's health and safety.

Fatigue effects can be thought of in two regards, although in practise they may well form the two ends of a continuum. Firstly, there is what has been referred to in the literature as "chronic fatigue". This is defined as:

> "… a general tiredness and lack of energy irrespective of whether a person has had enough sleep or has been working hard, and which persists even on rest days and holidays" (Barton et al., 1995a, p. 11).

Secondly, there is acute fatigue, which may be felt at particular times, such as towards the end of a long shift. Acute fatigue may be off-set by rest, e.g. taking a break during the shift, finishing work and/or sleeping.

Fatigue is a notoriously difficult concept to define precisely and unambiguously. Consequently, it is difficult to measure directly. Many studies have relied on self-reports of feelings of fatigue, while some have inferred changes in fatigue from observing changes in performance. However, as we shall see, the relationship between self-reported fatigue and performance is unclear. Acute fatigue effects are sometimes, although not necessarily, associated with the need or desire for sleep. Within the literature, the need for sleep (i.e. sleepiness) is commonly synonymous with levels of alertness.

1.5 Chronic health effects and organizational effects

Although clearly of major significance, fatigue is not the only source of concern regarding CWWs. Various aspects of shiftworking (e.g. nightworking, early starting day shifts) are associated with impaired physical and psychological well-being (Waterhouse et al., 1992; Åkerstedt, 1990). Therefore, many studies have been conducted to identify whether the particular features of CWWs have effects on workers' long-term health.

The rearrangement of work schedules is also likely to have a wide range of knock-on implications for the way in which employees function within an organization. For example, the extended time away from work that is often a feature of CWW means that workers may find it more difficult readjusting to, or reacquainting themselves with, the work environment on the first shift following a block of rest days. At the same time, CWW can have positive impacts that are incidental to the main reasons for reorganizing the shift patterns. For example, relative to an eight-hour shift system, workers on a 12-hour system are more likely to hand their shift back over to the same colleagues from whom they took over at the beginning of the shift (Wedderburn, 1996). This is likely to facilitate better communication and thus more efficient working within the organization.

1.6 Sleep and circadian rhythms

A key issue in the design of CWW schedules is the provision of sufficient time for recovery and sleep between successive shifts. However, sleep depends on more than simply *how much* recovery time the person has away from work during the shift cycle. The quality and quantity of the shiftworker's sleep is also a function of time of day at which sleep is taken. This, in turn, is influenced by the start and finish times of the shift. Consequently, shift work is often disruptive of the psycho-physiological mechanisms that govern sleep. Thus, for example, shift systems that require individuals to work at night and sleep during the day are commonly associated with chronic sleep deprivation. Before discussing detailed findings of research on the impact of CWWs on sleep, it will be useful to briefly outline what is currently known about the mechanisms governing sleep and the way in which they are affected by shiftworking.

The great majority of species has evolved a mechanism known as the body clock. The body clock enables the organism to anticipate regular cyclical changes in the environment, such as the alternation between light and dark every 24 hours. It does so by helping to regulate a vast range of bodily functions, so that the organism is able to meet the regularly changing demands of its environment. These regular fluctuations in bodily functions are known as circadian rhythms. Human beings have evolved over millions of years as "diurnal" creatures; that is to say, our body clock encourages us to sleep by night and be active by day. It has been suggested that asking someone to ignore their diurnal nature (e.g. when undertaking night work) is rather like asking them to become aquatic!

The body clock is thought to be largely responsible for the poor sleep reported by nightworkers attempting to sleep during the day between shifts. For example, when nightworkers get home from work early in the morning, their body clock is preparing the body for wakefulness. Consequently, nightworkers may find that they cannot sleep. This is despite the fact that they may have been awake for a very long time and are therefore extremely fatigued. Alternatively, they may fall asleep quite quickly when they get home, but do not sleep very well or for very long. Consequently, the nightworker awakes from his or her sleep feeling insufficiently rested. Thus the problems that nightworkers have when trying to sleep during the day are not simply due to it being noisier and lighter during the day, although clearly this will not help. They also stem from the body clock's difficulty in adapting to a nocturnal routine.

It is not only night shifts that are associated with sleep problems. A worker who has an early starting morning shift might have to get up at 04:00 or 05:00 in the morning. It might seem sensible in this case to go to bed very early the night before, in order to compensate for this early start. However, in practice, shiftworkers often fail to do this. This is partly because they do not want to compromise their domestic and/or social life by going to bed especially early, but it is also partly reflecting the influence of the body clock. In the early part of the evening, the body clock is acting to maintain a heightened level of alertness. This prevents the individual from being able to initiate sleep. It is only in the latter part of the evening that the body clock changes its output so as to facilitate sleep. Thus many individuals find themselves unable to advance the onset of sleep in order to prepare for an early start the next day, even if they want to. As a result, early starting morning shifts are often associated with truncated sleeps (Folkard and Barton, 1993).

As well as the problems of trying to sleep in opposition to their body clocks, shiftworkers also experience problems trying to remain awake at times when their body clocks are encouraging them to sleep. Sleepiness is partly a function of the rhythm of the body clock, and partly of the need for recovery that builds up the longer we are awake. The point of maximum sleepiness in the cycle of the body clock occurs in the early hours of the morning — approximately 03:00 or 04:00. When this influence is combined with the effects of inadequate sleep prior to the night shift, the urge to sleep can become literally irresistible. The potential implications for the performance and safety of shiftworkers who are fighting the urge to sleep while on shift are obvious. However, there is also a substantial body of evidence to suggest that prolonged exposure to fatigue and inadequate sleep may have negative impacts on the long-term health of shiftworkers.

1.7 Methodological issues

There are a number of methodological issues which need to be borne in mind when considering the evidence to be reviewed here. The popularity of CWWs means that care must be taken when interpreting evidence gathered from the self-reports of workers on CWW schedules. There is a danger that the benefits of CWWa will cause workers to overlook, or possibly even deliberately underplay, the disadvantages of CWWa, in order that they may continue on their preferred CWW schedule. This is not to say that self-report data should be ignored. For one thing, subjective opinions reflect factors that will have a significant bearing on how successful the implementation of a new shift schedule will be. Secondly, it is very risky for researchers to assume the existence of "hidden" psycho-social entities (e.g. unreported stress) without good empirical evidence. Thirdly, from a practical perspective, objective data on the impact of CWWs are relatively rare. Thus we would likely be placing unnecessarily strict limitations on ourselves if we were to confine ourselves to evaluating CWWs purely on the basis of objective data, which are themselves not without problems of interpretation. Nevertheless, a review of research on the impact of CWWs should try to avoid over-reliance on subjective data where possible.

Another difficulty is that introducing CWWs will almost inevitably mean several features of the shift system changing simultaneously. For example, compressing the working week often involves extending shift length from eight to 12 hours. However, it will also probably mean changing the number of shifts worked before a rest day, the amount and distribution of recovery time during the shift cycle, the timing of sleep periods, etc. Thus it becomes difficult for the researcher to say with any certainty whether any effects of the change are due to either the increase in shift length, the reduction in number of shifts per cycle, or whatever. This, in turn, makes it more difficult to recommend the best way to design a CWW schedule.

In field studies, the experimental implementation of a new shift system is often accompanied by changes in other aspects of the work environment. For example, it may be necessary to reorganize aspects of the job to fit with the new shift patterns. Alternatively, extra managerial support may be provided in order to ease the transition to the new shift pattern. In order to study the effects of CWWs, we need to be able to attribute any effects (e.g. improvements in morale) exclusively to the new shift system, rather than, say, changes in the way management treats the workforce. If it is not possible to make this distinction, then the study has confounded the change in shift system with the change in management style. To take another example, a group of workers may self-select themselves into a trial of CWW, e.g. by vote. Workers who chose to work CWWs may not be representative of the larger workforce. There may be particular features of this group of workers which make them more suited to working CWWs than the rest of the workforce, e.g. their age, domestic circumstances, length of commute, etc. Hence they may show less ill-effects of CWWs than a more representative sample of the workforce would. Alternatively, a worksite may be selected for a CWW trial for operational reasons. Again, these operational factors may have significant bearing on the outcome measures. For example, the group that is selected to trial CWW may do work that is less demanding and is thus better suited to longer shifts.

Laboratory studies should be able to eliminate many of these potential confounds. However, even a laboratory comparison of a CWW system with a “conventional” system will have difficulty in separating out the effects of shift length from, say, the number of consecutive shifts worked in a cycle, or the distribution of rest periods, etc. Moreover, the interpretation of laboratory-based findings will be tempered by the fact that laboratory settings are highly artificial. Thus behaviour that is observed in the laboratory may not necessarily be the same that would be observed in the workplace.

Many stress-related problems, particularly chronic health effects, tend to develop as a result of prolonged exposure to a stressor over several months or years. Hence it is important to allow time for the impact of a new work schedule to manifest itself. Similarly, when considering employees’ responses towards a new system it is important to allow time for an initial period of adjustment, while the system “beds-in”. Employees’ attitudes towards the new system may fluctuate quite substantially (either positively or negatively) in the first few months of a new work schedule. Hence it is important to allow sufficient time for teething troubles to be eliminated and for any “honeymoon period” to pass. There is no clearly established standard interval for the measurement of post-implementation effects. As a rule of thumb, researchers should be especially cautious when interpreting measures taken less than six months from the implementation of a new work schedule. It is arguable that chronic health effects may not manifest until years after implementation of a new schedule. However, very few longitudinal studies have examined CWWs over such prolonged periods. Moreover, very long-term studies have particular difficulty controlling for a broad range of extraneous factors that may confound a comparison over such a long period, e.g. changes in health and safety management practise, provision of health care, etc.

Cross-sectional studies sample data at just one point in time. Thus they are more likely to involve the comparison of one group working a CWW schedule with another group who works a conventional schedule. Cross-sectional studies have particular methodological limitations which affect the interpretability of their results. The researcher needs to ensure that the groups on the different shift systems are as similar as possible to each other in every other respect that could affect the outcome variables. This will include both the individual characteristics of the members of each group, the type of work they are doing, and so forth. These other variables are “extraneous variables”. Failure to ensure such parity will mean that the comparison is confounded by such extraneous variables.

While longitudinal studies are generally considered methodologically superior, it could be argued that cross-sectional studies have some potential advantages. For example, the findings of at least some cross-sectional studies may be less influenced by the respondents’ attempts to paint a more positive picture of the shift system they prefer. In studies where the respondents are working well-established schedules, the comparative nature of such studies may be less apparent to respondents, unless it has been made explicit to them by the researchers. Unfortunately, it is rarely possible to know whether the respondents will have been aware of the purposes of the study in which they have taken part.

Particular care is needed when comparing between different shift lengths that the overall length of the working week is the same on both schedules. Clearly, a comparison that confounds longer shifts with a longer working week cannot be viewed as studying the effects of compressing the working week. Longitudinal studies of a change in shift length are less likely to make this confound, although it is possible.

1.8 Outline of the review

In the sections that follow, we will begin by examining the impact of CWW schedules on sleep and recovery (section 2.1). This will then lead us onto an examination of the associations between CWW schedules and fatigue. Initially we will consider the acute effects of CWWs on productivity and performance (section 2.2), as well as fatigue and alertness (section 2.3). This will lead us into a discussion of the impact of CWWs on safety and accident risk (section 2.4). Then we shall turn to consider chronic effects related to CWWs. These are effects that are not related to particular points within the shift cycle, but instead are observed as overall differences in comparisons between CWWs and conventional shift systems. In particular, we will focus upon the potential long-term effects on health (section 2.5). We will then go to consider the impact of CWWs on absenteeism and turnover (section 2.6), followed by job satisfaction and workers' attitudes towards, and preferences for, CWWs (section 2.7). This will be followed by discussion of the role of individual differences in determining the effects of CWWs (section 2.8). There then follows a consideration of the particular risks of overtime and moonlighting when working CWWs (section 2.9). Next, we will discuss the limited evidence regarding very long shifts in CWW schedules (section 2.10). Finally, we will consider CWWs within the context of developing countries (section 2.11). However, as we shall see, empirical evidence in this last regard is in very short supply.

The approach of this review, as just outlined, is intended to simplify the presentation and digestion of a large range of research findings that have adopted a panoply of approaches, designed to address a broad range of inter-related questions. In practise, the issues, and the studies that address them, do not always fall neatly into such categories. Thus it is inevitable that there will be some crossover between the sections that follow. The empirical studies cited in the text are summarized in a set of three tables presented in the appendix. Table 1 describes the field studies of CWWs that involve extended shifts. Table 2 describes the field studies that have examined quick returns. Table 3 describes investigations of CWWs that have been conducted in the laboratory. The tables do not include studies that do not directly compare the effects of CWWs with "conventional" schedules, nor do they include meta-analyses or other studies based on the aggregation of previously published data.

2. Research findings

2.1 Sleep and recovery

A number of studies have found that 12-hour shift systems result in better sleep than eight-hour shift systems. This seems to be because the CWW schedule affords a better "fit" with workers' circadian rhythms, as well as with their social and domestic routines. Consequently, shiftworkers who change from an eight- to a 12-hour shift system may not only report improved sleep, but also that they find it easier to make the fit between their work schedule and non-work activities, e.g. meal times and social, domestic and recreational activities. For example, in their study of police officers, Peacock et al. (1983) reported that officers were able to maintain a normal diurnal sleep pattern for 75 per cent of the new shift cycle.

2.1.1 Questionnaire surveys

Several recent questionnaire surveys have reported either neutral or positive effects of CWWs on sleep. Duchon et al. (1994) studied mine workers who changed from eight- to 12-hour shifts. They found that the large majority of workers reported improved sleep following the change. Prunier-Poulmaire et al (1998) reported that customs officers who worked 12-hour shifts had better sleep than colleagues working either six- or eight- hour shifts. Tucker et al. (1998a, 1998b) reported a cross-sectional survey of industrial workers in 17 companies, in which 12-hour shifts were generally associated with longer, better quality sleeps. Makowiec-Dabrowska et al. (2000) described a comparison of nurses working either eight- or 12-hour day shifts, in which longer shifts were associated with longer sleeps. Johnson and Sharit (2001) reported longer sleeps among a group of production workers, following the change from an eight- to a 12-hour system.

However, there are exceptions to this generally positive trend. In a survey of chemical workers, Tucker et al. (1996) found little difference between the sleeps of eight- and 12-hour shiftworkers that could be attributed to shift length. L. Smith et al. (1998a) studied police officers who changed from eight- to 12-hour shifts. There were no effects on sleep, fatigue or alertness that related directly to the change in shift length. Heslegrave et al. (2000) reported no effects on sleep duration of a change from nine- to 12.5-hour shifts at a nuclear power station. Other studies have reported negative effects of CWWs on sleep. A study of female electronics workers in Singapore found that 12-hour shiftworkers reported shorter sleeps than a control group of eight-hour workers, although there were no differences in the proportion of participants reporting sleep problems (Chan et al., 1993). Similarly, a study of intensive care unit nurses found that 12-hour shifts were associated with a higher level of general sleep disturbance, compared to eight-hour shifts (Iskra-Golec et al., 1996). Finally, Havlovic et al. (2002) reported a range of negative effects of CWWs, including increased interference with sleep, among a large sample of Canadian nurses. In the latter study, the effects were only reported by nurses working rotating shifts, while no such effects were reported for non-rotating CWW schedules.

The contrasting findings give us our first indication that the impact of CWWs is a complex issue. There may be particular reasons why the last three studies described above produced negative outcomes. The negative findings reported by Chan et al. (1993) may be linked to the climate of Singapore. Kogi et al. (1989) reported that the implementation of a 12-hour shift system in many industries in Singapore in the early 1980s had to be abandoned due to the negative effects on workers' well-being and productivity. The problems were ascribed to the workers being unable to get sufficient sleep due to the hot climate and daytime noise. Iskra-Golec et al. (1996) ascribed their negative findings to the effects of prolonged exposure to the particularly emotional demands of working in intensive care. Finally, Havlovic et al. (2002) found that negative effects were unique to CWW schedules that featured rotating shifts. Their findings are in accordance with earlier comparisons of nurses working permanent versus rotating shifts (e.g. Barton et al., 1995b). It was suggested that permanent shifts reduce disruption to the circadian system by facilitating circadian adaptation.

2.1.2 Sleep diary studies

All of the above studies relied on the single administration of a self-report questionnaire in order to gather sleep data for each type of shift system. A more methodologically robust approach is exemplified by field studies conducted in the energy industry by Rosa and colleagues (Rosa and Colligan, 1989; Rosa, 1991; Rosa and Bonnet, 1993). Participants kept a sleep diary throughout their shift cycle, providing self-report data on their sleep before every shift, over the five weeks of the test schedule. Greater sleep disruptions and shorter sleeps were reported after the change from eight- to 12-hour shifts. These deficits persisted in the 3.5-year follow up of the first study (Rosa, 1991).

A longitudinal study by di Milia (1998) examined the change from a slowly rotating eight-hour shift system to a rapidly rotating 12-hour system by a small sample of electricians working in a coal mine. In common with Rosa and colleagues, sleep data were collected at the start of each shift, with participants providing sleep data for a complete shift cycle. While there was no overall change in sleep length, sleep was redistributed throughout the cycle. Shorter sleeps were taken on the night shift and longer sleeps taken on day shifts and rest days. The effects on sleep were ascribed primarily to the change in speed of rotation, rather than shift length. Despite the redistribution of their sleep, workers preferred the 12-hour system, because of benefits to non-work life.

In contrast, several sleep-diary studies have identified either neutral or positive effects of CWWs involving 12-hour shifts. A longitudinal study of a change from a slowly forward rotating eight-hour system to a rapidly rotating 12-hour shift system at three sewage treatment plants identified no effects on measures of sleep quality or tiredness (P. Smith el al., 1998). The previously mentioned study of police officers reported improvements in sleep quality and quantity following the change to 12-hour shifts (Peacock et al., 1983). A study by Mitchell and Williamson (2000) reported that a change from eight- to 12-hour shifts by a sample of power station workers resulted in improvements in perceived sleep quality, with less broken sleep patterns being reported, and less use of sleep aids (e.g. alcohol).

Axlesson et al. (1998) took the unusual approach of examining power plant workers who worked eight-hour shifts during the week and 12-hour shifts at weekends. This approach eliminated many of the potential confounds commonly associated with more conventional approaches. They found that 12-hour day shifts were associated with longer sleeps than eight-hour shifts. There was no effect of night shift length on sleep.

Lowden et al. (1998) reported on a change from an eight- to a 12-hour shift system among a sample of chemical plant control room operators, with a group of day workers serving as a control group. Positive effects of the change were observed in a range of self-report measures, including items relating to sleep quality and duration. In addition, participants' sleep patterns were measured using activity monitoring devices ("actigraphs"), worn on the participants' wrists. Participants also recorded their perceived sleep quality upon each awakening. Analyses of these data indicated no substantial effects of the introduction of 12-hour shifts on either sleep or alertness. However, it was noted that the shift system change had been from an unpopular eight-hour shift system that included quick returns and backward rotation, with up to four consecutive night shifts being worked in row. By comparison, the introduction of the 12-hour system gave workers more rest days and more weekends off. It was noted that the positive findings were in contrast to those of the earlier field study by Rosa and Bonnet (1993). It was suggested that the timing of shift changeovers in the later study were more appropriate with regard to sleepiness (06:00 and 18:00, as opposed to 08:00/09:30 and 20:00/21:30). It was also noted that in the earlier study, sleep was much shorter on some days towards the end of the week. Moreover, the work involved was more physically demanding in the earlier study. The system in the earlier study also provided fewer rest days than the system studied by Lowden et al.

While the majority of studies mentioned so far have focused on a change to 12-hour shifts, Paley et al. (1998) reported a study of fire fighters who changed from a slowly rotating eight-hour schedule to a rapidly rotating one made up of ten-hour days and 14-hour nights. No effects on sleep durations were found.

2.1.3 The effects of shift start and finish times

Several comparisons involving CWW schedules have identified effects on sleep that are attributable, at least in part, to differences in the start and/or finish times of particular shifts (Tucker et al., 1996; Aguirre et al., 2000; Hossain et al., 2004). Thus for example, Hossain et al. (2004) reported a change from an eight- to a ten-hour shift system in which the start time of the day shift was earlier by one hour (to 07:00) and the finish time of the night shift was earlier by five hours (to 03:00). These changes had the effect of reducing the length of sleep on the day shift and extending the length of sleeps on the night shift. This can be explained in terms of the circadian rhythm of sleep propensity (see above). Advancing the start of a morning shift tends to result in the truncation of sleep. This was demonstrated by Folkard and Barton (1993) who examined the time at which shiftworkers went to sleep the night before early starting morning shifts. They found that, on average, shiftworkers advanced their sleep onset the night before by just 5.3 minutes for each hour earlier that their shift started. On the other hand, advancing the end of the night shift enables the shiftworker to initiate sleep before the decline of sleep propensity at the end of the night, thereby promoting better sleep (Keklund and Åkerstedt, 1995; Tucker et al., 1998a).

2.1.4 Quick returns

As noted above, the working week may be compressed by simply reducing the interval between the end of one shift and the start of the next, without any need to change the length of the shifts. However, the issue of quick returns has received relatively little attention in the CWW literature. Quick returns have been associated with shorter sleeps (Kurumatani et al., 1994; Axlesson et al., 2004). Indeed, evidence suggests that even the difference between a nine-hour and an eight-hour quick return can have a significant impact on sleep quality, mood and fatigue (Nesthus et al., 2003). The impact of quick returns on sleep duration is likely to be exacerbated by long commuting times and other factors, such as family responsibilities (Kogi, 1982). However, quick returns are not necessarily associated with more disturbed sleep (Barton and Folkard, 1993; Axlesson et al., 2004). Nevertheless, even in the absence of negative effects on sleep, there is evidence (albeit limited) that quick returns are associated with more rapid declines in self-reported alertness across the shift (Tucker et al., 2000).

2.1.5 Conclusions

In summary, there is mixed evidence about the impact of CWWs on sleep. Several studies suggest an overall improvement in sleep with the move from eight- to 12-hour shifts. This seems to be because the latter often allow for a greater number of nights of “normal” sleep over the cycle. However, some studies that have examined sleep patterns in detail have identified decrements in sleep, particularly associated with 12-hour night shifts.

The impact of a shift schedule on sleep is likely to depend on the complex interaction of a wide range of factors, including both schedule design and job characteristics. Thus, for example, a night shift that finishes relatively early (e.g. 06:00) will promote better day-sleeps than one that finishes relatively late (e.g. 08:00) (Tucker et al., 1998a; Hossain et al., 2004). The pattern of findings outlined thus far would suggest that a well-designed CWW schedule that avoids quick returns may not lead to chronic sleep deprivation and the associated long-term health problems. However, it also suggests that CWWs are more likely to be associated with acute problems and, in particular, the maintenance of adequate performance, alertness and safety at certain points within the shift cycle.

2.2 Productivity and job performance

2.2.1 Industrial studies

A number of early studies in industrial settings sought to identify the impact of CWWs on productivity. They produced a mixture of positive, neutral and negative findings (Latack and Foster, 1985; Rosa, 1995). Accordingly, a recent meta-analysis found no relationship between CWWs and productivity, although CWW schedules were associated with improved supervisor ratings of job performance (Baltes et al., 1999). One factor that may be crucial in this regard is the number of successive shifts that are worked in a row. Baker et al. (1990; cited by L. Smith et al., 1998b) found that when five to seven shifts were worked consecutively, there was a significant decline in productivity, compared to when the same number of eight-hour shifts were worked. This evidence is consistent with the view that rotating shift systems should minimize the number of consecutive shifts, particularly night shifts, in order to minimize the build up of fatigue (e.g. Knauth, 1996). Interestingly, this study appears to be unique in showing that the positive relationship between the number of consecutive shifts and fatigue is stronger for 12-hour shifts than it is for eight-hour shifts.

One of the few recent studies to relate CWWs directly to measures of productivity and work performance in an industrial setting was reported by Williamson et al (1994). They studied a sample of computer operators who changed from a system which involved working a combination of eight-hour shifts during the week and 12-hour shifts at weekends, to one that involved only 12-hour shifts. The new system had no impact upon work quality and productivity (i.e. operator errors), while measures of subjective well-being improved.

2.2.2 Studies of health-care workers and police officers

Several studies have identified negative impacts of CWWs on job performance in health-care settings. Here the primary concerns tend to be the allocation of human resources and effective, economic provision of care. A study of nursing staff reported negative effects of a change to 12-hour shifts upon patient care, especially in latter part of shift (Todd et al., 1991). The same group of researchers also reported that nurses took more unofficial breaks on the 12-hour system, presumably as a means of pacing their work on the extended shifts. Patient contact declined as a result. In addition, it was also reported that learning experiences of student nurses declined under the 12-hour system (Reid et al., 1993). More recently, a comparison of nurses working either eight- or 12.5-hour day shifts found the longer shifts to be associated with poorer clinical performance (Fitzpatrick et al., 1999). Havlovic et al. (2002) found that nurses on CWWs that involved rotating shifts reported providing lower quality service to their patients. However, no such effects were found for nurses on non-rotating CWW schedules.

In contrast to these negative findings, Mills et al. (1983) found no effects on overall job performance among a small sample of nurses who changed to 12-hour shifts. However, there were increases in both self-reported fatigue and errors on tasks involving grammatical reasoning and medical record reviewing. Similarly, Dunham et al. (1987) reported a study of health workers which included nursing staff, in which the introduction of a CWW resulted in improved supervisor ratings of workers' job performance.

There is also some evidence that CWW schedules may be unsuited to the work routines of police officers: deCarufel and Schaan (1990; cited by Amstrong-Stassen, 1998) reported that 12-hour shifts caused more difficulties in following up investigations if they were not completed by the end of the shift, in contacting officers concerning their cases and in finding volunteers for transfers to positions on days. However, Peacock et al. (1983) reported that police officers in their study viewed the effects of CWWs on their work routines as positive.

2.2.3 Factors other than fatigue

The inconsistency among these findings suggests that the impact of CWWs on productivity will be occupation specific. However, we have also noted inconsistencies within occupational settings (e.g. between the studies in health-care settings), which may be due in part to methodological differences, such as the use of various measures of job performance. In any case, productivity and job performance are rather crude measures. A primary focus of CWW research has been to identify the potential impact of fatigue on work performance. However, work performance is influenced not only by fatigue, but also by a range of other factors. These include the workers' motivation and morale. The benefits associated with CWWs may result in improved morale. The extent to which motivation influences outcomes (e.g. work performance) will vary from one setting to another. It will depend upon, among other things, the characteristics of the shift rota and the type of work being performed (L. Smith et al., 1998b).

CWW schedules can influence other work-related factors that, in turn, can affect job performance and organizational effectiveness: for example, job performance may be enhanced on CWW schedules by improvements in communication at the handover of the shift.

2.2.3.1 Communication

Wedderburn (1996) notes that, relative to an eight-hour system, workers on a 12-hour system are more likely to hand their shift back over to the same colleagues from whom they took over at the beginning of the shift. This is likely to facilitate better communication and thus more efficient working within the organization. However, other aspects of CWWs may degrade communications and thus performance. For example, a CWW schedule may cause a reduction in the amount of overlap between the work hours of the shiftworker and their managers (Wilson and Rose, 1978; P. Smith et al., 1998). Moreover, extended absence from work may result in greater need for reorientation on return to work. Johnston et al (1989; cited by L.Smith et al, 1998b) reported that nurses had become more 'detached' from their job after an extended absence and thus needed greater reorientation. They found that accuracy on a cognitive task was lower on 12-hour shifts, particularly on the first day back. This suggests that the choice of work tasks should take into account lower performance capacity at the start of shift sequences, where reorientation is a problem (L. Smith et al., 1998b). While reorientation may be more of a problem after extended blocks of rest days, it may be less of a problem between successive shifts of a CWW schedule. This is because CWWs tend to involve shorter intervals between successive shifts (e.g. 12 hours on a 12-hour system, as opposed to 16 hours on an eight-hour system).

2.3.4 Conclusions

There is little consistent evidence from industrial settings of CWW schedules causing decrements in job performance or productivity. However, some studies have identified negative effects on the work of nurses. There is conflicting evidence regarding the impact of CWWs on the work routines of police officers. However, job performance and productivity are affected by a wide range of factors and this may be one of the reasons for the mixed findings in relation to the effects of CWWs. Twelve-hour shifts can be associated with improved shift handovers. However, they can also result in workers becoming more "detached" from their work after an extended break between shift cycles. Consequently, it may take them longer to readjust to, and reacquaint themselves with, the work environment on the first shift back after a block of rest days.

2.3 Fatigue

2.3.1 CWW schedules that involve longer shifts

2.3.1.1 Self-reported fatigue and sleepiness

A number of researchers have reported heightened levels of self-reported fatigue and lower levels of alertness towards the end of extended shifts. For example, Ugrovics and Wright (1990) reported heightened fatigue among nurses in the last hour of the first 12-hour shift. Heslegrave et al. (2000) studied the change from a nine- to 12.5-hour shift system in a nuclear power plant. Workers reported greater perceived performance impairment (memory attention and alertness) at end of the 12-hour day and night shifts, as well as more fatigue, lapses in attention, incidence of shift work paralysis (i.e. physical paralysis while on shift, usually occurring in the early hours of the morning; Folkard et al., 1984) and problems driving home e.g. near miss, falling asleep, lapses of attention.

Tucker et al. (1998b) examined variations in self-rated alertness as a function of time of day among industrial workers on eight- and 12-hour shifts. While there were no overall differences in alertness between the two groups, the 12-hour workers were less alert in the afternoon, but somewhat more alert in the morning and late evening. The afternoon difference was partly attributed to differences in elapsed time-on-shift (the eight-hour workers started the afternoon shift at either 14:00 or 15:00; the 12-hour day workers started at either 06:00 or 07:00). It was also noted that the differences in alertness reflected differences in sleeps reported by the two groups prior to shift. Similar patterns of alertness were also observed in an earlier comparison of eight- and 12-hour chemical workers (Tucker et al., 1996).

Some studies have found no effects of the change to CWWs on self-reported fatigue and alertness. Washburn (1991) found no differences in alertness between nurses working either eight- or 12-hour shifts. Aguirre et al. (2000) studied a group of paper-mill workers who changed from an eight-hour system to a more rapidly rotating 12-hour shift system, following a vote. Alertness levels were logged three times every shift for a month and no effect regarding the change was found. A study of fire fighters who changed to a ten-hour day/14-hour night CWW schedule was reported by Paley et al. (1998). They found that, in keeping with the absence of effects on sleep duration, there was no impact of the new schedule on sleepiness and mood ratings taken at multiple points throughout each shift. P. Smith et al. (1998) reported that changes from an eight- to 12 hour shift system among sewage workers had no impact on self-reported sleep quality, tiredness or fatigue on either day or night shifts.

In summary, studies of self-reported fatigue on CWW schedules have, once again, shown mixed findings. Differences were more likely to be detected when measures were taken at multiple points throughout each shift and throughout the shift cycle. However, even then, some studies identified no difference. Thus it seem that, as noted above, other factors, such as the particular features of schedule design and the nature of the work, are muddying the picture. Moreover, the interpretation of self-report measures is inherently problematic, for the reasons outlined above.

2.3.1.2 Objective measures of fatigue and sleepiness

We have previously noted difficulties of interpreting either job performance measures or self-report measures of fatigue. It is thus perhaps unsurprising that many of the more recent field studies of fatigue in relation to CWWs have tended to focus upon objective measures. These studies involve fatigue-sensitive behavioural and physical performance tasks, either instead of, or in addition to, self-report measures. In the majority of these studies, multiple measurements of the outcome variables were taken on the various shifts that were worked and at various points throughout each shift. Such an approach makes for more robust findings, and allows for a detailed comparison of the strengths and weaknesses of the CWW schedules under study. Some of these studies seem to confirm self-reports of increased fatigue in 12-hour shifts, particularly in the later stages of the shift. As we will see, effects on performance tend to parallel differences in sleep outcomes, outlined earlier.

2.3.1.2.1 Industrial studies

A series of studies by Rosa and colleagues identified negative effects of CWWs on performance that were paralleled by negative effects on sleep. Initially they reported a laboratory study comparing 48-hour weeks of eight- and 12-hour shifts, using a battery of standard performance tests and self-report scales (Rosa et al., 1985). They found mixed performance effects, together with higher levels of subjective fatigue associated with 12-hour shifts. In the first of their field studies, they examined process-control room operators before, and seven months after, a change from an eight- to a 12-hour shift system. They used the same set of measures as in the laboratory studies, together with sleep and activity logs (Rosa and Colligan, 1989). Decrements in cognitive performance and increased subjective fatigue were observed following implementation of the new system. Daily sleep logs indicated that a one-hour sleep debt had been built up by the end of the working week. However, performance did not decrease over the week, which suggested that some of the disadvantages of the longer work days were off-set by the shorter working week. A follow up study 3.5 years later found that declines in alertness with time-on-shift persisted and reductions in sleep were still apparent (Rosa, 1991). In a subsequent study, they examined the change from an eight- to a 12-hour shift system at a natural gas utility (Rosa and Bonnet, 1993). Again, decrements in performance and alertness were observed towards the end of the 12-hour shift ten months after the implementation of the new system. Sleep loss was most apparent on the 12-hour night shifts. Declines in alertness were most apparent at night, when lowered circadian arousal added to fatigue resulting from hours of work. It has been pointed out subsequently that the 12-hour shift roster included “on-call” periods which may have caused poorer sleeps than on genuine rest days (Williamson et al., 1994).

In contrast, a number of other studies have reported either neutral or positive effects of CWWs on performance, fatigue and alertness. In general, these tend to be the same studies that identified positive effects of CWWs on sleep, noted above.

Peacock et al. (1983) reported no negative effects on alertness among police officers after the implementation of a 12-hour shift system, as well as improvements in sleep and physiological fitness. Axlesson et al. (1998) reported that, in keeping with their finding of no ill-effects of 12-hour shifts on sleep, there were no effects on either cognitive task performance or sleepiness after controlling for extraneous variables. However, it was noted that the work tasks at the weekend (i.e. on the 12-hour shifts) were more passive, thus requiring less effort. Another possible explanation for the lack of difference was that alternation between eight- and 12-hour shifts may be less fatiguing than working permanent 12-hour shifts. Lowden et al. (1998) found no negative effects of a change from eight- to 12-hour shifts on reaction time performance at the beginning and end of shifts. Moreover, self-ratings of sleepiness taken at two to four hourly intervals were lower on the new system. In their field study of a change from an eight- to a 12-hour shift system in a power station, Mitchell and Williamson (2000) found that, in keeping with reported improvements in sleep, workers felt fresher at the beginning and end of the 12-hour shifts. In addition, they found no ill-effects of 12-hour shifts on four out of five performance measures. However, they found that performance on a vigilance task declined over the course of 12-hour shifts, while no such decline was observed on eight-hour shifts. Duchon et al. (1994) reported neutral and positive effects in the majority of a range of fatigue-related measures of behavioural performance and physiological function, as well as improvements in sleep, following a change to 12-hour shifts in a mine. However, workers did report feeling more fatigued on the 12-hour night shift. It was noted that the findings may have been influenced by the fact that the 12-hour workers lodged at the mine site during the work period. This resulted in better sleep between shifts, compared to the eight-hour workers.

The latter finding of no ill-effects of CWWs is perhaps especially surprising, given the highly physically demanding work environment of a mine. Two more recent studies have indicated that the extent of decline in performance associated with extended shifts is dependent upon the nature of the workload. A laboratory study by Rosa et al. (1998) examined the impact of CWWs on musculo-skeletal fatigue in a physically demanding task. In contrast to the findings of their earlier field studies, they found that the shorter working week of the 12-hour schedule did not offset the fatigue associated with longer shifts. Macdonald and Bendack (2000) reported two studies of CWWs, one conducted in the laboratory and the other a field study. While moderate negative effects of 12-hour shifts were observed in a range of behavioural measures, the greatest fatigue effects were associated with long shifts performed under conditions of high workload.

2.3.1.2.2 Health care

A number of researchers have examined the cognitive performance of nurses working CWWs. Todd et al. (1991) found no differences between samples of eight- and 12-hour workers in the performance of a memory and search task. Similarly, Washburn (1991) identified no differences between two groups of nurses working either eight- or 12-hour shifts in their performance of a grammatical reasoning task. However, Mills et al. (1983) found that a change to 12-hour shifts was associated with increased errors in grammatical reasoning and medical reviewing tasks. Similarly, Johnston and Pollard (1991) reported that nurses on 12-hour shifts performed less accurately in letter cancellation and choice reaction time tasks. Such inconsistencies are likely to stem from several sources, including methodological issues (e.g. the type of performance measure used), as well as differences in the characteristics of the job tasks, organizational characteristics and schedules involved.

2.3.1.3 Ten-hour shifts

While traditionally the compression of the working week has taken the form of a change from eight- to 12-hour shifts, a number of studies have considered the less dramatic change from eight- to ten-hour shifts. Volle et al. (1979) compared two groups of factory workers, working either four consecutive ten-hour, or five consecutive eight-hour day shifts per week. They reported no differences in the majority of measures, taken at the beginning and end of the working week, although two measures indicated greater fatigue accumulated over the week, among the CWW group. However, no direct statistical comparisons were reported, and the study did not examine nightworking. A more recent study compared two groups of air traffic controllers (Schroeder et al., 1998). They found no differences in day-shift performance on a battery of cognitive tasks, although again, no measurements were taken on the night shift. Hossain et al. (2004) reported a change from eight-hour to ten-hour shifts in an underground mine. The change resulted in improved cognitive test performance on the night shift. However, it is likely that improvement was largely due to other changes to the schedule that were implemented at the same time (e.g. the change of the shift finish time, from 07:00 to 03:00), rather than shift-length *per se*. In summary, while there is little to suggest a negative effect of compressing the working week from eight- to ten-hours, it is hard to make firm conclusions either way on the basis of existing evidence.

2.3.1.4 Conclusions on shift length effects

Several studies have identified heightened decrements in self-reported and objectively measured fatigue in the later stages of 12-hour shifts. However, the trend is not universal, with some studies finding that the decrement is no greater than in eight-hour shifts. Increases in fatigue towards the end of extended shifts may be greater in high-demand working environments (Macdonald and Bendack, 2000). It has been suggested that the work of Rosa and colleagues' participants was relatively demanding and included on-call work. In contrast, Axlesson et al. (1998) reported that 12-hour shifts were associated with lower work demands than the comparison eight-hour shifts, while Lowden et al. (1998) reported that their participants' work was relatively undemanding. However, the finding of no additional performance decrement in the high-demand environment of a mine (Duchon et al., 1994) runs counter to this argument. The failure to identify a greater decline in this latter study may be accounted for by the fact that the 12-hour workers lived on-site during the shift cycle, unlike the eight-hour comparison group.

As well as workload, it seems that the impact of 12-hour shifts will be determined by other factors such as the nature of the job and also schedule features, e.g. shift start and finish times. While there is little to suggest that ten-hour shifts are substantially more fatiguing than eight-hour shifts, the current paucity of evidence is only able to offer them equivocal support.

2.3.2 Fatigue, rest breaks and recovery

Excessive fatigue occurs when a work schedule does not allow sufficient recovery from work. While it is intuitively likely that an increase in work hours will result in increased fatigue, it is important to remember that CWWs do not involve an extension of the average length of the working week. Thus it is possible that the extra strain experienced in sustaining effort over a prolonged shift may be off-set by the extension of recovery times between shifts. Similarly, the effects of a short interval between individual shifts (quick returns) may be off-set by extended recovery periods between shift cycles. Thus it is the way that recovery is distributed that is one of the key issues in the relationship between CWWs and fatigue.

2.3.2.1 Rest breaks within a shift

Regular rest breaks within the shift can be an effective means of maintaining performance, managing fatigue and controlling the accumulation of risk over prolonged task performance (Tucker et al., 2003; Tucker, 2003). In a review of the impact of extending the duration of shifts, Rosa (1995) recommends that rest breaks should be distributed liberally throughout the shift in order to provide temporary recovery from the task at hand. However, evidence is equivocal on whether rest breaks can mitigate the negative consequences of extending the length of shifts. For example, in a study of nurses cited earlier (Reid et al., 1993), patient contact time actually declined because of an increase in the number of unofficial breaks being taken following the change to 12-hour shifts. Costa et al. (1995) concluded that the extension of nurses' night shifts to ten hours was acceptable, so long as the workload was reduced and sufficient rest pauses were introduced. However, no direct comparison with shorter night shifts was reported. In a study of bus and truck drivers, Harris et al. (1972; cited by Brown, 1994) found that the third three-hourly break did not aid physiological recovery, nor did it arrest an increasing trend in errors that occurred after nine hours of duty. Moreover, a decline in psycho-physiological indexes of alertness continued unabated after the break. Thus it remains unclear whether increasing the number of rest breaks will necessarily be sufficient to counteract the increase in risk associated with the latter stages of a long duty period.

2.3.2.2 Rest between shifts

With regard to rest between shifts, once again there is relatively little empirical evidence to guide best practice. It has already been noted that, from the workers perspective, one of the main perceived advantages of CWWs is the greater number of rest days. It may be presumed that many workers prefer to take these rest days in a single extended span of time away from work (c.f. Patkai and Dahlgren, 1981). However, excessive fatigue has been associated with those 12-hour rotas which include very long spans of rest days and a concentration of long shifts in a short space of time. Wallace and Greenwood (1995) cite examples of systems comprising either six 12-hour shifts worked in eight calendar days, or blocks of seven consecutive 12-hour shifts. It was reported that workers became so exhausted during the span of work that the lengthy time off was largely taken up by the recovery process.

Tucker et al. (1999) compared two groups of industrial workers on 12-hour shifts which differed in terms of the distribution of rest days in the shift cycle. One group worked two day shifts, followed by two rest days and then two night shifts (i.e. a break of 72 hours between the end of the second day shift and the first night shift). The other group worked two day shifts, followed by two night shifts and then four rest days (i.e. a break of 24 hours between the end of the second day shift and the first night shift). The first group (long break between days and nights) reported slightly higher mean levels of alertness and slightly lower levels of chronic fatigue than the second group. There were no effects on measures of physical or psychological health. In this study, neither schedule was especially demanding. Shift systems incorporating longer spans of consecutive shifts may have been more likely to show substantial effects. It was also found that the short break between day and night shifts tended to exacerbate the effects of different shift change-over times. This was confirmed by analysis of sleep diaries that were kept by a sub-sample of the surveyed participants (Macdonald et al, 2000). Early night-to-day shift change-overs were detrimental to sleep on the day shift (due to the truncation of sleep the night before), but beneficial to sleep on the night shift (due to the earlier on-set of sleep after the shift; see above). These differences were more marked among the short-break group.

In contrast to these findings, di Milia (1998) concluded that three or four successive 12-hour night shifts were likely to be preferable to just two. However, this conclusion was based on a comparison between the previous slowly rotating eight-hour system and a replacement 12-hour system that involved working three or four consecutive shifts (combination of days and nights), interspersed with blocks of two rest days. Moreover, it was conceded that the conclusions were based on the findings from a small sample of participants. The recommendation of slower shift rotation runs counter to the recommendations of a number of researchers (e.g. Knauth, 1996). They argue that the number of consecutive night shifts on a rotating system should be kept to minimum, in order to minimize circadian disruption. However, the issue is not without controversy (e.g. Wilkinson, 1992; Folkard, 1992).

Åkerstedt et al. (2000) considered the issue of rest and recovery in the re-analysis of the alertness data from 12-hour shift workers, originally presented by Lowden et al. (1998). They concluded that those who work long sequences of long shifts require three successive rest days for recovery, whereas a sequence of two or three successive 12-hour shifts does not seem to cause accumulated fatigue. They also point out that long periods of night work are likely to promote circadian disruption and are therefore likely to necessitate extended recovery periods, and that one day of recovery is never sufficient.

2.3.2.3 Quick returns

Axlesson et al. (2004) examined recovery in relation to quick returns. They studied a group of workers whose schedule incorporated two quick returns in 36 hours (i.e. an eight-hour night shift, followed by eight hours off, followed by an eight-hour afternoon shift, followed by nine hours off, followed by an eight-hour morning shift). They found that quick returns were associated with reduced sleep. However, they also noted that a single recovery sleep after the shift sequence was sufficient for recovery. Their conclusions were consistent with previous findings that the effects of quick returns are primarily acute in nature (Barton and Folkard, 1993; Tucker et al., 2000). It was also noted that, while the majority of the sample (70 per cent) were satisfied with this form of CWW, the minority who were dissatisfied with the schedule were more vulnerable to the quick returns, both in terms of sleep sufficiency and alertness on shift.

2.3.2.4 Conclusions on rest breaks and recovery

It seems likely that the incorporation of frequent, short rest breaks within extended shifts will help mitigate some of their negative effects on fatigue. However, further research is needed to establish clear guidelines for the most effective way of scheduling rest breaks within a shift (e.g. frequency, timing and duration of breaks). Similarly, there is insufficient evidence to draw firm conclusions about the distribution and duration of rest between shifts, within a shift cycle. Limited evidence suggests that the number of successive long shifts should be kept to minimum, particularly when nightworking is involved. A small number of studies have indicated that quick returns should be avoided, because of their negative effects on fatigue and alertness on shift.

2.3.3 Conclusions on fatigue

There is a broad range of often conflicting findings regarding the effects of CWWs on fatigue and performance. We have noted previously that self-report measures must be treated with caution. Moreover, the interpretation of job performance data is also problematic. However, even findings based on “objective” behavioural and physical performance measures fail to provide a consistent trend on which to base firmer conclusions.

However, one consistency to emerge from the findings was that effects on fatigue and/or performance tend to parallel effects on sleep. Improvements in sleep were either associated with positive changes in performance/fatigue-related outcomes (Peacock et al., 1983; Duchon et al., 1994; Williamson et al., 1994; Tucker et al., 1998a; Mitchell and Williamson, 2000) or neutral effects (Duchon et al., 1994; Mitchell and Williamson, 2000). Sleep decrements were largely associated with negative fatigue-related outcomes (Kogi et al., 1989; Rosa et al., 1989; Rosa; 1991; Rosa and Bonnett, 1993; Tucker et al.; 1998a; Havlovic et al., 2002). Exceptions to this trend were limited (Mitchell and Williamson, 2000). In contrast, there are relatively few consistencies in the relationships between job performance and cognitive task performance (Todd et al., 1991; Mills et al., 1983), or between job performance and self-reported fatigue (Mills et al., 1983).

In conclusion, it is evident that the impact of CWWs will depend on the specific features of the shift system (e.g. number of consecutive shifts, start and finish times of shifts, distribution of rest, etc). It will also be influenced by the nature and demands of the job, and also by the individual characteristics and circumstances of the worker. The fact that several studies have identified heightened fatigue towards the end of 12–hour shifts is a particular cause for concern. It has potentially significant implications for the impact of CWWs on alertness and accident risk.

2.4 Safety

Evidence of decrements in performance and alertness in the final hours of extended shifts have lead several authors to voice concerns about the implementation of CWWs, particularly within safety-critical industrial processes and services. Moreover, it is a concern that is shared, at least in some quarters, by shiftworkers themselves (Folkard and Hill, 2001). However, the review by L. Smith et al. (1998b) notes that few early studies provided direct evidence of increased risk, at least in respect of 12-hour shifts.

2.4.1 Methodological issues

Before going on to examine the research in detail, the reader should note the following "health warning": caution is required when interpreting accident data of the kind reported in these studies. There are several difficulties in conducting this type of epidemiological research, as highlighted by Nachreiner (2001). Firstly, it should be remembered that the type of accidents that are recorded (e.g. whether it is only severe accidents or all accidents and near-misses) may impact on the patterns observed. Secondly, the data may contain systematic reporting errors that could bias the results. For example, a worker who dislikes a particular shift system may be more inclined to report minor incidents that they otherwise would not. Alternatively, unsuccessful implementations of schedules may go unreported, as the organizations involved may be less willing to collaborate with researchers. Thirdly, the analyses must accurately control for variations in other factors that may vary systematically with variations in shift length or elapsed time-on-shift e.g. the type of work that is undertaken at different times of day. Finally, accidents are rare events, which means that statistical techniques will sometimes not be sensitive enough to detect underlying trends, unless a large dataset is available, e.g. one collected over many years.

2.4.2 Extended shifts

2.4.2.1 Comparisons involving CWW schedules

In a survey of 50 worksites, Wilson and Rose (1978) found either no increase, or a decrease in risk associated with 12-hour shifts. Laundry and Lees (1991) compared accident risk before and after the change from eight- to 12-hour shifts, and found a decrease in minor accidents, but an increase in off-job major accidents. A suggested explanation for the latter finding was that increased opportunities for leisure activities resulted in an increased exposure to risk in such activities. However, the comparison was made over a period of ten years, when many other changes (e.g. safety culture, technology) may have counteracted or masked any underlying increases in risk (Nachreiner, 2001). In a study of two companies which changed to 12-hour shifts, Pollock et al. (1994) reported no overall change in risk, although severe incidents increased in one company while minor incidents decreased. The different patterns were ascribed to the different work practices involved in the two companies, as well as possible differences in safety culture (L. Smith et al., 1998b).

More negative conclusions were reached by Kelly and Schneider (1982) in a study conducted for the nuclear industry. In the absence of appropriate data from actual 12-hour shifts, they extrapolated from previous research that had examined performance over shorter periods of time. Their analysis indicated a doubling of human error with 12-hour shifts and the researchers recommended against 12-hour shifts. However, according to L.

Smith et al. (1998b), 12-hour shifts were nevertheless subsequently implemented, without adverse effects on incidents.

Since the review by L. Smith et al. (1998b), just two studies have been published of which the author is aware, which directly examine the impact on accident risk of CWWs incorporating extended shifts. Johnson and Sharit (2001) reported the change from an eight- to a 12-hour shift system among a group of production workers. They found no change in occupational injury rates following the change, based on analysis of records two years prior to and eight years after the change. However, the comparison is likely to have been confounded (Nachreiner, 2001). Firstly, the change coincided with a reduction in the degree of manual handling involved in the job, which may have reduced risk. Secondly, individuals were largely able to choose whether or not to change shift systems. Consequently, the comparison involved different samples of workers who may have been differentially at risk of having an accident.

Baker et al. (2003) examined accident data collected at a mine that changed to a CWW schedule. The change was from a slowly backward rotating eight-hour system, to a more rapidly rotating 12-hour shift system in which overtime working was restricted. No effects on accident risk were detected, other than a decrease in one section of the mine. It was noted that that the change in shift system coincided with a reduction in the workforce and a pay rise for the remainder.

2.4.2.2 Conclusions on comparisons involving CWW schedules

Thus, despite concerns raised by findings of decrements in performance towards the end of 12-hour shifts (e.g. Rosa and Colligan, 1989), there appears to be little conclusive evidence that CWW schedules involving 12-hour shifts result in increased risk. However, as noted above, there are several methodological difficulties associated with studies of accident rates which may have served to obscure underlying trends (Duchon and Smith, 1993). Thus the absence of effects of 12-hour shifts in these studies may have been due in part to other changes that confounded the change to CWWs, e.g. changes in management practice. Moreover, the motivation associated with a preferred schedule may temporarily improve performance and thus safety, but this effect may not last over the longer term. Thus it is important to note, particularly when considering matters of safety, that a lack of hard evidence is not necessarily synonymous with the absence of any actual impact, all other factors being equal.

2.4.2.3 The relationship between risk and elapsed time-on-shift

Despite the absence of direct evidence linking the implementation of CWWs with increased risk, there is a growing body of evidence regarding the relationship between shift length and risk that deserves particular attention. Nachreiner (2001) discusses research that demonstrates positive associations between elapsed time-on-shift and accident risk. These studies are based on aggregated data taken from a variety of sources (e.g. national statistical databases: Åkerstedt, 1995; Hanecke et al., 1998; Nachreiner, 2001; previously published studies: Folkard, 1996). The relationship generally takes the form of an exponential curve, with some estimates (Åkerstedt, 1995; Folkard 1996) suggesting an approximate doubling of risk in the twelfth hour of work, compared to the mean risk during the normal eight-hour working day. The precise point at which this exponential rise occurs differs between estimates. Some (Folkard 1996; Hanecke et al., 1998) have it beginning after seven to eight hours of work, while others (Åkerstedt, 1995; Nachreiner, 2001) identify a marked increase after nine or ten hours of work. There are several discrepancies between the studies which could account for the differences. One possibility, suggested by a comparison of the findings of Hanecke et al. (1998) and Nachreiner (2001), concerns the severity of the accidents. The former analysis deals with accidents resulting in more than three days' lost time, while the latter is based on fatal accidents. It is speculated that, in the early stages of fatigue (i.e. around eight hours), workers are able to compensate for errors that would otherwise have serious consequences, while in the more advanced stages of fatigue, they are not. Regardless of the precise point at which risk begins its exponential risk, it seems safest to conclude that extending the daily working hours beyond eight hours is an inefficient strategy for optimizing performance, given the associated increase in accident risk. However, Nachreiner (2001) also notes an important caveat to the interpretation of such analyses. He notes that an extended shift that is worked as part of overtime may be more risky than an extended shift that is part of a well-designed shift system that incorporates adequate rest. It is not clear to what extent the data on which these analyses are based are derived either from overtime working or CWW schedules.

2.4.2.4 The relationship between shift length and number of consecutive shifts

Even if extended shifts that feature in CWWs are associated with increased risk, it is also possible that other features of CWWs may mitigate the increased risk. CWWs tend to involve fewer shifts being worked in a shift cycle. Accident risk increases with the number of successive shifts worked in a row, particularly when the shifts are worked at night. Thus, while an increase in shift length will serve to increase the level of risk over a block of shifts, a concomitant reduction in the number of successive shifts worked will influence risk in the opposite direction, particularly if they are night shifts (Folkard and Tucker, 2003). Thus it is conceivable that the impact of extended shifts may be off-set by restricting the number of consecutive shifts worked in a row. However, studies of accident risk in CWWs have yet to determine fully the nature of the relationship between shift length and number of shifts worked consecutively before a break.

2.4.3 Quick returns

While many researchers have focused upon the risk implications of extending the shift, few have considered risk in relation to quick returns. We noted previously that quick returns are associated with truncated sleep and hence a reduction in the opportunity for recovery between shifts. However, it was also noted that evidence regarding the impact quick returns is quite sparse, with only limited evidence of their negative impact of upon alertness (e.g. Tucker at al., 2000). The one study that the author is aware of that has examined the relationship between quick returns and accident risk found only limited evidence of an association (Macdonald et al., 1997), suggesting a need for further research in this area.

2.4.4 Conclusions on safety

There is little direct evidence of an increase in risk resulting from a change to CWWs. However, evidence from several strands of research suggests that this apparently benign picture should not be accepted at face value. Evidence from field studies suggests increases in fatigue towards the end of extended shifts in at least some settings. In accordance with this trend, there is a growing body of evidence that accident risk increases with elapsed time-on-duty. Moreover, the evidence suggests that risk increases dramatically in the latter stages of shifts longer than eight hours in duration. It is possible that other features of CWWs (e.g. reduced number of consecutive shifts) may counteract the increase in risk associated with longer shifts. This may account for the lack of direct evidence of increased risk in CWW schedules, noted above. Finally, there is an urgent need for research to examine the impact of schedules that allow limited recovery (e.g. quick returns, inadequate rest breaks within shift), in order that minimum standards may be identified.

2.5 Health

2.5.1 *Early research*

In their review of the impact of 12-hour shifts, L. Smith et al. (1998b) concluded that, in general, workers on extended shifts do not have greater problems with sleep and health and may even show improvements in these areas. However, notable exceptions to this trend were identified. For example, Iskra-Golec et al. (1996) reported negative effects upon well-being of a change to 12-hour shifts among intensive care nurses. This was ascribed to the effects of prolonged exposure to the high emotional demands of the work. Similarly, it was noted that prolonged exposure to physical environmental stressors (e.g. heat, noise) and toxic chemicals could also result in harm. The regulations governing exposure limits for such hazards may sometimes be based upon a standard eight-hour shift, and may not take into account the impact of extending the length of individual shifts (Knauth, 1993). It was also noted by L. Smith et al. that a range of other factors may exacerbate the potential effects of longer work periods on fatigue, e.g. individual differences in social and domestic circumstances, including commuting time, staffing levels within the organization and distribution of rest breaks within the schedule. In other words, the same CWW schedule may affect different workers in different ways, depending upon their individual circumstances. It was also noted that many such individual factors have not been fully explored in relation to CWWs.

2.5.2 *Recent evidence*

2.5.2.1 Longitudinal studies

Evidence published since that review largely seems to confirm the picture of relatively benign effects of CWWs on health. However, while this is true for the majority of studies, there are again some notable exceptions. In the study of power workers who changed to CWWs, reported by Mitchell and Williamson (2000), neutral and positive effects were observed on self-reported physical and psychological health. Measures were taken ten months after the change. The change was from a slowly backward rotating eight-hour system to a rapidly rotating 12-hour system. Johnson and Sharit (2001) reported improvements in self-reported physical and psychological health 11 months after a change from eight- to 12-hour shifts amongst a group of production workers who had voted for the change. However, few details of the shifts systems were given, other than that both were rotating, with the eight-hour system rotating every seven days. Moreover, as noted above, the comparison was confounded by a change in the nature of the work tasks and selection effects (Nachreiner, 2001).

A couple of longitudinal studies have been published which have identified negative changes in health following the introduction of CWWs. However, it seems that the negative outcomes may have been due to the particular form of CWW schedule, and/or because of the particular way in which the new schedule was implemented and subsequently managed. Yamada et al. (2001a) reported a longitudinal study of a change from an eight- to a 12-hour shift system among workers in an electronics factory clean-room. They examined medical records, which, they argued, reduced the potential influence of intentional attitudes towards the shift system upon the outcome measures. While no differences were observed in physical health complaints, fatigue-related psychological symptoms (poor sleep, head heaviness, diminished alertness and unwillingness to go into the workplace) were increased two-fold or more. The effects were significant immediately after the change to the new schedule, and remained high (though only bordering on the statistically significant) one year after implementation. They also reported an average 1 kg weight-gain in a year by those who had changed to the 12-hour system. Unusually for a change to CWW, the change involved a slowing of the speed of rotation from a weekly rotation (such that a week of nights was worked every three weeks) to fortnightly rotation (such that night shifts were worked in blocks of two weeks). This may have accounted, at least in part, for the negative impact of the new schedule. In a later cross-sectional study conducted in the same setting (Yamada et al., 2001b), 12-hour workers complained of poorer health and more fatigue. However, psychological health, as determined by a self-report measure designed to detect psychiatric morbidity, was unaffected. Evidence was produced to suggest that the higher body mass reported in the earlier study may have been a reflection of less-healthy lifestyles adopted by the 12-hour workers, e.g. more sedentary activities. It was unclear whether the work schedule was responsible for the differences in lifestyle between workers on the two schedules. However, it is conceivable that a more fatiguing schedule will demand greater recovery and thus encourage more sedentary activity during time away from work.

The study of police officers reported by L. Smith et al. (1998a) examined the change from a rapidly backward rotating eight-hour system to one of rapidly rotating 12-hour shifts. They found no impact upon physiological health. However, psychological well-being declined among a sub-sample of the 12-hour workers who changed to an inflexibly scheduled system that involved early (06:00) night-to-morning shift changeovers. There were no such effects among those who changed to a flexible 12-hour system that involved later (07:15) changeovers.

2.5.2.2 Cross-sectional studies

Josten et al. (2003) reported a cross-sectional comparison of nurses working either eight- or nine-hour shifts. The latter group had changed to nine-hour shifts within the previous ten or 21 months. Poorer health was reported by the nine-hour group, most especially among those who had not chosen to change to the longer shifts. (However, it is worth noting that only a very small proportion had chosen to work the extended shifts.) The negative impact of the extended shifts was attributed in part to the combination of extended shifts and high workloads of the respondents. It was also noted that longer shifts were especially problematic for the part-time nurses, who formed the majority (77 per cent) of the sample. It is interesting to note that the change to nine-hour shifts had coincided with a *reduction* of two hours in the working week for all nurses. However, it was not clear that the overall weekly hours of the part-time workers (i.e. the majority of the participants) had been controlled for in the study.

Another cross-sectional study, reported by Kaliterna and Prizmic (1998), found no effects of shift length upon self-reported health in a sample comprising nurses, air traffic controllers and police officers who worked rapidly rotating eight- or 12-hour shift systems. However, in this case, it was not clear that the length of the working week had been controlled for in the analysis.

Tucker et al. (1996) reported a cross-sectional study comparing chemical workers on eight- and 12-hour shifts, in which the number of hours worked per week were controlled for in the analyses. They identified a higher incidence of cardiovascular symptoms among the 12-hour workers. No differences were found on any other measures of physical or psychological health. In a subsequent larger survey of industrial workers on eight- and 12-hour shifts, Tucker et al. (1998a) found 12-hour shifts to be associated with somewhat better psychological health (neuroticism). However, 12-hour shifts were also associated with more physical health complaints (cardiovascular symptoms and musculo-skeletal pain), especially when the schedule featured early night-to-morning shift change-overs. However the differences were quite small (though significant) and it was concluded that they may have reflected the influence of extraneous variables. It is also worth noting that the overall length of the working week for both groups was in excess of 40 hours per week, with more than 10 per cent of the weekly work hours being worked as overtime. The combination of overtime (i.e. over 40 hours per week) and long shifts is thought to be especially deleterious to health and safety (e.g. Caruso et al., 2004).

In a survey of nurses, Lipscombe et al. (2002) found higher incidence of back pain to be associated with longer shifts (over eight hours), while the combination of very long shifts (over 12 hours) and working more than 40 hours a week was associated with increased incidence of neck, shoulder and back disorders.

The study reported by Prunier-Poulmaire et al. (1998) involved a comparison of customs officers working either four six-hour shifts, three eight-hour shifts or two 12-hour shifts (rapid shift rotation in all cases) with a reference group of day workers. The six- and eight-hour workers reported a broader range of health problems (i.e. leg pain, cardiovascular problems and gastro-intestinal complaints), compared to the 12-hour workers (leg pain and visual problems).

Martens et al. (1999) examined the impact of a range of flexible work practices upon a wide range of self-reported health complaints. CWW was defined as working at least ten hours per shift, and most of the cases examined were said to involve working four ten-hour shifts per week or three 12-hour shifts. The survey was conducted among patients consulting their GPs. This approach was said to have the advantage of not highlighting to respondents the possible associations between health and their work schedules. CWWs were associated with poorer subjective health and poorer sleep quality, when compared to a matched control group who worked non-flexible schedules but a similar number of hours per week.

2.5.2.3 Health behaviours

The author is aware of one study that has examined CWWs in relation to health-related behaviours. A survey of nurses by Trinkoff and Storr (1998) indicated that long night shifts (over eight hours) were associated with increased alcohol use and smoking. Those working rotating long shifts were more likely to report alcohol use. It was suggested that the findings may have been linked to higher stress levels. Alternatively, it was suggested they might reflect increased opportunity for substance abuse, i.e. greater autonomy and less supervision. However, it was not made clear why this should especially be the case for those working longer shifts.

2.5.2.4 Quick returns

Two cross-sectional studies have examined the relationship between quick returns and self-reported health. In a study of industrial and service workers, Barton and Folkard (1993) found slightly higher incidence of self-reported physical health problems when backward rotating eight-hour shifts incorporated a quick return, i.e. inter-shift interval of eight hours. However, in a later survey of industrial workers from 15 organizations, no effects of quick returns on self-reported health were found (Tucker et al., 2000). On the basis of this rather limited evidence, it was concluded that the impact of quick returns are primarily acute in nature (e.g. sleep duration; see above). However, there is a clear need for further research on this issue, given the growing body evidence that "need for recovery" *("... related to insufficient unwinding after the exposure to workplace related stressors"*, Sluiter et al., 2003, p. i62) is a strong predictor of a range of physical and psychological health problems (van Amselsvoort et al., 2003; de Croon et al., 2003; Sluiter et al., 1999, 2003).

2.5.3 Conclusions

The overall picture that has emerged in recent years confirms the view reached by L. Smith et al. (1998b): several studies have identified few, if any, negative health effects associated with CWWs, with some identifying a positive impact. However, specific factors, such as the arrangement of shift sequences and the way in which new schedules are implemented and managed, will determine the success of their implementation. In particular, positive health outcomes have generally been associated with a change to rapidly rotating 12-hour shift systems with later night-to-morning shift change-overs. The cross-sectional studies produced mixed findings, although negative outcomes were especially associated with extended shifts in combination with either high workloads or regular overtime working, i.e. more than 40 hours per week. However, it should be noted that such conclusions are necessarily based on a majority of studies which utilize self-report measures of health. It is interesting to note that the two studies whose methodologies were less likely to alert respondents to the comparative nature of the research both found negative impacts of CWWs. In several cases, studies failed to give adequate detail of the schedules (e.g. change-over times, speed of rotation, hours worked per week). Thus for example, it is not always clear, particularly among cross-sectional studies, that comparisons of different shift lengths have not been confounded by the number of hours worked per week. This limits the extent to which meaningful interpretations can made of the comparisons reported, in terms of the effects of CWWs.

2.6 Absenteeism and turnover

2.6.1 Research findings

Absenteeism may be regarded as a rather indirect measure of health, as it confounds a number of factors relating to work organization, socio-economic conditions and the characteristics of the individual concerned (Costa et al., 2000). Alternatively, absenteeism may be regarded more appropriately as an indicator of job satisfaction, along with staff turnover. Early studies indicated no apparent effect of CWWs on absenteeism or turnover (e.g. Ivancevich and Lyon, 1977; Wilson and Rose, 1978; Latack and Foster, 1985; Chan et al., 1993). Barton-Cunningham (1981) reported an improvement in absenteeism and job satisfaction following a change from a five times eight-hour schedule to a four times ten-hour schedule by mineworkers. One study that appeared to identify a positive association between 12-hour shifts and absenteeism (as well as in injury rates, sickness and intoxication) confounded age with shift system (Jozef, 1984, cited by L. Smith et al., 1998b). Workers on the longer shifts were older, and thus more likely to report health problems, regardless of the shift system worked.

More recently, Venne (1997) reported a longitudinal study of a change from an eight- to 12-hour shift system by prison guards in which there was no statistically significant change in absenteeism rates. Campolo et al. (1998) reported no effects of the introduction of 12-hour shifts on staff retention or sick leave among a sample of Australian health-care workers. Aguirre et al. (2000) reported a 57 per cent reduction in absenteeism and turnover following the introduction of CWWs at a paper mill. Baker et al. (2003) reported no initial changes in absenteeism rates after change from eight- to 12-hours shifts in a coal mine. However, absenteeism rates did increase in one sector of the mine after the subsequent introduction of unregulated and excessive overtime working. The one exception to the generally neutral/positive trend was noted by Williamson et al. (1994), who reported that the amount of sick and recreation leave taken increased following the introduction of a CWW schedule. However, short-term absence and turnover remained unaffected. Confirming the picture painted by the results of these individual studies' findings, Baltes et al. (1999) report a meta-analysis in which no relationship was found between the compression of the working week and absenteeism rates.

CWWs can make a job more attractive to employees and potential recruits. Conrad-Betschart (1990) reported that the introduction of 12-hour shifts resulted in a decrease in staff turnover and an increase in the supply of new job applicants. Similarly, Lum et al. (1998) reported that nurses on 12-hour shifts had lower intention to quit their jobs.

2.6.2 Conclusions

There is little evidence that the implementation of CWWs affects absenteeism rates. However, caution is needed when examining absenteeism statistics in relation to CWWs. A reduction in absenteeism rates may be an artefact of the way in which rates are calculated, as there are fewer days to be absent from on a CWW schedule. In keeping with the positive image that CWWs have among many workers, CWWs are associated with lower staff turnover.

2.7 Job satisfaction, attitudes and preference

2.7.1 Research findings

The successful implementation of new work schedules is highly contingent upon the way in which it is implemented. A crucial issue is the question of what problems, or more importantly, whose problems are being addressed by the change. An implementation is more likely to produce positive effects when the new system is chosen by the workforce (Kogi, 1991). When the new system is imposed without regard to the opinions of the workforce, its implementation is more likely to fail (e.g. Wilson and Rose, 1978). Amstrong-Stassen (1998) cites evidence published in the United States of particularly high levels of abandonment of implementations of CWW schedules (Galenson, 1991; Olmsted and Smith, 1989). She goes on to suggest that successful implementation will be contingent on (1) the identification of jobs that are appropriate for CWWs, (2) the identification of which CWW form is best, (3) preparation of employees for CWWs, and (4) preparation of mangers and supervisors for CWWs.

Conrad-Betschart (1990) showed that participation by the workforce in the negotiation of the new system was critical for the acceptance and positive effects of the new schedule. For example, the participative process helped improve the design of the new system, through the incorporation of extra rest breaks and improved meal facilities at night. It was noted that, while it will inevitably be difficult to get the full consent of the workforce, as no system can suit all preferences, such problems will be transitory if all stakeholders have an opportunity to be involved in the process. As noted earlier, L. Smith et al. (1998a) reported on the implementation of 12-hour shifts among two groups of police officers. At one site, the implementation of an inflexible system with an early night-to-morning change-over resulted in decreases in alertness, sleep quality, psychological well-being and satisfaction. However, improvements were observed in the other group which changed to a more flexible system with a later change-over.

Individual differences will affect attitudes towards a new shift system. For example, the value that an individual attaches to extended rest breaks between shift cycles may depend upon their domestic circumstances and/or their age (Kundi et al., 1995). Older workers tend to be less enthusiastic about 12-hour shifts (Conrad-Beschart, 1990). Similarly, the nature of the job may influence an individual's preference for CWW. Smiley and Moray (1989) noted that, while nuclear maintenance staff preferred 12-hour shifts, control room supervisors did not. This was attributed in part to the supervisors feeling an increased burden of responsibility on the longer shifts. It was also noted that jobs of the maintenance staff were more active, varied and self-paced, while the operators and supervisors performed mostly sedentary monitoring tasks.

Positive reactions of workers to CWWs were reported in several recent empirical studies of CWWs (e.g. P. Smith et al., 1998; Lowden et al., 1998; Tucker et al., 1996, 1998b; Aguirre et al., 2000). Moreover, this trend was reflected in the results of the meta-analysis reported by Baltes et al. (1999). However, as may be anticipated from the discussion at the outset of this section, the picture is not entirely positive. For example, Kundi et al. (1995) reported a survey of nurses who rated neither eight- or 12-hour shifts as particularly appealing. Interestingly, they concluded that, despite the higher potential value of free time in 12-hour shifts, as compared to eight-hour shifts, this value may be lost due to increased need for recovery. As a consequence, the effective free time remaining may be no more than in the eight-hour schedule (see also Saito, 1982). The importance of schedule characteristics of CWWs is provided by Havlovic et al. (2002). They reported that nurses on CWW schedules that involved rotating shifts were more dissatisfied with their schedule than those on non-rotating CWW schedules.

An important point to note is that workers' attitudes towards their schedule need bear no relation to the impact that the schedule has on indices of their health and safety. Thus, for example, Rosa (1991) reported that workers continued to express positive attitudes towards their CWW schedule, 3.5 years after the implementation, despite on-going decrements to fatigue and sleep.

2.7.2 Conclusions

The successful implementation of a new shift system (including CWW schedules) depends on the way in which it is implemented and subsequently managed. Participatory approaches are associated with greater chances of success. It is rare that any form of work schedule will meet with universal approval of the workforce, as attitudes will be influenced by individual worker's characteristics and circumstances. Worker contentment does not necessarily predict positive health and safety outcomes.

2.8 Individual differences

2.8.1 Domestic circumstances and gender

As noted above, when an organization adopts a CWW schedule, the new system will suit some workers within an organization better than it suits others. Take, for example, the often-cited benefits that 12-hour shifts have on life outside work, such as reduced disruption of social and/or family life (e.g. Kaliterna and Prizmic, 1998; P. Smith et al., 1998; Lowden et al., 1998; Tucker et al., 1998b; Aguirre et al., 2000; Mitchell and Williamson, 2000; Makowiec-Dabrowska et al., 2000). The value of such benefits will be influenced by individual differences. For example, Barton-Cunningham (1981) reported limited evidence that younger married 12-hour shiftworkers were more satisfied with their family relations as a result of working CWWs. This appeared to reflect perceived improvements in the quality of time, rather than the quantity of time, spent with families.

It is notable that the participants in the majority of the afore-mentioned studies were either exclusively or predominantly male. That said, the limited evidence available from these studies regarding gender differences gave no indication that females evaluated the impact of CWW on non-work time activities any differently to males (Kaliterna and Prizmic, 1998). Nevertheless, other authors have suggested that the advantages of CWWs may be out-weighed or negated by other aspects, particularly among women. For example, a number of studies of nurses have reported that CWWs have a negative impact on non-work activities (Blanchflower, 1986; Kundi et al., 1995). This may be because recovery from extended shifts impinges on rest day activity. It has also been suggested that CWWs may be less popular with women as they may experience more disruption to child care when working extended shifts (Armstrong-Stassen, 1998). CWWs may cause increased disruption to child care because, in most cases, it is a daily activity, i.e. it has to be undertaken on both work days and rest days. For individuals in this situation, the advantage of having more days away from work during the week may be outweighed by the reduction in free time (e.g. for child care) on work days. Fast and Frederick (1996) found that women experienced more time-stress on CWWs than men. They attributed this to the fact that many household tasks, such as meal preparation and child care, cannot be easily delayed or rescheduled. It was suggested that working longer days makes these times of peak stress – morning and after work – even more stressful. They also speculated that women working CWWs may be under greater pressure to accomplish more household tasks during their additional rest days. As many household tasks are continuous and repetitive, this makes it difficult to say that such work is finished. (See also Kogi et al., 1989, cited below in section 2.11.1).

2.8.2 Age

It has been suggested that older workers could experience more problems on longer shifts (Kogi, 1995). In support of this suggestion, Northrup et al. (1979) reported that older workers reported more fatigue, poorer appetites and lower overall physical well-being as a result of changing to 12-hour shifts. Similarly, Conrad-Betschart (1990) found that older workers were less likely to report positive experiences (e.g. use of leisure time, sleep, general health) as a result of the change from an eight- to 12-hour shift system. However, this latter finding was attributed, in part, to the reduction in moonlighting opportunities. Other authors have suggested that older workers may be more susceptible to fatigue on longer work days (Armstrong-Stassen, 1998). However, Keran et al. (1994) found no interaction between age and shift length in psychological and physical measures among a sample of mineworkers. Similarly, in a study of petrochemical workers who had been working 12-hour shifts for 20 years, Bourdouxhe et al. (1999) found no age-related effects on sleep, fatigue, workload, accidents, work satisfaction, or social and family life. There was no evidence that the observed declines in health indices were any more than would be expected among a non-shiftworking population. By comparison, a control group of non-shiftworkers and former shiftworkers reported greater declines in health with age than the shiftworkers. It was concluded that the absence of negative effects among the older shiftworkers may have been due to the "healthy worker" effect. This is a selection effect, where individuals who are less tolerant of shift work leave it, leaving only the most hardy and shift work-tolerant individuals who show few, if any, ill-effects of shiftworking.

Laboratory studies are not troubled by such methodological concerns. Reid and Dawson (2001) reported a laboratory simulation of a 12-hour shift system, in which older participants (mean age 44 years) were less able than their younger counterparts (mean age 21 years) to maintain cognitive task performance over the shift duration.

Thus on the one hand, despite concerns about the impact of CWWs on the older worker, there is scarce evidence in this regard. Nevertheless, there is a substantial body of evidence which shows that as shiftworkers get older, they experience reduced tolerance to shift work, decreased circadian adjustment, and increased problems of sleep and general health. Therefore, guidelines for the design of shift work schedules for the older worker are likely to be as pertinent to CWWs as to other forms of shift work. The design of shift systems for older workers should based on (1) increased flexibility for the worker, (2) increased time for recovery and work breaks, (3) less night work, (4) quickly rotating shift systems and (5) earlier shift change times in continuous shift work. In addition, it has been suggested that older workers would benefit from shorter overall work hours, although empirical data on this issue is scarce (Härma and Ilmarinen, 1999; Härma and Kandolin, 2001). However, a survey found that a majority of older workers with health problems agreed that shorter working hours would help them to stay in work until normal retirement age (Torgen et al., 2001).

2.8.3 Conclusions

An individual's unique characteristics and circumstances will play a crucial role in determining how he or she is affected by shiftworking. Factors such as gender, domestic circumstance and age are just some examples. Thus it is important that the implementation of CWW schedules not only takes into account the well-being of the workforce as whole, but is characterized by flexibility and sensitivity to individual worker's needs.

2.9 Overtime and moonlighting

2.9.1 Research evidence

Overtime is of particular concern in relation to extended shifts, especially if it reduces what may already be limited opportunity for rest and recovery (e.g. Rosa, 1995; L. Smith et al., 1998b; Caruso et al., 2004). Therefore it is recommended that overtime be limited in CWWs. Moreover, overtime should be distributed as evenly as possible among workers, although in practice that may not always be feasible, given that overtime working is often voluntary. Baker et al. (1994) reported an association between average annual overtime and safety incidents that were attributed to operator fatigue. Thus it is essential that when changing from an eight- to a 12-hour schedule, overtime arrangements, including safety margins, should be redesigned to take into account factors unique to extended shifts and CWW schedules, e.g. additional fatigue, reduced opportunity for recovery between shifts, impact on non-work activities, etc. (Rosa, 1995; L. Smith et al., 1998b).

Another concern about CWWs is the extra opportunity it affords for moonlighting (i.e. taking up additional jobs) during the periods designed for rest and recuperation. Greater amounts of leisure time and potential for boredom are a by-product of longer periods away from work. Colligan and Tepas (1986) reported that 25 per cent of 12-hour shiftworkers were moonlighting. They noted that, by extending work activity beyond 12-hours, individuals would be returning to work, possibly at night, already tired from their extra-mural activities.

2.9.2 Conclusions

The successful and safe implementation of CWW schedules requires that overtime and other forms of additional working (e.g. moonlighting) are carefully controlled and, where appropriate, restricted. Restrictions on the opportunities for overtime working may limit the degree of flexibility associated with CWW schedules.

2.10 Very long shifts

2.10.1 Research evidence

A small number of studies have examined the effects of compressing working time into very long shifts, e.g. 16 hours. Takahashi et al. (1999) compared nurses working a conventional eight-hour shift system with a system that involved working three times eight-hour day shifts and a 16-hour night shift, followed by at least one day off. Several fatigue counter-measures were introduced to reduce the impact of the 16-hour shifts. These included increasing the number of nurses per shift, allowing a two-hour nap during the night shift, reducing nursing duties on nights and scheduling at least one rest day after the 16-hour shifts, thus allowing for longer recovery sleeps. The 16-hour shifts were associated with similar or lower levels of sleepiness, concentration, fatigue, physical activity and heart rate, compared to the eight-hour shifts. It was concluded that the counter-measures were crucial to the successful implementation. However, it was conceded that the fact that the participants were all young, single and living alone may have contributed to this success. Moreover, it was also noted that the study did not take any measures of error or accidents. In this regard, it is notable that evidence from physicians working very long shifts suggests deterioration in various measures of cognitive performance (Gander et al., 2000; Leonard et al., 1998; cited by Caruso et al., 2004).

Kecklund et al. (2001) reported the implementation of a system involving 15.5-hour shifts (double shifts) among a group of construction workers who had voted for the schedule. They noted increases in fatigue and sleepiness, especially towards the end of the cycle in which two 15.5-shifts were worked consecutively twice. Short sleeps were obtained in the 8.5-hour interval between double shifts. However, these sleeps were not as short as might have been expected because the workers lived away from home, close to site, and thus lacked any day-to-day family responsibilities. Some symptoms increased over the year (pain, sleep, exhaustion), although in the absence of a control group it was not clear whether this was an effect of the schedule. General health remained unchanged. It was noted that the relatively modest nature of the effects may have been attributable to the fact that it was a self-selected group who chose to work the schedule, and also that the work pace and demands (stress) were not high.

2.10.2 Conclusions

There is limited evidence that very long shifts are feasible in certain circumstances, for certain individuals. However, the long-term effects of such extreme schedules have not been studied. Hence their use cannot be not generally recommended until further evidence using a broader range of measures is available.

2.11 Developing countries

Living and working conditions in middle- and low-income countries are usually harder and worse than in industrialized countries. Workplaces are often more dangerous and less healthy. Outside the workplace, poor transport infrastructure may result in difficult or very long commutes, and access to health care may be limited. Recent years have seen a growth in foreign-owned assembly plants in developing countries. It is reported that there are high numbers of labour violations in such places, and that working conditions are much worse than in their countries of origin. Concern has been expressed about the effects of importing complex industrial processes into countries where it is more difficult to obtain adequate healthy working conditions (Fisher, 2001). It has also been suggested that findings from shift work research are nation-specific, to a degree (Tepas et al., 2003). Therefore it may sometimes be inappropriate to extrapolate from research conducted in industrialized countries to work settings in developing countries.

The nature and extent of the problems encountered by shiftworkers in developing countries will be highly dependent upon the size and location of the employing organizations, as well as the state of technology and human research policies that they use. Rural areas may lack fundamental facilities such as drinking water, sanitation, adequate tools and basic protection equipment, and workers may face hard physical work and possible exposure to pesticides and other chemicals. In urban work environments, risks may be posed by physical, chemical and biological risks. Compared to rural areas, workloads may be less physically demanding but more cognitively demanding. Conversely, working conditions in high-technology industries may be much better, with employers concerned to achieve more efficient work practices and a good organizational climate. They are more likely to provide on-going training and other incentives, such as stimulating activities and flexible work hours. Thus a wide range of approaches is needed when addressing occupational health and safety issues in developing countries that feature such a diversity of working environments (Fisher, 2001).

2.11.2 CWWs and climate

Published research on the implementation of CWWs in developing countries appears to be almost entirely lacking. However, Kogi et al. (1989) provide an illustration of the problems of implementing CWW schedules in the sort of hot climates that commonly feature in developing countries. Twelve-hour shifts were abandoned two months after implementation in Singapore, as workers complained of tiredness, being unable to concentrate, and experiencing deterioration in health. The problems were ascribed to the workers being unable to get sufficient sleep due to the hot climate and daytime noise. As a result, they were unable to sustain previous productivity levels over the prolonged work days. As well as lowered productivity, there were problems of high labour turnover and also reports of workers taking up part-time work in their time off, thereby adding further to fatigue levels. Two-thirds of the workforce complained that 12-hour shifts interfered with family life and social activities. Mothers complained of finding it more difficult to juggle the multiple roles of worker and housekeeper when working 12 hours a day.

A more recent study conducted in western India provides further illustration of the unique difficulties of shiftworking (though not specifically CWW schedules) in hot climates. Nag and Nag (2001) found that high climatic temperatures were associated with increased accident risk among shiftworkers. It was found that those working permanent night shifts were at more risk than those on rotating shifts, especially towards the end of their shift.

2.11.2 Economic incentives

In developing countries, it may be especially tempting to allow the economic imperative to over-ride considerations of occupational health and safety. This may apply at all levels of society. Governments may be eager to attract foreign investment and improve productivity whatever the human cost. Individual organizations will be subject to the pressures and incentives of working in a competitive market. Individual workers may be more than willing to take on as much work as possible in order to maintain an adequate standard of living for themselves and their families. This may involve working additional shifts, or taking on additional jobs (Manuba, 2001). However, research suggests that such economic constraints to the improvement of working conditions can be overcome through the collaboration of employers and workers, working together to provide low-cost practical solutions (Khai et al., 2001; Chaikittiporn et al., 2001).

2.11.3 Socio-cultural factors

Developing countries may feature socio-cultural (e.g. religious) practices that do not exist in the industrialized countries from which manufacturing operations have been imported. These may place constraints on the design of shift schedules. For example, Manuba (2001) cites the example of Balinese hospital workers working double shifts so as to facilitate attendance at religious ceremonies.

A survey of shiftworkers in Singapore found that a high proportion of shiftworkers, and especially permanent nightworkers, were women (Ong and Kogi, 1990). It was noted that this was the reverse of situations in industrialized countries, where nightwork is traditionally worked by men. It was noted that the night shift makes it easier to keep up with domestic activities and maintain family commitments. The health and safety implications of this double-burden of female shiftworkers have been noted elsewhere (Beermann and Nachreiner, 1995), but these findings suggest that the problem may be especially prevalent in developing counties. Moreover, it suggests that developing countries may experience higher incidence of shift work-related reproductive health problems (c.f. Uehata and Saskawa, 1982; Infant-Rivard et al., 1993).

2.11.4 Guidelines

A wide range of general occupational health guidelines for developing countries have been published by several authors. Fisher (2001) lists specific guidelines for the occupational health of shiftworkers, as follows:

- *Health evaluations*. Given the large numbers of workers in unhealthy workplaces and the potentially harmful effects of night- and shiftworking, continuous surveillance of the work environment and periodic health examinations are essential to detect health problems in their sub-clinical stages.

- *Accident prevention and health promotion*. Sleep disturbance should be carefully investigated. The impact of new or existing shift schedules on sleep should be examined, by comparing sleep before and after shiftworking.

- *Improving sleeping quarters*. Shiftworkers in developing countries may face unfavourable climatic conditions (usually high temperatures), as well as poor housing conditions. This may result in inadequate sleep, particularly during the day between night shifts. Companies should provide financial aid for the provision of climatic comfort, which can be implemented at low cost. This is especially important for workers involved in monitoring tasks, such as drivers and other professionals, who must be highly alert during the entire duration of their shift.

- *Participatory programmes*. Providing workers with control over the design and management of their shift systems and other aspects of their work environment improves the work climate and the impact on the individual worker.

2.11.5 Conclusions

The preceding section has identified a range of studies and a set of general guidelines relating to shiftworking in developing countries. However, it has also identified an urgent need for research that specifically investigates the impact of CWWs in developing countries. The difficulties posed by the combination of a highly demanding schedule, together with restricted opportunities for recovery, may be especially acute in developing countries. The opportunities for moonlighting that are a feature of CWWs may present a temptation that is especially hard to resist in countries where poverty is prevalent. Despite some studies suggesting improvements in work/non-work conflict with CWWs, such schedules may restrict daily non-work activities (e.g. child care, religious practices) on work days. This may be especially problematic in some cultures. Finally, the majority of research on CWWs in industrial settings has involved male participants, and thus little is known about the impact of CWWs on female industrial workers. The prevalence of female industrial shiftworkers in developing countries makes filling this gap in current knowledge an urgent priority.

3. Conclusions and recommendations

When considering the impact of CWWs, it is important to consider the way in which the new shift system is implemented. It is also important to consider the role of other shift schedules and work-related parameters, besides shift length and inter-shift interval. The evidence reviewed suggests that the design of work routines should pay particular attention to possible increases in fatigue and decreases in alertness. Such problems are likely to be especially prevalent at night and particularly towards end of the shift. The research reviewed has suggested a range of issues when contemplating the implementation of CWWs. These are summarized below.

3.1 Whether to implement CWWs

Rosa (1995) recommends that if a job is already considered dangerous when worked as eight-hour shifts, shift length should not be extended to 12 hours.

Costa et al. (2000) conclude that:

> "Extended workdays (9-12h) should only be contemplated when the nature of the work and the workload are suitable (adequate breaks, no overtime) and the shift system designed to minimise (i) the accumulation of fatigue and (ii) toxic exposure, by minimizing the number of successive work days before a span of rest days."

This begs the question of how to characterize work that is more or less suited to CWWs. The current review has identified a range of parameters likely to be crucial to the successful implementation of CWWs, as summarized below. However, it remains unclear whether particular job characteristics make some occupations or types of work better suited to CWWs than others. The overall workload that is experienced by an individual is determined by the complex interaction of a range of environmental factors, including work schedule characteristics. The identification of appropriate workload thresholds in the context of CWWs is likely to require the assessment of performance, subjective reports and psycho-physiological indices of the response to demand (Hockey, 2001).

3.2 How to implement CWWs

3.2.1 Fatigue counter-measures

If the decision is made to implement CWW schedules, the following fatigue counter-measures are suggested. They are derived from previously published guidelines from a range of sources (Gould, 1989; Rosa, 1995; Costa et al., 2000), as well as observations from individual studies described in the forgoing review.

- Overtime should be avoided where it impacts on recovery.
- Moonlighting or other forms of additional employment should be avoided where they impact on recovery.
- Long commutes should be avoided where they impact on recovery.
- Employ fatigue counter-measures in order to minimize the impact of extended shifts (e.g. liberal rest breaks, job rotation) to avoid boredom.
- Allow shorter, more frequent breaks within shifts, rather than fewer long ones.

- Ensure adequate recovery between shifts; for example, long sequences of long shifts require three successive rest days for recovery. Moreover, long periods of night work are likely to promote circadian disruption and are therefore likely to necessitate extended recovery periods, i.e. three to four days (Åkerstedt et al., 2000).

- Take account of changes in risk outside the workplace. These may include increased risk of fatigue while commuting after a long shift. Other non-work activities may also be affected by, or may influence the impact of, changes in the work schedule, e.g. domestic care duties.

- Re-adjust margins of error that are built into the work design (e.g. rules governing overtime), so as to take into account the effects of extended shift length and/or quick returns.

- Ensure availability of sufficient personnel to cover all shifts, as overtime is more risky on longer shifts.

- Redistribute workloads to be low at times of high fatigue, e.g. last few hours of the shift, especially at night. Moreover, a change in shift systems may mean a substantial change in alertness among the workforce at other times of day (e.g. mid-afternoon). Thus workloads should be adjusted accordingly.

3.2.2 The implementation process

The review highlighted the value involving the workforce in the design and implementation of the shift system. We also noted that the implementation should be characterized by flexibility and sensitivity to individual worker's needs. A participative approach will also help to prepare the workforce and management for the experience of working the new schedule.

The review also highlighted the fact that the impact of CWWs is likely to be influenced by the characteristics of the job. For example, there is evidence that CWWs may be less well-suited to high-demand jobs. Clearly, it is impossible to consider here the individual characteristics of every type of job that may utilize CWWs. However, the effects of some general characteristics have been discussed. It is therefore essential that the impact of a new schedule is continuously monitored following its implementation, using a broad range of metrics of health, fatigue, organizational efficiency, etc.

3.2.3 General shift work guidelines

Several issues that have been discussed relate to shiftworking in general and are not specific to CWW schedules. The following general guidelines for shift system design and implementation should be adhered to (Costa et al., 2000):

- minimize night work;

- favour quick shift rotation;

- avoid permanent night work except for safety critical conditions, where complete adjustment is necessary;

- favour clockwise rotation;

- avoid early morning change-overs;

- maximize regularity, free weekends, minimum of two consecutive days off, promote flexible work practices;

- assess working environment for hazards and stressors;

- assess individual for health status (health problems, over 45 years, alcohol/drug addictions) and domestic situation (women with children under 5 years of age, long-distance commutes), individual differences (neuroticism, morningness, rigid sleeping habits);

- give regular health checks.

3.2.4 Future research

There is a general need for methodologically rigorous research to refine the points made above. The reporting of this research needs to include full details of the methodologies employed. For example, in the current review, the interpretation of some of the findings was hindered by inadequate descriptions of the features of the shift systems involved.

The review has also identified some key areas in which research evidence is lacking. Further research is need regarding:

- the most effective way of scheduling rest breaks within a shift, e.g. frequency, timing and duration of breaks;

- the distribution and duration of rest between shifts, within a shift cycle;

- the acute and chronic effects of quick returns and the appropriate minimum interval between shifts;

- the role played by different forms of extended shifts (i.e. overtime working versus CWW) in the association between time-on-task and accident risk;

- the impact of very long shifts;

- the impact of CWWs in developing countries and the impact of CWWs upon female industrial shiftworkers;

- the job characteristics that may make some occupations or types of work more or less suited to CWWs.

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Appendix

Table 1: Summary of field studies examining compressed working weeks schedules that involve extended shifts

Table 2: Summary of field studies examining compressed working weeks schedules that involve quick returns

Table 3: Summary of laboratory studies examining compressed working weeks schedules that involve extended shifts

Table 1: Summary of field studies examining compressed working weeks schedules that involve extended shifts

Key to effects of CWWs:

++ = All positive; + = Mostly positive; +/0 = Mixture of positive and neutral; +/- = Mixture of positive and negative; 0 = Mostly or all neutral; +/0/- = Mixture of positive, neutral and negative; -/0 = Mixture of negative and neutral; - = Mostly negative; -- = All negative

Study	*Sample*	*Method*	*Sleep*	*Job performance/ productivity*	*Fatigue (self-report/objective measure)*	*Safety*	*Health*	*Satisfaction*	*Absenteeism and turnover*	*Non-work interference*	*Comments*
Aguirre et al. (2000)	Paper mill workers: 205	Longitudinal	+/-		+/0	+	++	++	++	++	Shift system confounded with shift start/finish times
Axlesson et al. (1998)	Power station workers: 31	Within subjects	+/0		0						
Baker et al. (2003)	Mineworkers	Longitudinal, epidemiological				+/0			0		
Barton-Cunningham (1989)	Mineworkers: 290	Longitudinal; control group	0		--	++	0	0	+/0	+/0	
Blanchflower (1986)	Nurses: 15	Longitudinal		+/-	-			-		--	
Chan et al. (1993)	Female electronics workers: 383	Cross-sectional	-/0		--		0		0		
Conrad-Betschart (1990)	Oil refinery workers: 230	Longitudinal	+		+/0		+/0	+	++	+	
Duchon et al. (1994)	Mineworkers: 41	Longitudinal; control group	++		+/0						
Dunham et al. (1987)	Health-sector workers: 140	Longitudinal		+				+		0	
Fast and Frederick (1996)	General population	Cross-sectional					0/-				Neutral outcomes for males; negative outcomes for females
Fitzpatrick et al. (1999)	Nurses: 34	Cross-sectional (?)		0/-							8-hour versus 12.5 hour shifts

Study	Sample	Method	Sleep	Job performance/ productivity	Fatigue (self-report/objective measure)	Safety	Health	Satisfaction	Absenteeism and turnover	Non-work interference	Comments
Havlovic et al. (2002)	Nurses: 520	Cross-sectional	-/0	-/0				-/0		-/0	Negative outcomes associated with rotating schedules
Heslegrave et al. (2000)	Nuclear power workers: 86	Longitudinal	0	--	--	-					9-hour versus 12.5 hour shifts
Hossain et al. (2004)	Mineworkers: 241	Longitudinal	+/0/-	+/-	+/-	+	++				8-hour versus 10-hour shifts. Shift system confounded with shift start/finish times.
Iskra-Golec et al. (1996)	Nurses: 126	Cross-sectional	--		--		0/-	0		++	
Ivancevich and Lyon (1977)	Production workers: 302	Cross-sectional		0/+			+/0	+/0	0		10-hour versus 8-hour shifts
Johnson and Sharit (2001)	Production workers: 412	Longitudinal; control group (injury data)	+	++		0	++	++		++	
Johnson and Pollard (1991)	Nurses: 66	Cross-sectional			+/0/-						
Josten et al. (2004)	Nurses: 134	Cross-sectional		0/-	-		-	-			8-hour versus 9-hour shifts
Kaliterna and Prizmić (1998)	Nurses, air traffic controllers and police officers: 208	Cross-sectional	0		0		0	0		++	
Kundi et al. (1995)	Nurses: 880	Cross-sectional			-		-	0/-		+	
Latack and Foster (1985)	Computer operators: 84	Cross-sectional			0				+		
Laundry and Lees (1991)	Manufacturing company	Longitudinal, epidemiological				+/0/-					
Lipscombe et al. (2002)	Nurses: 1,163	Cross-sectional					-				< 9-hour versus > 9-to 11.5-hour versus >= 12-hour shifts
Lowden et al. (1998)	Control room operators: 32	Longitudinal, control group	+/0		+/0		+/0	++		0/+	
Lum et al. (1998)	Nurses: 361	Cross-sectional							++		

Study	Sample	Method	Sleep	Job performance/ productivity	Fatigue (self-report/objective measure)	Safety	Health	Satisfaction	Absenteeism and turnover	Non-work interference	Comments
Macdonald and Bendack (2000)	Production workers: 40	Cross-sectional			0/-			0			Negative effects for 12-hour shifts with high workload
Makowiec-Dabrowska et al. (2000)	Nurses: 705	Cross-sectional	++		-			+		++	
di Milia (1998)	Coal mine electricians: 3	Longitudinal	+/0/-					+			
Martins et al. (1999)	GP's patients: 480	Cross-sectional	--				--				< 10-hour versus >= 10-hour shifts
Mills et al. (1983)	Nurses: 30	Longitudinal		0	--						8-hour versus 12.5-hour shifts
Mitchell and Williamson (2000)	Power station workers: 27	Longitudinal	+/0		0		++	++		0/+	
Paley et al. (1998)	Fire fighters: 24	Longitudinal	0		0						8-hour versus combination of 14-hour night and 10-hour day shifts
Peacock et al. (1983)	Police officers: 75	Longitudinal	++		0		+	++		++	
Pollock et al. (1994)	Chemical manufacturing	Longitudinal, epidemiological				+/0/-		+			
Prunier-Poulmaire et al. (1998)	Customs officers: 302	Cross-sectional	0				-/0				Outcomes were neutral/negative relative to day working control group, but superior to 6- and 8-hour shiftworkers
Rosa et al. (1989)	Control room operators: 55	Longitudinal	--		-		0/+	++	0	+	
Rosa (1991)	Control room operators: 20	Longitudinal	--		-		+/-	++		--	
Rosa and Bonnet (1993)	Gas industry workers: 27	Longitudinal	-		-		-	++		0	
Schroeder et al. (1998)	Air traffic controllers: 52	Cross-sectional			0						10-hour versus 8-hour shifts

Study	Sample	Method	Sleep	Job performance/ productivity	Fatigue (self-report/objective measure)	Safety	Health	Satisfaction	Absenteeism and turnover	Non-work interference	Comments
Smiley and Moray (1989)	Nuclear power workers: 35	Longitudinal						+/-			
L. Smith et al. (1998a)	Police officers: 90	Longitudinal; control group	+/-		+/-		+/0/-	+/-		0	Negative outcomes for early starting, inflexible schedule
P. Smith et al. (1998)	Sewage workers: 72	Longitudinal, control group	+/0		+/0		+/0	++			
Takahashi et al. (1999)	Nurses: 40	Cross-sectional			0		0				8-hour versus 16-hour night shifts
Todd et al. (1991; Reid et al: (1993)	Nurses: 1,038	Longitudinal		--	-/0			+/0/-			
Trinkoff and Storr (1998)	Nurses: 3,917	Cross-sectional					-				
Tucker et al. (1996)	Chemical workers: 162	Cross-sectional	0		0/-		0/-	+/0/-		+/0	
Tucker et al. (1998a, 1998b)	Industrial workers: 842	Cross-sectional	+		+		+/-	++		++	
Venne (1997)	Prison guards: 102	Longitudinal, control group							0		
Volle et al. (1979)	Production workers: 33	Cross-sectional		0	0/-						10-hour versus 8-hour shifts
Washburn (1991)	Nurses: 117	Cross-sectional			0						
Williamson et al. (1994)	Computer operators: 75	Longitudinal	+/-	0	--		++	0	-/0		Combination of 8-hour and 12-hour shifts versus 12-hour shifts
Yamada et al. (2001a)	Clean room workers: 205	Longitudinal, control group	-		-		-				
Yamada et al. (2001b)	Clean room workers: 433	Cross-sectional	0		-		0/-	-			

Table 2: Summary of field studies examining compressed working weeks schedules that involve quick returns

Key to effects of CWWs:

++ = All positive; + = Mostly positive; +/0 = Mixture of positive and neutral; +/- = Mixture of positive and negative; 0 = Mostly or all neutral; +/0/- = Mixture of positive, neutral and negative; -/0 = Mixture of negative and neutral; - = Mostly negative; -- = All negative

Study	***Sample***	***Method***	***Sleep***	***Job performance/ productivity***	***Fatigue (self-report/objective measure)***	***Safety***	***Health***	***Satisfaction***	***Absenteeism and turnover***	***Non-work interference***	***Comments***
Axlesson et al. (2004)	Paper mill workers: 317	Cross-sectional	-/0		0						
Barton and Folkard (1993)	Industrial and service workers: 261	Cross-sectional	+/0		0		0	--		--	
Kurumatani et al. (1994)	Nurses: 239	Cross-sectional	--							-	
Macdonald et al. (1997)	Manufacturing company	Longitudinal, epidemiological				-					
Nesthus et al. (2003)	Air traffic controllers: 71	Cross-sectional	-/0		--						
Tucker et al. (2000)	Industrial workers: 611	Cross-sectional	0		-		0	0		0	

Table 3: Summary of field studies examining compressed working weeks schedules that involve extended shifts

Key to effects of CWWs:

++ = All positive; + = Mostly positive; +/0 = Mixture of positive and neutral; +/- = Mixture of positive and negative; 0 = Mostly or all neutral; +/0/- = Mixture of positive, neutral and negative; -/0 = Mixture of negative and neutral; - = Mostly negative; -- = All negative

Study	***Sample***	***Method***	***Sleep***	***Job performance/ productivity***	***Fatigue (self-report/objective measure)***	***Safety***	***Health***	***Satisfaction***	***Absenteeism and turnover***	***Non-work interference***	***Comments***
Macdonald and Bendack (2000)	Laboratory participants: 8	Within participant comparison			--						7.2-hour versus 12-hour shifts
Rosa et al. (1985)	Laboratory participants: 6	Within participant comparison			+/-						
Rosa et al. (1998)	Laboratory participants: 16	Within participant comparison			-						