Working time

Its impact on safety and health

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Preface

There is now substantial evidence that working time is becoming increasingly diversified among workers. The diversity of working time arrangements that are emerging - different shift patterns, more flexible hours of work, different statuses of employment, etc. - imply that traditional methods of organizing and regulating employment are increasingly being challenged. National survey results suggest diverging trends in the timing of work: workers in many countries are more likely to work "non-standard" hours, such as shift work, night work and weekend work, as well as more flexible or irregular work schedules. In addition, despite some decreasing tendency in actual average working hours in most industrialized countries, long hours remain a problem. In fact, there appears to be an increasing number of workers who are working long hours - 50 hours, 60 hours, or more per week - in many countries.

Under these circumstances, there is a real need for a better understanding of the effects of working hours and the organization of working time, in order to assist governments and the social partners to make strategic choices which effectively meld economic efficiency and social protection. This report focuses on the effects of both hours of work and how working time is organized - working time arrangements - in two vitally important areas: worker health and safety. In particular, this study examines the effects of working time on the occupational health and safety of workers engaged in shift work, night work, "compressed" workweeks (in which workers work the same number of hours in fewer days), and similar "non-standard" working time arrangements.

This report highlights issues of importance that are often faced in attempting to organize work in ways that are both productive and also conducive to enhancing health and safety in the workplace. This study examines the impact - both positive and negative - that different types of work patterns can have on the well-being of workers who experience them. Based upon these findings, the author uses a behavioural risk management framework to outline a set of practical suggestions to enhance the health and safety of those workers engaged in “non-standard” working time arrangements. This risk management framework can be used by those who are interested in identifying potential hazards, assessing the associated risks, and developing and implementing appropriate measures to address them.

It is hoped that this report will provide useful information to researchers and policy makers as well as workers and employers concerned with the impacts and management of working time. We also hope that this report will contribute towards the goal of maximizing enterprise productivity while, at the same time, minimizing health and safety risks for workers. We thank the author, Dr. Anne Spurgeon of the University of Birmingham (UK) Institute of Occupational Health for her work in preparing this study, as well as the Occupational Safety and Health Research Institute in the Korean Occupational Safety and Health Agency (KOSHA/OSHRI) for their timely assistance in bringing this publication to final fruition.

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Executive summary

Background

During the last fifty years major changes have taken place in the organization of working time throughout the world. Most noticeable has been the move towards non-standard patterns of working hours which have emerged to meet the demands of the new information technology, sophisticated communication system and the requirements of a 24-hour society. Increasing numbers of people are now employed in forms of shift working which include night work, or are required to adjust to flexible and irregular work patterns. In recent years there has also been a tendency towards longer working hours in many countries, largely reversing the trends evident in the first half of the 20th century. These changes raise new concerns about the potential effects of health and safety of various aspects of working time.

Fortunately, much research has been carried out in this field, and this monograph is intended to this gather international evidence regarding what we now know about the risks and benefits of various work patterns. It offers both general guidelines as well as specific intervention measures that are broadly applicable for optimizing working time arrangements. This report is thus aimed specifically at employers and employer organizations, trade union leaders and worker organizations, government officials concerned with health and safety policy, and the various professionals involved with occupational health and safety.

Initial chapters of the report provide details of the current trends in working patterns across

the world and briefly summarize new international legislation enacted during the 1990's, such as the Night Work Convention. These sections also underline the importance of working time as a factor in people's general health and well-being and the need for detailed consideration of its influence on health and safety.

Attention is also drawn to the various methodological issues surrounding research in this field. Appreciation of the potential pitfalls which researchers face is essential to an understanding of the limitations of some of the evidence presented and the controversy surrounding it. For example, perhaps the greatest difficulty in studying the long-term effects of a particular work pattern is the propensity for individuals who are affected negatively by it to leave the workforce or choose alternative employment. The emerging health picture may therefore underestimate the size or nature of any problem. Methodological problems such as these do not necessarily negate the research findings, but as in any field of investigation, there is often a need to exercise caution in the interpretation of the available data.

Two of the largest sections of the report are concerned with the potential effects on health and safety of different working time arrangements, such as a variety of shift patterns and compressed workweeks, which are often lacking in existing research but are needed as more "non-standard" working time arrangements emerge. For convenience, issues of health and issues of safety have been addressed separately, although potential interaction between these elements is underlined. Important aspects of working time and work organization which are considered in the report are:

- The effects of overtime and long working hours, and the risks associated with exceeding certain limits
- The effects of irregular and unpredictable working hours
- The effects of different patterns of rotational shiftworkers and in particular the problems associated with night work
- The effects of compressed working time, notably 12-hour shifts
- The influence of attitudinal factors on health and safety outcomes

A number of specific health and safety effects are examined in relation to each work pattern, which can be summarized as follows:

- Sleep disturbance and fatigue
- Cardiovascular problems
- Gastrointestinal problems

- Mental health problems
- Reproductive disorders
- Somatic and non-specific symptoms
- Social and behavioural difficulties
- Accidents and injuries

The risks associated with particular work patterns are also considered in terms of the nature of the work undertaken and the environment in which it takes place. Other important features which are highlighted are the individual characteristics of the workers concerned, in terms of their age, gender, family and social circumstances and their physiological and psychological make-up. Each of these factors is examined in order to provide general guidelines for optimizing working time arrangements. The key findings of the report regarding the effects of various aspects of working time on workers' health and safety are summarized below.

The effects of working time on health: Key findings

Long hours and health: The current picture

The report examines the effects of the number of hours worked on the health of workers. Key findings in this area are as follows:

- Regularly working in excess of 48 hours per week appears to constitute a significant occupational stressor which reduces job satisfaction, increases the effects of other stressors and significantly increases the risk of mental health problems.
- Regularly working more than 60 hours per week, and perhaps working more than 50 hours per week, appears to increase the risk of cardiovascular disease.
- Individual attitudes and motivation appear to modify the response to work stressors, but whether these, or variations in physiological response, reduce long-term health risks has not so far been adequately investigated.
- Long hours appear to be associated with increased prevalence of somatic symptoms and health threatening coping behaviours such as increased smoking and poor and irregular diet.
- Some workers have reported adverse effects on family relationships, particularly where hours are in excess of 50 per week. However, data are limited in this area.
- There is some limited evidence that associates long working hours with an increase in (1) pre-term births and (2) musculoskeletal disorders. Both these health outcomes

require considerably more investigation.

- The effects of increased exposure to other physical and chemical workplace hazards due to extended hours of work have not been properly investigated and require assessment.

Shift work and health: The current picture

The report also investigated the effects of shift work on the specific types of health problems listed above. The key findings regarding shift work and health are as follows:

- Sleep disorders are widely reported
- There is strong evidence of cardiovascular disorders
- There is strong evidence of gastrointestinal disorders
- There is some evidence of reproductive disorders
- In most cases, night work increases the risk of health disorders
- Except for sleep disorders, the underlying cause of any association is not fully understood
- Individual differences in physiology, attitudes and behaviour are likely to be important in modifying the health effects of shift work.

The effects of working time on safety: Key findings

Overtime and 12-hour shifts: Effect on safety

The report examined the effects of both overtime and compressed (12-hour) shifts on worker safety. The major findings of the report in this area are as follows:

- Data on long hours and safety are very limited.
- Analysis of accident data in 2 countries indicates a rise in accident rates after 9 hours of work.
- Experimental data from cognitive psychology predicts an increase in worker errors after 8 hours of work.
- Most data from studies of 12-hour shifts show an equally good, or in some cases better, safety record following a change from 8-hour to 12-hour shifts.
- However, these data should be viewed with caution and not viewed as unequivocal evidence that long shifts are safe. There are a number of possible explanations for the

data which have not been properly investigated (e.g. the influence of a particular work schedule organization).

Shift work and safety: The current picture

Finally, the report investigated the effects of shift work and safety, and concluded that:

- The data relating to both shift work in general, and night work in particular, are inconsistent and inconclusive.
- Despite the lack of consistent and conclusive evidence, it should not be concluded that shift work is safe. There are numerous possible explanations for the varying effects of shift work on safety:
  - The data or its interpretation may be biased by the nature of the accident reporting system, or the particular organizations which were studied, and
  - The occurrence or not of more accidents is likely to depend on a number or characteristics of the individual, the job and the workplace.

General guidelines and specific interventions to promote worker health and safety

Based upon the key findings of this study, the report suggests both some general guidelines and specific interventions that can be used to promote worker health and safety with respect to working time. In terms of general guidelines, the report recommends the following:

- Night work is best avoided or limited where possible
- Unpredictable or irregular hours are best avoided or limited where possible, especially when other risk factors are present (e.g. long hours, circadian (daily sleep cycle) disruption, other sources of stress)
- Overtime should be limited, distributed among workers, and not routine
- Where possible, overtime should be avoided where jobs are highly stressful either physically or mentally
- Workers should be consulted about the organzation of their working time
- A system of health surveillance should be in place for those working non-standard hours
- Where work extends beyond an 8-hour period, a re-assessment of physical and chemical health risks should be conducted

- Provision of good facilities for catering, transport and health and safety should be made for all work schedules
- Care should be taken in shift schedule design to minimize fatigue
- 12-hour shifts should be introduced with care, but are not necessarily detrimental to safety
- Reliable accident monitoring systems should be in place

These general guidelines are enlarged upon in a later section of the report, which deals with specific measures shown to be effective in reducing the potential negative effects of working time, based primarily on the available evidence regarding shiftworking. Three types of intervention measures are recommended here:

- Measures which focus on work schedule organization, such as the optimum number of hours, optimal start and stop times, the optimum speed of shift rotations, optimal rest breaks, the limitation of overtime, and the limitation of night work;
- Measures which focus on aspects of the working environment such as lightning, the adjustment of temperature, reductions in physical workload (where possible), and the availability of workplace facilities (e.g. catering, transportation) during non-standard working hours; and
- Measures which concentrate on modifying the responses of the individual workers via training and education, including sleep management, health promotion (e.g. diet, exercise), and counselling and stress management.

The management of working time: Towards a comprehensive strategy

Finally, the key findings and intervention measures discussed earlier are incorporated into a set of practical recommendations for the development of a comprehensive strategy for the effective management of working time. This strategy is based on a risk management framework, an approach that will be familiar to many health and safety professionals. A risk management framework provides a useful diagnostic tool that enables enterprises to identify workplace hazards, assess the risks associated with each of them, and then develop appropriate, customized solutions that fit within the wider health and safety policy of an organization.

Five core stages of the risk management process are identified in the report:

- Identification of the hazard
- Assessment of the risk
- Institution of measures for risk reduction and control
- Monitoring the effectiveness of the measures undertaken
- Appropriate adjustment of those measures

For any organization, each of these stages of the risk management process should be considered in relation to the particular aspects of working time which could constitute a health and safety hazard, for example:

- Working hours that are sometimes or always outside standard daytime hours
- Extended working hours
- Irregular or unpredictable hours

The report makes specific suggestions regarding risk assessment, for example in terms of eliciting information from the workforce about themselves, their health, the workplace and their attitudes towards it. The derivation of intervention measures from this information represents the next stage in the process. These intervention measures include various options for (1) creating a more appropriate work schedule; (2) modifying the working environment, and (3) the instituting health training and counseling where appropriate. The report recommends the following specific measures in each of these three areas:

Creating a more appropriate work schedule

- Night work is best avoided or limited where possible
- Unpredictable, irregular hours, particularly where these are beyond the worker's control, should be avoided if possible, or limited
- Overtime should be limited, distributed between workers, and not routine
- Where shifts rotate, forward rotation (clockwise) is preferable
- Weekly shift rotation is undesirable
- Slow rotation (2-3 weeks) is likely to produce an adjustment in the sleep cycle (e.g. an adjustment to working at night and sleeping during the day)
- Fast rotation (1-2 days) maintains workers on a normal circadian (daily sleep) cycle
- Adjustment in the sleep cycle is preferred for workers whose jobs are routine an therefore particularly susceptible to fatigue effects
- Jobs which are mentally stimulating are less susceptible to fatigue effects and probably more suited to schedules where sleep cycle adjustment does not occur

- Traditional starting times for shifts, notably 6 a.m. for the morning shifts, may not be optimal. Later starts (7-8 a.m.) should be considered
- Shift changeover times are vulnerable points in terms of errors and accidents
- Evidence relating to 12-hour shifts is largely positive, given certain conditions
- Where work is extended beyond an 8-hour period, a re-assessment of other occupational risks (e.g. chemical, ergonomic, etc.) should be carried out
- The participation of workforce representative in the design of work schedules is highly recommended

Modifying the working environment

- Introduction of bright light on night shifts where adjustment in the sleep cycle is desired
- Limitation of heavy physical work on nightshifts where possible
- Temperature adjustment (an increase in the temperature) for nightworkers
- Provision of equal facilities (catering, transport, health and safety, recreational, health promotional) on all shifts

Health training and counselling for employers

- Guidance on sleep management
- Guidance on diet content and regulation of meals
- Awareness of the positive effects of physical exercise
- Stress management training

Questions about health surveillance are addressed in the light of recent EU legislation which includes a requirement for this to be carried out. In particular the need to identify and assist workers with special health problems is discussed, whilst emphasizing the need to avoid where possible the exclusion of such vulnerable individuals from the workforce. Evaluation of the effectiveness of risk management measures is considered in terms of two essential elements: (1) evaluation of the process, and (2) evaluation of the outcome. Although linked, these are essentially separate issues and approaches to each are examined in turn.

Areas for future research

Inevitably, however, an examination of the evidence relating to the effects of working time on health and safety has revealed numerous gaps in the available information. The report

therefore offers some recommendations for future research in this field. Five broad areas of potential inquiry are identified, including: situations that have been under-investigated (e.g., irregular and unpredictable hours); effects which have been under-investigated (e.g. family and social effects); potential effect modifiers (e.g., the possible influence of attitudinal variables on effects); the effectiveness of various potential interventions; and issues related to systems of health monitoring.

Both professional researchers and practitioners in industry and commerce have a role to play here if the knowledge base is to continue to grow.

Conclusion

It should be emphasized that, although the optimization of working time arrangements represents a major health and safety challenge for the 21st century, this challenge need not be limited simply to avoiding harm. The evidence reviewed in this report suggests that when managed effectively, working time can also be used positively - to actively promote the health and well-being of the workforce.

Chapter 1.
Background and scope

The number and pattern of hours which people are required to work, has a pervasive influence not only on their working lives but also on their home and leisure time. As such working time, the subject of this book, is one of the most important elements of peoples' conditions of work with the potential to influence significantly their health, their safety, and their general social well-being.

During the 19th century it was common practice, even in the supposedly more developed parts of the world, to neglect the physiological and psychological limitations of people in the workplace. The needs of the worker were regarded as subordinate to the technological needs of the industrial process with an implicit but erroneous assumption that more hours equaled more production. The first challenge to this assumption came at the end of the 19th century with some pioneering experiments carried out at the Mather and Platt engineering works in Manchester UK (Mather 1884). Here the management took the somewhat radical step of abolishing before-breakfast working and were able to demonstrate that a reduction in weekly hours actually increased production as well as reducing sickness absence. These experiments marked the beginning of a more general change in attitude towards the well-being of the industrial workforce. In many countries, during the following hundred years there was increasing recognition of the importance of occupational health and safety and, as part of this, a shift in public attitudes towards working time. There is now much greater acceptance of the importance of rest and relaxation and as a consequence there has been a gradual reduction of the number of hours worked. The continuation of this trend into the next century cannot be assumed

however. During the last quarter of the twentieth century accelerating technology and accompanying social change have fuelled new concerns about working hours. Advanced technology, increased competitiveness and customer demands for round the clock services mean that working time arrangements are becoming ever more complex, comprising numerous combinations of shift times and lengths with much greater use of flexible systems and irregular hours. There are new concerns that the demands of work may be having an unacceptably disruptive effect on peoples' lives. For many workers the advent of sophisticated communication systems has meant that the distinction between work and leisure time is becoming increasingly blurred.

There is now general agreement that working patterns should not be detrimental to well-being, either physically or socially. Soundly-based policies on working time should therefore be part of any effective health and safety management system. Translation of this agreement into action however requires that those charged with the responsibility for developing such systems have access to proper information to assist them. This is particularly important today for two reasons. First, although health and safety regulations exist in some form in most countries, the current international climate is increasingly one of deregulation which, while allowing some flexibility in the achievement of good health and safety in the workplace, also requires a responsible and mature approach on the part of employers. Central to this approach is the concept of managing *risk*. Modern health and safety practice is concerned not so much with piecemeal and often uninformed compliance with specific regulations, but with an over-arching policy which starts with the identification of all potential hazards in the working environment, assesses the nature and level of risk associated with those hazards and then institutes a system to prevent harm occurring. This is essentially a proactive approach which demands a level of knowledge and skill on the part of those involved. In the particular field of working time there is a second reason why dissemination of information is now urgently required. Health and safety policies are now much broader in scope than hitherto, encompassing a growing emphasis potential psychosocial problems in the workplace in addition to the more traditional concerns of physical and chemical hazards. To many health and safety professionals this is a relatively new area focusing as it does not only on the importance of psychological well-being, but also on the potential of emotional distress to impact on physical health. Taken together therefore, current trends in health and safety management appear to demand much more careful and thoughtful consideration of the issues than is required by straightforward compliance with the law.

The objectives of this monograph therefore are two-fold. First, the intention is to describe the information which is currently available about the impact, both positive and negative, which

different types of work patterns can have on the well-being of the workers who experience them. Well-being in this context encompasses both physical and psychological health, physical safety and more generally, quality of life. While much research is at group level, consideration will also be given to the importance of individual differences in order to highlight contra-indications for particular working patterns. Clearly not every work pattern can be covered in a review such as this, and indeed not every work pattern has been studied. It should be stated at the outset therefore that it is not the intention here to provide exhaustive coverage of all the available scientific literature in the field, but rather to highlight the main issues of concern and the published evidence relating to these thus providing sufficient information to derive general principles on which to base real-life health and safety decisions. Inevitably some of the published evidence is contradictory and controversial since, as in other fields of scientific research, there are numerous methodological difficulties in this area which need to be borne in mind. An important aspect therefore is the identification of what is currently known and what remains to be clarified or further explored.

A second major objective is to examine how available information can be used effectively to offer people working time arrangements which allow them to live healthier and more productive lives. Separate sections are therefore devoted to what is known about the effectiveness of different measures designed to address the problems created by working time arrangements and to suggestions and recommendations about policy development. The approach adopted throughout is to address issues by reference to the key scientific evidence and to illustrate points by use of specific examples.

The book is primarily addressed to the very large number of people who directly or indirectly have a role to play in optimizing conditions at work. Most obviously this includes employers, health and safety officers and personnel officers, but also representatives of employers' and employees' organizations, the employees themselves, and the many government officials who are concerned with health and safety policy.

Chapter 2.
Current trends

What is working time?

The organization of working time can take many forms and will be determined by a range of factors associated with the needs and expectations of both employers and employees. In terms of its impact on health and safety two important dimensions can be distinguished, first the *number* of hours worked and second the pattern or schedule of those hours. Within each of these a number of forms can be identified which may differ in terms of their effects. Thus any discussion of such effects will require first a description of the type of working time under consideration and second, the essential features of this type which are relevant to matters of health and safety.

Number of hours

The appropriate number of working hours is something which has received much legislative attention throughout the world and is now the subject of a growing body of research activity. Agreement on numbers of hours at an organizational or national level is important in the context of defining both “normal” hours of work and, as a consequence, what constitutes “overtime”. For example Article 16 of the ILOs Reduction of Hours of Work Recommendation (1962) states that “overtime” means “all hours worked in excess of normal hours”. Currently, however, the definition of normal, and hence of ‘overtime’ varies throughout the world. Although it is almost

always dictated by national laws, numerous cultural and economic factors will often have played a major determining role. In most countries what is regarded as “normal hours” tends to fall somewhere between 35 and 54 hours with a median of around 40 hours, although within any one country a single standard may not apply to all workers. Throughout the world normal hours, that is limits on hours set by law, has been steadily decreasing in recent years. However, normal hours do not necessarily bear any relation to the actual hours that people work, since many jobs will require hours in excess of those set by law. In some cases extra hours are worked as part of an hours-averaging scheme and may be unpaid. More often however, they are worked as paid overtime with national legislation setting daily, weekly or monthly limits on what is allowable. The various advantages and disadvantages of overtime for employers and employees have been summarized by Brewster and Tregaskis (1996) as follows:

employers

advantages

- It allows plant and premises to be utilized or services provided for longer hours than the standard day.
- It allows the completion of projects, or an increase in output to occur.
- It can be used to cover absence of other employees.
- It reduces the administration, selection and training problems associated with many other forms of flexible working.
- It enables employers to respond to additional work demands or emergencies in a readily manageable way.

disadvantages

- Overtime often involves extra costs. It is usually paid for at premium rates; or by the allocation of time off in lieu.
- It can reduce the motivation to work effectively as employees try to sustain work long enough to achieve some premium rate working time.
- It encourages employees to concentrate upon the time they spend at work rather than the output they achieve. This may lead to disputes between colleagues.
- The long hours involved in overtime working are positively correlated with increases in tiredness, sickness, stress, and increase in accidents.
- Overtime is linked to absenteeism - because workers get tired, get stressed, have accidents and are restricted in the time they have for non-work aspects of their lives, overtime creates absenteeism.
- Paid overtime is still used in some organizations as a way for local managers to overcome low pay.
- Overtime, beyond those cases where it is used to cover exceptional circumstances, reduces the per hour productivity of employees. The evidence is less clear, but also suggests that it reduces the quality of work. In part, these findings are directly linked to tiredness.

employees

advantages

- Overtime hours are paid at advantageous premiumrates.

disadvantages

- Hours of work are irregular.

Here health and safety issues are here placed under the heading of disadvantages to *employers* (on the grounds of a resultant increase in sickness absence) but not to *employees*. This is an over-emphasis on the economic case however. Health and safety considerations, from a humanitarian as opposed to a strictly economic standpoint, may not be the only factors which have encouraged a general reduction in working hours during the last hundred years, but they have undoubtedly played a major role. In the future as we move towards consensus on "normal" hours such considerations are likely to be paramount.

Current trends in the number of hours

Any definition of numbers of hours necessarily involves a reference period. This has most often been in terms of a single day (24 hour period) or a single week. Recently, however, because of the irregular nature of hours in many occupations, longer reference periods for example, a month or more, have been introduced both by employers and legislators. The most extreme version of this has occurred with the "annualization" of working hours where hours are averaged over a part or full year.

It has already been noted that historically there has been a gradual reduction in weekly and annual working hours in industrialized countries over the last 100 years. During the second half of the 19th century 12 hour days and six day working weeks were the norm in many countries. The relationship between hours of work and production was assumed to be linear. Hence if 10 units were produced in one hour it was expected that 120 units would be produced in 12 hours, every day over an indefinite period. By the end of the 19th century however average hours for many workers had decreased to around 55 per week. This was the result of a combination of increasing humanitarian concern and the empirical evidence already noted which showed that, contrary to popular belief, productivity actually increased as working hours were reduced. At the Mather and Platt engineering works in the 1890s, weekly hours were reduced to 48 and regular rest breaks were introduced. The results demonstrated that there were good economic as well as humanitarian reasons for reducing hours of work. These experiments were repeated by Zeiss Optics in Germany in 1901 and by the Engis Chemical Works in Belgium in 1905 with the same results. As the century progressed there was an increase in laboratory research into the physiological aspects of human fatigue and growing awareness of the unacceptable human cost of poor working conditions. Legislation was gradually introduced so that by the middle of the 20th century the 48-hour week was the norm in many industrialized nations. New technology which improved the efficiency of production helped this process further. In many ways the downward trend has continued during the last years of the century. Table 1 shows the changes in annual working time in 19 industrialized countries between 1987 and 1997. For reference, a

worker working 48 hours per week on average would work 2,496 hours per year while a worker working an average of 40 hours per week would work 2,080 hours per year.

Table 1. *Annual working hours 1987 - 1997*

Country	Annual average duration of work (in hours)		Percentage Change
	1987	1997	
Portugal	2,025	1,823	-10
West Germany	1,716	1,573	-8,3
Japan	2,138	1,990	-6,9
Denmark	1,756	1,665	-5,2
Finland	1,784	1,716	-3,8
Italy	1,800	1,736	-3,6
Switzerland	1,913	1,844	-3,6
Ireland	1,864	1,802	-3,3
Belgium	1,756	1,702	-3,1
Sweden	1,800	1,752	-2,7
The Netherlands	1,748	1,715	-1,9
Austria	1,743	1,713	-1,7
Spain	1,800	1,782	-1,0
Luxembourg	1,800	1,784	-0,9
United States	1,912	1,904	-0,4
Norway	1,740	1,733	-0,4
United kingdom	1,778	1,774	-0,2
France	1,771	1,771	+/-0
Greece	1,840	1,840	+/-0

Source: UIMM Social International 1998 (reproduced from World of Work, No: 25, 1998).

Only two countries, France and Greece, show no reduction. If one assumes an average of 261 days per year as potential working days, even Japan, the country with the largest number of hours, approximated to an eight hour working day in 1987, falling to a 7½ hour day in 1997. Average reduction across all countries was 3% with the largest reductions occurring in Portugal and Germany. However, figures such as these depend on the particular organizations and individuals included in the sample, which varies from country to country. In addition many workers in professional and managerial positions often work long hours of unofficial and therefore unrecorded overtime to cope with excessive work demands. For example, in a survey

of over 1300 managers in the UK 74% reported that they often or always worked over their contracted hours, (Worrall and Cooper, 1999). Average figures also mask the significant percentage of workers who continue to work the longest hours. A recent survey in 16 European countries (Paoli 1996) showed that, while the largest percentage of workers now works 39 hours or less per week, a substantial proportion in a variety of occupational sectors still work more than 60 hours.

Table 2. *Amount of hours worked per week in main paid job, by sector (% of workers)*

Sector	39 hours or less	40 - 44 hours	45 - 59 hours	over 60 hours
Agriculture, hunting, forestry, fishing	37	21	23	18
Mining and manufacturing	50	31	13	4
Electricity, gas and water	52	33	7	7
Construction	35	35	24	5
Wholesale and retail repairs	45	25	20	10
Hotels and restaurants	41	17	21	21
Transport and communication	42	26	22	10
Financial intermediation	56	22	17	4
Real estate, business activities	45	28	18	10
Public administration	67	22	9	1
Other services	25	25	13	5

Adapted from Paoli P, 1996.

There are also differences between employed and self-employed workers with three in every ten of the self-employed reporting that they work more than 45 hours per week as compared with one in every ten of the employed. Women tend to work shorter hours than men, presumably because of additional domestic responsibilities. Overall, however, the figures from this survey indicate that in 1996 in Europe there were more than 17.5 million male and female workers working over 60 hours per week. It would seem that in terms of numbers of hours therefore the problems of the early part of the 20th century have not disappeared and may in fact be increasing.

Pattern of hours

If long hours represent a potential problem, what is the situation in relation to how those hours are arranged? There is a wide variety of ways in which peoples' working time can be

organized since alongside the more traditional shift patterns, numerous other systems have developed in recent years to meet the changing needs of modern industry. For the purposes of this review a broad distinction may be usefully drawn between those working patterns which come under the general heading of 'shift work' and those which represent various other forms of 'non-standard working'.

Shift work

Shift work is not generally popular with workers, particularly when it involves night work. However, it appears to be an increasing trend in modern society with its demands for 24 hour services. Some occupations have always required shiftworking, for example emergency services and health care, but the need for continuous provision or production is extending into more and more areas of life. For employers shiftworking has considerable economic advantages in that it avoids costly start up and shut down procedures and allows maximum use of expensive industrial plant. From the workers' point of view however the benefits are often confined to the increased wages provided as compensation for unsocial and inconvenient hours.

A useful general definition of shift work has been provided by Knauth and Rutenfranz (1987) as "work either permanently or frequently at unusual times or at changing times". Since a large number of different systems exist throughout the world it would be impossible to evaluate all of these separately. However, in terms of effects on health and safety a number of key characteristics can be identified. First, what type of system is employed? There are two main categories of shift systems namely permanent (fixed) systems and rotating systems, some of which may be discontinuous (running from Monday to Friday or Saturday) and others continuous (including weekend working). In each case a particularly important feature is whether night work is involved. If the system rotates, does it rotate backwards or forwards and how fast does this rotation occur? What is the length of the shift and what are the start and stop times? Each of these factors may have some influence on the general well-being of those employed.

Non-standard working

Extended 12-hour shifts, for example those which reduce the working week to four days or nights, have become increasingly popular in recent years but not without some disquiet about potential effects on health and safety. In fact 12-hour shifts are just one example of a form of non-standard working which is more generally termed "compressed working time" where the

usual weekly number of hours is compressed into a smaller number of days. In another example compressed working weeks may consist of working longer hours over four and a half days a week or nine days over two weeks. Nine or ten hour shifts are also quite common in this situation. Potential advantages for employees of compressed working time include a reduction in commuting problems and costs, fewer workdays with no loss of pay and increased opportunities for several consecutive days off. For the employer these arrangements tend to provide more efficient production or service provision, ease of covering all jobs at required times, a decrease in start-up times and a need for fewer supervisory personnel overall. There may, however, be some disadvantages to both employer and employees which tend to centre on health, safety and absenteeism problems associated with increased fatigue.

A particular form of compressed working time occurs where people are required to work away from home. Most obvious examples of this occur in the mining, oil and merchant shipping industries. In the oil industry, for example, workers often work 12-hour shifts over a continuous 14-day period, followed by 14 days leave. Whilst this pattern has evolved to meet the needs of the industry it also recognizes the fact that leisure hours or days off have little value within the confines of this type of workplace.

In addition to shiftworking of various types it is possible to identify at least four other specific forms of working, which may be termed “non-standard”.

Flexitime - requires that employees must complete an agreed number of hours within a set time frame, but allows them a certain amount of discretion in terms of when those hours are worked. For example, some employees prefer to start and leave work one hour early, to avoid busy commuting times. Usually flexitime arrangements stipulate that workers must be present at certain peak hours of the day to maintain the efficiency of the organization. Flexitime may have the effect of creating irregular working hours although these are often under the control of the employee. The major application of flexitime is in office environments such as public administration and financial services where they provide organizational benefits to the employees with no loss to the employer.

Hours averaging - is a departure from the traditional approach where working hours are usually regulated with reference to normal daily or weekly hours. Instead, hours are averaged over a period longer than one week. Accordingly, an employee’s daily and weekly hours may fluctuate greatly during the reference period as long as the average weekly hours over the entire period do not exceed the permitted limits.

Annualized hours - The terms “annual hours” or “annualized hours” are used when the reference period used is one year. Here the employer can vary the number of hours worked within the context of an agreed standard of working hours for the year. Although a number of forms of this system exist, most involve keeping back a set number of hours in pre-paid “reserve banks”. These banks are used to cover increases in demand, absences and holidays. The size of the bank may vary and many firms offer different levels of annual hours contracts. Others have provisions for “buying” additional committed hours if needed.

Hours averaging and annualized hours are attractive to employers because they allow the rescheduling of hours to accommodate fluctuation in demand or seasonal cycles of production. Thus workers work more hours during peak periods and fewer hours during slow periods. Furthermore, working hours exceeding the permitted weekly limits during a given week may not be considered overtime unless the total hours exceed the number permitted during the reference period. Consequently employers often find that this system allows them both to use resources more efficiently and to achieve more predictable labour costs. In addition, some companies find that it enables them to manage the European trend towards a reduced workweek more effectively. For workers, there is some benefit in terms of increased job security and in receiving a salary that remains constant throughout the year. However, those workers whose income previously included a high degree of overtime pay may receive less if the new regular rate of pay is not adjusted to compensate for this. Also their hours are likely to be irregular and they may at times be required to work for very long periods, or at times when there is social and domestic pressure for time off, for example traditional holiday times. Although in some countries, such as Austria and Denmark, hours averaging can be implemented only by collective bargaining agreements, in many other places workers have little control over their working hours and the planning of rosters for long periods ahead may mean there is little flexibility in the system.

Part-time work - may be irregular in its timing and its duration. Generally, legal and collectively agreed overtime regulations (i.e. restrictions and bonuses) apply to full-time employment relationships. One result of this is that overtime bonuses for part-time staff are only required to be paid beyond the same absolute number of hours as is applicable for full-time workers (a demarcation line which can - as in the German retail trade - lie several hours above contractual working time). Thus part-time contracts offer companies considerably greater bonus-free room for flexibility than do full-time contracts. They also seem to result in a high degree of turnover. Thus there is a trade-off between workplace flexibility and workplace stability.

On the other hand some forms of part-time work offer both stability and the flexibility to fit working hours around domestic arrangements. A good example is term-time working which obviously involves many workers in the educational sector, but is also ideal for parents with children of school age. Another form of part-time work is job-sharing which is again particularly popular amongst women with children.

Finally, in addition to the above, a number of other forms of working time exist which may also be grouped under a general heading of non-standard hours. These include on-call work where workers are required to work on an as-needed basis, and casual work described by the Irish Congress of Trades Unions as consisting of "very short periods of employment interspersed with periods of unemployment". This is particularly common in the construction industry but also occurs frequently in the hotel and catering sector. Zero-hours contracts are a relatively recent phenomenon, and may also be considered as a variant of on-call work. Under such contracts, the employee has no guarantee of work, but agrees to be available as and when the employer requires. In practical terms, this means that workers are required to work whatever hours are required, often at very short notice, an arrangement common in retail and catering sectors. This system also operates in the educational sector in the UK where it is termed "supply teaching". Here qualified teachers are available on a register to go into schools at short notice to cover classes when the regular member of staff has called in sick. Other categories of non-standard hours are self-employment and freelance professional work which may provide full employment overall, but is likely to be organized in a non-continuous, unpredictable fashion. Finally some workers have non-standard hours because of the nature of their occupation which requires them to organize their own working time. Examples here include mobile salespersons, heavy goods drivers, community-based public servants and teleworkers.

Clearly not all of these forms of non-standard hours have negative implications for the health and safety of employees. In general it is those which, as a result of the pattern of work, substantially increase the number of hours or demand work at unacceptable times outside the workers control, which may raise concerns. Those which confer obvious benefits such as flexitime and term-time working provide examples of the positive aspects of working time organization, particularly since they involve an element of choice on the part of the worker.

Current trends in the pattern of hours

Figures on the number of people employed in various patterns of work in different countries are difficult to interpret and compare because of differences in the way the data are collected. However some general trends can be identified. Most countries which report statistics on

patterns of working time indicate a gradual increase in shiftworking, although this varies greatly between industrial sectors. For example in France a survey by the Ministry of Labour showed that between 1981 and 1990 the prevalence of shift work increased from 11% to 12.5% with the greatest increase in blue collar workers (from 18.5% to 22.6%) (Bloch - London 1992). More than 50% of workers employed in steel, glass and rubber and plastics manufacture for instance were shiftworkers as compared with around 20% in consumer services. Data from a number of countries suggest that shiftworking is increasing amongst women. For example, figures from the UK Labour Force Survey (Jones et al, 1994) showed that between 1992 and 1994 there was a 7% increase for males and a 10.7% increase for females in those reporting that they "usually" do shift work. In 1994 just over 15% of the total employed population in the UK described themselves as shiftworkers. In the Netherlands 9.6% of those employed reported working irregular shifts in 1991. This represented an increase of 68,500 workers since 1988, of whom two thirds were women (CBS 1993).

In general shiftworking is more common in large organizations than in small enterprises. Figures from Germany in 1993 for instance showed that only 2% of those working in companies with less than 5 employees worked shifts as compared with 23% in companies with 500 or more employees (Knauth and Hornberger 1995). Similarly in the UK in the same year 8.3% of workers in companies with up to 10 employees worked shifts as compared with 23.6% of workers in companies with more than 50 employees.

Hours averaging schemes are also becoming more popular. For example in Japan in 1995 39.4% of workers were subject to such schemes. By 1998 this had risen to 44.1%. Most of these workers are employed in enterprises with 1000 or more employees. A number of countries have recently enacted laws permitting hours averaging. These include the following:

Reference period	Country
3 weeks	Ireland
4 weeks	Czech Republic, Finland, Sweden
2 months	Hungary
3 months	Belgium
4 months	Portugal
6 months	Denmark, Germany
1 year	Austria, France, Italy, Spain, Switzerland

The EC Directive on working time also provides for hours averaging and allows a maximum reference period of four months for application of the maximum weekly working time which is 48 hours. However, Member States may derogate from this standard, allowing a set reference

period of up to 12 months in collective agreements, agreements between the two sides of industry for objective or technical reasons, or other reasons concerning the organization of work.

The most noticeable trend is in fact in the number of unusual or non-standard patterns of hours which are developing to meet manufacturing and consumer needs, particularly in developed countries. The Netherlands is a typical example where working outside the conventional nine-to-five routine is becoming increasingly common and traditional hours are being replaced by a whole range of different work patterns. The Labour Force Survey for the Netherlands in 1996 (CBS 1996) showed the percentages of workers employed on different types of work schedules to be as follows:

- Regular 52%
- Irregular 48%
- Night/evening 15%
- Evening 17%
- Weekends (daytime) 16%

Figures from other European countries tend to support this trend. For example in France in 1978 65% of employees worked the same hours every day. In 1984 this proportion had dropped to 59% and in 1991 to 52%. Similarly 15.5% of men and 13.9% of women in 1991 worked a variable number of days each week, as compared with 11.8% and 10.3% respectively in 1984, (Dussert and Vinck 1993). In the UK Watson (1994) notes that by 1993 what might be termed the “flexible” or non-standard workforce accounted for 38% of all people in employment. Such trends are not limited to developed countries. Many irregular shift systems now operate particularly in the service sector in developing countries. For example in Thailand where 96 shift systems were surveyed, 88% operated on a semi-continuous or discontinuous basis, mostly alternating every week, resulting in a different number of days off each week (Osiri *et al* 1994).

As noted earlier some of these patterns confer real benefits on employees and their effects may be largely positive. However, the driving force for their introduction is more likely to be an economic one which underlines the need for vigilance in matters of health and safety.

Legislation

A number of changes in international legislation on working time have taken place during the 1990s. These changes reflect the social and economic trends of the latter half of the 20th

century, in that they take account of increasingly complex working arrangements and underline the need for core standards in health and safety provision. The International Labour Organization Convention number 171 and International Labour Organization recommendation number 178 concerning night work are intended to apply to both genders and nearly all occupations (International Labour Organization 1990). They focus less on matters of prohibition of night work for particular categories of workers as previously, and more on the health and

Table 3. *Specific core measures required for nightworkers by the International Labour Organization Convention concerning night work (no 171) and the recommendation concerning night work (no 178), both published in 1990.*

Area	Measures to be taken
Convention No 171	
Health assessment or advice	Health assessment and advice on how to reduce or avoid health problems associated with night work (i) before assignment, (ii) at regular intervals, and (iii) when experiencing work-related health problems
Transfer to day work	Transfer to similar job when certified as unfit for night work
Maternity protection	An alternative to night work before and after childbirth for at least 16 weeks and for additional periods necessary during pregnancy, with protection as to no dismissal and income
Compensation	Compensation in the form of work time, pay or benefits
Social services	Appropriate social services
Consultation	Consultation on the details of schedules, health and social services before work schedules involving the services of nightworkers
Recommendation No 178	
Hours of work	Normal hours of work not exceeding 8 in any 24-hour periods; avoiding overtime and no overtime in occupations involving special hazards or heavy physical or mental strain; no consecutive full-time shifts; at least 11 hours between shifts
Maternity	Assignment to day work as far as possible at any point during pregnancy
Social services	Services to reduce transport time, improve quality of rest, enable workers to obtain suitable meals and beverages, overcome constraints on family duties or cultural and recreational activities
Training	Benefit from training opportunities, including paid educational leave like other workers
Transfer	Special consideration for transfer to day work for workers with a given number of years of night work
Retirement	Special consideration for voluntary early or phased retirement

(From Kogi 1998)

safety measures required to protect all employees from the potential adverse effects of shiftworking. The specific measures provided for by the legislation include, for example, provision of health assessments and advice, appropriate social services and consultation on the details of schedules prior to their introduction.

Similar emphasis on health and safety provisions is evident in the core provisions of the European Directive on Working Time (93/104/EC) which provides for a maximum working week of 48 hours and specific measures relating to the scheduling of shifts, rest breaks, and health assessments. Again special attention is paid to the need to protect nightworkers.

Table 4. *Core provisions of European Council Directive 93/104/EC*

Area	Measures to be taken
Organization of work	
Daily rest	A minimum daily rest period of 11 consecutive hours per 24-hour period
Breaks	A rest break where the workday is longer than 6 hours
Weekly Rest Period	A minimum uninterrupted rest period of 35 hours per each 7-day period
Weekly working time	Maximum working hours of 48 per week
Annual leave	At least 4 weeks of paid annual leave
Night Work	
Length of night work	Average 8 hours in any 24-hour period
Health assessment	Free health assessment before assignment and at regular intervals
Transfer to day work	Transfer whenever possible to day work when suffering from health problems recognized as being connected with night work
Other night work matters	Certain guarantees for workers incurring risks to their safety and health linked to night-time work; notification to the competent authorities about regular use of nightworkers
Night and shift work	
Safety and health	Safety and health protection appropriate to the nature of night work; appropriate protection and prevention services or facilities with regard to the safety and health equivalent to those for others
Pattern of work	Account taken of the general principle of adapting work to workers with a view, in particular, to alleviating monotonous work and work at a predetermined work rate, and of safety and health requirements, especially regarding breaks during worktime

(From Kogi 1998)

Interestingly the basis of the Directive in health and safety provisions was confirmed when one member state, the UK, challenged its implementation on the grounds that it was in fact a social measure, which would have required unanimous rather than majority consent. The EC court overruled this objection, “taking into consideration the major contribution of the regulations to the improvement of occupational health and safety”.

Underpinning these regulations therefore is the body of information we now have about the potential effects on worker well-being of shift work, night work, extended hours and various other irregular work patterns. Ideally such information can also provide the basis for designing work schedules which optimize health and safety in an increasingly complex working environment. The current state of knowledge in this area is the subject of the remaining chapters.

Chapter 3.
Methodological issues

It is clear that the term working time encompasses a wide variety of working arrangements each of which will have it own particular consequences for the health of working people. Since we do not have comprehensive and reliable statistics on how many workers are currently participating in non-standard working arrangements it is difficult to assess the overall significance of adverse health effects associated with working time. However, it is safe to assume from the statistics which are available that the implications for health in large sections of the population are considerable. In discussing these implications it is important to underline once more that any observed effects may well be positive rather than uniformly negative. While excessively long and irregular hours may produce fatigue, consequent ill-health, poor performance and adverse effects on home life, certain other working patterns may significantly facilitate domestic and leisure activities and thus enhance general quality of life. Further, in some cases potentially adverse effects on health may be avoided or considerably alleviated by the presence of important modifying factors such as environmental and domestic circumstances and attitudes and belief systems.

These considerations underline the fact that modern concepts of health are much broader than those generally assumed in the past. Increasingly in recent years health has come to mean not only the absence of disease, but the presence of an overall sense of well-being, requiring attention to the psychological and social as well as the physical aspects of an individual's life. Furthermore, the somewhat artificial distinction between physical and psychological health is gradually being replaced by what is termed a "biopsychosocial" approach which recognizes the

essential interaction between the two. In the field of occupational health and safety this has, in many countries, been reflected in a broadening of perspectives to include a concern not only with the more traditional preoccupations of accident prevention and exposure to toxic chemicals, but also with the psychosocial aspects of the working environment. Addressing the problems of dust, fumes, noise and unguarded machinery are still important therefore, but so too are the causes and potential effects of stress and fatigue.

The study of working time therefore represents a particular example of an area where a number of physical, psychological and social factors may all come into play to determine the general well-being of the worker. Not surprisingly the expression of that well-being may also take numerous forms and a range of potential effects will therefore need to be considered. These include the more immediate experiences of acute fatigue and psychological strain and also a number of longer-term health outcomes, to which the cumulative effects of these factors may contribute, notably cardiovascular disease, gastrointestinal problems, mental health disorders and adverse effects on reproductive function. Added to these are effects on performance and safety and a range of outcomes which may be subsumed under the general heading of social effects, encompassing effects on domestic and personal relationships, on leisure activities and even on the well-being of workers' children and other family members.

The picture is therefore a complex one, requiring for its understanding a broad multidisciplinary perspective. It draws extensively on the fields of occupational medicine and epidemiology but also recognizes the importance of subjects such as physiology, psychology and sociology. For example, epidemiological studies are essentially designed to establish whether an association exists between a particular factor, for example regular night work, and a particular health outcome. Such studies cannot always unequivocally determine a causal relationship however, nor are they intended to explore explanatory mechanisms. These aspects are often better addressed by the more experimentally-based approaches common in the fields of psychology and physiology.

In each of these areas a number of methodological difficulties exist which need to be borne in mind when examining the scientific data. A summary of these is useful at this point since they will be referred to at intervals in the discussion of the evidence which follows in subsequent chapters.

As noted above, much of the information relating to the effects of working time is derived from large scale epidemiological studies. Essentially problems can occur in three aspects of this type of study, namely (i) the type of design, including the population selected, (ii) the

assessment of working time arrangements, (iii) the definition of outcome. In relation to (i) it is more usual in this field of enquiry to find cross-sectional studies, which assess the situation at one point in time, rather than longitudinal studies which follow up workers over a period of years. Although cross-sectional studies are easier to conduct and less demanding on resources than longitudinal studies they suffer from a number of well-documented problems, in particular the difficulty of determining the direction of any observed association. Cause and effect are particularly difficult to identify from this type of data. For example some studies have demonstrated an association between certain personality characteristics and a preference for shiftworking. The question therefore arises as to whether shiftworking encourages these characteristics or whether those with such tendencies are more likely to choose shiftworking. None of the existing studies can answer this question.

Other problems relate to population selection. Unless a proper sampling procedure has been carried out and the participation rate is high, a bias may result which is difficult to estimate in terms of either size or direction. People may be reluctant to take part in research for a variety of reasons, including concerns about their health, and perhaps their job. This may result in a disproportionate number of healthy people in the study population. Conversely individuals without health problems may decide the research is of no particular value to them and similarly refuse to participate, in this case producing the opposite effect.

A related and commonly occurring problem in occupational health research is that which is generally termed the “healthy worker” or “survivor” effect. This refers to the fact that working populations as a whole tend to be healthier than non-working populations and healthier than the general population at large, which necessarily contains numbers of non-working individuals. Further, within any working population, individuals who are better able to cope with the particular factor under investigation, for example rotating shift work, are more likely to select themselves into this kind of work initially and less likely to select themselves out at a later date as a result of health problems. The result in any cross-sectional study may be a study population containing large numbers of healthy well-adjusted workers, with affected individuals and hence the size of any adverse effect considerably underrepresented.

Other problems in this type of study relate to the necessity of including a control group, matched on a range of potentially confounding factors (usually age, gender, socio-economic group and type of work). Control groups are frequently criticized on the grounds of inadequate matching or poor participation rates. Not surprisingly access to an appropriate and enthusiastic control group, which will have no personal interest in participation, presents considerable problems for researchers. Moreover an entirely satisfactory control group may be inherently

impossible to obtain. A well-accepted problem in assessing the effects of nightworking for example derives from the well-documented differences between day working and nightworking in the same factory carrying out the same tasks. Night work is typically characterized by less supervision, less social contact, fewer catering and other facilities and reduced health and safety provision often resulting in less accident reporting. Use of day workers as a comparable group, or indeed use of accident statistics as an outcome measure, is therefore questionable. These various difficulties all point to the superiority of longitudinal data, either retrospectively or prospectively obtained, which includes follow-up of those who have left the workforce. Unfortunately in this as in many other fields, longitudinal studies tend to be in the minority.

The assessment of working time arrangements (ii) really refers to what is commonly termed "exposure" in occupational health and safety research. In this case there are considerable problems associated with assessing how long an individual has participated in particular working arrangements. Typically such arrangements vary throughout a person's working life. Further, any observed effects may be confounded by the presence of other factors, typically age, but also exposure to chemicals, heavy manual work or other psychosocial stressors.

The assessment of outcome (iii) can be more problematical than might at first be apparent. Most health conditions, for example cardiovascular, gastrointestinal and reproductive disorders may each include a number of different forms which it may not always be appropriate to group together. The most obvious example of this is the peculiarly Japanese phenomenon known as "*karoshi*" (literally translated as death from overwork) which has received much publicity in recent years. Here a causal link has been suggested between prolonged excessive working hours and sudden death in relatively young, apparently healthy individuals. Post-mortem results, however, have revealed a variety of causes of death in this group, including stroke of different types, acute heart failure, myocardial infarction and aortic rupture, (Uehata 1991[a]). Although it may perhaps be appropriate to group these under a general heading of "vascular event" the range of underlying health problems they represent calls into question what initially appeared to be a strong relationship between overwork and sudden death.

Other difficulties arise where the outcome in question is not so much a specific disease as a state of mind or group of non-specific symptoms. This occurs for example in the assessment of fatigue, stress or in some cases mental health disorders. Here questions arise over the validity and reliability of the measures (usually questionnaires) employed. Not all studies use standard, psychometrically sound assessment tools which both detracts from the credibility of the data and makes it difficult to compare their results meaningfully with those of other studies. Finally some studies employ direct measures of performance such as accident rates, episodes

of sickness absence or aspects of quality control. All these present special difficulties of definition and measurement, notably in respect of the particular reporting system in operation, which if left unspecified can seriously distort interpretation of the data.

Discussion so far has centred on the potential difficulties associated with epidemiological studies. Laboratory-based investigations tend to allow for greater control to be exercised over "exposure" to working time arrangements and over potential confounding variables. However, they require careful design, for example, to take account of "practice" effects where repeated questionnaire or performance measures are involved and like epidemiological studies they require attention to the quality of any assessment tool employed. By their very nature laboratory-based investigations can only be concerned with acute effects of short-term situations and frequently suffer from the fact that participants are volunteers rather than "real" workers whose responses might be somewhat different. As in other fields of investigation therefore no study in this area is likely to be entirely free from methodological difficulties. Assemblage of a reasonably comprehensive picture of the information therefore requires examination of data which may have emerged from a number of different standpoints.

Currently the largest body of available evidence relates to issues concerning shiftworking in its various forms. However, there is also an increasing literature on the effects of long hours and overtime with somewhat less on other forms of irregular or non-standard hours. For convenience the following chapters will look first at consequences of working time for health and well-being and secondly at its effects on performance and safety. These areas tend to be treated separately in the scientific literature. However, it should be reiterated that in the real world such effects are very likely to be interactive.

Chapter 4.
Working time and health

Numbers of hours

The general impetus towards reducing working hours over the last hundred years has been underpinned by the assumption that long hours are potentially injurious to health. Conventionally therefore research in this field has taken place within a framework which focuses on the risks of working excessively long hours, thus viewing working time as a potential workplace hazard. There is no evidence, however, that work itself is bad for people. In fact numerous studies have shown that those who are in employment are healthier and psychologically better adjusted than the unemployed (Banks and Jackson 1982; McPherson and Hall 1983). While this may be viewed simply as a selection effect, further supporting evidence of the beneficial effects of work is provided by other studies which document the progressive deterioration in health and well-being which tends to follow job loss and subsequent failure to find work (Jackson and Warr 1984; Morrell *et al* 1994).

Further, a number of working arrangements have been specifically designed to meet the needs of particular groups of workers such as parents (term-time working) women (job-sharing) and commuters (flexitime). Scientific research tends to focus, reasonably enough, on potential problems and there are consequently fewer published data on positive effects. However, where these particular non-standard work patterns have been studied systematically the results have been reassuring (Pierce and Newstrom, 1983).

Up to a certain point therefore working time may be viewed as positive, rather than negative or simply neutral in its effects and it should not be assumed that all unconventional work patterns have negative consequences for health. The question thus becomes one of identifying a period of working time which both maximizes the probability that workers will be optimally motivated and productive, and minimizes any risks to their health. If such a period could be identified this would presumably provide the definition of "normal" working time which, not surprisingly, currently differs from country to country. As noted earlier, the concept is crucially important, since overtime work and the definition of excessive hours are clearly both dependent on how "normal" is defined.

The central health concern in relation to the numbers of hours worked is the development of fatigue and, associated with this, occupational stress, either directly as a result of fatigue or as a consequence of increased exposure to other workplace stressors. Understandably therefore, the literature on this subject focuses largely on long-term health outcomes which have frequently been associated with cumulative exposure to fatigue or stress. These include, in particular, mental health problems and cardiovascular disease, although some others such as reproductive disorders and musculoskeletal problems have occasionally been investigated. In addition there has also been some concern about behavioural responses to stress which includes lifestyle factors such as smoking, diet and exercise and somatic symptoms such as headache, insomnia and cognitive difficulties.

Fatigue itself is a difficult concept to define and hence to measure. As a potential determinant of health problems it tends to be defined operationally in terms of the number of hours worked over a certain period. This assumes a certain uniformity of response however. One of the difficulties of assessing the health effects of any pattern of working time is the individual differences apparent in the perception of fatigue. This variation is as much psychological as physiological in nature. It is well-established for example that the first barrier encountered in any continuation of effort is invariably a psychological rather than a physiological one. This was first demonstrated by some experiments in the 1950s which showed for example that the maximum duration for which young men could suspend from an elevated bar could be increased by the promise of monetary reward (Craig and Cooper, 1992). Many subsequent experiments and observations have confirmed the influence of motivational factors on the limits of both physical and mental performance.

The point at which people *perceive* themselves to be tired is therefore the point at which they start to experience a sense of stress at maintaining their performance and also become more vulnerable to other sources of stress in their environment. Further, this point is likely to be

influenced by a range of personal attitudes and circumstances. Any workforce or study population will include individuals with varying degrees of enthusiasm for the hours which they work. A study carried out in an American manufacturing company, for example, showed that employees' willingness to work paid overtime was significantly related to their level of job satisfaction, their identification with the organization and their perception of the fairness of overtime payments (Hollman 1980).

White-collar workers often undertake unpaid overtime and their acceptance of this may depend on how justified or necessary they feel it to be. The results of a study in the UK of over 1,300 managers demonstrates the range of attitudes which may be encountered, (Worrall and Cooper, 1999). In this survey 74% often or always worked over their contracted hours with a further 16% stating that they sometimes worked overtime. Fifty-five per cent of the managers surveyed felt that working long hours was necessary to meet deadlines. Nevertheless one in five regarded working such hours as unacceptable, whilst also feeling that this was expected of them and that they had little choice in the matter. By contrast 38% did not object to long hours because they "took their work seriously" and 10% felt that long hours were necessary "to get ahead". A further 15% stated that they actually preferred long hours and interestingly 14% of the group as a whole stated that they regarded work as "more important" or "much more important" than home.

Employee attitudes, and also the level of stress generated by the job, may thus be important modifiers of the relationship between long hours, particular work patterns and the risk of long-term health problems. Data on these aspects are currently rather limited. However, attitudes do appear to influence perceived tiredness thresholds and, for this reason, measures of fatigue which rely solely on numbers of hours alone represent only part of the picture. In particular epidemiological studies of working time, which investigate the relationships between hours of work and particular health outcomes are more usually carried out without reference to intervening variables. Smaller scale studies on the other hand, particularly those which deal specifically with stress and mental health tend to investigate individual perceptions in more detail.

Mental health

The majority of modern studies which explore the relationship between long working hours and mental health have been carried out within the wider context of occupational stress research. Here the relative importance of long hours as a source of pressure is assessed alongside that of other potential stressors. Although these studies are in the main cross-sectional, many are strong in two particular respects. First they explore workers' *perceptions* of

their working hours as a source of stress rather than the actual number of hours. This is usually carried out by employing a rating scale, thus taking account of individual variation in response. Secondly they tend to use valid, reliable assessment tools for measuring mental health.

Two examples of studies in contrasting occupations in the UK

- ***Bus Drivers :*** The mental health of urban bus drivers was compared with that of a matched group of attenders at a primary care health centre. The mental health of the bus drivers was significantly poorer than that of the comparison group using a valid, reliable measure. When asked to rate different sources of stress the bus drivers identified family problems associated with long working hours as a major source. (Duffy and McGoldrick, 1990).

- ***Accountants :*** The mental health and psychological well-being of a group of accountants was assessed using valid, reliable measures. Perceived sources of stress were also assessed. Quantitative work load associated with long working hours was significantly related to poorer mental health scores. (Daniels and Guppy, 1995).

On the other hand studies which use a quantitative measure of actual hours worked do have some advantages and tend to complement investigations which make reference to employee perceptions and attitudes. In particular the results of quantitative studies help to define what approximates to a "safe" number of hours for the *majority* of workers. This is a helpful starting point for employers and particularly useful for legislators, although some would dispute its validity. The European Directive on Working time for example imposed a limit on working hours of 48 per week, thus fuelling much debate about the quality of the evidence on which this was based. Interestingly, however, the results of those studies which do employ quantitative measures tend to support this figure. In addition a recent meta-analytical review which drew together the quantitative data from all those studies meeting certain quality criteria, produced the same general conclusion (Sparks *et al*, 1997). The most recent studies which quantify hours and which are concerned with stress and mental health are summarized in Table 5.

Table 5. *Long working hours and their effects on health*

Country	Study population	Hours worked	Effects	Authors
Japan	Factory workers	> 9 hours/day	Mental health problems	Ezoe and Morimoto 1994
Japan	Managers	≥ 10 hours/day	High stress Low quality of life	Maruyama and Morimoto 1996
Germany	Medical staff	> 48 hours/week	High stress	Kirkaldy *et al* 1997
UK	Junior doctors	> 73 hours/week	Mental health problems	Houston and Allt 1997

In many cases, where overtime is worked to cope with an unmanageable work load, it is difficult to separate out the stress of long hours *per se* from that associated with other sources of pressure. Clearly these (usually managerial and professional) jobs are inherently subject to considerable general strain. However, a recent study of travelling salespeople (Borg and Kristensen, 1999) who had many potential stressors in their working life was able to demonstrate that poor mental health was not, as expected, related to factors such as nights away from home, time away from the office, and low perceived support from colleagues but instead was significantly related to long working hours, and non-day work. In this context it is also useful to note the results of the factory workers' study in Japan (Ezoe and Mammoto, 1994) where extra work undertaken was simply an extension of routine production, but nevertheless increased the risk of mental health problems.

In discussing the effects of long hours perhaps the most disturbing accounts relate to incidents of sudden death and suicide. The occurrence of karoshi in Japan has already been mentioned. In addition, the Japanese National Policy Agency reported 922 work-related suicides in 1991 rising to 1,257 in 1996. The causes of these appear to be multifactorial and, unlike the case of *karoshi*, there is no suggestion that they were related specifically to long hours, although this is undoubtedly cited as one important aspect of occupational stress. Major concern about work-related suicide has so far been confined largely to Japan where particular cultural expectations may have a role to play. Cases are not unknown elsewhere however. Such deaths appear to represent the extreme end of a spectrum of psychological harm which may result from generally excessive demands at work. Overall the scientific evidence in relation to less severe but nevertheless debilitating mental health problems is consistent in suggesting that long hours is often a significant part of those demands.

Cardiovascular disorders

The evidence linking long working hours to an increased risk of cardiovascular disease is not entirely consistent but gives grounds for increasing concern. As noted above the most well-publicised statistics come from Japan where Uehata (1991[b]) reports on 203 cases of *karoshi*, 196 men and 7 women, who suffered fatal cardiovascular attacks. Two thirds of these had been working regularly for more than 60 hours per week, more than 50 hours overtime per month or more than half of their fixed holiday before the attack. The direct association between their deaths and overwork in terms of long hours remains in dispute however. Cardiovascular attacks in middle-age are not uncommon in the general population, and these numbers are not significantly large in epidemiological terms. Detailed descriptions of several of the cases by Uehata (1991[a]) also suggests multifactorial causes including various other sources of stress.

More convincingly a number of large scale epidemiological studies of different designs carried out since the 1950s have suggested a direct link between cardiovascular disease and long working hours.

- 71 of 100 coronary patients in an American hospital under the age of 40 had worked more than 60 hours/week over a prolonged period, more than 4 times the number in a matched control group. (Russek and Zohman, 1958).
- Working more than 48 hours per week doubled the chance of dying from coronary heart disease during a three-year period in California, USA. (Buell and Breslow, 1960).
- Men employed full-time by the Bell Telephone Company in the USA who also went to night school had a significantly increased risk of death from cardiovascular disease during a 5-year period. (Hinkle *et al*, 1968)
- Almost 50% of a group of 50 patients admitted to hospital with myocardial infarction in Oklahoma USA regularly worked more than 60 hours per week, compared with 25% of a matched control group. (Thiel *et al*, 1973)
- In Japanese men the risk of myocardial infarction increased with greater increases in working hours. (Sokejima and Kagamimori, 1998)

The contradictory evidence comes from Sweden (Starrin *et al*, 1990) where morbidity and mortality data collected over a 20 year period up to 1983 failed to find any relationship between cardiovascular disease-related mortality and long working hours, at least in males. Perhaps surprisingly an association was identified in females, which might be explained by differences in domestic workloads. A study in Canada for example demonstrated that women who reported an average professional working week of just over 31 hours, also had a domestic working week of over 19 hours (Tierney *et a*l, 1990). The Swedish evidence on male cardiovascular disease is difficult to explain but may reflect individual differences in either physiological response or in attitudes and health behaviour which have so far been little explored. For example individual variations in cardiovascular reactivity to stress are well-established (Carroll *et a*l, 1991) and in one Japanese study of overtime work, Kobayashi *et al* (1992) found significant differences between normotensive and hypertensive workers in terms of changes in blood pressure and heart rate at different times of the day.

Other problems

Occupational stress may sometimes lead to a range of behaviour patterns which have

negative consequences for health. These include, for example, increases in smoking and alcohol consumption and a poor and irregular diet. In addition stress may be expressed in terms of a range of non-specific or somatic symptoms such as headache, nausea, insomnia and exhaustion as well as cognitive difficulties such as poor memory and concentration. It is common for researchers to investigate these outcomes in relation to occupational stress in general and in many cases long working hours has been identified as a significant source of that stress.

Two other health outcomes of long hours should be mentioned briefly since they have received some limited scientific attention. First, a study in France (Mamelle *et al*, 1984) investigated various risk factors for pre-term birth in working women. They noted there was a regular increase in the rate of premature birth as the number of working hours per week increased, from 3.6% for part-time jobs to 10% for more than 45 hours per week. They point out that this was not simply a reflection of different types of job which might involve differing levels of either physical or psychological stress. The same relationship obtained for all categories of occupation studied, from unskilled factory workers to secretarial and administrative staff. Other data on pregnancy and birth are scarce however, despite a considerable amount of information on the effects of shift work on reproductive health. This appears to be an area which would merit further investigation.

- In a study of smoking habits among members of an Israeli kibbutzim, long working hours were positively related to smoking intensity and negatively related to smoking cessation (Westman *et al*, 1985)
- A survey of coping behaviour among Australian coach drivers showed that long working hours were the most significant predictor of stimulant use and sleep disorders, which in turn predicted reports of non-specific symptoms and visits to doctors (Raggatt, 1991)
- In Japanese middle managers, long working hours were shown to be associated with a poor lifestyle which included irregularity of daily life, meals and sleeping patterns (Maruyama and Morimoto, 1996)
- In American automotive workers, increased overtime was significantly associated with impaired performance on several cognitive tests of attention and information processing. It was also associated with increased feelings of depression, fatigue and confusion (Proctor *et al*, 1996)

Secondly there has been some limited investigation of the effects of long hours on musculoskeletal problems. In jobs which place heavy and possibly repetitive demands on the musculoskeletal system there are strong reasons to expect an increased risk with long hours. In addition there is now a substantial body of evidence linking these problems to high stress levels

in the workplace. Direct investigation of the association between long hours and problems such as back pain and upper limb disorders are rare. However, a large study of female grocery checkers in America found that the prevalence of hand/wrist symptoms characteristic of carpel tunnel syndrome, was significantly associated with the average number of hours worked per week and years employed in that occupation (Morgenstern *et al*, 1991).

In a sense this last study hints at another wider problem of long working hours, that of increased exposure to other workplace hazards, which may be controlled only to the extent that they do not place workers at risk in the course of a "normal" eight hour day. A range of physical and chemical hazards which have occupational exposure limits based on the traditional 8-hour "Time Weighted Average" fall into this category. To date, this problem seems to have been virtually ignored, at least in terms of human investigation, but certainly seems to merit consideration when assessing the overall risk attributable to working time patterns.

In addition to specific effects on health it is clear that long hours can also have detrimental effects on social and family life, although actual data on this aspect are surprisingly few. A study in Canada of dual-earner spouses (Galambos and Walters, 1992) showed that stress, anxiety and depression in husbands was related not only to their own inflexible work schedules but also to the long working hours of their wives. Wives' levels of stress on the other hand appeared to be related to their own work schedules, but not to those of their husbands. These results suggest that women experience pressure as a result of dual roles and domestic expectations, while men are more likely to be negatively affected if their wives' work prevents them from adequately fulfilling those roles. In a survey of white-collar workers in the UK (Austin Knight, 1995) more than 50% of men reported that they felt their family life suffered because of their long working hours, and 20% felt that their relationship with their partner had been put at risk. This was matched by women senior managers where similarly over half felt that their family life had suffered and a quarter felt their relationship was threatened. These women, however, regularly worked long hours, 70% over 40 hours a week and 23% more than 50 hours. Women working in less senior positions and shorter hours were much less likely to be concerned about the risk to their family life.

As noted earlier, studies in this area are few, and the Austin Knight results were based on a response rate of only 50%. However, intuitively it seems reasonable to assume that long hours will have predominantly negative effects on life outside work, and this is likely to be the case for the majority. However, it should be remembered that some individuals' work may represent their primary life activity and source of satisfaction. Considerably more research, perhaps of a qualitative rather than a quantitative nature, is required to address these issues.

Long hours and health : The current picture

- Regularly working in excess of 48 hours per week appears to constitute a significant occupational stressor which reduces job satisfaction, increases the effects of other stressors and significantly increases the risk of mental health problems.
- Regularly working more than 60 hours per week and perhaps more than 50 hours per week appears to increase the risk of cardiovascular disease.
- Individual attitudes and motivation appear to modify the response to work stressors, but whether these, or variations in physiological response, reduce long-term health risks has not so far been adequately investigated.
- Long hours appear to be associated with increased prevalence of somatic symptoms and health threatening coping behaviours such as increased smoking and poor and irregular diet.
- Some workers have reported adverse effects on family relationships, particularly where hours are in excess of 50 per week.
- There is some limited evidence which associates long working hours with an increase in (i) pre-term birth (ii) musculoskeletal disorders. Both these health outcomes require considerably more investigation.
- The effects of increased exposure to other physical and chemical workplace hazards have not been properly investigated and require assessment.

Shift work

The vast majority of workers who are employed on shifts work on a rotating schedule which includes night work. The effects on health and well-being of these schedules have been extensively researched during the last twenty years, with the result that many potential problems have been reasonably well documented. Essentially these fall into two main areas; first the impairment of physical and psychological health as a result of interference with normal body rhythms and second, the disruption of family and social life. Of these the former has received by far the larger share of scientific attention.

Under normal circumstances human physiological processes are programmed for daytime activity and night-time sleep. A range of body processes, such as heart rate and blood pressure, respiration, temperature, and digestive functions have been shown to vary predictably over a

twenty-four hour period. Alongside this the production of certain hormones encourage the body towards either wakefulness or sleep at different times during this period. These cyclical fluctuations are known as “circadian” rhythms (from the Latin “circa dies” meaning “about a day”).

They are determined partly by endogenous factors, the internal body clock, and partly by environmental cues such as daylight, noise and the social habits of the individual. Shift work, and particularly night work, requires that people behave in opposition to their natural biological timing system. Often, particularly in relation to daytime sleep, they fail to do this successfully, producing a cumulative sleep deficit. Evidence from the wider literature on sleep research suggests that this deficit has two components, first a reduction in the actual number of hours slept, and secondly fragmentation of those hours. Normal sleep appears to consist of different phases which occur at intervals throughout the night. The most important type of sleep for brain restitution, slow wave sleep, tends to occupy the first five hours of the sleep cycle. In shiftworkers sleep is displaced to an inappropriate time in the circadian cycle, when hormonal activity is geared to promote wakefulness. Continuous sleep is therefore difficult to maintain and is likely to become fragmented at a point when slow wave sleep would normally occur. This has been confirmed by the self-reports of shift workers (Lavie *et al*, 1989) and by electroencephalographic studies (Walsh *et al*, 1981). In addition to this problem shiftworkers are then required to work at a time which is sub-optimal in terms of their normal body clock.

The most obvious and direct effects of shiftworking therefore relate to sleep deprivation, fatigue and a general sense of malaise which may be expressed in terms of a range of non-specific symptoms. These problems have been reported by rotating shiftworkers in a range of occupations such as electronics workers in Singapore (Chan *et al*, 1987), textile workers in Bangladesh (Kaleque, 1991), and nurses in Spain (Escriba *et al*, 1992) and in Israel (Barak *et al*, 1995). This is despite the fact that shiftworkers are likely to be a self-selected population, namely those who are better able to adjust.

At first sight data on actual morbidity and sickness absence however appear to contradict the view that shiftworking impairs health. A series of studies by Taylor and colleagues in the UK in the early 1970s suggested that shiftworkers might actually be healthier than their day-working counterparts (Taylor *et al*, 1972a, Pocock *et al*, 1972). The results of these and several other studies throughout the world, the most recent published in 1998, (Kleiven *et al*, 1998), have consistently shown that shiftworkers have lower rates of sickness absence than dayworkers. Explanations for these findings however tend to centre on the survivor effect, particularly since one study by Aanonsen in Norway (1964) showed that in metallurgy workers, those who had the

highest rates of sickness absence were day workers who had previously worked shifts. More recently Neidhammer and Marne (1994) interviewed a group of French nurses on two separate occasions in 1985 and in 1990. She found that reporting of sleep disorders at first interview predicted a transfer from shift work to day work. As a consequence there was no significant excess of reported sleep disorders in shiftworkers over day workers at the second interview.

Certain other factors may also be important. In a recent study of nearly 4½ thousand Italian railway workers, Costa *et al* (1987) found that shiftworking was in fact associated with higher rates of absenteeism but also noted the important influence of various other psychosocial and organizational aspects of the job. It is generally accepted that the decision to be absent from work and the length of that absence is driven by a range of factors, of which the severity of illness is only one. Taylor himself noted that his data were not entirely straightforward since within shiftworking groups certain aspects of pay and conditions appeared to be significantly associated with higher sickness absence rates (Taylor *et al*, 1972[b]). Studying morbidity in shiftworkers via sickness absence data therefore may obscure certain effects on health and well-being. In terms of shiftworking in general, as opposed to particular features of shift work, most occupational physicians and scientific researches appear to regard four potential health outcomes as being particularly important. These are mental health, cardiovascular disease, gastrointestinal disorders and reproductive effects.

Mental health disorders

A number of researchers have investigated the possible psychological consequences of working on shifts. In general the results do not support the contention that shift work alone has adverse effects on mental health. However, the majority of studies in this field involve psychologically demanding occupations, such as medicine and nursing, or jobs which contain another significant stressor such as machine pacing. While, therefore, work schedule has often been identified as one contributor to either perceived stress or clinical conditions such as anxiety and depression, it is frequently cited alongside other factors and its impact may be lost. Added to this, cross-sectional studies are the norm in this area and one must assume that where no effects are found one may be dealing with a shift work-tolerant population. For example, an American study of nearly 500 nurses on a variety of different shifts (day, afternoon, night and rotating) found no evidence that shift work was linked to the nurses' mental health or that their mental health was poor in relation to that of the general population (Skipper *et al*, 1990).

A limited number of studies have focused particularly on night work and its relationship to mental health disorders. While results are somewhat mixed it should be noted that, once more,

Interestingly it has been suggested that in some groups of workers apparent tolerance for shift work may constitute a form of denial. Spelton *et al* (1993) carried out a "reminiscence study" on a group of retired UK police officers who had subsequently taken on other daytime jobs.

They were asked to reminisce about how they had felt while still working on shifts as a police officer, as well as recording for comparison their current mental state. The results clearly indicated that in retrospect individuals perceived their situation as being worse than they realised at the time. It is possible that some shiftworkers gradually habituate to their problems and consequently underestimate them.

those workers studied are likely to be self-selected groups. An investigation of Italian textile workers by Costa *et al* (1981) underlines this point. He found a significantly higher rate of neurotic disorders among shiftworkers, particularly nightworkers compared with day workers. He also observed that 72% of permanent nightworkers who subsequently gave up night work did so primarily because of neurotic problems. Among those who developed neurotic disorders, the average time taken to develop the problem from beginning employment on a particular schedule was 3.6 years for nightworkers, as compared with 9.7 years for day workers.

There is in fact quite a lot of evidence to link the personality trait of neuroticism with shiftworking (Cole *et al*, 1990). Virtually all these data derive from cross-sectional studies and the direction of any causal association is therefore difficult to determine. Certain individuals may be psychologically more vulnerable than others to the stresses of shiftworking, particularly nightworking. It has also been suggested that those who remain as permanent nightworkers, a relatively small percentage of the workforce world-wide, may be a special category of employee who have particular personal or circumstantial reasons for preferring this type of work.

Two studies illustrate these points.

- 29 full-time night nurses in a hospital in Belgium were compared with 44 nurses working a two-shift system with only occasional nightwork. The full-time night nurses were more vigorous, less rigid in their sleeping habits and reported fewer health complaints. They also evaluated shiftwork much more positively (Verhaegen *et al*, 1987)
- 97 permanent night security guards in Sweden were compared with a sample from the general Swedish population in terms of a range of health complaints including mental health disorders. Only levels of sleep disturbance and fatigue were higher in the security guards (Alfredsson *et al*, 1991).

Barton and Folkard in a study of psychiatric nurses in the UK (1991) emphasized the importance of individual differences in response, and noted that the extent to which a workers' mental health suffered as a result of his/her shift schedule appeared to depend greatly on their general satisfaction with the particular schedule and how far it was perceived to harmonise with other aspects of their life. This said, however, it is difficult to escape the conclusion that shift work, including night work, increases the risk of mental health disorders in large numbers of workers.

Cardiovascular disease

Before 1980 shift work was not generally considered to be a risk factor for coronary heart disease. The data, reviewed by Harrington (1978), gave no particular grounds for concern. Since then however several new studies, often with much improved methodology, have been published and the position appears to have reversed. There is now mounting evidence of an association between shiftworking, particularly nightworking, and cardiovascular disorders. Given that heart disease has long been associated with factors such as anxiety, social and occupational stress and sleep disorders (Jenkins, 1996) this is hardly surprising. Bøggild and Knutsson (1999) have carried out a careful review of the data from 17 studies published between 1949 and 1993. Taking into account the methodological quality of these various studies they argue that the balance of the evidence suggests a 40% increased risk of cardiovascular disease in shiftworkers. On the other hand Bøggild and colleagues subsequently published the results of a prospective cohort study in Denmark (Bøggild *et al* 1999) and found that social class was an important confounder of the relationship between shift work and ischaemic heart disease in that shiftworkers were more likely to come from lower social classes where cardiovascular disorders are more common. Few studies appear to have taken this into account. An alternative approach adopted by Olsen and Kristensen (1991) involved a review of all epidemiological data in Denmark which was concerned with possible causes of heart disease. They then calculated the "aetiological fraction" for shift work, this fraction being defined as the proportion of the disease which would not have occurred if the risk factor had not existed in the population. For shift work the fraction was calculated to be 7%. Clearly the methodological quality of the studies on which these conclusions are based is very variable. However in an earlier review Kristensen (1989) noted that there was a positive correlation between study results and study quality, in that the better studies consistently found a stronger association between shiftworking and cardiovascular disease. Again it is difficult to avoid the conclusion that an increased risk exists, but perhaps its precise magnitude and cause both remain in question.

As Bøggild and Knutsson (1999) point out, it is an understanding of the nature of the causal

link between shift work and heart disease which will ultimately be of value in reducing the risk. Scientists have studied a number of biological markers for the atherosclerotic process which is thought to precede a cardiovascular attack, in particular cholesterol levels and blood pressure. The balance of evidence, again carefully reviewed by Bøggild and Knutsson (1999), suggests that shiftworkers do have a tendency towards higher cholesterol levels but no apparent increased risk of hypertension. Increases in cholesterol may be linked to a range of behaviour patterns associated with shiftworking, notably frequent consumption of high fat and high carbohydrate snacks and irregular timing of meals. For example one study found that cholesterol levels of shiftworkers correlated with the distribution of their meals, being higher when larger proportions of the total diet were eaten at night (Lennernas *et al*, 1994). Other behavioural factors which may be important are smoking, alcohol consumption and lack of exercise. Many studies which examine the relationship between shiftworking and cardiovascular disorders tend to control for these variables as concomitant risk factors for heart disease. However, such factors may in fact be over-represented in some shiftworkers because of their lifestyle and related stress. Far from being confounders, therefore they may go some way towards explaining the association and thus signal the need to adopt measures aimed at minimizing their presence and hence the associated risk.

A number of studies have compared the smoking habits of shiftworkers with other workers in the general population. Approximately half of these find no difference and half find that shiftworkers smoke significantly more. In terms of alcohol consumption, which in moderate amounts is thought to be a protective factor for cardiovascular disease, the majority of studies find little difference between shiftworkers and comparison groups, although there are some exceptions. The data on exercise are similarly inconsistent with some shiftworkers exercising more on a regular basis than their day-working counterparts. The picture is clearly a complex one and the causes of increased heart disease are likely to be multifactorial. However, in view of the wider literature on cardiovascular risk factors it seems reasonable from a preventative point of view to target known high-risk behaviours. This aspect will be taken up in a later section.

Gastrointestinal disorders

The most frequently reported health problems of shiftworkers, both from an anecdotal and scientific perspective are gastrointestinal disorders. Employees on nightshifts tend to report more appetite problems and general symptoms of digestive disturbance than do either day workers or shiftworkers not on the nightshift. From a physiological point of view this is unsurprising. There is a circadian rhythm to gastric secretion and during the night the digestive system is ill-equipped to cope with the quantity and composition of a normal daytime meal. The

question for researchers however has been whether these acute symptoms are translated into chronic health problems when they occur on a regular basis over a long period of time. An increased risk of peptic ulcers in shiftworkers was first identified in the 1950s and 60s. However much of the evidence at that time was contradictory and inconclusive. Early studies were frequently criticized on the grounds that the results were heavily influenced by the "survivor" effect. Subsequently studies from Norway and Germany (Aanonsen 1964, Angersbach et al, 1980) have followed up those leaving shift work and have shown that peptic ulcers are significantly more common in former regular shiftworkers than those who have always been dayworkers. Moreover they found a significant decrease in gastrointestinal disorders in these workers following a transfer out of shift work. Once more the nightshift appears to cause more problems than other aspects of shiftworking.

Costa studied peptic ulcers and gastroduodenitis in 573 male textile workers in Italy. There was a significantly higher incidence of each complaint in nightworkers and in those who had been doing shiftwork for between 9 and 16 years. For those who developed gastrointestinal disorders the interval between the beginning of the particular schedule of work and the appearance of the illness was shorter for 3-shift workers and particularly for nightworkers.

Time to deveiopment of illness

Work schedule	Gastroduodenitis	Peptic ulcer
Day work	12.6 years	12.2 years
Two shifts	7.8 years	14.4 years
Three shifts	7.4 years	5.0 years
Night work	4.7 years	5.6 years

(Adapted from Costa *et al*, 1981)

Many of the workers in Costa's study changed schedules specifically because of gastrointestinal problems. For example 67% of rotating shiftworkers opted for a schedule which did not involve night work and 23% of permanent nightworkers gave up night work for this reason. Overall the results of this study indicated that the risk of gastrointestinal disorders was between three and six times higher in shiftworkers, where work included night work, than in day workers.

Reproductive effects

There is a growing body of evidence which suggests that shiftworking, and particularly

nightworking, may present special risks for women of childbearing age. Why this should be so is poorly understood, but most suggested explanations involve a combination of increased psychological stress and hormonal disturbance due to regular disruption of circadian rhythms. The term "reproductive effects" encompasses a range of outcomes, only some of which have been studied in relation to shift work. The majority of evidence relates to spontaneous abortion. However, sub-fertility, measured as time to pregnancy, pre-term birth and to a lesser extent menstrual irregularity have also been studied. There are special difficulties in measuring effects in this particular field of research since much of the data relies on self-report. The identification of spontaneous abortion in the very early weeks of pregnancy for example is often unreliable and the definition of pre-term birth and foetal growth retardation requires accurate reporting of length of gestation. In all the studies carried out so far the data have been collected retrospectively, a process known to be subject to various distortions. Notwithstanding these problems, however, there appear to be some discernible trends.

Spontaneous abortion

A review by Nurminen (1998) indicated that seven out of nine available studies showed a higher risk of spontaneous abortion in shiftworkers as compared with regular dayworkers. In five of these studies the effects of night work were analyzed separately and three produced positive results. In the most recent study in Sweden the increase in risk in relation to night work was mainly in terms of later stage spontaneous abortion (Axelsson *et al*, 1996).

Subfertility

The evidence in relation to subfertility is less clear. Of six recent studies, four suggested some association with shiftworking although not always in the expected direction. For example a multicentre investigation involving Denmark, France, Germany, Italy and Sweden found that subfecundity defined as more than 9.5 months time to pregnancy was significantly greater in those working changing or rotating shifts than those with regular daytime, evening or night work (Bisanti *et al*, 1996). The most recent study carried out in Thailand (Tuntiseranee *et al*, 1998) found that long working hours but not shift work was associated with subfecundity.

Pre-term birth

Pre-term birth is often difficult to separate from low birthweight and retarded gestational age. Overall however the evidence that shift work and particularly night work can have an effect on either or both of these aspects of pregnancy is fairly convincing. In his review Nurminen identifies six relevant studies of which only one found no association between night work or shift work in general and pre-term delivery.

Irregular menstrual cycle

This is the least researched area of reproductive health in relation to shift work. Two studies in Japan, ten years apart (Uehata and Sasakawa, 1982; Miyauchi *et al*, 1992) both reported that women doing night work from a variety of occupations had higher rates of irregular cycles. The only other data comes from France (Messing *et al*, 1992) indicating that women working on shifts where the beginning of the workday varied, were more likely to have irregular cycles than women working on morning or afternoon shifts which changed on a regular weekly basis.

Overall, therefore, while the evidence for reproductive effects is somewhat contradictory and confusing, the best summary is perhaps provided by Nurminen following his careful and thoughtful review: "although the evidence is not ample and remains ambiguous, it is prudent to consider shift work as a potential risk to reproduction".

Shift work and health: The current picture

- Sleep disorders widely reported
- Some evidence for mental health disorders
- Strong evidence for cardiovascular disorders
- Strong evidence for gastrointestinal disorders
- Some evidence for reproductive disorders
- In most cases night work increases the risk of health effects
- Except for sleep disorders the underlying cause of any association is not fully understood
- Individual, differences in physiology, attitudes and behaviour are likely to be important in modifying health effects

Compressed working time

One of the most common forms of compressed working time is the 12-hour shift. Contrary to general opinion this is not a particularly new working arrangement, having been introduced originally in the early 1970s. However, like other forms of shift work it has become the focus of increasing scientific attention in recent years, particularly in the light of new recommendations

about length of hours and rest breaks. Twelve-hour shifts differ from conventional overtime in terms of the psychological mindset of those who work them. Here the expectation is of regular hours, a predetermined stop time, a longer period of continuous leisure and no expectation of extra pay. The strictly physiological concerns however are, like overtime work, related to the potential for acute and cumulative fatigue. This has obvious implications for performance and safety (dealt with elsewhere) but also for health and for general well-being for example in terms of home and social life.

The first target of investigation therefore tends to be the fatigue of the workers, usually assessed by self-reports of sleepiness or conversely general alertness. Perhaps not surprisingly it is the point at which fatigue occurs in the 24 cycle which differs for 12-hour shift workers as compared with workers on other schedules, rather than the level of fatigue *per se*. This can become rather complicated as shown below:

> 92 British chemical workers employed on two 12-hour shifts (days and nights) were compared with 70 chemical workers working on three 8-hour shifts. Duration of sleep reported by the 12-hour groups when working on days was significantly longer than that reported by the 8-hour group on the morning shift but significantly shorter than that of the 8-hour group on the afternoon shift. Self-reported alertness was similar for 12-hour and 8-hour groups in the mornings, but the 8-hour group reported higher levels of alertness during the afternoons. By 8 o'clock in the evening there was no difference in the alertness of the two groups, although the 12-hour group had only just begun work whereas the 8-hour group was nearing the end of their shift. The pattern of sleepiness and arousal therefore seems different for different shift schedules although in this study no differences between the groups in levels of chronic fatigue were observed.
>
> From Tucker *et al*, 1996

Many studies in this area involve comparisons of workers on 12-hour shift systems with those on other schedules. There are certain disadvantages to this approach in that it compares different groups of workers who may have very different attitudes and personal circumstances. In addition, working conditions may differ markedly on different schedules.

Some researchers however take advantage of opportunities which arise to conduct "natural experiments" where organizations are in the process of changing from 8-hour to 12-hour shifts. Here the same workers can be studied before and after the change, hence ruling out at least the effect of individual differences. One potential problem with this approach is the "Hawthorne

effect" (named after the organization where it was first documented). This is the tendency for workers to report initial enthusiasm for a change in working conditions as a result of being specifically observed or the general focus of attention, rather than as a result of any actual benefits of the new situation. Generally speaking such effects are not maintained long-term and better studies therefore carry out extended follow-up investigations. Rosa (1991) for example studied a group of control room operators in a continuous processing plant in America over a long period. Seven months after a change from 8-hour to 12-hour shifts the workers reported some decrements in alertness. These were similarly reported at a further follow-up three and a half years later. These decrements were not maintained over the work week, with day-to-day recovery from the extended work shift occurring. The workers remained very enthusiastic about the shift system and rightly or wrongly seemed willing to tolerate some increased fatigue in return for the perceived benefits of the schedule.

The results of this study highlight an important aspect of 12-hour shifts. They are generally very popular with workers because of the longer periods away from the workplace which they provide. The results of numerous studies testify to this. For example the most recent of these carried out among workers at a chemical plant in Sweden (Lowden *et al*, 1998) found that a change from a rotating 3-shift schedule to a 12-hour schedule increased reported satisfaction with work hours, sleep and time for social activities. These assessments were made ten months after the change in work schedule. Another study in Australia compared the effects on sewage plant workers of a change from slowly rotating 8-hour shifts to a schedule involving rapidly rotating continuous 8-hour and 12-hour shifts (Smith *et al*, 1998). This change produced a range of self-reported benefits for the workers, including improvements in the quality of home and social life, which were more marked for 12-hour shifts. Again these assessments were carried out several months after the changeover.

There are however some dissenters to the common view. A study of nurses in Austria for example showed dissatisfaction with shift work in general and particularly with 12-hour shifts in respect of adverse social and leisure effects (Kundi *et al*, 1995). Clearly one cannot assume that all types of workers will derive social benefits from compressed working time and where social stress develops health complaints are likely to follow. In America the introduction of a three day compressed working week in a police force (Vega and Gilbert, 1997) whilst producing generally positive results in terms of public satisfaction, employee morale, productivity, recruitment and reduced absenteeism did result in certain problems. These included fatigue and some discontent over long hours together with certain operational difficulties specific to their particular form of work. For example, communication at shift changeover about events occurring during time off was more difficult when time off was as long as four days. In addition,

compressed working time tended to encourage secondary employment, seen by some as an advantage, but not necessarily beneficial to the operation of the service or the health of the officers.

Given a preponderance of favourable attitudes towards 12-hour shifts one might expect this to be translated into better health and less sickness absence. Some studies have demonstrated this.

Comparison of reported workplace morbidity in 8-hour and 12-hour shifts in one plant

775 workers at a Canadian production plant were studied during two 10-year periods. During the first they worked a rotating 8-hour shift schedule and during the second a 12-hour shift schedule. Data extracted from plant medical records showed a significant fall in the incidence of stress-related complaints such as headaches, gastrointestinal upsets and alcohol-related complaints. The incidence in other complaints, considered to be unrelated to stress, remained the same. A similar but even more marked reduction in the incidence of stress symptoms was found in a group of 247 workers who had 10 years experience in each shift system.

From: Lees and Laundry, 1989

Others have shown no difference in health or absence rates. For example in Singapore, Chan *et al* (1993) compared over 300 female electronics workers who had been employed for at least one year on 12-hour shifts, with workers on permanent night or day shifts, or rotating shifts. There were no marked differences in terms of health or sickness absence between the groups, apart from increased complaints of tiredness in nightshift workers.

Most studies do in fact indicate either no real change, or marked improvements in health and well-being following a change to 12-hour shifts. This also seems to be the case with other forms of compressed time which have been studied. For example in Ottawa, Canada, the police force work 10-hour day shifts, while retaining 8-hour night shifts, which allows a six day rest period following night shifts. Because of the generally positive results reported in Canada a police force in the UK adopted the same system. An evaluation 6 months after the change indicated significant improvements in well-being, and a significant reduction in personal and social disruption as compared with officers at police stations where no change took place (Totterdell and Smith, 1992).

Despite the apparent advantages of compressed time to both employer and employees,

however, most researchers stress the importance of taking into account the particular circumstances and views of the workers when such systems are introduced. Most research tends to take place in companies where there is a degree of concern about potential effects on the workers and hence systems such as compressed working time are unlikely to have been introduced without worker consultation.

> "A mistake that management makes is to try to force everybody to be on the same schedule. It's imperative that each department or group be allowed to set its own schedule.
>
> Different areas within an industrial facility will have different characteristics and different workloads and therefore should have different schedules. Which schedule is best depends a great deal on the preferences of workers and how they view the quality of the time off the schedule offers, as well as the number of weekend breaks. The schedule with a long seven day break is attractive to employees who work at a remote site and like to have their time off in large blocks so they can travel to visit friends. Another influence: spare-time activities - the types of events where people need multiple days off - fishing, hunting - or just a few hours - chess, bridge, tennis, golf - they don't want 12 hour days because that ruins those activities - and they don't want a whole day to play bridge either!"
>
> Adapted from Mr Preston Richey, former shiftworker in USA
> Source: Verespej 1990

To date therefore while there is no strong evidence that compressed working time adversely affects the health and well-being of a consulted and consenting workforce, it cannot be assumed that all workers will view such schedules positively. Further there remains some concern about acute fatigue, which will be addressed more fully in the following chapter on safety. Finally, as in the case of overtime work, there is one very major gap in the data, namely the matter of increased exposure to toxic chemicals and other workplace hazards. This underlines the need to take into account not only the characteristics of the worker but also of the workplace and the job itself in any decision to adopt such schedules.

Consider compressed working time if…

- Workforce has been consulted
- Workforce has indicated positive attitude
- Job does not involve hazardous exposure
- Job is not excessively stressful or physically tiring
- Good health surveillance systems are in place

Some special work groups

Some work schedules do not fit neatly into the categories of either long hours or shift work but may contain elements of both. Most of the working hours described below are also irregular.

On call

On call is a particular form of working pattern affecting a wide range of employees such as staff in the medical and emergency services and those responsible for maintaining a range of public services such as gas and electricity. It is also a feature of watch keeping duties on board ship. For example some of the duties of the crew of a Swedish merchant ship were documented by Torsvall *et al* (1987).

> Every 2-4 nights the officers had watch duty during which they could sleep but were woken by an alarm in the event of machinery malfunction. Some 40% of all nights at sea were spent on this type of duty. About 15% of such nights were disturbed by alarms and 13% for other reasons. Sleep was reduced by about 1½ hours on such occasions.

Torsvall and colleagues noted that in the marine officers, sleep was also perceived to have been disturbed when no alarms occurred. Nights on call were characterized by a higher level of uneasiness aptly termed “apprehension stress”. In one of the very few investigations specifically concerned with the health effects of on-call work Imbernon *et al* (1993) studied employees of the French National Electricity and Gas Supply Company. He found no evidence of a significant

increase in any specific health complaints, compared with a control group. However on three aspects of a measure of psychological equilibrium those on call had significantly worse scores. These three measures were social disturbance, satisfaction with private life and global well-being, There was also a trend, although not statistically significant, for on-call workers to take more medication for minor complaints (aspirins, tranquillisers and stomach remedies).

Junior doctors

The work of junior hospital doctors includes a combination of long hours and on-call duty. A number of studies have been carried out to assess health, specifically mental health, effects in these doctors whose hours in many countries routinely exceed 55 per week, often involving continuous periods of up to 32 hours. In extreme cases doctors may work for 70 hours without proper rest. There is little doubt that the mental health of doctors in training is generally poor (Spurgeon and Harrington, 1989) as a result of fatigue and work stress. Observation of such effects has prompted recent reviews and revision of work schedules of hospital doctors both within hospital systems and at government or professional association level. For example, the New York State Commissioner of Health enacted regulations, effective from July 1989, limited emergency room shifts for house staff to 12 hours. Limitations were also placed on the number of hours worked by other house staff including limiting duty to 80 hours per week averaged over a 4-week period, limiting the maximum consecutive number of hours worked to 24 with an 8-hour break and requiring at least one 24-hour day off each week (Scott, 1992).

Similar measures have recently been introduced elsewhere representing some improvement on the excessive demands made upon junior doctors. The situation is still far from ideal however and continues to represent a significant risk to health.

Transport

Maritime workers

The number of seafarers in the EU flagged fleet alone is estimated to total about 162,000. Hours of work appear to be increasing in the maritime industry. Figures from the British merchant navy, for example, show that British seafarers frequently work 90 hours or more per week with continuous shifts of 20 hours or more (Reyner and Baulk, 1998). The pattern of working time in this industry however varies considerably according to the type of voyage routinely undertaken and the occupation on board ship.

Watchkeepers, already referred to, work 4 hours on and 8 hours off, or sometimes 4 hours on and 4 hours off, and there is a growing body of evidence that this is particularly disruptive to circadian rhythms. Monitoring of biological indicators, for example, indicates that phase adjustment fails to occur (Plett *et al*, 1988), resulting in both fragmentation and overall reduction in sleep. Consequently watchkeepers suffer from both acute and chronic fatigue problems, (Rutenfranz *et al* 1988, Sanquist *et al* 1995).

Data collected from the crews of 8 ships over a period covering 10-30 days into the voyage, found that while the average sleep duration for all mariners was 6.6 hours, watchkeepers obtained their sleep in fragmented periods that were frequently less than 5 hours in duration. Of particular concern were those on the 04.00 hrs to 08.00 hrs schedule who slept less than 4 hours in a 24-hour period (Sanquist *et al*, 1997). Fatigue and stress have been identified as major problems in marine personnel in general (Parker *et al*, 1995; Reyner and Baulk, 1998), although longer-term health problems in seafarers have been studied less often.

Parker *et al* (1995) provided a review of potential health problems in Australian maritime workers which noted increased risks of anxiety, depression and cardiovascular disease as well as increases in smoking and alcohol consumption. These problems were associated with a range of factors peculiar to the seafaring environment such as separation from family and harsh physical conditions. However organization of working time was also an important factor.

Sparks (1992) carried out a survey of the health of ships' pilots in Seattle, United States. This is a group of workers whose pattern of working time throughout the world is both irregular and unpredictable, dependent as it is on tides and weather conditions as well as the demands of ships' schedules.

In Sparks' study some of the ferries ran on schedules which were described as having "highly erratic" start and finish times and for these particular crews there were significantly more complaints of poor sleep patterns and physician consultations for insomnia and significantly higher rates of sickness absence.

Some occupational mortality studies have been carried out among seafarers mainly in Western Europe, and a more recent study (Roberts, 1998) compared occupational mortality amongst British, Hong Kong and Singaporean seafarers. Where deaths from illness were concerned, British seafarers, in common with others in Western Europe, died more frequently from cardiovascular disease and gastrointestinal disorders than did Asian seafarers who were more likely to die as a result of work-related accidents. Roberts notes the apparent role of

lifestyle factors (alcohol and smoking) in occupational mortality in British seafarers. Both these factors have a relationship with work stress.

In general, the available data suggest that the health of seafarers is often poor. Although a combination of factors appears to be responsible, long hours and poor sleep patterns are a major focus of concern.

Drivers

Road transport workers of various types also work irregular schedules, particularly those drivers involved in road haulage. Van Ouwerkerk (1987) in a review commissioned by the International Transport Workers Federation found that the average working day of the professional international truck driver was about 12 hours, including cargo handling, truck maintenance and waiting time at border crossings. On a trip lasting several days a driver might begin the first day at 8 a.m., the second at 5 a.m. and the third at 2 a.m. Not surprisingly Van Ouwerkerk's review identified considerable evidence of fatigue in these drivers.

Similar long working hours and a heavy manual workload were found in two more recent studies of lorry drivers in different parts of the world. Van der Beek and Frings-Dresen, 1995 found that most of a sample of 32 Dutch lorry drivers worked at least 11 hours per day with approximately 50% spent driving. Arnold *et al* (1997) found that in one Australian state, where driving hours were unrestricted, about 38% of lorry drivers exceeded 14 hours per day of driving and 51% exceeded 14 hours of driving plus other non-driving work.

The most common health problems found in professional drivers are musculoskeletal disorders, hypertension, gastrointestinal disorders and cardiovascular disease (Backman, 1983). Clearly drivers have a number of hazards in their working environment in addition to sleep loss and fatigue. These include prolonged sitting in cramped conditions, intermittent heavy manual work, stress, exposure to exhaust fumes and whole-body vibration. Most of these problems are likely to be experienced both by long distance drivers and those working short distances, for example urban bus crews. Such problems are undoubtedly exacerbated by long working hours and others, such as irregular unbalanced eating habits, may be a direct result of work schedules. Van der Beek *et al* (1994) investigated relations between work demands and health complaints in lorry drivers and found a significant relationship between work demands, characterized by working hours and work pressure, and psychosomatic complaints. Raggatt and Morrissey (1997) investigated a similar group of workers, long distance bus drivers, and found that their heart rate, blood pressure and catecholamine levels were elevated during the

entire workday compared with rest days. Interestingly these gradually reduced between the 9th and 12th hour of driving. These data do not necessarily support the view that health and safety risks are reduced after nine hours of driving however. The authors suggest that such changes were probably indicative of anticipation of the end of the shift and hence a reduction in stress, changes which would presumably occur earlier in shorter shifts.

Railway workers

Almost one million people were employed in rail transport in the 15 Member States of the EU in 1995. A special feature of this industry is the intermittent nature of the work particularly in rural areas. As a result working hours are often irregular. The health of railway workers has not been extensively studied although in a review carried out by Cox (1984) for the UK railway workers union ASLEF, it was noted that train drivers complained of alimentary and gastric disorders, sleep problems and tiredness as a result of their work. There is also some evidence from occupational mortality statistics that drivers suffer from ischaemic heart disease more than might be expected from their socio-economic class and age. More recently Aguirre and Foret (1994) found that railway workers working irregular hours more often rated their health as poor compared with those working permanent mornings or three shifts, frequently reporting digestive, respiratory, osteoarticular and nervous symptoms as well as sleeping difficulties. They also found difficulty with sleep on rest days. Dekker *et al* (1993) found that locomotive engineers on irregular work schedules showed higher caffeine consumption, shorter sleep length and reported more negative moods than did a comparable group on regular shifts. In general, therefore, the problems of railway workers appear to be significantly increased by irregular hours.

Studies of other groups of workers also support the view that irregular schedules are not conducive to good health. For example Prunier-Poulmaire *et al* (1998) studied French customs officers. Although their work schedule was based on four 6-hour shifts, rotation was rapid, with a highly irregular cycle characterized by the need to schedule six and a half shifts to complete weekly work. Prunier-Poulmaire identified two major factors associated with health problems in these workers, namely hostile confrontations with travellers and working hours. Stressful interactions with the public and the irregular 4-shift system were associated with gastrointestinal symptoms, shortness of breath, chest pains and arrhythmia. These effects were also evident in customs officers working more traditional rotating 8-hour shifts but not in those working 12-hour shifts. The results of this study also underline the importance of taking into account the additive effects of working time and other sources of stress in the working environment.

Air crews

It is estimated that in 15 Member States of the EU alone there are approximately 375,000 employees working for air transport companies, of which about 20% are flight crews.

Aviation presents a unique combination of factors not encountered in other professions, namely long unbroken and often monotonous periods of duty at all times of the day and night, rapid time changes, uncomfortable conditions for rest and periods away from home. Not surprisingly therefore air crews are at risk of a range of health problems associated with long hours and circadian disruption, notably chronic sleep difficulties and fatigue (Ono *et al*, 1991), Air transport, particularly long-haul, perhaps presents the most problematical situation of all in terms of working time arrangements.

Negative features of non-standard hours

From these various examples it is possible to identify some particular features of non-standard hours which give grounds for concern.

- A combination of irregular hours and long hours
- A combination of irregular hours and circadian disruption
- Short recovery times between work periods, even where work periods are relatively short
- Unpredictable, irregular work periods, particularly where these are outside the worker's control
- Irregular and/or unpredictable hours coupled with exposure to other significant stressors (physical, chemical or psychosocial)

Working time and health general guidelines

- Night work is best avoided or limited where possible
- Unpredictable irregular hours are best avoided or limited where possible, especially when other risk factors are present (long hours, circadian disruption, other sources of stress)
- Overtime should be limited, distributed between workers and not routine
- Workers should be consulted about the organization of their working time
- A system of health surveillance should be in place for those working non-standard hours
- Where work extends beyond an 8-hour period a re-assessment of physical and chemical health risks should be conducted
- Provision of good facilities for catering, transport and health and safety should be made for all work schedules

Chapter 5.
Working time and safety

Human performance at work has two important dimensions, productivity and safety. Here we are concerned principally with the latter, while recognizing that modern health and safety practice would view the two aspects as interrelated.

The study of safety in relation to working time is primarily the study of fatigue. Most of the scientific literature in this area is therefore concerned with the effect of different work schedules on the development of fatigue, and with the effects of that fatigue in terms of errors, accidents or unsafe behaviour. The first question which always arises in this context is one which has been touched upon briefly before. What do we mean by fatigue? There have been numerous attempts at definition over the last hundred years, most of which simply underline the difficulty of characterizing something which has both physical and mental dimensions, which may be acute or chronic, and which has both subjective and objective forms of expression that often appear to be only loosely related. Most definitions therefore consist of ways of "operationalizing" fatigue, that is, they represent different ways of measuring its effects. Three modes of effect are generally recognized (i) subjective: how fatigued do people report that they feel (ii) performance: how is fatigue reflected in how well or quickly people do things (iii) organic: how is the body's physiological function or chemistry affected. While the previous chapter on health was primarily concerned with (iii), the subject of this section will focus much more on self-report and performance measures, although as noted above, performance in this context refers chiefly to accident levels (safety) rather than to quantity and quality of work (production).

A recently published paper from Germany (Hanecke *et al*, 1998) has neatly encapsulated the two interrelated aspects of working time which are likely to be associated with a risk of accidents in the workplace. The investigation was concerned with accident risk as a function of the *number of hours at work* and the *time of day* and analyzed data from 1.2 million accidents in German workplaces for the year 1994. The results showed that the risk of an accident increased exponentially after the 9th hour at work, but that this risk differed considerably according to the time of day. For example, for those working 3 shifts, later starting times were associated with a dramatic increase in accident risk beyond the 8th hour of work. Most of the data published in this field are concerned either with the effects of long hours, or with the effects of circadian disruption, with little consideration of the potential interaction between the two. This potential should be borne in mind, however, when contemplating both shiftworking and long hours or overtime.

Long hours/overtime

There are very few safety studies which are concerned specifically with long hours worked as overtime, as opposed to those which are part of long (e.g. 12-hour) shifts. Data from other fields of enquiry such as cognitive psychology, however, predict that fatigue measured in terms of "time on task" is likely to result in errors which may of course include unsafe behaviour. Long periods of effort tend to produce what is termed "reactive inhibition" which is simply a disinclination of the brain to continue producing the same response over and over again. Depending on the complexity of the task this may result in unusually long response times, inappropriate responses or, more seriously, complete disorientation. A recent workplace-based demonstration of the production of cognitive errors in response to overtime work has been provided by Proctor *et al* (1996). Automotive workers were tested on a range of cognitive performance tests and their results correlated with the number of hours they had worked beyond a standard 8-hour day, during the week before testing. Increased overtime was significantly associated with impaired performance on several tests of attention and information processing. These data appear to be in agreement with the German data of Hanecke (1998) previously mentioned. A constant accident/injury rate was shown for the first nine hours of work with a progressive increase thereafter, up to three times that rate after 16 hours of work.

However, studies which translate national trend data into examples in specific industries are rare. A study of hand injuries in Hong Kong machine operators (Ong *et al*, 1982) did identify long working hours (average 11 hours per day) as a major risk factor. However, the characteristics of the two most vulnerable groups, namely those who were new immigrants and

those with less than one years experience, suggested that other factors such as training were of considerable importance. In a study of a contrasting population, this time German medical staff, Kirkaldy *et al* (1997) also identified a range of predictors of accidents. These included long working hours (more than 48 hours per week), but also distance from home to work, gender, job-related stress and number of dependent children. If anything can be gleaned from this paucity of data it is that the risks associated with long hours are likely to result from a combination of fatigue associated directly with those hours and that produced from prolonged exposure to other sources of stress. Currently, however, information in this area must be extrapolated from that available in the similar but not identical situation of compressed working time.

12-hour shifts

The growing literature on 12-hour shifts increasingly incorporates investigations of safety as well as concerns about health. Given the aforementioned evidence from cognitive psychology and the quoted accident statistics it would be reasonable to predict that, whatever the preferences and good health of the 12-hour shiftworkers, safety is likely to be compromised by these work practices. This is not borne out by the evidence however. Data on both errors and accidents over 20 years present a generally positive picture although most information in this area is derived from large companies in Canada and North America.

It would be fair to say however that the picture is not uniformly positive. A number of investigators have produced either equivocal findings, or results that suggest problems in specific organizations. These studies are interesting in that they highlight a number of factors which may modify the relationship between 12-hour working and safety.

- In a pulp and paperboard factory in Canada a change from 8 to 12-hour shifts resulted in a 27% decline in operator error rates (Gould 1988).
- At an experimental nuclear reactor in America a change from 8 to 12-hour shifts resulted in a 25% decrease in errors in completing operational logs (Lewis and Swaim, 1986).
- Accident reports of a Canadian company manufacturing synthetic yarn were analyzed for 10 years before and after the change from 8 to 12-hour shifts. Overall accident rates were reduced on the 12-hour shift schedule (Laundry and Lees, 1991).
- A petrochemical plant and fertilizer producing company both showed no change in injury frequency rate after implementing a 12-hour shift system (Pollack *et al*, 1994).

One factor may be the type of work undertaken at the company and how more or less demanding tasks are distributed across the shift. Some employers have attributed lower accident rates to the reduced number of shift handovers which 12-hour shifts produce, since shift changes are known to be vulnerable points in terms of accident risk. This may be countered, however, by long rest periods between blocks of shifts which mean that workers are psychologically out of touch with the working environment when they return to start a new shift cycle. Other issues which have been raized relate to the potential decrements in performance which may result from successive 12-hour work periods which may not be evident from the study of a single shift. For example one study demonstrated significant decreases in productivity on five to seven consecutive 12-hour shifts. After four weeks of 6 to 7 consecutive 12-hour shifts there were even greater decrements. These data relate to productivity, not safety, but they may have implications for errors and accident risk in that they are suggestive of increased fatigue. A further aspect, so far unexplored, is the difference in attitude which may be engendered by overtime as opposed to 12-hour shifts. Those on compressed schedules are engaged in their normal working pattern which includes the expectation of an extended rest period. Those on overtime on the other hand are extending their normal working day, outside their normal pattern, with the knowledge that they are reducing their rest period.

Finally some researchers have pointed to the importance of the existing safety culture in an organization which may reduce the potential for adverse effects with any introduction of a new shift system. Much of the data on 12-hour shifts has come from organizations where safety is at a premium because of risks to the public as well as to the workforce, for example nuclear installations and the petrochemical industry. It is also interesting to note that in at least one study while injury frequency rate was reduced following 12-hour shift introduction, further analysis showed that at one site there was a higher percentage of more serious injuries and a lower rate of minor injuries. By contrast at another site no differences were observed (Pollack *et al*, 1994). The authors suggest the explanation may lie in the different nature of the work and characteristics of the environment on the two sites. However a difference in safety culture is another possible explanation.

Rotational shift work

The previous section was concerned with the fatigue which results when people are required to sustain effort over long periods of time. Usually this effort tended to take place during normal waking hours. In that sense at least therefore the question was a relatively straightforward one, that of determining how long and under what circumstances people can

Overtime and 12-hour shifts: The current picture

- Data on long hours and safety are very limited.
- Analysis of accident data in 2 countries indicates a rise in accident rates after 9 hours of work
- Experimental data from cognitive psychology predicts an increase in errors after 8 hours work
- Most data from studies of 12-hour shifts show an equally good, or in some cases better, safety record following a change from 8-hour to 12-hour shifts. But these data should be viewed with caution and not viewed as unequivocal evidence that long shifts are safe. There are a number of possible explanations for the data which have not been properly investigated
- The importance of attitudes and motivation
- The prevailing safety culture which may be more positive in companies which report data
- The influence of particular schedule organisation
- The importance of the particular type of work undertaken

maintain acceptable accident-free performance. Where rotational shift work is concerned, however, other circadian components come into play and the situation is inherently more complex. The wider psychological literature on biological rhythms and performance has a considerable contribution to make in this area. Essentially this literature is concerned with the quality of performance in terms of both speed and accuracy and as such it focuses primarily on human error. This is not of course the same as safety since fortunately not all errors are translated into accidents. However, most accidents are directly or indirectly the consequence of human error and thus the two fields of enquiry are strongly linked.

Circadian rhythms and performance

It has long been established that performance measures vary with stages in the biological cycle. In particular, performance shows gradually increasing efficiency when the body core temperature is in a rising phase, and decreasing efficiency as temperature falls. This is not usually interpreted as a causal relationship, but simply a case of temperature acting as a convenient marker for more general biological rhythms. A large number of other physiological variables show similar rhythmicity, notably the production of hormones which can be measured

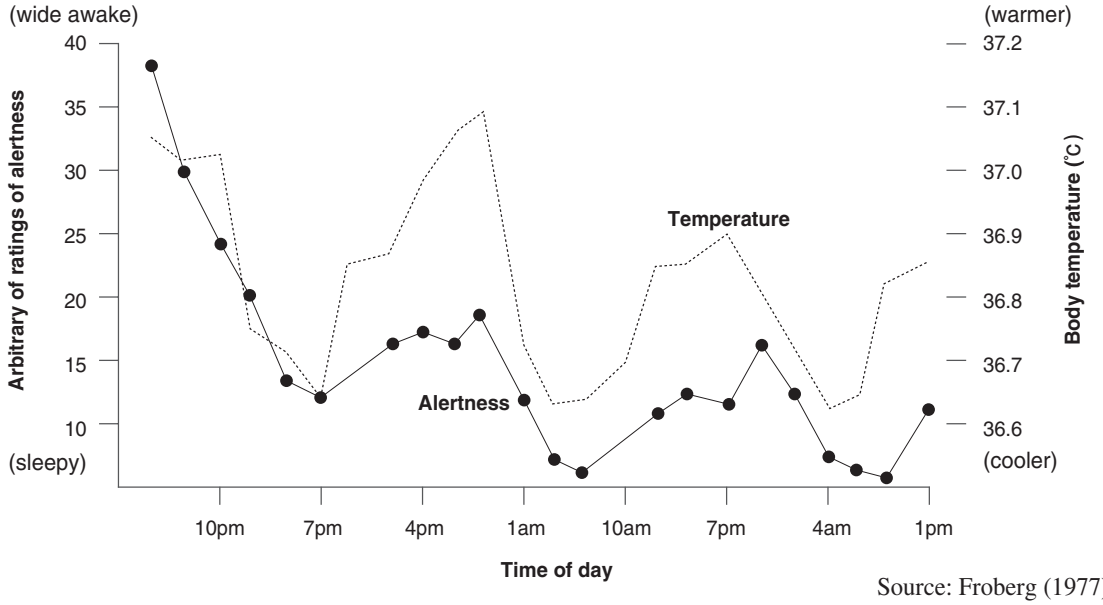
in the bloodstream or the urine. Cortisol, for example, which appears to be associated with promoting wakefulness, peaks in the morning, while melatonin, considered to be sleep-inducing, peaks at night. Under normal conditions body temperature, and alongside this performance efficiency, begins to rise around 7 a.m., ending with peak performance in mid-evening around 9 p.m. Both are at their lowest in the early hours of the morning, approximately between the hours of 2 and 6 a.m. This is illustrated in a study by Froberg (1977) who measured body temperature and self-reported alertness in 15 young health volunteers who stayed awake over a 72-hour period.

Recognition of these variations led psychologists to conduct a wide range of laboratory-based experiments to determine specific effects on different tasks at different times in the circadian cycle. The results of these experiments, while confirming the basic cyclical nature of human performance, also demonstrated that a number of other factors are important. Essentially these fall into three categories (i) task-related (ii) situation-related and (iii) individual-related.

Task-related

Early studies tended to measure performance by means of fairly tedious tasks of vigilance which required that people stay alert, but demanded little else in the way of higher levels of cognitive functioning. These studies were important in that they tended to demonstrate the most

Figure 1. *Body temperature and alertness from a group of 15 young subjects experiencing 72 hours of constant wakefulness*



Source: Froberg (1977)

extreme effects of biological phase on performance. However, later studies, involving a wider range of cognitive skills, showed that effects were generally less marked when tasks were more interesting and demanding and hence more arousing. This has obvious implications for the workplace where, for example, a watchkeeper may be primarily involved in solitary vigilance-type tasks, while a junior hospital doctor is required to interact with patients and other staff, process information and make complex decisions.

Even the extent of normal diurnal variation in performance is related to the type of task. Generally speaking such variation is predictably more in keeping with biological rhythmicity where the task is less complex, for example in the case of tests of simple visual-motor skills or manual dexterity such as reaction time, and less predictably so where tasks involve high memory loads or problem-solving abilities. 1An additional factor to consider is the precise nature of any performance impairment. Is this for example in terms of speed or accuracy, and what is the trade-off between the two? As a rule speed of performance is inclined to follow the pattern of normal diurnal temperature variation in that as the day progresses subjects in laboratory experiments tend to perform faster. On the other hand, when accuracy is measured, the reverse is often true with fewer errors at the beginning of the day. Again this may have implications for the workplace in terms of whether speed or accuracy is the critical factor to maintain.

Situation-related

Closely linked to the type of task is the situation in which the task is performed. For example, how important is the presence of other stressors? In a series of experiments Smith and colleagues (Smith and Jones, 1992) investigated the effects of both noise and night work on cognitive performance. Again effects varied according to the type of task with simpler tasks less affected than more complex ones. This can be readily explained by reference to the well-established “arousal hypothesis” (Yerkes and Dodson, 1908) which characterizes the relationship between arousal and performance as an inverted-U function. Both under arousal and over arousal results in impaired performance, with optimal arousal occurring at the top (mid-point) of the curve. Hence in a state of under-arousal, produced by a combination of a simple tedious task and a low point in the circadian cycle, noise may act as a stimulant and improve performance. At the same circadian point however the demands of a more complex task may in themselves serve as a sufficient stimulant to improve performance. The introduction of noise at that stage will therefore push arousal beyond the optimal point and hence impair performance. A simple additive influence of other stressors cannot be assumed therefore, depending as it does on the nature of the task and of the stressor itself.

Another group of factors which have been investigated by psychologists come under the general heading of “motivation”. These refer to the individuals' attitudes to the task and the value they place on certain aspects of performance such as accuracy and speed. Although this might in one sense be viewed as a feature of the individual, in the workplace it is very likely to be determined by the nature of the task and the culture of the organization. For some jobs, where safety is at a premium, accuracy may always be preferred over speed. In others pressure for speed may encourage the dilution of quality. An experiment by Smith (1992) showed that by manipulating the anxiety levels of subjects it is possible to remove the diurnal variation in task performance.

> Two groups of subjects carried out a routine vigilance task in the morning and in the afternoon. One group was told that their results would be announced to the rest of the subjects, thus increasing their anxiety level and motivation. This increase was associated with an improvement in the accuracy of their performance, particularly in the afternoon when anxiety levels were assessed to be at their highest. The other group showed no difference in performance.

Beliefs about the importance of accuracy and the cost of mistakes are also likely to influence the strategies which people adopt to carry out their jobs successfully. It has been shown for example that not only task performance but also task strategies vary throughout the day. This has been demonstrated most clearly in relation to tasks involving attentional control, where narrowing of attention and attentional selectivity is known to occur with lowering arousal levels. Depending on the importance of error-free performance this may however occur to a greater or lesser degree, and may influence the aspects of the task which receive attention. Some workers may for example prefer to fail-safe or as described by one junior doctor “fail-blinkered”. The task perceived to be the most important is done and is done well, but others are completely neglected.

Individual-related

The final group of determinants of performance in relation to cyclical rhythms are those which come under the heading of individual differences. Although discussed more fully in the next section brief mention will be made here. Two particular factors have been studied in depth, namely age and a personality dimension usually referred to as the “morningness-eveningness” continuum. In the latter those who exhibit extreme “morningness” have considerable difficulty in adapting to shift work because of their inability to cope with night work. Similarly extreme evening types are likely to perform poorly in the early morning and thus have difficulty with other elements of the shift cycle. Since this is a continuum, however, many individuals do not fall at

either end of the distribution. Age has links with this dimension in that for various reasons, people tend to shift towards "morningness" as they get older, usually in the fourth or fifth decade of life. This presumably accounts for the difficulties some previously well-adjusted shiftworkers begin to experience in middle age.

From a practical point of view, how important is it to know about the various factors which may modify the otherwise straightforward relationship between diurnal variation and performance? First it is important to be aware that the relationship is *not* straightforward and a range of characteristics of a particular occupation or environment may change its nature. Secondly it is useful to appreciate that, whatever the occupation, those who work on rotating shifts may (i) be a survivor population who may be better suited to the demands of shift work and (ii) may nevertheless contain individuals who have special difficulties. This last point will be addressed more fully in the next chapter.

So far therefore this section has looked at the laboratory-based evidence relating to circadian rhythms and human performance.

This can be summarized as follows:

- Speed and accuracy of human performance tends to follow circadian rhythms of which core temperature is a useful marker.
- Temperature and performance tends to increase from early morning, around 7 a.m., reaching a peak around 9 p.m. Lowest points are reached between 2 and 6 a.m.
- The most straightforward relationship between circadian rhythms and performance occurs with simple routine tasks.
- More interesting and demanding tasks may effectively raise arousal and performance levels at otherwise low points in the cycle.
- The presence of other stressors may enhance or further reduce performance depending on the nature of the stressor and the task.
- The strategies adopted to complete tasks and the nature of any impairment (speed or accuracy) will depend on the perceived relative importance of each of these in the particular situation.
- Individual physiological and psychological differences may also modify effects on performance, and adjustment difficulties may increase in middle age.

Two questions now remain. How far is this evidence borne out by studies of real workers in real workplaces, and how far are performance decrements translated into safety problems, again in terms of real workplace-based statistics?

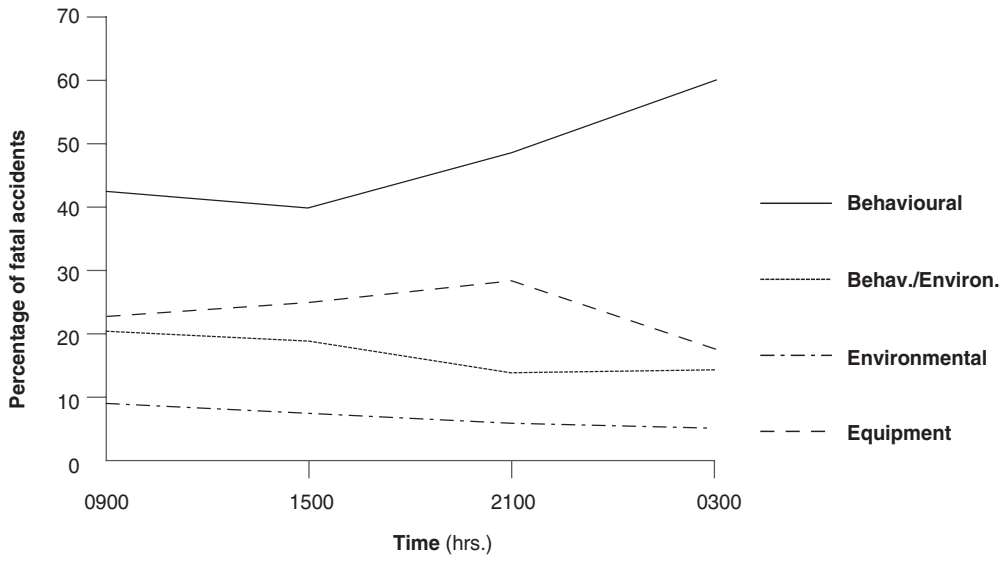
Errors and accidents

Although there are several studies which investigate the relationship between shift work and general productivity, the study of errors in this context is relatively rare. This is perhaps unfortunate as errors may provide a useful measure of performance which is relevant to the prediction of accidents. Most existing data are rather old, having been collected in the 1940s and 50s. Browne (1949) studied the answering of telephone calls by switchboard operators and Bjerner *et al* (1955) monitored meter readers at a gasworks in Sweden. Both these studies showed a significant increase in errors on the night shift. In Bjerner's study 75,000 mistakes were logged over a period of twenty years. The 24-hour distribution of errors showed a peak at around 3 a.m. with a further peak around 3 p.m. The latter may be explicable in terms of what is known as the "post-lunch dip" where performance impairments have been observed, particularly in terms of sustained attention, following consumption of lunch.

A more recent study in Australia (Williamson and Feyer 1995) has attempted to examine the relationship between different types of errors and accidents. Williamson and Feyer began by collating all reports of work-related fatal accidents in Australia between the years of 1982-4. Initial analysis of the time of day of these accidents indicated that most took place in the late morning or early afternoon. However, when these figures were expressed in terms of the estimated number of people at work they showed that the proportion of accidents occurring at night was in fact more than double that during the day. Accidents were then classified in terms of four types of preceding event (i) mainly behavioural (human involvement), (ii) mainly environmental, (iii) equal involvement of behavioural and environmental and (iv) equipment malfunction or breakdown. On this basis 43.9% were classified as behavioural and 18.7% as behavioural/environmental. Further, the mainly behavioural precursors were most common in the early hours of the morning (between midnight and 6 a.m.) and least common during daytime hours. The reverse was true for mainly environmental precursors.

Finally Williamson and Feyer analysed the type of error which appeared to be associated with accidents at certain times of the day or night. From a psychological point of view errors may be categorized as (i) "skill-based", those which occur in routine and well-learned tasks (ii) rule-based which occur on tasks where rules are applied, or (iii) knowledge-based where tasks

Figure 2. *Frequency of occurrence of each type of accident sequence for each time of day*



Source: Williamson and Feyer, 1995

involve application of existing knowledge to problem-solving. Overwhelmingly the most common form of error was “skill-based”. The frequency of these errors, in terms of their association with accidents, did not vary across different time periods. Other types of errors occurred much less frequently but, in terms of their distribution across time periods, tended to occur more often during the daytime than during the night.

This study is particularly interesting in that it constitutes one of the few attempts to examine in depth the associations between circadian disruption, human error and accident causation. The results provide support for the view that in a large percentage of accidents human error is a cause or a contributory factor. Further most of these errors occur when people are performing routine tasks and their arousal or attention level is low i.e. during the early hours of the morning. Errors in tasks which required more information processing, and presumably therefore raised arousal levels, appeared to happen less during the night than during the day, at least in so far as they were associated with fatal accidents. This is entirely consistent with predictions from laboratory-based data. The finding that “skill-based” errors occurred equally across all time periods however is perhaps surprising, although there was in fact a small, but non-statistically significant increase during night hours.

The above date, although interesting, relate only to fatal accidents and, in addition, include

all workers, not just those employed on some form of shift system. Although a higher proportion of accidents occurred at night it is not known, for example, how many of those involved in fatal accidents during the day were actually rotating shiftworkers.

Other researchers have compared accident rates for those working on rotating shifts with those doing normal day work, and have included all types of accidents. In a study of work injuries in an iron and steel mill in Singapore (Ong *et al*, 1987) non-shiftworkers had a lower injury frequency rate than shiftworkers. Similarly Gold *et al* (1992), found that rotating shiftworking nurses had twice the rate of reported errors and accidents as nurses who worked on day/evening shifts. By contrast Hardman et al (1991) found no relationship between accident rate and shift schedule in Australian nurses. This study included nurses working permanent days, permanent nights and rotating day/evening shifts. Similarly Novak *et al* (1990) found no difference in overall injury rates between shiftworkers and non-shiftworkers at a chemical plant in Texas.

These and other studies have also compared accident rates for shiftworkers at different phases of a rotating schedule. It has often been pointed out that some of the most serious disasters in modern times have involved human error during nightshift work. The near meltdown of a nuclear reactor at Three Mile Island, USA in 1979 occurred because, between the hours of 4 a.m. and 6 a.m., shiftworkers failed to recognise the loss of core coolant water resulting from a stuck valve. While the initial problem was a mechanical one, this was compounded by subsequent human failure. The official report of the USA Presidential Commission on the space shuttle Challenger accident also cited the contribution of human error and poor judgement related to sleep loss and nightshift work. Fatigue and human error are reputed to have played a part in the explosion at Chernobyl in 1986, which occurred in the early hours of the morning and in the grounding of the oil tanker Exxon Valdez in 1989 which also occurred just after midnight.

Perhaps surprisingly however the results of a number of research studies carried out in less dramatic circumstances since the 1940s do not provide unequivocal support for the view that accident rates are higher on the nightshift. One of the earliest of these conducted by Andlauer and Metz in 1949 (subsequently reported by Andlauer and Fourre, 1962) analysed the accident rates of workers operating a rotating 3-shift system at a metallurgical plant in France. They found that the overall accident rate on the night shift was actually lower than on the other two shifts. In probably one of the largest studies Wyatt and Marriott (1953) analysed the accident records of nearly 14,000 men in five factories. Frequency of accidents was slightly higher on the nightshift in each factory but the difference was not statistically significant. More recent studies carried out in the 1980s and 1990s have also produced inconsistent results.

- An American study of reportable occupational injuries in 17,000 paint production workers, working on rotating shifts, indicated an increased rate of accidents on the night shift, particularly during the last 3 hours of the shift (Levin *et al*, 1985)
- A study of 423 rotating shift workers at an iron and steel mill in Singapore showed no overall increase of injuries on the nightshift (Ong *et al*, 1987)
- A study of 109 injury reports from nurses at an Australian hospital showed that accident rates, adjusted for the number of people at work, did not differ between shifts (Hardman *et al*, 1991)

Most reviewers in this area therefore tend to regard the evidence concerning accidents and shiftworking, particular nightworking, as inconclusive. However, a number of points should be made here. First, data on accidents and injuries are heavily influenced by the nature and reliability of the reporting systems in place. At least two studies for example which report no increase in overall accidents at night, also report that accidents which did occur on the nightshift tended to be more serious than those occurring on the dayshift (Andlauer and Fourre, 1962; Ong *et al,* 1987). This may represent a reporting bias since there is a tendency towards under-reporting of minor accidents at night in many organizations, where health and safety facilities may be less readily available than during the day. Secondly, national statistics which compare accident rates between night and daywork may be biased by the fact that some industries with a known high rate of serious accidents, for example the construction industry, usually only operate during the day. Conversely, of course, so do many office workers with particularly low accident rates. Finally even within organizations it is often difficult to equate working conditions in night and daywork in order to make a true comparison.

A further factor which seems to be important, although current data are limited, is the adjustment time which may be required following a shift changeover.

> An experienced maintenance engineer servicing a British Airways plane replaced the plane's windscreen between 3 and 5 a.m. on his first nightshift of the week. Unfortunately he used bolts of the wrong size, some were 0.026 inches less in diameter than required, others were 0.1 inches too short. The following day the plane's windscreen blew out during a routine passenger flight. Source: Moore-Ede 1993

Novak *et al* (1990) noted that in his sample of chemical workers the average number of injuries was 2-3 times higher during the first four days of the day and night shifts. Similarly staff at a plant

control room of a chemical company reported increased perceived difficulty in working, and decreased perceived productivity and safety on the first night of the nightshift (Budnick *et al*, 1994).

The changeover problem has also been noted in the off-shore oil industry where alternating shifts were found to have a much larger injury rate on the first day than non-alternating shifts, (Lauridsen and Tønnesen 1990). It would seem therefore that simple comparison of accident and injury rates on different shifts may mask trends which may be discerned by more detailed analysis.

Shift work and safety: The current picture

- The data relating to both shift work in general, and nightwork in particular, are inconsistent and inconclusive.
- It should not be concluded that shift work is safe. There are numerous possible explanations for these different results:
  - Data or its interpretation may be biased by the nature of the accident reporting system, or the particular organizations which are studied

Special work groups

Hospital doctors

Poor performance by junior doctors clearly may have serious consequences for their patients as well as affecting their own safety. Concern about the long hours worked by junior doctors has prompted a number of studies of their health and performance in recent years. These were reviewed by Spurgeon and Harrington in 1989 and again by Leung and Becker in 1992. Both reviews conclude that the data are equivocal. For example of the fourteen studies reviewed by Leung and Becker, seven showed that long hours and sleep loss had adverse effects on physician performance, six found no adverse effects and one actually found an improvement in cognitive performance with decreases in sleep. There are a number of possible reasons for these contradictory results which relate to those various factors, discussed earlier, which can modify the relationship between fatigue and performance. First, the methods employed for assessing performance varied between cognitive performance tests and work-related tasks. It is well known that sleep loss is selective in its effects on performance and the results will therefore depend heavily on what is assessed. For example where tasks are monotonous, routine and hence unstimulating performance is most likely to be degraded, while attention can be maintained much more successfully where tasks are demanding and

interesting. Further, in some situations speed may be compromised in order to maintain accuracy while in others the reverse may hold. The trade off between speed and accuracy is usually determined by the perceived cost of errors. In real working situations doctors will perceive this cost to be very high while this is unlikely in a laboratory testing situation. Attention and performance can also be raised intermittently for short periods to meet acute demands, while reverting to a low level between these events. Finally a well-established effect of fatigue is the narrowing of attention as a coping strategy. Thus individuals become selective in the tasks they complete and the matters they attend to. Given the effects of sleep deprivation which have been documented in laboratory studies for many years (Smith, 1996), it is unlikely that some aspects of a doctors performance will not be compromised by the schedules they are currently required to work in many countries.

Transport

Maritime workers

Marine accident statistics, though not comprehensive, suggest that fatigue has been either the primary or a contributory factor in a number of accidents at sea over recent decades. Examples such as the grounding of the Torrey Canyon and the Exxon Valdez are well known because of the serious environmental consequences resulting from the subsequent oil spills. Other less conspicuous incidents occur on a regular basis however.

- In July 1996 the Peacock, a reefer operating in Australia ran aground on the Great Barrier Reef. The pilot had failed to alter course because he had fallen asleep 15 minutes before the incident.
- In March 1997 the Cita a German owned container ship ran aground during the night in the English Channel. The mate who was keeping watch had fallen asleep 2½ hours before the incident.

Sanquist *et al* (1997) carried out a large survey of seafarers on tankers and cargo ships and identified a significant fatigue problem. The reasons for this were listed as follows:

- An overall reduction in sleep time between working at sea (6.6 hours) and at home (7.9 hours)
- Fragmented and therefore poorer quality sleep
- Having to sleep at physiologically inappropriate times
- Insufficient breaks for rests between shifts
- Sleep disturbance due to environmental conditions

Watchkeepers in particular had less and poorer quality sleep. The particular pattern of watchkeeping hours either 4 hours on, 4 hours off or 4 hours on, 8 hours off, tended to produce a significant decline in alertness on the 04.00 hrs to 08.00 hrs watch. This was noted to be consistent with statistics collected by insurance companies on the incidences of shipping collisions at each hour of the day. A higher percentage of collisions occur in the early morning. The results of some recent research has in fact led to a strong recommendation that the traditional watchkeeping system should be changed to one which allows a single full-length sleep each day (Colquhoun *et al*, 1988).

Occupational mortality figures collected by Roberts (1998) for merchant seafarers in Britain, Singapore and Hong Kong also give rise to concern. During a fifteen-year period 16% of the deaths occurring in the three fleets were the result of occupational accidents on board. In the British fleet 83% of all deaths were due either to an occupational accident or a cardiovascular attack, suggesting that seafaring is both a stressful and a hazardous occupation.

Drivers

Data from a number of countries such as the United States, Israel, Germany and Sweden show that falling asleep at the wheel accounts for a considerable proportion of vehicle accidents on monotonous, non-urban roads such as motorways. Figures from a survey in two areas of the UK during the period 1987-92 are fairly typical of those found in other developed countries. The data show that in the south west of England 16% of all vehicle accidents were sleep-related while on major motorways in central Englend the figure was 20% (Horne and Reyner, 1995a). Accidents of this type also tended to peak at 02.00 hrs, 06.00 hrs and 16.00 hrs. Hence like collisions at sea, a significant number occur during the night or in the early morning. Interestingly other data from Finland (Summala and Mikkola, 1994) has shown that younger drivers are more likely to have accidents between midnight and 06.00 hrs and older drivers during the late afternoon. This is consistent with the circadian tendency towards “eveningness” in the young and “morningness” in middle-aged and older persons. Although these data relate to all drivers they nevertheless underline the risk to those who drive professionally, particularly on long-haul routes. In reviewing the literature on driver fatigue Brown (1994) concludes that fatigue and its effects stem as much from prolonged and irregular working hours, as from time spent at the wheel. Similarly Horne and Reyner (1995[b]) in their review note the importance of circadian factors in producing drowsiness in drivers. It would seem that fatigue and accidents occur as a result of a combination of factors which include the number of hours worked, the time of day, the time of starting the shift, the amount of sleep during the previous 24 hours and the age of the driver. As Horne and Reyner note, the only safe countermeasure when fatigue occurs

is to stop for a rest break which includes sleep. Since drivers often underestimate their level of fatigue and, for example, never recall falling asleep at the wheel, the strict enforcement of regulations which limit driving hours and prescribe regular breaks is extremely important. Examples of such regulations are summarized below.

Table 6. *Summary of the main provisions of selected regulations on hours of work and in road transport*

Area regulated	US Code of Federal Regulations Title 49	EEC Regulation 543/69	Amendments to EEC Regulation 543/69 effective from 29/9/86	ILO Convention No. 153	ILO Recommendation No. 153
Maximum daily driving period	10	8	9 (10 hours twice a week)	9 (average)	9 (average)
Maximum driving period without break	--	4	4½ (working time excluding waiting)	4 (5 in some cases)	4 (5 in some cases)
Maximum weekly driving period	--	48	90 per fortnight (weekly rest must be taken after 6 driving periods)	48 (average)	48 (average)
Working day	15 (maximum hours)	--	--	--	8 (average; maximum 10) ("normal hours", subject to exceptions)
Working week	60 (maximum hours)	--	--	--	40 (average) ("normal hours", subject to exceptions)
Minimum daily rest	8	11 (8 in some cases)	11 (average over 2 weeks) (minimum 9 hours three times a week) (minimum continuous 8 hours; if rest period is broken minimum total is 12 hours)	10 (average) (minimum 8 hours twice a week)	11 (average)
Minimum weekly rest	--	29 plus daily rest	11 (average over 3 weeks) (minimum 36 hours continuous at home, minimum 24 hours continuous away from home)	--	24 plus daily rest (preferably on Sunday and at home)

Source: McDonald, 1985

Railway workers

Train drivers, especially on long distance routes, experience monotony, boredom and irregular work schedules. Cabon *et al* (1993) using physiological measures (EEG and eye-blink frequency) demonstrated a large number of lapses of vigilance in train drivers during typical journeys. Despite this, railway accidents occur much less frequently than do occupational accidents at sea or on the road, although generally receiving more publicity. Existing data do not suggest that fatigue is a major cause of safety-related incidents on the railway either in drivers or other groups of staff such as trackside workers and signalmen. In 1992/93 British Rail (BR) conducted an extensive statistical analysis of the relationship between working time and various safety-related incidents in British Rail train drivers (Wharf, 1996). The survey collected data on booking-on and booking-off times for all shifts of all 16,000 BR train drivers over two years and examined almost 7,500 safety-related incidents. There was no increase in safety risk for working long hours (up to 12) in a shift. However, incident rates peaked in the early hours (2nd to 4th hour), a finding not explained by traffic variation within the day, type of work, age, variation in start time or type of incident. The BR study also found that there was no deterioration in safety performance with long weekly hours (i.e. up to 70 hours), or sustained runs of consecutive shifts (i.e. up to 14 shifts). There was also no evidence of any worsening in safety performance as the daily rest interval between consecutive shifts shortened. However there was some evidence of increased risk on the first shift after a break. Neither the duration nor the cause of the break had a significant effect on the risk.

The survey was later extended to other groups of staff - trackside staff, signalmen and staff in workshops - a total of 50,000 employees and over 11,500 safety-related events. The results showed very similar findings.

Although these data do not suggest that fatigue presents a major problem for railway workers they do point to more problems occurring early in new shifts after a break, and in the early morning hours, which is consistent with data from other industries.

Air crews

Flight crews and flight attendants on long-haul routes suffer from repeated circadian disruption, a requirement to work at sub-optimal times and unfamiliar and uncomfortable sleeping arrangements. Fatigue in these workers is well documented (Samel *et al*, 1995) and in many aircraft accidents flight crew error has been documented as a contributory factor. Although detailed analysis of why a human error occurred is not usually carried out, it seems reasonable to assume that fatigue may often have played a part.

Systems for monitoring the health of air crews in order to ensure their fitness for duty are fairly well-developed in the aviation industry. However not all national rest-duty time regulations appear adequately to take account of the repeated circadian disruption which these crews experience. Although it is difficult to take account of such factors, it is not impossible, as the UK regulations demonstrate. These regulations, based on the latest research in circadian physiology, stipulate maximum permitted hours depending on a sophisticated calculation involving the number of time zones crossed, the time the crew have had to adapt and what time of day it is (CAA, 1990). In addition all airline staff responsible for aircraft scheduling receive training in the effects of circadian rhythm disruption and sleep deprivation. Regulations of this type provide a good example of how health and performance effects can be minimized even where irregular working hours are unavoidable.

Summary

This chapter has highlighted some of the potential problems of fatigue but has also shown that the data linking fatigue to accidents is often inconsistent and inconclusive. At first sight this might be regarded as a somewhat confusing picture or worse, a justification for continuing with over-demanding work patterns. Viewed in another light however, the fact that the relationship between shift work or long and irregular hours and accident rates is not inevitable but appears to depend on a range of other variables is actually rather encouraging, since it offers the possibility of improving health and safety via manipulation of these variables, something which will be returned to in a following chapter.

Working time and safety general guidelines

- Nightwork is best avoided or limited where possible
- Unpredictable irregular hours should be avoided or limited where possible
- Overtime should be limited and not routine
- Where possible overtime should be avoided where jobs are physically or mentally highly stressful
- Care should be taken in shift schedule design to minimize fatigue (see chapter 6)
- 12-hour shifts should be introduced with care but are not necessarily detrimental to safety
- Reliable accident monitoring systems should be in place

Chapter 6.
Individual differences

Much of the data discussed in the previous sections is derived from large-scale studies. These pre-suppose a generalized response to particular aspects of working time, or at least assume that the effects of individual variation will be neutralized in the course of studying large samples of workers. However, it has long been recognized that some workers are more tolerant than others of particular work schedules. Indeed, it has already been noted that much of the current research in this field is somewhat blighted by the "survivor" effect. Studying individual differences, or rather the individual factors which make some people more or less vulnerable than others to particular work patterns is important for a number of reasons. First, and perhaps most controversially, it may aid the selection of suitable people for particular work schedules. A more acceptable version of this is perhaps the suggestion that workers can be more fully informed of the potential risks to their health at the time of recruitment. A second reason is that knowledge of some individually-based but modifiable factors can inform advice and counselling for existing workers. Finally and perhaps most importantly, those responsible for the health and well-being of the workforce should be aware of any individuals who may need special help or surveillance.

Reference has so far been made to "particular work patterns". In reality, however, only one type of work pattern has been studied in any depth in this context, that of rotating shift work which includes night work. Most of this section is therefore devoted to what is known about the factors affecting shift work tolerance or intolerance, with only passing reference to long hours and overtime. As in many other areas however this simply represents a lack of research rather

than an acceptance that such work schedules are equally acceptable to all.

A range of factors have been considered as individual determinants of shift work tolerance. Broadly these are of four types, (i) individual circumstances, (ii) personality and behavioural factors, (iii) physiological and health status, and (iv) job type. In addition there are two important demographic characteristics, gender and age, which do not fit neatly into any of these four categories although they tend to overlap with most other factors in some way. These will be discussed first.

Gender

Many countries have a long tradition of prohibiting the employment of women on shift systems which involve night work. The International Labour Organization Convention of 1948 (International Labour Organization, 1948) was followed by a number of national laws which have stayed in place for much of the remainder of the 20th century. Recent moves towards gender equality in employment however have prompted a questioning of these prohibitions, which in any case have for a long time existed alongside exemptions for certain occupations such as nursing, where women predominate. According to the International Labour Organization Convention No: 89 (1948) national regulations could permit night work for women under defined conditions, which allowed some countries where equality was already an issue to reconcile this with their need to protect women from any adverse effects of night work. More recently, however, with the advent of International Labour Organization Conventions No. 171 and No. 178 (International Labour Organization, 1990) the emphasis has shifted further towards equality in emphasizing the need to provide protection for nightshift workers in general. These new international labour standards define health and safety measures which are clearly intended to apply to both men and women. Given this background, what is the evidence that men and women respond differently to shift work, particularly that involving night work? Is it reasonable to remove distinctions in terms of prohibition, or should women be at least discouraged from shiftworking where possible? In a study of Polish steelworkers (Oginska *et al*, 1993) younger women shiftworkers reported more sleep disturbance, more health problems and visited a doctor more frequently than their male counterparts. These findings are fairly typical of those of studies which compare the self-reported health status of male and female shiftworkers. The question therefore arises as to whether this represents poorer shift work tolerance in women and if so, is the basis for this physiological, psychosocial or an interaction between the two?

Suggestions that men and women differ physiologically in terms of their circadian adjustment have been largely discounted by the available evidence. For example Hakola *et al* (1996) studied 20 experienced shiftworkers, 9 men and 11 women, in controlled laboratory conditions who, after one night of habituation, worked one-day shift and three nightshifts. Temperature, salivary melatonin and cortisol and subjective sleepiness were measured at regular frequent intervals throughout the study. The circadian rhythms of physiological measures changed significantly between workshifts but there were no differences between men and women. The only difference between the genders was in terms of self-reported sleepiness in that men felt more sleepy than women during consecutive nightshifts. Other studies have reached similar conclusions regarding the physiological parameters. Current thinking therefore tends to focus on social and attitudinal differences as an explanation for the more frequent self-reported health complaints of female shiftworkers. It is well-documented in the more general medical literature that women tend to report health symptoms more frequently than do men, particularly in relation to mental health, Jenkins (1985). In part therefore the symptom-reporting of female shiftworkers may simply reflect an aspect of this wider circumstance. On the other hand Nachreiner *et al* (1995) reported that women tend to develop a shift work-specific structure of health complaints earlier than men. This is despite the fact that actual morbidity in shiftworkers does not appear to differ between men and women (Beerman and Nachreiner, 1995) and in some industries at least, women seem to leave shift work less often than men (Oginska *et al*, 1993). The explanation for the increased difficulties of women is widely accepted to relate to their greater domestic obligations and consequent increased workload and decreased leisure time. For example a study in Canada mentioned earlier (Tierney *et al*, 1990) amply demonstrated that measuring the working hours of women simply in terms of their time at work seriously underestimated their working time. Beerman and Nachreiner (1995) also demonstrated clear differences in the domestic obligations and hence the workload and time for leisure of men and women. Oginska *et al* (1993) found that shift work-specific complaints observed in younger women at a steelworks decreased in women over the age of 50, in opposition to the trend for men, and that they became more tolerant of shift work around that time. This further supports the view that impairment of general health and well-being are linked to a heavy overall workload, which for many women may substantially decrease in late middle-age.

One area where women may be more vulnerable than men, although not necessarily so, is that of reproductive health. Reference has already been made in an earlier section to this and to the fact that data are currently inconclusive. New international standards and legislation recognize the need to take into account the potential risks to both genders in this area, although making special reference to maternity protection. In the future data on men's reproductive health may lead to other specifications.

Age

It might be expected that as shiftworkers get older they would cope better with shift work. Firstly they have more experience of coping with the problems, secondly they are reaching a time of life when domestic pressure (for example the demands of young children) may lessen and thirdly it is well known that older people seem to need less sleep than younger people. From a research point of view it might also be expected that the older members of any sample might report fewer shift work-related problems (the 'survivor' effect once more), hence creating the impression (perhaps erroneously) from the data that increasing age equals increasing shift work tolerance. In fact none of these suppositions are supported by the evidence. A series of studies (reviewed by Harma, 1995 and again by Nachreiner, 1998) all indicate that age, beginning around late forties and early fifties, results in a decreasing ability to cope with shift work. The reasons for this are not fully understood but appear to be related to the changing sleeping patterns of older workers. With age, sleep becomes shorter and more fragmented. This does not necessarily reflect a need for less sleep but simply an inability to achieve what is needed so easily. This in turn may be related to a shifting and flattening of circadian rhythms which tends to occur in middle age and results in a move towards "morningness", early bedtimes and early rising, which, as discussed below, is not conducive to coping with most forms of shift work In addition to these problems, there is further evidence that the circadian rhythms of older people are slower to adjust than those of the young. Taking these factors together therefore the well-documented problems of older shiftworkers are perhaps unsurprising. One cautionary note should be added to this generally consistent picture however. The results of the study of Polish steelworkers, already mentioned (Oginska *et al*, 1993) found that while men exhibited the expected pattern of health deterioration with age, the subjectively reported health of women improved, particularly after the age of 50. This was despite the fact that at a younger age they exhibited more symptoms of shift work intolerance (psychoneurotic, digestive, circulatory and chronic fatigue) than did their male counterparts. A probable explanation for this is the reduced social and domestic pressure which working women often experience in later years. Age effects may therefore have strong circadian component but may also be modified by the influence of social circumstances.

Individual circumstances

A variety of factors come under this heading which might also be referred to as the social determinants of adjustment to shift work. It has already been noted that the domestic circumstances of women appear to play a major part in the development of symptom reporting

and that these circumstances may also interact, sometimes positively, with the physiologically-based adjustment problems associated with ageing. The domestic obligations of both women and men predominantly relate to spouses and partners and to children. Clearly there will be other individual circumstances, for example responsibility for ageing or sick relatives, which impact on peoples' work situation. However, in terms of scientific evidence it is issues surrounding partners and children which have been studied most often. Essentially these have been looked at from two related perspectives, first the effect on family relationships and domestic organization of shiftworking partners or parents, and second the extent to which the presence of a partner or children determines adjustment to shift work.

Within a domestic situation an individual may have a number of roles, notably those of caregiver, companion, sexual partner and parent. Most research in this area has focused on the heavy domestic burden which shift work, or having a shiftworking partner, places on women. Most studies indicate that the presence of children significantly adds to the problems of shiftworking for women, although to a lesser extent this is also true of men (Beerman and Nachreiner, 1995). Studies which have examined the perceived domestic consequences of shiftworking for men and women tend to show that men are equally concerned about negative effects on their family relationships. For example Lushington *et al*, (1997) studied 50 Australian nurses and their partners (26% of whom were also shiftworkers) and asked them to rate on a 5-point scale the amount of disruption caused to various aspects of their interpersonal relationships by shift work. Figure 3 shows the percentage of nurses and partners reporting a moderate or greater amount of disruption for each aspect.

Figure 3. *The effects of shift work: the case of Australian nurses*

From Lushington *et al*, 1997

Among those who had children (44%), 55% of the nurses and 40% of their partners felt that the nurses' contact with their children was insufficient, especially following night and evening shift work. Interestingly the perception of contact between partner shiftworkers and their children is not reported, perhaps reflecting the assumptions about the importance of the women's role in this respect. In fact some recent research has indicated that the children of shiftworking fathers also experience stress within the family and that in daughters, but perhaps surprisingly not sons, this was reflected in an increase in depressive symptomatology (Barton *et al*, 1998).

In some circumstances aspects of the family situation may operate in a positive fashion by the provision of social support. For example, some recent studies have indicated that support from family members can be a major determinant of shift work adjustment (Loudoun and Bohle, 1997; Pisarski *et al*, 1998).

Intuitively it also seems likely that in geographical areas where shiftworking is the norm, individual acceptance and family support are likely to be much greater. Conversely social isolation may result from a work pattern that is radically different from one's neighbours. These so far unresearched influences in terms of social and leisure activities, may be significant modifiers of adverse effects on well-being. However, this simply underlines the importance of adapting work schedules to the particular needs of the workers as far as possible. The overall conclusion to be drawn from the current published literature is that shift work frequently places a considerable strain on family relationships. It should be noted that the International Labour Organization Recommendation on Workers with Family Responsibilities specifies that wherever practicable and appropriate the special needs of workers including those arising from family responsibilities should be taken into account in shift work arrangements and assignments to night work (International Labour Organization, 1981).

Personality attitudes and behaviour patterns

Psychologists tend to make a distinction between aspects of personality (traits) which are considered to be relatively fixed dispositions to behave in a certain way, and attitudes and behaviour patterns which are regarded as learned responses and which can therefore be modified to some extent. In the occupational setting the former could only operate effectively in the context of pre-employment selection, whereas the latter may provide a basis for counselling and training. A number of these factors have been investigated in terms of their potential to enhance or reduce adjustment to shift work.

Introversion

Several studies have identified a consistent relationship between a tendency towards neurotic introversion and an intolerance for shift work (Iskra-Golec *et al*, 1995; Taylor *et al*, 1997). For completeness a brief discussion of this evidence is included, although its practical relevance in the workplace is doubtful. The concept of introversion was first defined by Eysenck in the 1940's as part of his now well-established theory of personality, (Eysenck and Eysenck, 1963). Stable introversion is characterised by calm, thoughtful and controlled behaviour while unstable or neurotic, introverts tend to be moody, anxious and pessimistic. Both of these types contrast with extroverts who in turn may be stable (sociable, carefree, easygoing) or unstable (restless, impulsive, aggressive). Because Eysenck's theory has been so pervasive and influential it is perhaps natural to turn to this classification system when investigating the relevance of personality to shift work tolerance. The theory is not without its critics however, partly on the grounds that it represents an oversimplification of personality, and more particularly in terms of whether extroversion and introversion constitute stable personality traits or simply expressions of transient moods. From the point of view of shift work research this is an important distinction. Most of the data relating to personality and shift work is correlational and derived from cross-sectional studies. The question inevitably arises therefore as to whether a tendency towards neuroticism is actually an exclusion factor for shift work, an effect of shift work or simply happens to be related to a third currently unidentified predictive variable. Existing data cannot answer these questions and the status of the current evidence cannot therefore be said to provide any grounds for employing personality tests of this type in any selection procedure.

Hardiness

Another psychological concept, that of hardiness (Funk, 1992), similarly suffers from controversy about whether it is a stable trait or a learned behaviour pattern, and again supporting evidence in relation to shift work comes from correlational data. Hardiness in psychological terms is characterized by three characteristics, commitment, challenge and control. Wedderburn (1995) found that in a sample of male and female shiftworkers in a textile and an electronics factory hardiness was positively correlated with an increased liking for shift work and reduced reporting of physical complaints. Conversely low hardiness was associated with poor adjustment to shift work. There is evidence that hardiness can in fact be improved by counselling and training (Maddi and Kabasa, 1984) and in one study of shiftworkers it was shown to be related to another measure of coping strategies (Olsson *et al*, 1987). It may therefore hold some promise as the basis for an approach to increasing adjustment via behavioural change.

Attitudes

The idea that attitudes to shift work and to home and leisure time may help to determine who finds shift work particularly difficult is intuitively appealing, particularly as it offers the possibility of improvement via attitude change. Unfortunately although a number of studies have touched briefly on this aspect direct research in this area is currently very limited. Singer *et al* (1994) demonstrated that nightshift workers differed significantly from day workers in terms of a range of attitudes towards safety, management, family support and health maintaining behaviour. The nightshift workers had more negative attitudes to personal and job safety, and towards management support for maintaining their health. Given the generally held view that conditions on nightshifts do tend to be considerably different to those on dayshifts, however, this may reflect an objective reality rather than merely a worker perception. Nightshift workers were not uniformly negative in their attitudes. For example they were much more positive than day workers about social support from family and friends, and about family support for health maintenance. The fact that this was not translated into better-perceived health, (they reported adverse health symptoms much more often) further supports the conclusion that in this case at least there were real problems in the workplace which needed to be addressed. This is not to say that attitude change or modification may not be a helpful approach in promoting worker adjustment, simply that is should not be considered a substitute for first improving workplace conditions.

An unrelated but nevertheless attitudinal line of enquiry has explored the value of different periods of leisure time and its relationship to satisfaction with certain work schedules. Even in today's world of non-standard working hours it would seem that most individuals maintain a preference for time-off in the evenings and at weekends, placing much higher value on these hours than comparable hours during weekdays, (Hornberger and Knauth, 1993). Alongside this however is a need for compatability between a shift system and the demands of non-work activities. Gadbois (1981) demonstrated the importance of this in a study of French nurses noting the high priority given to accomplishment of domestic tasks, which for example took precedence over attempts to make up lost sleep.

These largely unconnected fragments of research, although currently limited in terms of application, point to the fact that this is an extremely under-researched area. Exploration of worker attitudes is important first because it identifies for employers the particular features of workplaces or shift schedules which make adjustment difficult for certain individuals, and second because it may provide a basis for behaviour modification where this is appropriate.

Physiological and health status

Morningness and eveningness

The existence of two different circadian types has long been recognized. Morningness (Horne and Ostberg, 1976) is characterized by a tendency to wake up early and to go early to bed, while for eveningness the reverse holds. There is some evidence that morningness is more often associated with shift work intolerance (Folkard *et al*, 1979) and this has often been suggested as an explanation for the increased intolerance of older workers since morningness tends to increase in late middle age. As with psychological variables, however, it should be noted that these data are once more correlational. In fact when tested longitudinally (Kaliterna *et al*, 1995) eveningness showed no validity as a predictor of shift work tolerance. Folkard et al (1979) have suggested that a more meaningful approach is to include a number of factors in attempting to predict who will adapt best to shift work. Their questionnaire, in addition to morningness, also covers sleep pattern rigidity and general vigour. In combination with morningness those who have a tendency to keep to fixed bedtimes and working times regardless of the situation, and those who score low on a scale of general vigour are likely to suffer more as a result of shift work. A number of studies appear to confirm the validity of this measure, although whether or not these circadian features are susceptible to change remains an unanswered question. Again therefore the notion of using currently available questionnaires as a selection tool should be viewed with caution. More usefully such information could provide the basis for pre and post employment counselling and for optimizing work schedules to suit worker needs.

Some health conditions

A number of health conditions have been suggested as likely to reduce people's ability to cope with shift work. Primarily these include pre-existing complaints of the type for which shift work is thought to be a risk factor, notably gastrointestinal disorders, mental health problems and cardiovascular disease. Usual additions to this list are a history of alcohol or drug abuse, epilepsy, diabetes and those on regular long-term medication for other complaints. In terms of the last three, however, it must be said that their inclusion is based on medical concerns about management of their condition, rather than any firm evidence that individuals in this position are inevitably unable to cope with shift work. In one of the few studies in this area, for example, Poole *et al* (1992) found that the control of diabetes in insulin treated diabetics who worked shifts was no worse than those who worked days only, although slowly rotating shifts were associated with better diabetic control than more rapidly rotating shifts. On balance the

information in this area points to a similar conclusion to that relating to other individual differences, namely that some people are likely to be more vulnerable to the negative effects of shift work, but should not for this reason be considered automatically excluded. Consideration of individual differences simply underlines the need for carefully considered pre-employment counselling and subsequent health surveillance.

Job type

Jobs can be categorized in a number of different ways, for example whether they are manual or non-manual, full or part-time, office, factory or agriculturally-based. However, from the point of view of whether they present particular problems for shiftworkers, or those working non-standard hours, it is more useful to classify work in terms of certain features of the job. Essentially shift work and non-standard working constitutes (i) a potential source of stress (ii) a potential source of fatigue. Jobs which are already high in one or both of these factors are therefore likely to be specially vulnerable jobs, requiring particular attention in terms of health and safety.

High fatigue jobs

- Heavy manual
- Harsh environment
- High monotony (boredom)

High stress jobs

- High social demands (e.g. nurses, social workers)
- Dangerous (e.g. law enforcement)
- Potential for trauma (e.g. emergency services)
- High demands, low control (e.g. call centres)
- High monotony - low stimulation
- Presence of physical stressors (e.g. noise)
- Time pressure
- High responsibility (e.g. air traffic control)

The addition of shift work to jobs which already contain one or more of these features is unfortunately common and in some cases, such as health and emergency services, unavoidable. This points to the need for optimal work scheduling as well as active stress management policies (see chapter 6). Non-standard hours are however better avoided in high stress jobs where this is possible.

Shift work is not advisable for workers with the following characteristics:

- Over 50 years old
- Morningness/sleep rigidity
- History of sleep disorders
- History of psychiatric disorders
- History of gastrointestinal problems
- History of cardiovascular disease
- History of drug or alcohol abuse
- Neurotic introversion
- Epileptic
- Diabetic
- Regular long-term medication
- Heavy domestic responsibilities
- Low family support
- High stress job
- High fatigue job

Chapter 7.
Intervention strategies

There is plenty of evidence in the preceding chapters that certain aspects of working time can have extremely negative effects on employees, and particularly on certain vulnerable groups. This is clearly an unacceptable state of affairs. As stated at the outset working time arrangements should not be detrimental to workers' health, well-being or safety. What strategies are therefore available to alleviate or remove the problems which working time may create? The research literature suggests a number of approaches and although not all have been fully evaluated many hold considerable promise. Today there is an increasing emphasis on positive management of working time issues both at an individual and an organizational level.

Essentially measures which are aimed at reducing the negative effects of working time fall into three categories: (i) those which focus on the specific work schedule organization (ii) those which focus on other aspects of the working environment, and (iii) those which concentrate on modifying responses at the individual level. Generally speaking a comprehensive management strategy would consider all three areas in an attempt to minimize the risk to employees. The sections which follow deal primarily with shift work, partly because most of the available information relates to this, but also because issues surrounding overtime and long hours are relatively less complex. Brief reference will however be made to these.

Work schedule organization

3-shift rotation

Although a large number of shift patterns now exist, one of the most common is still the three 8-hour shift rotation. From the point of view of optimizing conditions for the workers two basic questions need to be addressed. Firstly in what direction should such a system ideally rotate? Usually this is a choice between forward (clockwise) rotation (mornings, afternoons, nights) or backward (anticlockwise) rotation (nights, afternoons, mornings). Secondly, how fast should this rotation occur?

In their discussion of shift work schedules Monk and Folkard (1992) note that there are essentially two important aspects of the human circadian system which should be taken into account here. First, for most individuals retrainment (phase-adjustment) takes place slowly. Adjustment to night work for example, usually requires more than a week. As a result, shifts which rotate on a weekly basis, unfortunately a common pattern, are those most likely to result in problems. On the one hand there is insufficient time for complete adjustment to a new schedule, but sufficient time to build up a sleep debt during the process of attempting to adjust. This leaves the worker in a state of both circadian disruption and sleep deprivation. Given a rotating schedule therefore the preferred options appear to be either much slower rotation, with a period of three weeks or more between changes, or very rapid rotation with only one or two days between each change, the former producing total phase adjustment and the latter none. Expert opinion appears to be divided between these alternatives. While neither system is ideal, however, both appear to be preferable to a weekly cycle.

A second important factor is that the human biological clock has a tendency to run slow and under conditions where there are no social constraints will actually tend to run to a 25-hour rather than a 24-hour cycle. Perhaps for this reason shift rotation in a clockwise direction tends to produce more rapid adjustment than does anticlockwise rotation (Czeisler *et al*, 1982). On balance therefore decisions about speed and direction of rotation seem to depend on whether phase-adjustment is desired or not. Task considerations (below) may also be important here.

Task considerations

Monk and Folkard (1992) also draw attention to the importance of considering the nature of a worker's task when designing shift schedules. It has already been noted that largely routine tasks which might include for example watchkeeping and driving tend to be particularly

susceptible to the fatigue which results from lack of phase-adjustment and the requirement to maintain attention at a low point in the circadian cycle. More demanding tasks however which involve complex problem-solving tend to be performed well at night even by day-oriented workers (Monk and Embrey, 1981), presumably because such tasks raise arousal levels. The need to phase-adjust therefore would appear to be particularly important for workers whose jobs are likely to be mentally unstimulating for long periods of time. For other workers however, very rapid rotation, which precludes adjustment, might be the preferred alternative.

Shift-timing

Akerstedt (1998) noted the importance of shift start and stop times observing that an increase in fatigue and errors tends to occur on the morning (6am-2 pm) shifts. Hildebrandt *et al* (1974) also reported this nearly two decades earlier and observed that it was most likely to be due to workers going to bed at the usual time, rather than early, the night before. There may also be some interaction with the type of task here. For example, laboratory studies have shown that performance on more complex tasks tends to peak earlier in the day than performance on more routine tasks. Evidence in this area is rather sketchy but does suggest a serious questioning of the traditional 6am starts for all job-types, and that worker habits also need to be considered.

Rest breaks

An important factor in offsetting fatigue in any work situation is the scheduling of rest breaks. Essentially there are two elements to a rest break, its length and what takes place during the break. There are a number of alternatives to each which may suitable for different types of jobs or used in combination within one job.

Length of break

- Integrated into a task which is partly automated
- Frequent short breaks
- Longer less frequent breaks
- Frequent microbreaks of a few seconds

Type of break

- Passive rest from mental activity
- Passive rest from physical activity
- Time away from an environmental stressor (heat, cold, noise, vibration)

- Time on a different job using different body parts
- Active rest (e.g. walking, exercising)

In considering which types of break are suitable for a particular work situation Konz (1998) notes the following axioms

- Many jobs do not have constant loads but have peaks and troughs of demand
- Fatigue increases exponentially with time in all jobs
- Rest is more beneficial if it occurs before the body part (e.g. cardiovascular system, musculoskeletal system, brain) has too much fatigue. Therefore machine-paced or standardized rests are probably less effective than rests under operator control
- The value of rest declines exponentially with time (there is more recovery in the first part of a break than the later part)
- Different body parts have different recovery rates

In relation to workplaces in general the International Labour Organization (International Labour Organization, 1979) has published a system for determining “fatigue allowances”, or rest times, which identifies three categories of such allowance (physical, mental and environmental) and the factors which need to be considered in each category. Similarly (Konz, 1998) has summarized the evidence for the types and lengths of rest break appropriate for different types of jobs.

Some general principles

- Frequent short passive breaks for heavy manual work (e.g. lifting)
- Frequent short mentally or physically active breaks for monotonous routine work (e.g. data entry)
- Passive or physically active breaks for demanding mental or socially stressful work (e.g. jobs involving interaction with public)
- Frequent active microbreaks for jobs involving static postures (e.g. jobs requiring standing)
- Frequent alternative task breaks for non-heavy physical work (e.g. production line)
- Provision of appropriate facilities to allow removal from environmental stressors (e.g. warm or cool room for those working in cold or heat respectively)

Clearly it is of particular importance to institute appropriate rest breaks where people are working non-standard hours. There is currently little research directed specifically at non-standard working and optimum breaks, but in applying general principles the fact that shiftworkers and overtime workers are likely to be more vulnerable to fatigue and its effects should be taken into account.

An area of controversy relating particularly to shiftworkers is the question of short sleep periods at work, sometimes adopted unofficially by workers as a coping strategy.

In some countries, notably Japan, the official scheduling of short naps known as "maintenance naps" during nightshift work has become common practice as a means of offsetting fatigue. There has been no systematic evaluation of the effectiveness of such naps and concerns have been raised as to whether napping on successive nights actually reduces circadian adjustment.

In one laboratory study however (Gillberg, 1985), was able to demonstrate that one hour of sleep was more effective in increasing alertness than one hour of rest while awake in subjects required to stay awake for 24 hours. Clearly more information is required here but current evidence suggests that naps during the workshift may be effective at reducing fatigue in the short-term where phase-adjustment is not desired, for example where shifts rotate rapidly and only one or two successive nights may be spent on the nightshift. The scheduling of formally sanctioned naps, but also rest breaks in general, is currently a neglected area of shift work research and merits much more scientific attention.

Schedule design

The design of a shift system is a complex process which perhaps accounts for the continuing preference for traditional continuous 8-hour weekly rotating schedules. Such schedules are relatively straightforward but may not be ideal from the point of view of the workers or indeed the company. During the last few years there has been increasing recognition that the introduction of a new shift system is much more likely to be accepted and successful if workers are able to participate fully at the design stage (Kogi and Martino, 1996). This can be problematical however since the interests of employers and employees may often conflict. In fact there are three factors which should ideally be taken into account; the operational requirements of the company, the preferences of the workers and the existing information on health and safety matters. Until relatively recently however an approach which involved all these elements presented a formidable challenge and was probably adopted by very few. With the

advent of computers and the development of scheduling programmes this is now beginning to change and it has become possible to develop expert systems which will assist in the design and implementation of tailor-made schedules. A good example of this is described by Gissel and Knauth in Germany (1998).

> A knowledge-based software system was developed to support the participatory design and implementation of shift systems as a joint planning process between shiftworkers, the workers committee and the management. Knowledge to develop the system was acquired by discussion with experts and an extensive literature search of over 1,700 relevant publications on the effects of shift work. Application of the system allows users to derive good examples of shift systems already in use which meet their requirements. These provide a basis for participative discussions which take account of worker preferences and from which modifications can be derived. A further module of the system allows users to monitor continuously, during the modification process, the possible negative effects associated with certain characteristics of a shift system, prior to development of the final design.
>
> Adapted from Gissel and Knauth (1998)

Systems such as this are currently at an early stage but are beginning to appear in the literature. For example a recent paper by Fletcher and Dawson (1997) described a predictive model of work-related fatigue based on hours of work.

Progressive development and use of such systems in the future should encourage the implementation of working time arrangements which are less simplistic and which are able to take much more account of the needs and well-being of the various parties involved.

Overtime

Very few authors have addressed the question of design of overtime schedules, the vast majority confining themselves to different forms of shiftworking. An exception is McCrobie (1996) who reported on an overtime policy currently being implemented at Honeywell Air Transport Systems Division in the United States, which he noted had been adapted from other in-place policies at various manufacturing sites in America. Taking into account the available scientific literature on overtime and its effects the policy contained the following points:

- Overtime should not be scheduled continuously. Suggested limits are 1 day per week, 1 week for every 6 months and no more than 1 month maximum for 1 year.

- Overtime should be rotated among employees rather than limiting it to certain employees.

- It is preferable to extend hours per day rather than days per week.

- For jobs that have physical demands that are close to being exceeded on an 8-hour shift, overtime should be avoided. For all jobs that require overtime an ergonomic evaluation of the work should be conducted, to ensure that overtime does not put employees at a higher risk of musculoskeletal disorders.

Adapted from McCrobie, 1996

Interestingly this policy puts special emphasis on the avoidance of musculoskeletal disorders, which is actually one of the least researched areas in terms of the health effects of overtime work. However, in doing so it draws attention to one important general point, that overtime work should not put employees at risk as a result of longer exposure to other workplace hazards. It thus provides a useful model for dealing with this issue.

Modification of the working environment

Bright light

For many years light was not considered to be an important influence on the circadian cycle. Social and endogenously determined time cues were considered to be much more important. This changed somewhat dramatically in 1980 when Lewy and colleagues demonstrated in a laboratory experiment that daylight levels of illumination were sufficient to suppress endogenous melatonin production at night (Lewy *et al*, 1980). The hormone melatonin is associated with tiredness and promotion of sleep and under normal circumstances tends to be produced during night hours. The work of Lewy triggered a large programme of research into the possibility of using bright light to accelerate the phase adjustment of shiftworkers and hence counteract the effects of fatigue. To a certain extent the results of this research have been encouraging. For example laboratory studies in the United States (Czeisler and Dijk, 1995) have confirmed that bright light can have a powerful influence on the adjustment of the circadian system. In the workplace Costa *et al* (1993) found that exposure to short periods of bright light

on two consecutive night shifts reduced self-reported tiredness and produced an improved sleeping pattern in nurses, as compared with two nightshifts with normal lighting. Performance on a cognitive test was also improved, although no change in physiological correlates of phase shifting was observed (hormonal levels and body temperature).

Two complicating factors have emerged in this area. First the precise relationship between the application of bright light (its timing, intensity and duration) and the extent of phase adjustment, known as the "phase-response curve" is yet to be specified. More research is needed to determine the optimal parameters of light production which will produce particular phase shifts. Secondly, in terms of applying bright light intervention to real shift workers a very practical problem has emerged. Successful application of bright light appears to depend to a great extent on equally effective blocking out of light at inappropriate times of the day. While this is not a problem in a laboratory-based experiments or indeed tightly controlled workplace-based investigations, for the real worker in the real world total protection from light exposure during the day is an unrealistic prospect. Again more research is needed to determine exactly how important this is likely to be, in addition to the importance of other socially determined external cues. At the present time therefore the efficiency of bright light as a practical intervention measure in the workplace is the subject of a promising but currently inconclusive line of research which may produce fruit in the near future.

Temperature

There are good reasons to suppose that the ambient temperature in the workplace might affect the performance and well-being of shiftworkers. The effects of temperature in otherwise normal working conditions have been well-documented, (Hygge, 1992; Brook and Ellis, 1992). In addition the body temperature of shiftworkers may be lower on certain shifts, notably the nightshift, in accordance with circadian rhythmicity. Unfortunately information in this area is rather limited. There appear to have been no studies on the effects of low temperatures and those very few studies which have investigated high temperatures have produced insufficient information on which to base any intervention strategy. A study in Germany, for example, (Ottman *et al*, 1985) compared the cognitive test performance of office workers at two different temperatures (23.4°C and 27.7°C) on a week of dayshifts and a week of nightshifts. The higher temperature appeared to affect the performance of dayshift workers in terms of reducing their ability to cope with complex tasks. On the nightshift workers performed more poorly generally but this was not affected by differences in temperature. Both temperature levels in this study were fairly high however. A larger reduction in temperature may have produced more marked performance decrements in nightshift workers whose body temperatures were already relatively

low. This is another area which needs much more careful and detailed investigation since optimal temperatures for comfort and performance are very likely to vary between shifts. At present it represents an area where workers' preferences should be taken into account.

Physical work load

The capacity to carry out and sustain physical work depends on the production of energy which in turn depends on the interaction of a range of cardiac, respiratory and metabolic variables. Circadian changes in the relationships between these variables are likely to affect the workers ability to produce and maintain energy at different times of the day. In particular activity in a number of physiological systems tends to be reduced at night and it is reasonable to predict therefore that workers on nightshifts will find physically demanding work harder than the same work carried out on other shifts. Studies of energy expenditure in shiftworkers tend to support this, showing that more energy is expended to achieve a similar level of work on some shifts than on others. Further the gradual decrease in ability to perform physical work which normally occurs under daytime conditions over the period of an 8-hour shift, is significantly magnified in nightshift workers.

> At a glass factory in Poland workers were examined before work and at 4 points during the work shift. Pulmonary ventilation and oxygen uptake were significantly higher on the night shift than on other shifts, with energy expenditure 10% higher, but work speed slightly slower.
>
> (Wojtczak-Jaroszowa, 1977, source: Rosa *et al*, 1990)

Although there are few demonstrations of this problem under controlled conditions it seems reasonable on physiological grounds to assume that these effects would be replicated in other studies and in the workplace. Where work is particularly demanding therefore the potential interaction between this and shift schedule may be an important consideration in designing systems of work.

Workplace facilities

General commentaries on the problems of shiftworking frequently refer to the reduced provision of various workplace facilities which tends to occur outside normal daytime hours. Although these have not been studied systematically it is worth listing them as potential areas

where practical intervention is likely to improve feelings of general well-being among workers employed on shifts or overtime.

- Catering
- Transport
- Health and safety
- Recreational/health promotional

Modification of individual responses

Pharmacological approaches

The use of medication by shiftworkers may involve either (i) sedative-hypnotics to increase sleep during non-work hours (ii) stimulants to improve alertness during work hours or (iii) drugs designed to manipulate the normal sleep/wake cycle. The effectiveness of sedative-hypnotics, specifically benzodiazepines, in this context has not been extensively studied. There is some evidence that certain compounds may increase total daytime sleep time and reduce the frequency of waking in nightshift workers, but there may also be a persistent sedative effect during subsequent work hours (Walsh *et al*, 1995). There has been even less research into the effects of stimulant use by shiftworkers, despite anecdotal reports of frequent use. The potential for abuse and evidence that effectiveness tends to decline over time are both significant concerns and the use of sedatives and stimulants are not generally recommended by occupational physicians for these reasons.

The use of drugs to alter the normal sleep/wake cycle on the other hand appears more promising. For example the use of melatonin has been shown to be effective in regulating the sleep patterns of insomniacs (Zhdanova *et al*, 1995), and alleviating the problems of jet lag sufferers (Arndt *et al*, 1995). To date the application of this and similarly acting compounds to the problems of shiftworkers is controversial but may constitute an interesting line of enquiry in the future.

Behavioural approaches

Evidence from the wider health promotional and psychological literature suggests that approaches which focus on the behaviour and attitudes of individual workers could hold considerable promise as effective intervention techniques.

Sleep management

For shiftworkers in particular, but to a lesser extent overtime workers, achieving sufficient good quality sleep is a high priority. Two aspects of this have been highlighted, first the importance of optimising sleep during non-work periods, and second the possible use of napping either immediately before, after or during work time.

An increasing number of guides for shiftworkers are now available which provide advice on sleep maintenance during daylight hours (Wedderburn 1991, Monk and Folkard 1992). These cover standard practical aspects such as following sleep promoting routines, avoiding caffeine and alcohol prior to sleep, ensuring that the sleeping room is comfortable and taking steps to block out noise and light as far as possible. These measures are based on successful behavioural modification programmes developed for the treatment of insomniacs in a clinical psychological setting (Bootsin and Nicassio, 1978). They also make good practical sense and anecdotally appear to be extremely helpful.

More controversially it has been suggested, as noted earlier, that for nightworkers short naps during working time may help to offset the effects of fatigue. The advantages of such naps in situations where people are required to work for extended periods of two or three days with little sleep (usually military situations) have been well-documented (Naitoh *et al*, 1982). However, their value in more conventional workplaces is less certain. Theoretically it seems plausible that they would be of value in situations where shifts rotated rapidly, to help maintain a daytime orientation, and a hindrance in a slowly rotating schedule where phase adjustment was required. The only country where formally sanctioned napping has been well-documented appears to be Japan where Kogi (1981) reported that between 40% - 50% of workers napped during the nightshift, sometimes for as long as 2-3 hours. The long-term value of this "maintenance napping" awaits systematic study however.

An alternative to napping during the workshift is what is known as "prophylactic napping". Here a period of extra sleep, between 1 and 4 hours is taken on the day preceding the nightshift. Studies tend to show fairly consistently that this enhances subsequent performance (Nicholson *et al* 1985, Dinges, 1995). The difficulty lies however in the practical implementation of such measures in the lives of shiftworkers who may wish to maximize their time for home and leisure activities.

Diet

Clearly the timing of eating and drinking is likely to be different for shiftworkers as compared with dayworkers. Some studies have suggested that the type of food eaten is also different, indicating, for example, a tendency for shiftworkers to eat more frequently and to snack on convenience foods. Most studies of this type have been carried out in the United States or Western Europe, however, and caution should be exercised in generalizing such findings to other countries with widely different cultural and religious practices. Because gastrointestinal complaints are frequently reported by shiftworkers, manipulation of eating and drinking behaviour has often been suggested as a useful intervention measure. Advocates appear to have one of two objectives in mind, either to use timing and content of diet as a means of encouraging phase adjustment, or to promote eating and drinking habits which are conducive to sleep maintenance and more general well-being.

There is some evidence from animal studies that dietary manipulation can produce changes in circadian cycles, but this does not appear to transfer readily to the human situation. There has however been some success recorded using this approach with jet lag sufferers (Graeber, 1989). Although it has never been applied to shiftworkers, it is perhaps something which would merit further investigation. Alternatively dietary manipulation as part of a general "sleep hygiene" programme, for example avoidance of stimulants and foods which are more likely to cause indigestion just before sleep, has been widely recommended, although on the basis of anecdotal rather than scientific evidence. Attempts at wider application will of course need to take account of the well-known difficulties inherent in attempting to alter peoples' eating behaviour, and the need for long-term follow-up.

Exercise

Since shiftworkers, or more particularly nightworkers, are required to work at physiologically inappropriate times, some attention has been paid to the possible importance of their physical fitness. A number of researchers have investigated whether increased regular exercise, and hence improved fitness, might improve adjustment to irregular work schedules. In general the results of these intervention studies have been very encouraging. For example, (Harma *et al* 1988[a], 1988[b]) evaluated the effects of a 4-month physical training programme on Finnish nurses and nursing aides working irregular shifts in a hospital. Assessment was made of mood, sleep quality and symptom reporting in addition to physiological parameters. Those participating in the programme reported decreased fatigue, improved sleep and fewer musculoskeletal problems. Although this might be argued to be a manifestation of the "Hawthorne effect" (the study did not

report long-term follow-up), it should be noted that a change was also noted in physiological parameters, for example on average a 5-beat decrease in heart rate and a 5% increase in maximal volume of oxygen as compared with a control group.

Counselling and Stress Management

A range of techniques which have been described in the wider psychological literature, and in some cases applied in the workplace, may have some value in terms of increasing tolerance to irregular working hours.

Counselling is a broad term which may cover anything from practical advice on diet, sleep patterns and exercise to specific forms of psychological therapy. While there has been some limited application of the more practical aspects in the workplace, the use of techniques such as behavioural therapy to change attitudes and promote positive coping behaviour, or cognitive strategies to increase alertness and performance have not been reported. Their efficacy in other fields such as sports medicine however suggests that they could be powerful tools in promoting adjustment to working hours and possibly in reducing the risk of longer-term health outcomes. Although such techniques are demanding of time and resources other conventional stress management techniques, for example relaxation training (Benson, 1976) can be carried out successfully on a group basis. These have had wide application in the workplace as an approach to managing occupational stress (Ivancevich *et al*, 1990). In particular Stones (1987) in Canada noted the efficacy of relaxation training in improving the well-being of rotational shift workers.

Training and education programmes

It was noted at the beginning of this section that an effective intervention policy would probably include a number of different elements. Successful management of working time is unlikely to depend on one element but on the implementation of an integrated package of measures. A number of organizations are beginning to institute comprehensive education and training programmes, primarily aimed at shiftworkers but with potential application to those who work other forms of irregular hours. The majority of these programmes are developed by external consultants and include a range of elements which may include work schedule design and workplace adaptation, or simply be confined to education and information for individual shiftworkers.

Training and education programme
Typical format

- Questionnaire survey of current work schedule, effects on health, performance, safety and general quality of life
- Analysis of data and identification of specific problems
- Recommendation for schedule changes
- Implementation of shiftworker education programme to include:
  - Information provision and awareness raising
  - Education in different types of coping strategies
  - Education about lifestyle changes
- Assessment and review

Because such programmes are usually developed and implemented within the context of private consultancy they are rarely published or subject to external validation or review. Much potentially valuable information is therefore unavailable to the wider community. A small number of such programmes have been systematically evaluated and published (for example, Sharratt and Davies 1991, Popkin 1994) and the results tend to be rather mixed, with some elements clearly more successful than others. This in itself is useful information. The publication of more such programmes in the future would considerably assist their future development.

Summary of options for intervention

- Work schedule organisation
  - Forward shift rotation
  - Optimal speed of shift rotation*
  - Optimal shift start and stop times*
  - Optimal rest breaks*
  - Limitation of overtime
  - Limitation of night work

  (*Take into account individual characteristics and job demands)

- Environment modification
  - Bright light introduction
  - Attention to temperature
  - Where possible reduce physical workload at night
  - Optimize workplace facilities

- Individual help
  - Sleep management
  - Health promotion (diet, exercise)
  - Counselling and stress management
  - Training and education

Chapter 8.
The management of working time: practical recommendations

The risk management framework

Many current practices in the organization of working time represent potential hazards to the workers involved. Since the goal of occupational safety and health is to reduce as far as possible the resultant risks to workers it is clear that a comprehensive strategy of working time management is required. The development of the particular form of that strategy in any one organization or country is a matter for discussion and agreement between the partners, (employers, employees and regulators) involved. However, like other aspects of health and safety policy today it will almost certainly be carried out within a framework which is termed 'Risk Management'.

This framework recognizes that, while few if any environments can be totally risk free, important decisions have to be made about what constitutes a tolerable level of risk in relation to a particular agent or circumstance. The process which has been developed to address questions of risk in the workplace and elsewhere, although varying in detail between countries and organizations, essentially consist of five common core stages.

- Identification of the hazard
- Assessment of the risk
- Institution of measures for reduction and control
- Monitoring of the effectiveness of those measures
- Appropriate adjustment of those measures

Within this approach an important distinction is made between a *hazard*, something in the environment (in this case the working environment) which has the *potential* to cause harm, and *risk*, the *probability* that such harm will occur. Although originally conceived with more traditional physical and chemical hazards in mind, the process has been shown to be equally applicable to other forms of hazard, notably those which fall under the broad heading of "psychosocial", (Spurgeon, 1996). These include for example the management style of a company, its structure and culture and the consequent demands it makes upon its employees. The arrangement of working time is very frequently viewed in these terms, as an important part of the psychosocial make-up of the organization and increasingly its management is likely to be seen as part of an overall risk management strategy. This chapter therefore is concerned with how such an approach might be implemented drawing on the information about the effects of working time and potentially useful interventions which have been discussed in the previous chapters.

Identification of the hazard

A hazard is usually identified as such because evidence in the wider scientific literature indicates a potential for harm. In this sense it is clear that certain aspects of working time fulfil this criterion and thus the need for an assessment of risk is indicated. In general, working time arrangements in the following categories should be considered in this context:

- Working hours sometimes or always outside standard daytime hours
- Extended working hours
- Irregular or unpredictable hours

Assessment of risk

For more traditional hazards such as toxic chemicals, noise, radiation etc, the next stage in the process, the assessment of risk, is usually made by reference to an external standard which again is derived from scientific evidence concerning the level of exposure likely to result in harm. This is rarely possible in the case of psychosocial hazards however since the potential for harm is invariably linked to the individual's perception of and response to the hazard in question. It is clear for example that attitudes to overtime work may range from negative resentment through neutral acceptance to positive approval, each of which may have different consequences for the short or long-term health of the individual. While some general principles may be applied therefore, (for example regular working over 50 hours per week is usually not

advisable), proper assessment of risk in the context of psychosocial hazards normally requires some measure of the responses of the particular individuals concerned.

Occupational stress questionnaires designed to investigate sources and levels of stress and dissatisfaction in the working environment have proliferated over the last twenty years. These questionnaires are valuable for identifying which aspects of the workplace may be contributing significantly to psychosocial problems. As such they may identify "working hours" as one such aspect alongside, for example, workload or job content. However, within this context, that of a general stress survey, they are unlikely to provide much insight into the particular features of working hours which constitute a problem. This requires a more targeted approach. Until relatively recently those requiring such an approach would have discovered a virtual absence of valid reliable tools for the purpose. Fortunately this situation has been rectified to some extent during the last few years with the development of one or two questionnaires concerned specifically with aspects of working time. In particular a brief mention will be made here of the recently developed Standard Shift work Index (Barton *et al*, 1995) which provides a valuable diagnostic tool for determining the health and well-being of employees in relation to aspects of their working time arrangements.

The standard shift work index (SSI)

The SSI consists of a battery of self-report questionnaires which were developed for the purpose of assessing the impact of different shift systems on groups of individuals. It contains three types of scales (i) concerned with characterising the work context and shift system (ii) concerned with effects on health and well-being, and (iii) concerned with individual differences which may modify those effects. Normative data relating to two large groups of workers against which scores can be compared are also provided. The SSI represents a significant advance in the assessment process in that it provides a valid, reliable and practical tool for use in a wide variety of workplaces.

Whether or not the SSI is the questionnaire of choice however there are certain types of information about the workplace and the workforce which it is necessary to acquire in any risk assessment process.

The workplace

- Work schedule(s) currently in place
- Work type
- Working environment

The workforce

- Demographic composition (age, gender, marital status)
- Vulnerable individuals

Health status of the workforce

- Mental health
- Physical health
- Sleep quality and fatigue

Modifiers of adjustment

- Attitudes to current schedules
- Coping strategies (adaptive, maladaptive)
- Domestic and social circumstances
- Individual differences (e.g. circadian type)

Much of this information may be available from workplace records or from other sources of data such as pre-employment screening or existing health surveillance systems. However, one of the most important sections in this context, concerned with modifiers of adjustment to shift work, invariably requires gathering of new data with purpose-developed questionnaires.

Measures for reduction and control

If a risk assessment process has demonstrated that aspects of working time arrangements are having adverse effects on some or all of the workforce, the need for some kind of change or intervention is indicated. As noted in the previous chapter three options are available in this respect, which are not necessarily mutually exclusive:

- Change the schedule
- Modify the working environment
- Provide training or counselling for employees

These options are not necessarily mutually exclusive. In fact multi-channel interventions are much more likely to be successful, incorporating as they do a co-operative partnership between employees, who act to change the environment, and employees who undertake to change aspects of their behaviour.

Changing the schedule

Clearly a wide range of alternatives are available here. However, current scientific evidence points to a number of general principles which may assist in schedule design.

- Night work is best avoided or limited where possible
- Unpredictable, irregular hours, particularly where these are beyond the worker's control, should be avoided if possible, or limited
- Working weeks in excess of 48 hours on a routine basis should be avoided. Reduction of weekly working hours to below 40 is preferred
- Overtime should be limited, distributed between workers, and not routine
- Where shifts rotate, forward rotation is preferable
- Weekly rotation is undesirable
- Slow rotation (2-3 weeks) is likely to produce phase adjustment
- Fast rotation (1-2 days) maintains workers on a normal circadian cycle
- Phase adjustment is preferred for workers whose jobs are largely routine and therefore particularly susceptible to fatigue effects
- Jobs which are mentally stimulating are less susceptible to fatigue effects and probably more suited to schedules where phase adjustment does not occur
- Traditional starting times for shifts, notably 6 a.m. for the morning shift, may not be optional. Later starts (7 - 8 a.m.) should be considered
- Shift changeover times are vulnerable points in terms of errors and accidents
- Evidence relating to 12-hour shifts is largely positive, given certain conditions
- Where work is extended beyond an 8-hour period a re-assessment of other occupational risks (chemical, ergonomic, noise etc) should be carried out

- In all cases the participation of workforce representatives in schedule design is highly recommended -

Modifying the working environment

Although there is currently a scarcity of information in this area the following should be considered.

- Introduction of bright light on nightshifts where phase adjustment is desired
- Limitation of heavy physical work on nightshifts where possible
- Temperature adjustment (higher) for nightworkers
- Provision of equal facilities (catering, transport health and safety, recreational, health promotional) on all shifts

Training and counselling for employees

Evidence from the wider health promotional and psychological literature suggests that approaches which involve training and behaviour modification may have considerable benefits for workers, particularly shiftworkers. Certainly these have been enthusiastically adopted in some limited circumstances by private advisors. The lack of scientific evidence of evaluation should not therefore act as a deterrent to using such approaches and in fact provides an opportunity to carry out such evaluation. The following should be considered:

- Guidance on sleep management
- Guidance on diet content and regulation of meals
- Awareness of the positive effects of physical exercise
- Stress management training

Monitoring and adjustment of intervention measures

The last two stages in the risk management process are concerned with monitoring the effectiveness of any measures which have been put in place to reduce workplace risks, and with making adjustments to those measures where necessary. Essentially monitoring of the

effectiveness of any new system, whatever the particular field, involves two separate elements

- Evaluation of the process
- Evaluation of the outcome

Evaluation of the process is concerned with whether the new system or intervention has been put in place effectively, whether it is running smoothly and perhaps, where working time arrangements are concerned, whether it meets the production needs of the organization. Evaluation of the outcome on the other hand involves a re-evaluation of the factors which prompted the change or intervention, in this case the health, safety and well-being of the workers. An important element of this evaluation is likely to be a system of health surveillance, usually consisting of an initial health assessment prior to work assignment and at regular intervals thereafter. Recent international legislation has underlined the importance of regular health assessments, particularly for nightworkers. For many countries where regular health checks are already an established part of occupational health practice such assessments can be easily incorporated into routine health care. For others where this is not the case the advent of legislation has often necessitated the development of new health surveillance programmes. Other aspects of evaluation will include whole or part re-administration of questionnaires concerned with general social well-being, attitudes and coping strategies. The time allowed to elapse between the introduction of a new system or intervention and its evaluation should be determined with care. Most research-based evaluations tend to allow at least 6 months to avoid "Hawthorne" effects and ideally continue monitoring at annual intervals, although favourable results may reduce the need for this.

The importance of this stage of the risk management process cannot be over-emphasised. Unfortunately it has sometimes been neglected in the general field of psychosocial enquiry in the workplace, leading to a dearth of information on the effectiveness of some of the measures which have been implemented. The need for this evaluative research and other gaps in the scientific literature will be summarized in the following chapter.

Chapter 9.
Research needs

The preceding chapters have examined the currently available information about health, safety and working time. While this is quite extensive, inevitably there are numerous gaps in the literature, some of which are perhaps more significant than others. In this chapter an attempt will be made to summarize what appear to be the most pressing research needs in this field. Five broad areas of potential enquiry may be identified and within these specific areas of concern have been highlighted.

1. Situations which have been under-investigated
2. Effects which have been under-investigated
3. Potential effect modifiers
4. Potential interventions
5. Monitoring systems

Under-investigated situations

Irregular hours

One of the most noticeable omissions in the scientific literature relates to the study of various types of irregular and unpredictable hours. For example the “on-call” situation is a good example of a work pattern which has been virtually ignored by scientific researchers. Given that

many forms of irregularhours are a relatively new phenomenon, current scientific neglect is perhaps understandable. However, a number of anecdotal reports now suggest that irregular hours, particularly where these are outside the control of the individual, are destructive in terms of non-work activities and threatening to mental health. This pattern of work affects an increasing percentage of the workforce and raises fundamental questions about the nature of the work/non-work divide. How far should this be preserved and how far should work be allowed to intrude into life outside work? Clearly one of the difficulties in studying irregular hours is the wide and increasing variety of work patterns encompassed by the term. What may be needed initially therefore is a comprehensive review of these various patterns in order to determine common features which may impact on health and safety. Some such features can already be identified. For example what are the acute psychological and social effects of uncertainty about the timing of the next period of work? How important is the specific nature of the work or the degree of worker control in modifying or exacerbating these effects? If such work patterns cannot be eliminated this type of information is likely to be extremely important in terms of developing intervention and training programmes and perhaps for informing pre-employment screening.

Under-investigated effects

Increased exposure to other hazards

Occupational exposure limits for chemical hazards and similar standards for some physical hazards such as noise tend to be based on a “standard” 8-hour day. This has always been a potential difficulty in relation to overtime work but the problem has been brought into sharper focus in recent years by the increasing popularity of 12-hour shifts. In addition the increased risk of musculoskeletal problems resulting from extended work periods has not been fully addressed. This is a complex area, particularly in relation to the effects of chemical exposures, where the animal data from which many limits are derived has also been collected with 8-hour limits in mind. It is not a question which can be neglected indefinitely however.

Reproductive effects

While a number of specific health outcomes have been studied in recent years reproductive effects appear to have been somewhat neglected both in relation to shift work and long hours. Although special reference is made to pregnant and recently delivered women in current legislation, there are wider areas of concern here including for example fertility and pregnancy

outcomes and implications of work schedules for male reproductive capacity. Current evidence is inconsistent and thus inconclusive and although, as noted earlier, this is a difficult area to research, it undoubtedly merits further scientific attention.

Family and social effects

Regardless of the particular work pattern involved there has been surprisingly little systematic research on the effects of working hours on domestic and leisure activities and on family relationships. Current information is limited to that derived from occasional surveys of selected groups often with low response rates. In relation to both overtime and shift work, as well as irregular hours, investigation is needed of both the positive and negative effects of different work patterns and the particular factors which enhance or detract from worker adjustment and the well-being of their families. While various concerns are often expressed in the media, for example about the effect of long hours on family life, currently these tend to be based on anecdote rather than on the results of scientific research. Reliable data on the specific nature of these effects would again provide a better basis on which to design work schedules and to develop training and information packages.

Behavioural effects

From a psychological point of view the behavioural coping strategies which individuals adopt when under stress are usually categorized as adaptive (effective), or maladaptive, (ineffective). In general adaptive strategies focus on acknowledging and confronting difficulties and might include, for example, seeking information from others on how to overcome a problem. Maladaptive strategies on the other hand, tend to involve some form of denial or avoidance. Besides being ineffective therefore they may actually increase an individual's problems long-term. Examples include increased smoking, changes in eating habits and substance abuse, including alcohol. It has already been noted that control for these factors in studies of long-term outcomes of working hours such as cardiovascular disease may be inappropriate. These forms of behaviour may in fact occur more frequently in shiftworkers or overtime workers and therefore may in part explain the association between working hours and certain health problems. In addition studying the nature and frequency of ineffective coping might assist in the development of appropriate behavioural modification programmes. To date, however, behavioural outcomes have rarely been a specific focus of investigation in themselves, more often appearing as potential confounders in studies of other health outcomes.

Potential effect modifiers

Several investigations make reference to the potential role of various effect modifiers in explaining results which are inconsistent. In particular discussion tends to focus on the possible influence of attitudinal variables in determining whether or not the experience of certain working time arrangements is translated into health problems or accidents. At the present time this has been much discussed as a plausible theory, but never systematically investigated. Alongside behavioural outcomes however, attitudes and belief systems may constitute a further important link in the chain which explains the association between working hours, health and safety. Attitudes may for example help to determine general adjustment, the choice of coping strategy and the level of support offered by family and friends, all of which may in turn impact on health and performance. The exploration of these variables represents a potentially fruitful line of research in relation to interventions.

Potential interventions

Evaluative research which examines the effectiveness of various interventions perhaps represents the most important and promising field of investigation, particularly in relation to shiftworkers. Currently however such research is at a very early stage. Discussion of various potential interventions in chapter 6 only served to highlight the scarcity of published information in this field. Perhaps the most thorough investigations to date have concerned the manipulation of shift cycles and useful data is steadily emerging in this area. Much less attention has been paid either to aspects of the physical environment or to training, information and behavioural modification programmes. The use of psychological approaches in particular represents an intriguing line of enquiry, not least because of the success of such approaches in other fields, for example sports medicine. Where such interventions have been introduced into a workplace they are often set up as part of a consultant's advisory package rather than as a scientific research programme. Hence they may not be susceptible to systematic evaluation in the form normally required by scientific publications and in addition are likely to contain numerous different elements which make it difficult to study the effects of specific features. However there is no reason why researchers in this field should not be able to make use of “natural experiments” of this type in the workplace provided this is recognized at the outset and thus organized in such a way as to provide useful data.

Monitoring systems

The advent of new legislation with its requirement for health surveillance of certain groups of workers has necessitated the development of new systems of surveillance in those countries where such systems did not previously exist. These developments have highlighted two controversial issues.

First the legislation is non-specific in terms of either the precise nature of any health assessments or the frequency with which they should be carried out. Inevitably current practice varies between countries and organizations, and tends to be determined nationally by traditional ways of structuring and organizing both community and occupational health services. For example, in relation to the frequency of health checks, Scott and Ladou (1990) writing in America about medical surveillance for shiftworkers say "for most workers yearly surveillance is probably adequate". By contrast recent guidelines prepared by the Society of Occupational Medicine in the UK (1999) recommend assessment every three years up to age 45 and only recommend yearly assessment after the age of 60.

A second issue relates to the method of collecting, recording and collating the information gathered from routine health assessments. Again there are likely to be wide variations between countries. Potentially such information could provide an invaluable source of new data in this field. However, it is well known from other existing reporting systems, for example those relating to accident and disease notification, that interpretation of such data is heavily influenced by the nature of the reporting system in place. In both these areas, namely the definition of systems for assessment and for information recording, there is currently a dearth of evaluative research or discussion in the international literature. Hopefully recent legislation will stimulate such debate and alongside this, further scientific enquiry.

This chapter has concentrated on what appear to be the main *priorities* for future research in this field. Clearly numerous other gaps exist in the scientific literature which has been alluded to elsewhere. However, apart from some areas of specific concern such as reproductive effects and exposure to other hazards the main emphasis here is on future directions which will move the field forward rather than on consolidating existing information. In line with general trends in occupational health and safety particular attention has been paid to psychosocial factors in terms of the effects of working time, the potential modifiers of those effects, and in relation to intervention strategies. This is not to disregard the physiological aspects of the response to working hours but to emphasise the essential interaction between the physical, social and psychological elements of that response.

Chapter 10.
Conclusions

At the beginning of the 21st century the world of work is changing rapidly and dramatically. The advance of new technology and the demands of the 24 hour society mean that those who work “regular hours” - 8-hours for five days per week, during the hours of daylight are increasingly becoming a minority. Change, especially rapid change, is both threatening and challenging and the changes now taking place worldwide will have far-reaching implications for many aspects of society and the conditions under which we live. The organization of work and leisure time is a central element in this process of change.

In line with the stated objectives of this monograph substantial parts of the preceding chapters have been concerned with the impact on health and safety which working time can have. Perhaps initially, since research is usually directed at solving problems, much of this impact appears at first sight to be negative. However, some mention has also been made of the potential benefits of certain working time arrangements and considerable weight has been given to the possibilities for solving existing problems. The central premise of the book is that unpopular and harmful working time arrangements are not inevitable and unavoidable and can always be improved. Arrangements which are currently in place do not necessarily represent the best or the only way of organizing things.

Employed people spend a large percentage of their lives at work and it is thus of paramount importance that working time does not increase the risks to their health and safety. Work itself is not intrinsically harmful to people. In fact there is plenty of evidence to show that it

can be extremely beneficial to health, particularly mental health. To think only in terms of neutralizing the effects of potential hazards therefore is to miss an opportunity. In many situations working time arrangements can actually be used positively, to enhance the overall quality of peoples' lives. Further we must not assume that the so-called regular working hours with which we are so familiar necessarily represent the ideal standard. Today's changing world provides new opportunities for innovative working arrangements which can be much more compatible with people's home and family needs as well as fulfilling the requirements of the organization.

Working time should not therefore be left to chance, tradition or expediency but should be actively and positively managed with the needs of the worker in mind. Underlying this process are the principles which form the basis of all modern health and safety practice. First and foremost it is necessary to recognize fully the enormous influence that working time arrangements do have on peoples' well-being. This well-being encompasses the whole person, including psychological and social adjustment as well as physical health and safety. It is no longer realistic to treat these elements separately. Following directly from this it can be seen that designing the actual work schedule represents only one part of the total process. To be comprehensive and fully effective, assessment and intervention should include three other key areas, the components of the job, the working environment and most importantly the characteristics of the workers themselves. Throughout the process it is essential that workers and their needs occupy a central position. Many organizations have now realized the value of employee input into health and safety systems in general. Workers understand first hand the impact of their working time arrangements on their lives and are happy to accept ownership and maintenance of a system which they have helped to design.

Finally it has to be remembered that health and safety management is not a static but a dynamic process, subject to constant review and improvement. Once more the best source of evaluative information comes from the workers themselves, both in terms of their expressed satisfaction with their working arrangements and their health and safety as evidenced by the results of on-going health surveillance.

The optimization of working time therefore represents one important part of an overall occupational health and safety management system. The obligation to consider the well-being of the individual at work was first recognized over a century ago. The requirement to fulfil this obligation is now even more pressing in today's increasingly demanding world. Fortunately, in the field of working time, at least we now have a century's worth of information to help us with the task.

" ... the general march of industrial democracy is not towards inadequate hours of work, but towards sufficient hours of leisure. Working people demand time to look about them, time to see their homes by daylight, to see their children, time to think and read and cultivate their gardens - time, in short, to live".

Winston Churchill
President of the Board of Trade, UK (1908)

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A cover explanation

Korean Treasures 845. Angbuilgu (Hemispherical sundial)

"Angbuilgu" is the representative sundial of Joseon Kingdom, it was made by three scientists in 1434, the 16th year of King Sejong. The name came from its shape that the plate of sundial is dented such as an iron pot and seems like looking up the sky. It represents the round shape of the earth and is very useful to express time and season even with its small size.
This was the first public clock and valuable relic as the scientific cultural assets.