

Longitudinal study of the effects of shift work on health

Analyses of VISAT (ageing, health and work) data

Report submitted to the IOSH Research Committee

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The views expressed in this report are those of the authors and should not be taken to reflect the official position of the sponsors.

Abstract

The goal of this study was to provide new knowledge on the long-term effects of abnormal work schedules on perceived sleep quality, quality of life, metabolic dysfunctions, and cognitive health, in order to contribute to knowledge about how abnormal work schedules affect health and safety, and to contribute to updating practical recommendations concerning this.

Data were taken from the VISAT longitudinal study (a French prospective study examining how working conditions and age interact to influence a wide range of health resources, including sleep quality and cognitive efficiency).¹ The initial sample was collected in 1996 (t1, first data collection). It was composed of 3,237 present and former wage earners of both genders, aged from 32 to 62 years old. Two follow-ups took place in 2001 (t2) and 2006 (t3).

Main research findings

Sleep

Our analyses indicate that while participants who gave up shift work in late middle age (around 52 years or later) enjoyed a subsequent improvement in their sleep, those who gave up shift work before the age of 52 years did not. The latter group continued to report poor sleep, despite having left shift work relatively early in their working lives.

In summary, our findings suggest that, as long as workers who find the effects of shift work on their sleep and well-being intolerable, are able to leave shift work (for example, by transferring to day work or by retiring), and so long as they are not required to remain in shift work much beyond late middle age (approximately 52 years old), there is a relatively low likelihood of sleep problems persisting after they have stopped shift working.

Quality of life

We found that participants who had stopped working shifts between two successive measurement occasions reported a decrease in chronic fatigue, while all other groups reported an increase in chronic fatigue. A similar pattern was observed in the measures of emotional reactivity and social isolation, although the trends were not statistically significant. There were no signs of such a pattern in the measures of either stress or overall health.

Metabolic dysfunction

Our first analysis supported previous research findings, indicating that participants who were shift workers, or who had previously been shift workers, were more likely to exhibit symptoms of metabolic syndrome than participants with no experience of shift work (i.e. day workers).

Our second analysis built on the findings of previous research, by examining for the first time, how the risk of developing metabolic syndrome increases as a function of duration of exposure to shift work. Participants who had been working rotating shifts for more than 10 years were found to be more likely to exhibit symptoms of metabolic syndrome than day workers, even after controlling for age and gender.

Cognition

Results showed a clear and independent association at all three measurement occasions (t1, t2, t3) between shift work and cognitive performance. When examining the effect of shift work duration, it was found that the effect was significant for those who worked shifts for more than 10 years, but not for those who worked shifts for less than 10 years. When comparing current

shift workers with former shift workers who had returned to normal day work hours for five years or less and with former shift workers who had returned to normal day work hours for more than five years, it was observed that the first and the second showed similar cognitive performances. By contrast, those who had quit shift work more than five years ago exhibited higher cognitive performances, at the same level as people who were day workers. The findings support an interpretation in terms of a stress mechanism related to the chronic desynchronisation of biological rhythms.

A model of shift work effects on health and safety

The conceptual model of the aetiology of the problems that may result from the various features of abnormal work schedules is shown in Figure 1. The various levels of the conceptual model of the aetiology of the problems are considered as follows: the features of abnormal work schedules are seen as potentially disrupting the body clock, sleep, and family and social life, with the extent of this disruption being moderated by individual, situational and organisational factors. Body clock, sleep, and family and social life disruptions may result in acute effects on mood and performance (Level 4), which may also be influenced by job demands and workload. These acute effects may feed back to body clock, sleep, and family and social life effects, and may also result in chronic effects on mental health and in decreased safety. The chronic effects on mental health may also feed back and exacerbate the acute effects on mood, and be moderated by individuals' coping strategies. Finally, the chronic effects on physical health may impact on both physical health and safety.

Practical recommendations

Several practical recommendations are provided in the following report and for convenience are divided into three different areas, namely: (i) sleep and fatigue (ii) psychological and physical health (iii) family, social and leisure problems. Each of these areas is further divided into recommendations for employees and those for employers.

Key words

Shift work, VISAT, sleep, ageing, gender, metabolic syndrome, social measures, cognition

1 Project overview

This project was based on the VISAT (ageing, health and work) longitudinal study. VISAT is a French prospective study examining how working conditions and age interact to influence a wide range of health resources, including sleep quality and cognitive efficiency.¹ The current project focused upon the long-term effects of shift work and the implications for health and safety management, especially job design, work organisation and the development of educational materials. These questions are of critical importance since the workforce of industrialised countries is getting older, with an increasing trend towards delayed retirement. In particular, it is unclear how shift work may impact on health in the later part of working life, and how it may affect the quality of ageing. Investigation of these issues will help develop applications in physiological and cognitive macro-ergonomics (design of working environments adapted to an older population).

The way physiological and psychological health resources vary with advancing age depends on the working conditions to which individuals are subjected to throughout their working years (see for example, Derriennic, Touranchet and Volkoff;² Desplanques;³ Leclerc, Fassin, Grandjean, Kaminski and Lang;⁴ Marquié, Paumès and Volkoff⁵). The disturbance of biological rhythms over a long period of years may have deleterious long-term effects on health and ageing. However, the study of the long-term effects of working conditions on health and ageing is fraught with problems. One difficulty is being able to separate work-related and non-work-related influences. Another obstacle is the fact that certain effects are delayed, sometimes until a much later date; or they cannot be observed using current methods and therefore only show up when the effects are sufficiently great. Further theoretical and methodological difficulties concern the definition of health (disease versus small but numerous and permanent troubles affecting quality of life); selection processes such as the healthy worker effect; the interplay between historical changes in the working world and individual changes; and behavioural compensations that may mask health impairments and divert them towards other body parts or functions.

VISAT was designed to address several of these methodological challenges in studying the relationship between ageing, health and shift work. Very few studies on the health-work relationship have focused on age, and even fewer have done so in a longitudinal way.

The VISAT data has been obtained during yearly health examinations of 3,237 employees who were 32, 42, 52, and 62 years old at the time of the first data collection in 1996 (see Table 1). Additional data collection phases followed in 2001 and 2006/7. The structure of VISAT's sample is unparalleled in studies concerning shift work, health and ageing. A very extensive range of data was gathered on current and past working conditions, health (subjective measures collected via a questionnaire, and objective measures collected via the medical examination), life outside work, and cognitive functioning. VISAT was designed to allow the dissociation of effects of various time-related factors such as ageing, socio-historical factors and birth cohort effects (see Table 2). It provides data from a large and representative sample of participants from a range of occupations and sociocultural backgrounds.

Table 1: Distribution (per cent) of participants according to year of birth, socio-professional category, gender and working activity (active/non-active) in 1996 (reproduced from Marquié et al. ¹)

| | | Year of birth | | | | | Total |
|--------------------------------|---|---------------|-------|-------|-------|---------------|---------|
| | | 1964 | 1954 | 1944 | 1934 | 1934 | |
| | | N = 896 | N=972 | N=899 | N=470 | N=80 | N=3,237 |
| Gender | | | | | All | Still working | |
| | Males | 48.1 | 50.2 | 51.3 | 59.6 | 47.5 | 51.3 |
| | Females | 51.9 | 49.8 | 48.7 | 40.4 | 52.5 | 48.7 |
| Socio-professional categories: | | | | | | | |
| | Executives and high-rank intellectual occupations | 9.0 | 8.3 | 12.0 | 12.5 | 29.7 | 10.1 |
| | Technicians and line managers | 28.6 | 33.9 | 30.0 | 24.4 | 12.2 | 30.0 |
| | Office staff | 36.6 | 32.6 | 37.3 | 38.3 | 47.3 | 35.8 |
| | Blue-collar workers | 25.9 | 25.2 | 20.8 | 24.8 | 10.8 | 24.1 |

Table 2: VISAT cross-sequential strategy

| Cohort | Observation periods | | | | | | | | |
|--------|---------------------|------|------|------|------|------|------|------|------|
| 1934 | 1966 | 1971 | 1976 | 1981 | 1986 | 1991 | 1996 | 2001 | 2006 |
| 1944 | 1976 | 1981 | 1986 | 1991 | 1996 | 2001 | 2006 | 2011 | 2016 |
| 1954 | 1986 | 1991 | 1996 | 2001 | 2006 | 2011 | 2016 | 2021 | 2026 |
| 1964 | 1996 | 2001 | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 | 2036 |
| Age | 32 | 37 | 42 | 47 | 52 | 57 | 62 | 67 | 72 |

2 Project objectives

The overall aim of the project was to further examine the underlying cause(s) of the health and safety problems associated with abnormal work schedules. Previous attempts to reduce these problems (for example, by means of educational or counselling programmes) have met with only short-term success, with the problem levels returning to their pre-intervention level within a few weeks. It is arguable that this failure may reflect the fact that these programmes have essentially been designed to treat the symptoms rather than the underlying causes. Our aim is to identify these underlying causes with a view to developing educational material to treat these rather than the symptoms. As a theoretical framework we shall utilise the model (of Folkard⁶) in which the features of work schedules are seen as disrupting the body clock, sleep, and family and social life, with the extent of this disruption being moderated by individual, situational and organisational factors.

These disruptions result in acute effects on moods and performance, which also reflect on job demands and workload. These acute effects may feed back and may also result in chronic effects on mental health and in decreased safety. The chronic effects on mental health may also feed back and exacerbate the acute effects on mood, and be moderated by the individuals' coping strategies. Finally, the chronic effects on mental health may impact on both health and safety. Our intention is to refine this model using multi-level modelling (hierarchical linear model) and to establish the causal nexus of the various problems with a view to identifying their root causes.

Within this framework, the specific objectives were to determine the long-term effects of shift work on perceived sleep quality, quality of life, metabolic dysfunctions, and cognitive functioning.

The project aimed to identify the underlying causes of the various problems associated with shift work and ageing. The major project deliverables are three-fold: (i) publishing academic papers on the effects of shift work on several aspects of health, and based on the findings (ii) enriching or modifying current models and providing practical recommendations allowing employees, employers and practitioners to prevent shift work-related problems, and (iii) enriching or updating available practical recommendations.

Most of the tools utilised for currently managing shift work and its consequences have been intended to 'cure' shift work-related problems. We suggest that it is possible to develop a longitudinal model eliciting the interplay between all the variables associated with shift work and to show how these variables interact together over time. By doing so, we will be able to identify precisely the sources of shift work-related health issues and to propose some ways for preventing the emergence of such issues. The benefit of this project is that we will develop an ensemble of practical recommendations designed to foster primary prevention. Finally, by examining the root causes of the cognitive deficits associated with long-term exposure to shift work we should be able to throw light on the underlying cause(s) of the safety problems associated with shift work (for example, Three Mile Island, Bhopal, Chernobyl, Exxon Valdez) and identify appropriate techniques for minimising them.

3 Project methodology

(For more detailed information, see Marquié *et al.*)¹

The VISAT database has been obtained using clinical medical examination, questionnaires and interviews. It comprises three parts, relating to:

- working conditions (current and past working conditions)
- physical and mental health, quality of life, sleep and cognition (neuropsychological tests)
- personal life (life outside the job).

The neuropsychological tests were designed to measure the efficiency of some of the basic cognitive resources considered in the literature to account for young-old differences on a wide variety of tasks (for a review see Salthouse).⁷ Five tests were administered in the following order: (i) word list learning in three trials, each followed by immediate recall (ii) the WAIS digit symbol substitution subtest (iii) a selective attention test (iv) a delayed recall test of the material learned earlier, and (v) a recognition test on the same material.

VISAT incorporates both cross-sectional and longitudinal comparisons in order to facilitate the dissociation of three different time effects: ageing (developmental change) – changes occurring with individual physiological and psychological development; historical effects – changes related to a specific historical and sociocultural context; birth cohort effects – effects related to the characteristics of specific social groups in the same birth cohort.

The VISAT sample comprises 3,237 volunteer current or past wage earners born in 1964, 1954, 1944 and 1934 who were exactly 32, 42, 52, and 62 years old at the 1996 baseline (see Appendix 2). Participants were drawn at random from the lists of employees being seen by the VISAT physicians at the time of the first survey (or who had been seen by them up until retirement). Table 1 illustrates the breadth of the occupations and sociocultural backgrounds that the sample represents. Because of attrition (and therefore of statistical power) at the first ($n=2,288$) and second ($n=1,308$) follow-ups, some of the project's objectives will be addressed using the full initial dataset and others using the second or third follow-up data pool. Despite attrition, we have sufficient statistical power to address several of the important questions listed above using the full 10-year follow-up. Indeed, out of the 1,257 participants who were seen three times from 1996 to 2006/7, we have 160 current shift workers, 324 past shift workers and 755 volunteers who have never worked shifts.

The first data were collected in 1996 by companies' occupational physicians. Retired participants were asked to come to the physicians' offices especially for this purpose. The participants were fully informed and free to decide whether or not to participate. Normal ethical precautions were taken. The occupational questionnaire was filled out by the participants themselves in most cases, although help was provided if necessary by medical assistants who were careful to guide the participants without influencing their answers. Next, the occupational physicians filled out the medical questionnaires and carried out the cognitive tests. The third questionnaire about the participants' personal lives was then filled out by the participants outside the physicians' offices, again, with the help of the assistants if needed. Finally, the assistants performed the supplementary tests (respiratory, visual, and auditory). The total testing time for the participant averaged an hour and a half.

At each measurement occasion, the participants were asked four questions to determine whether they were on some form of shift system (for more than 50 days per year), with three possible responses, namely: 'yes, currently' (now), 'not now, but yes in the past' (past), or 'never' (never). The questions were (i) whether they were rotating shift workers, whether their work schedule (ii) did not allow them to go to bed before midnight, (iii) resulted in their having to get up before 5 a.m., or (iv) prevented them sleeping during the night. In the present article those who answered 'yes, currently' or 'yes, in the past' to any of these questions were considered to be working, or to have previously been working on some form of shift system and are referred to as shift workers or former shift workers.

4 Results

Main research findings

In this section we present the results obtained about the long-term effects of abnormal work schedules on (i) perceived sleep quality (ii) quality of life (iii) metabolic dysfunctions, and (iv) cognitive health.

Sleep*

The unique design of VISAT allowed us to investigate the cause and reversibility of sleep troubles associated with shift work. We examined to what extent poorer sleep quality in former shift workers, is due to initial sleep difficulties and frailness, or to sleep impairment caused by shift work. Our analysis also considered the role of selection effects, for example, whether they can account for our previous finding that duration of shift work affects cognition but not sleep quality.

Our analyses indicated that while those who gave up shift work in late middle age (around 52 years or later) enjoyed a subsequent improvement in their sleep, participants who gave up shift work relatively early in their working lives (before the age of 52) did not (see Figure 1). The latter group continued to report poor sleep, despite having left shift work. Their sleep was worse than that of their counterparts who had never worked shifts (despite the fact that neither group worked shifts at the time the measurements were taken). Moreover, these ‘early-quitting’ former shift workers were reporting the same level of sleep problems as their currently shift working counterparts (the latter group could be expected to have poor sleep due to the nature of their work schedule).

* More details can be found in the following articles: Tucker, Folkard, Ansiau, Marquié;⁸ Marquié, Ansiau, Tucker and Folkard.⁹

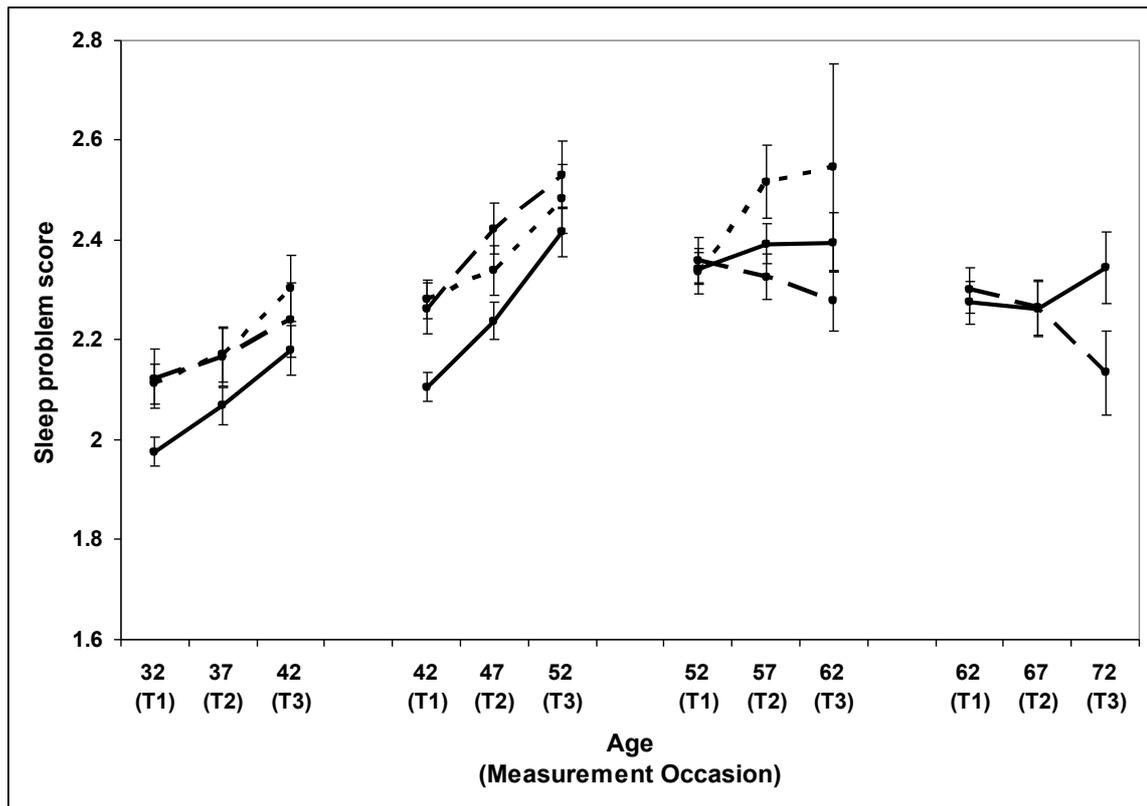


Figure 1: Sleep problem scores (averaged over the five symptom scores) as a function of shift work experience, cohort and measurement occasion. Short-dashed lines represent current shift workers, long-dashed lines represent former shift workers and solid lines represent non-shift workers. Error bars are (structural equation modelings) SEMs. (Note that although participants in the oldest cohort were excluded from the analyses, their mean scores are illustrated for comparison purposes.)

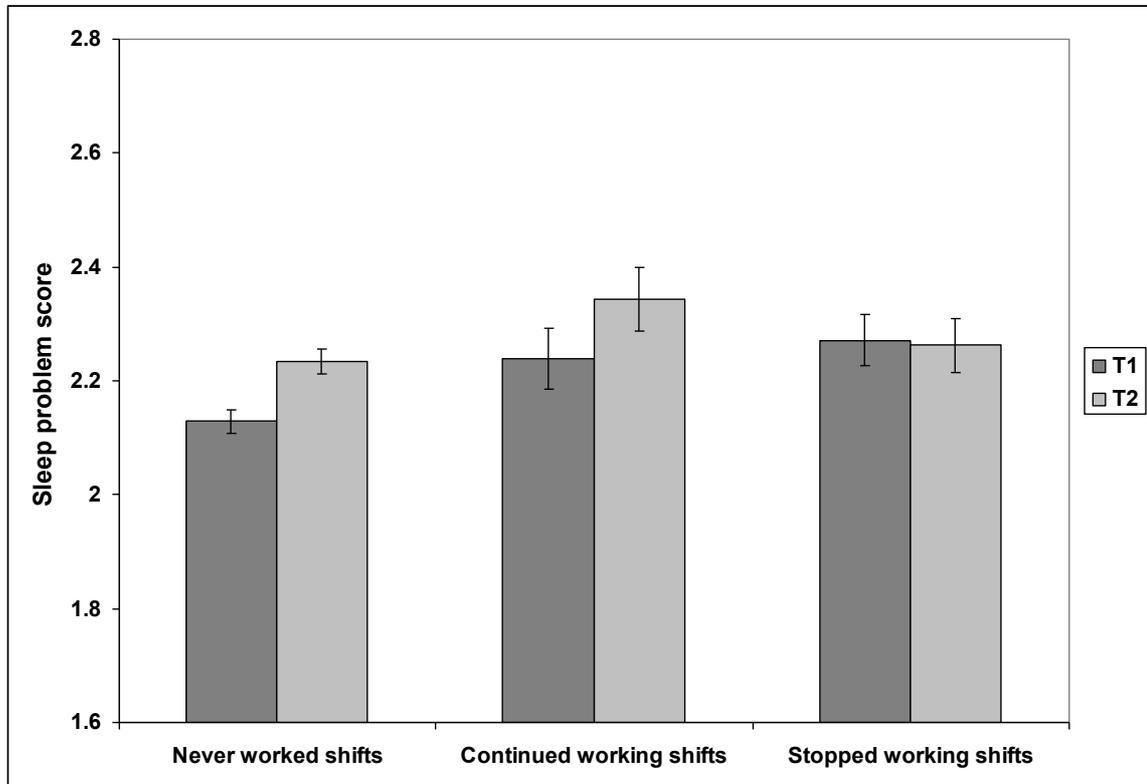
Why did those giving up shift work early in work life continue to experience sleep problems, while those who gave up in late middle age (at 52 years old or later) did not? It could be that the ‘early-quitting’ group was continuing to experience sleep problems that were originally caused by their exposure to shift work, i.e. the disruptive effects on sleep persisted after they exited shift work. However, there are no obvious reasons why the problems caused by shift work would persist in the ‘early-quitting’ group, but not in those who quit shift work at a later age.

The alternative explanation is that the ‘early-quitting’ group were poorer sleepers when they entered shift work, or that they were especially vulnerable to its disruptive effects. It may be that as a consequence of these difficulties early in their shift-working career, they could not tolerate shift work and so gave it up quite quickly. Conversely, the group who stayed in shift work until relatively late in their working lives, did so because they were more tolerant of shift work and did not experience such negative effects on their sleep. For them, the transfer from shift work to day work later in working life was more likely to be part of the normal process of career progression. They were less likely to be compelled by severe sleep problems to leave shift work early, in the way that the younger ex-shift workers perhaps were.

Our final analysis provided additional evidence that the effects of shift work do not persist after exiting shift work. Participants who gave up shift work between two successive measurement occasions showed no change in sleep quality, while those whose work situation remained unchanged showed an increase in sleep problems (Figure 2). At first glance this might suggest that the sleep problems of the former group persisted after exiting shift work. However, the trends in the other two groups indicate a general tendency for sleep problems to increase over the

five years between successive measurement occasions. So it seems that giving up shift work offset the (possibly age-related) accumulation of sleep problems that was observed in the other groups who did not change their work situation.

Figure 2: Sleep problem scores (averaged over the five symptom scores) as a function of shift work experience and measurement occasion. Error bars are SEMs.



In summary, our findings suggest that, as long as workers who find the effects of shift work on their sleep and well-being intolerable, are able to leave shift work (for example, by transferring to day work or by retiring), and so long as they are not required to remain in shift work much beyond late middle age (approximately 52 years old), there is a relatively low likelihood of sleep problems persisting after they have stopped shift working. For those who left shift work earlier in their working lives, poor sleep quality appears to have been a cause of their shift work intolerance.

Quality of life*

Many cross-sectional studies have reported a variety of adverse biological, psychological and social effects of shift work and other atypical work schedules on the worker. However, this project was among the first to focus on long-term psychological well-being (using the Nottingham Health Profile and other measures, see Marquié *et al.*¹ for more details on VISAT methodology, scales and measures) and its relationships with working conditions (for example, perceived stress, perceived social support) and work-life balance.

*More details can be found in the following communication: Tucker, Marquié, Folkard and Ansiau.¹⁰

Recent evidence suggests that for many shift workers, poor sleep quality is temporary and reversible, with reductions in sleep problems observed following the cessation of shift work (Åkerstedt, Nordin, Alfredsson, Westerholm and Kecklund;¹¹ Tucker *et al.*¹⁰). However, there have been no studies to date (of which we are aware) that have examined trends in broader measures of health and well-being, following the cessation of shift work.

Data were again obtained from the VISAT (ageing, health and work) longitudinal study. The current sample of participants who were seen at each measurement occasion was made of 680 individuals, 341 of whom were female. These participants were workers from a broad range of industries and occupations. Two age categories were taken into account: 32 and 42 at the 1996 baseline. The data were collected during annual medical examinations.

Shift work exposure was assessed through the following questions: ‘do you work a schedule involving (for more than 50 days per year):

- rotating shifts?
- being unable to go to bed before midnight?
- having to get up before 5 a.m.?
- being unable to sleep during the night?’

Participants had to choose between three different answers: ‘yes, currently’, ‘not now, but yes in the past’, or ‘never’.

According to their answers, participants were categorised as:

- shift workers if their answer was ‘yes, currently’ to any of questions 1–4
- day workers if their answer was ‘not now, but yes in the past’ or ‘never’ to all questions.

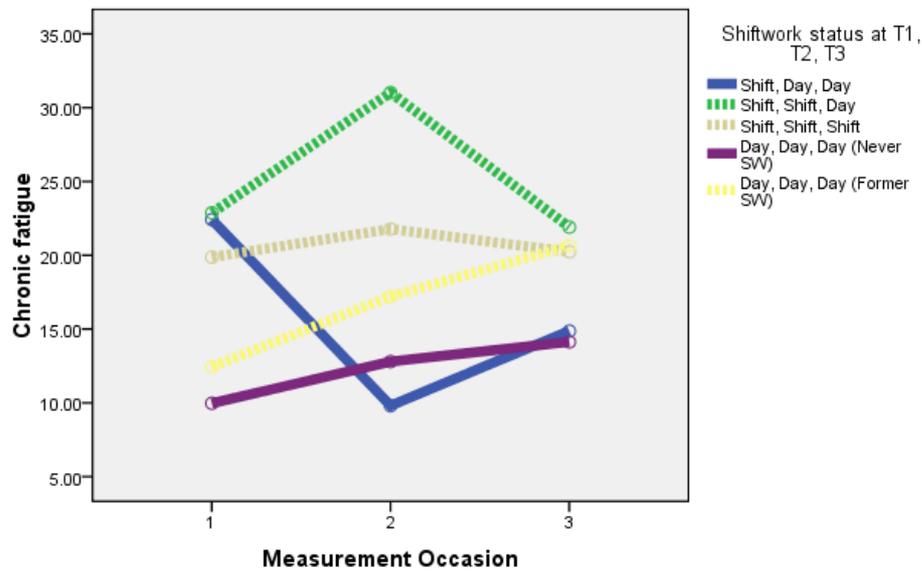
Finally, participants were grouped according to their work schedule status at t1, t2, t3:

- shift, day, day (n=40)
- shift, shift, day (n=25)
- shift, shift, shift (n=131)
- day, day, day (never a shift worker) (n=388)
- day, day, day (former shift worker, prior to t1) (n=96).

Five aspects of well-being were examined: (i) chronic fatigue (feeling tired all the time) (ii) emotional reactivity (affective disposition) (iii) social isolation (difficulties forming and maintaining relationships) (iv) stress and (v) overall health.

We found that participants who were working on shifts during the three measurement occasions (shift, shift, shift group) reported more ‘chronic fatigue’ than the day workers (day, day, day group). Figure 3 shows the interaction between shift work status, measurement occasion, and chronic fatigue. Results indicate that there is some evidence that fatigue declined following cessation of shift work. It seems also that, among those who did not change work schedule, fatigue increased or remained unchanged.

Figure 3: interaction between work schedule and measurement occasion in the measure of chronic fatigue



Note: Solid lines represent significant effect of Measurement Occasion

No significant effects were found for ‘emotional reactivity’. However, the main effect of ‘work schedule’ was marginally non-significant. We found the same pattern of results concerning ‘social isolation’ and ‘perceived stress’. Results were slightly different in terms of ‘perceived health’: there were no significant effects. However the main effect of ‘work schedule’ was marginally non-significant.

The measures of psychosocial well-being that were used in the current study have been shown to be sensitive to other aspects of working conditions. Moreover, our measure of overall health has been shown to correlate with objective health indices. This would suggest that our failure to observe an improvement in outcomes following exit from shift work in four out of the five measures is not due to the insensitivity of the measures. Rather it suggests that the adverse effects of shift work do not immediately dissipate following exit from shift work, with the exception of chronic fatigue.

Metabolic dysfunction

Shift-workers show a greater prevalence of symptoms associated with metabolic syndrome. Such disturbances may be at least partly responsible for shift workers' proneness to a range of physical health problems that include obesity, cardiovascular disease, peptic ulcers, gastrointestinal problems and failing to control their blood sugar levels (Knutsson;¹³ Boivin, Tremblay and James).¹⁴

Clinical measures were obtained during the medical examinations and included blood pressure, heart rate, weight and height. Information was also obtained on a range of medical parameters, including all past and present diseases. This information was used to classify participants in terms of being either very likely or very unlikely, to be suffering from metabolic syndrome. Classification was based on the criteria specified by the International Diabetes Federation,¹⁵ namely, central obesity plus any two of the following: raised triglycerides, reduced HDL cholesterol, raised blood pressure, and raised fasting plasma glucose. The current data set lacked measures of HDL (high-density lipoprotein) cholesterol. Hence, participants were classified as being highly likely sufferers of metabolic syndrome if they had a body mass index (BMI) of over 30, and if, in addition, they met any two of the following criteria: a diagnosis of dyslipidemia, either now or in the past (triglycerides greater than 2.0 g/L); systolic blood pressure over 130 mm Hg, or a diastolic blood pressure over 85 mm Hg, or a diagnosis of hypertension now or in the past; a diagnosis of type 2 diabetes either now or in the past. Conversely, participants were classified as being highly unlikely sufferers of metabolic syndrome if they had a BMI of 30 or under and met all of the following criteria: no diagnosis of dyslipidemia, either now or in the past; systolic blood pressure 130 mm Hg or under, diastolic blood pressure 85 mm Hg or under, and no diagnosis of hypertension, either now or in the past; no diagnosis of type 2 diabetes either now or in the past. Participants who could not be classified according to these criteria were excluded from the analyses that follow, which resulted in a final sample of 1,757 participants (see Table 3 for more details).

Table 3: Cross-tabulation of shift work experience and metabolic syndrome status

| | | Metabolic syndrome | | |
|--------------------------------|-------------------------------------|--------------------|------|-------|
| | | Yes | No | Total |
| Current or former shift worker | No (i.e. only ever a day worker) | 28 | 961 | 989 |
| | Currently or in the past | 40 | 728 | 768 |
| | Total | 68 | 1689 | 1757 |
| Rotating shift work experience | Never (i.e. only ever a day worker) | 28 | 960 | 988 |
| | 1–10 years | 10 | 300 | 310 |
| | More than 10 years | 17 | 260 | 277 |
| | Missing values | 13 | 169 | 182 |
| | Total | 68 | 1689 | 1757 |

Our first analysis supported previous research findings, indicating that participants who were shift workers, or who had previously been shift workers, were more likely to exhibit symptoms of metabolic syndrome than participants with no experience of shift work (i.e. day workers). The analysis took into account possible differences between the two groups in terms of age, sex, socioeconomic status, smoking, alcohol intake, perceived stress and sleep difficulty. Thus the higher prevalence of metabolic syndrome in the shift work group could not be ascribed to group

· More details can be found in the article by Tucker, Marquié, Folkard, Ansiau and Esquirol, Appendix 8.¹²

differences in these parameters, although it remained a possibility that these factors may have played a contributing role.

Our second analysis was built on the findings of previous research, by examining for the first time, how the risk of developing metabolic syndrome increases as a function of duration of exposure to shift work. Because of the structure of the database, it was only possible to examine the issue with respect to one form of shift work, namely rotating shifts. Participants who had more than 10 years' experience of working rotating shifts were found to be more likely to exhibit symptoms of metabolic syndrome than participants with no exposure to any form of shift work (i.e. day workers), even after controlling for age and gender (results shown in Table 4).

Table 4: Odds ratio (OR) of metabolic syndrome associated with exposure to rotating shift work (reference group=day workers)

| Predictor | 1–10 years | | More than 10 years | |
|----------------------------------|------------|----------|--------------------|-----------|
| | OR | 95% CI | OR | 95% CI |
| Shift work exposure ^a | 1.14 | .55–2.38 | 2.24* | 1.21–4.16 |
| Shift work exposure ^b | 1.62 | .76–3.48 | 1.94* | 1.02–3.66 |
| Shift work exposure ^c | 1.38 | .64–3.00 | 1.96* | 1.03–3.75 |
| Shift work exposure ^d | 1.29 | .59–2.83 | 1.82 | .94–3.55 |
| Shift work exposure ^e | 1.27 | .58–2.81 | 1.81 | .93–3.53 |
| Shift work exposure ^f | 1.32 | .60–2.91 | 1.86 | .95–3.63 |
| Shift work exposure ^g | 1.30 | .59–2.90 | 1.83 | .93–3.59 |

^aCrude; ^bOR adjusted for age; ^cOR adjusted for age and gender; ^dOR adjusted for age, gender, and socioeconomic status; ^eOR adjusted for age, gender, socioeconomic status, smoking, alcohol; ^fOR adjusted for age, gender, socioeconomic status, smoking, alcohol, stress; ^gOR adjusted for age, gender, socioeconomic status, smoking, alcohol, stress, sleep difficulty.

* $p < .05$

The findings represent a significant contribution to the literature, as identifying the time course of the development of illness is important for determining appropriate follow-up procedures for exposed workers and for the development of prevention strategies. In our conclusions, we noted that further research is needed in order to examine the time course of the development of metabolic syndrome in other forms of shift work (for example, permanent night shifts) and also to conclusively identify the mechanisms underlying the link between shift work and metabolic dysfunction.

Cognition

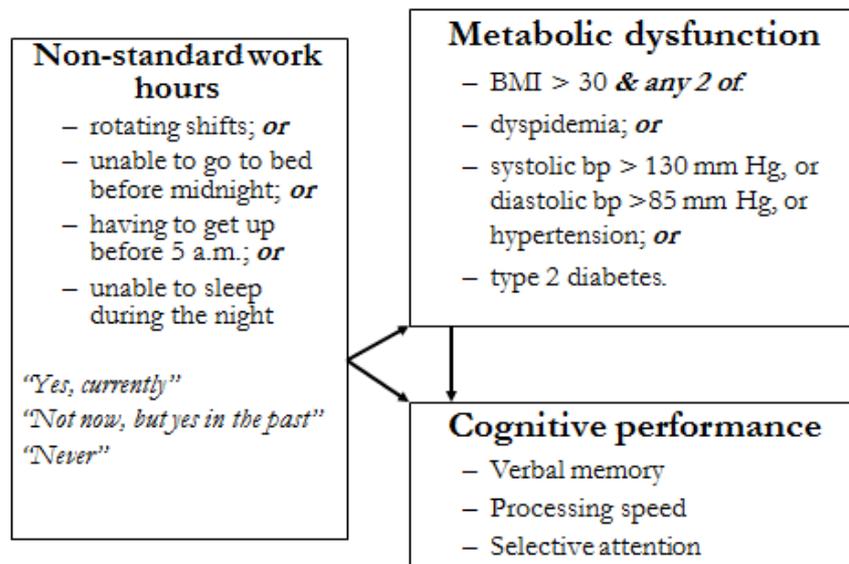
The project addressed the effects of disturbed circadian rhythms (as observed in shift work) on cognitive efficiency in young and older adults. Very few studies have assessed the long-term consequences of chronic sleep deprivation and repeated disturbances of circadian rhythms on the cognitive functioning of those exposed to shift work over prolonged periods of time. Atypical work schedules are thought to affect cognitive performance either via stress mechanisms (for example, Cho;¹⁷ Cho, Ennaceur, Cole and Suh)¹⁸ or via the impairment of brain functioning associated with chronic sleep deprivation. Cross sectional analyses of VISAT data favoured the first hypothesis (Rouch, Wild, Ansiau and Marquié).¹⁹ We analysed the VISAT longitudinal data (five and 10 year follow-ups) to further explore this question, and to overcome several methodological difficulties. One main originality of the study is that it allowed us to examine the

· More details can be found in the communication by Tucker, Marquié, Gentil, Folkard and Ansiau.¹⁶

effect of shift work exposure duration and the reversibility of the effects. We were also able to examine the role played in the observed effects by sleep deprivation and metabolic syndrome, two variables also associated with abnormal work schedules, and to control for other possible confounding factors.

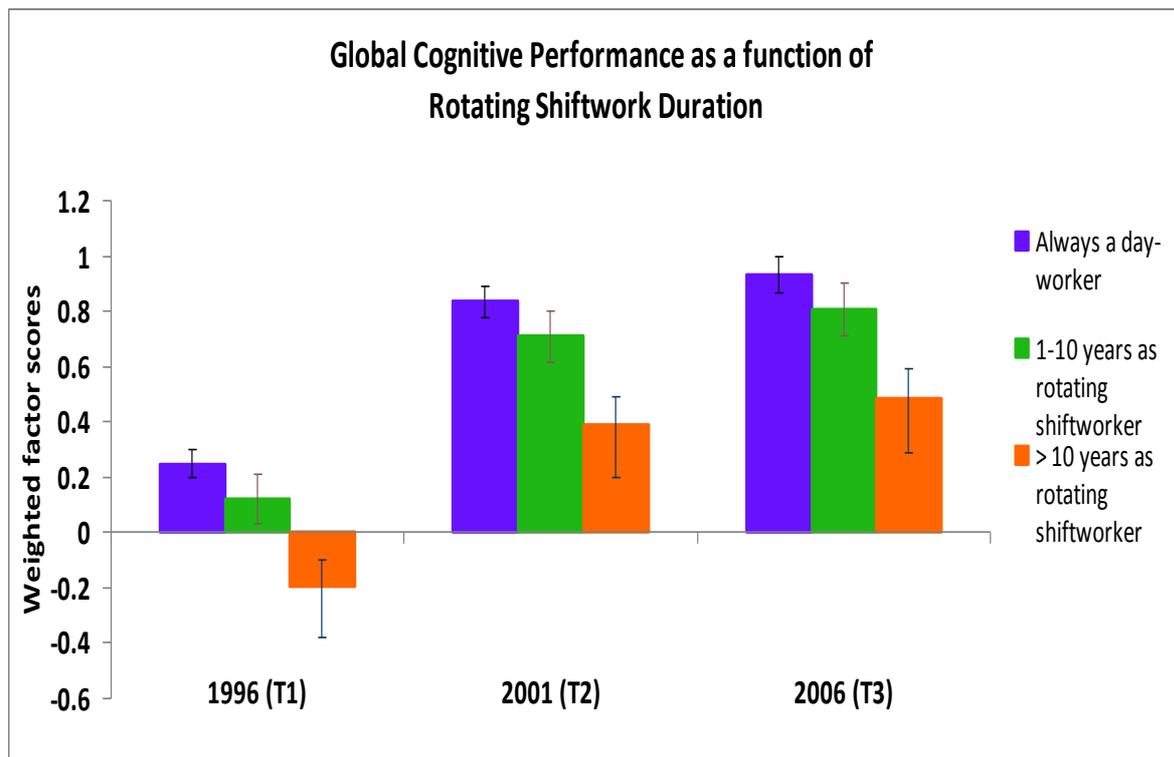
The status relative to shift work and other atypical work schedules (never, currently or in the past) as well as cumulative exposure duration was available for all participants through four items: (i) rotating shift work and work schedule (ii) that did not allow workers to go to bed before midnight, (iii) resulted in their having to get up before 5 a.m., and (iv) prevented them sleeping during the night. The time that elapsed since shift workers had returned to normal day hours was also recorded. Cognitive functioning (Marquié, Rico Duarte, Bessières, Dalm, Gentil and Ruidavets)²⁰ was assessed at all three measurement occasions through neuropsychological tests (speed, attention, verbal episodic memory). Other variables of interest were collected or calculated such as age, gender, socio-professional status, alcohol intake, tobacco intake, perceived stress, sleep quality, and metabolic dysfunction (for example, body mass index more than 30, diabetes, hypertriglyceridemia; cardio-vascular disease, arterial hypertension) and statistically controlled for in the analyses. Figure 4 presents a summary of the potential relationships between the variables of interest. The relation between cognitive functioning and atypical work schedule was analysed using linear mixed models for longitudinal data (Rabe-Hesketh and Skrondal).²¹ A correction was applied for the regression to the mean to the cognitive score at t1 (Marquié *et al.*)²⁰ Statistical analyses were performed using Stata V11.2 (a statistical analysis software).

Figure 4: Hypothetical relationships between atypical work schedules, metabolic syndrome, and cognitive performance



Results showed a clear and independent association at all three measurement occasions (t1, t2, t3) between shift work and cognitive performance. When examining the effect of shift work duration, it was found that the effect was significant for workers who experienced shift work for more than 10 years, but not for those who experience shift work for less than 10 years (see Figure 5). When comparing current shift workers with former shift workers who had returned to normal day work hours less than five years ago and with those who had returned to normal day work hours longer than five years ago, it was observed that the first and the second showed similar cognitive performances. By contrast, those who had quit shift work more than five years ago exhibited higher cognitive performances, at the same level as those of people who had always been day workers. We did not find any interaction with sleep quality and indices of metabolic dysfunction, which suggests that the observed effects are independent from these factors, as measured in this study. The findings support an interpretation in terms of a stress mechanism related to the chronic desynchronisation of biological rhythms. An article on this study is currently in preparation. The current follow-up study, along with the previous one by Rouch *et al.*¹⁹ based on cross-sectional data, are the first studies to show an effect of shift work on cognitive functioning.

Figure 5: Cognitive performance as a function of exposure to rotating shift work



The conceptual model

Due to an unfortunate coding error the number of shift workers in the VISAT sample was substantially fewer than we had anticipated when this project was first proposed. Therefore, there were only 131 individuals who were shift workers or former shift workers at all three measurement occasions. In the light of this, it was not possible to undertake the type of longitudinal, multi-level modelling of all the variables simultaneously that we had originally intended. Rather, we have used the conceptual model proposed by Folkard⁶ and Barton, Spelten, Totterdell, Smith and Folkard.²² This model has received support from a substantial number of studies (see review by Tucker and Knowles)²³ and has been modified slightly to take account of our various findings from the VISAT study.

The conceptual model of the aetiology of the problems that may result from the various features of abnormal work schedules is shown in Figure 6. The various levels of this model are considered in more detail below. Briefly, the features of abnormal work schedules are seen as potentially disrupting the body clock, sleep, and family and social life (Level 3), with the extent of this disruption being moderated by individual, situational and organisational factors (Level 2). These Level 3 disruptions may result in acute effects on mood and performance (Level 4), which may also be influenced by job demands and workload. These acute effects may feed back to Level 3, and may also result in chronic effects on mental health and in decreased safety (Levels 6 and 7). The chronic effects on mental health may also feed back and exacerbate the acute effects on mood, and be moderated by individuals' coping strategies (Level 5). Finally, the chronic effects on physical health may impact on both physical health and safety (Level 7).

Level 1

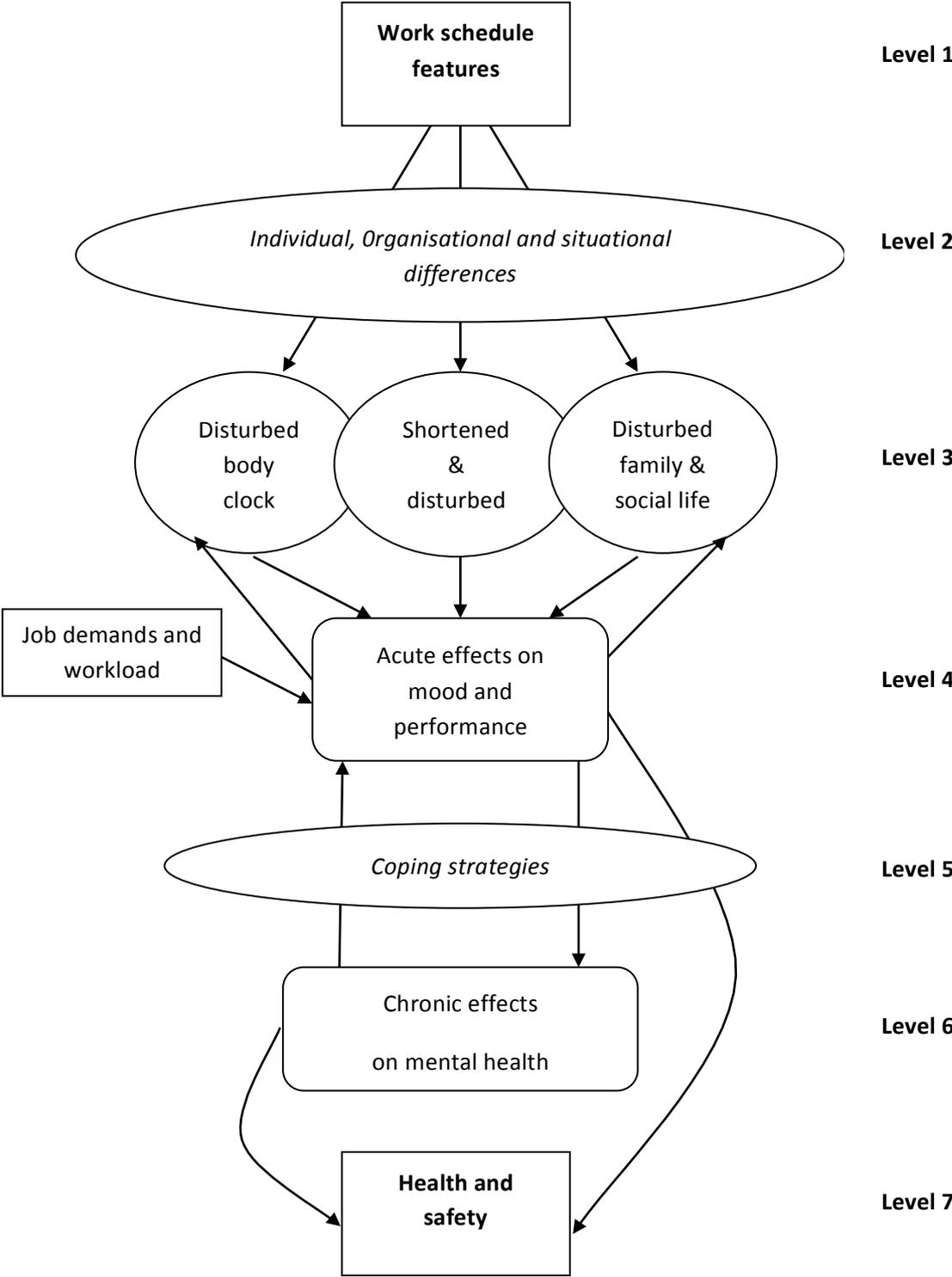
Abnormal work schedules may differ from one another with respect to a fairly wide range of features. These features will jointly influence the extent of the potential impact on Level 3 factors, namely the disturbances of sleep, body clock, and family and social life. The most important features of work schedules in these respects would appear to be those that determine the extent to which fatigue may accumulate, both over an individual shift and over successive shifts, and the opportunities that are provided for the dissipation of any such fatigue. These range from high frequency features such as the frequency and duration of breaks within a shift, through to low frequency features such as the duration of annual leave. In rough order of frequency they include: frequency of breaks, duration of breaks, start times of shifts, duration of shifts, start times of off-duty periods following shifts, duration of off-duty periods following shifts, number of successive shifts of a given type, sequencing of spans of successive shifts, number of successive work days, start time of a period of rest days, number of successive rest days, and the frequency and duration of longer periods of rest days such as annual leave.

These features will all influence either the extent to which fatigue accumulates, and/or the extent to which it may be dissipated during rest periods. Many of them will also determine the extent to which individuals' body clocks and their family and social life are disturbed. Other important features include the regularity or irregularity of the work schedule, the amount of notice that is given to individuals as to when they will be required to work, the extent to which individuals can choose their own schedule, or can swap work periods with one another (thus effectively modifying their rostered schedule to suit their needs), and the frequency and extent of any unscheduled overtime.

There is a fairly substantial literature relating features of work schedules to disturbances of sleep and the body clock. It is well established that night shifts and shifts that start early in the morning, may result in shortened (to as little as five to six hours) and disturbed sleep (Åkerstedt).²⁴ In the case of night shifts this shortening of sleep appears to be due to an inappropriate timing of sleep within the individuals' circadian cycles and stems from the fact that most shift workers show little, if any, circadian adjustment to their work schedules. Indeed, even among permanent or fixed night workers, only a very small minority show good circadian adjustment to night work (Folkard).²⁵ The results from our analyses of the VISAT study indicated that sleep disturbances were most frequent in middle-aged shift workers and that they were largely confined to premature awakening.

Rather less attention has been paid to the disturbances to family and social life, although the general finding appears to be that features of work schedules that prevent normal social and family activities, such as an evening shift, are the most problematic in this respect.

Figure 6: A conceptual model of the manner in which the various problems associated with abnormal work schedules relate both to one another and to the features of the work schedule



Level 2

The Level 2 factors of individual, organisational and situational differences comprise a wide range of factors that may moderate the impact of the Level 1 work schedule features on the Level 3 disturbances. The individual differences include all potential moderators that are endogenous to the individual, such as their gender, age and personality, whether they are habitually a long or short sleeper, a 'morning' or 'evening' type, and whether or not they find it easy to sleep at unusual times or in different locations. Organisational differences are those associated with the particular organisation or site that the individual is employed at and are, at least potentially, equally applicable to all individuals within the organisation. These would include factors such as the availability and quality of rest areas for the individuals to take their breaks. They also include a number of factors that might loosely be considered as 'stressful' such as the psychosocial conditions at the workplace, including the level of support from colleagues and supervisors, as well as more physical conditions such as noise, vibration, heat, and inclement weather.

Many of the Level 2 situational differences essentially reflect on the interaction between the individuals' personal and professional lives and, among other things, will determine the 'pre-shift' state of the individuals when they report for work. The classic example of a situational difference is the time it takes an individual to commute to or from work. This can have a major impact on, for example, the extent to which sleep is truncated prior to a morning shift. Indeed, these commuting problems may be compounded by another potential situational difference, namely the type of activities that the individual engages in during their rest periods. In theory, people should be able to dissipate any cumulative fatigue that may build up over successive shifts during their subsequent rest periods. However, many individuals may have a second job, and this may actually be encouraged by longer periods of rest days, while even those without a second job may have physically demanding recreations. The net result of these situational differences is that they may result in high levels of 'pre-shift' fatigue right at the start of a period of successive shifts.

Level 3

The disturbances of the body clock, sleep, and family and social life have been examined in a vast number of studies. In all three cases, the fact that these disturbances occur is established beyond any reasonable doubt, and considerable progress has been made both in linking them to the work schedule features, and in determining the moderating influences of individual, organisational and situational differences. Unfortunately, most studies have treated the disturbances of the body clock and sleep as outcome measures in their own right, rather than as hypothetical intervening variables and have failed to examine any of the 'higher level' outcome measures (i.e. Levels 4, 6 and 7 in Figure 6). Although it might seem reasonable to assume that these Level 3 factors are involved in the overall effects on health and safety (Levels 6 and 7), there is remarkably little evidence in the literature to support this assumption! The widespread failure of studies to examine all the levels shown in Figure 6 reflects on that fact that it is extremely difficult to conduct studies that do so. It is also the case that the Level 3 disturbances may be important in their own right, and this is particularly true of the disturbances of family and social life, which may have a direct impact on the individuals' quality of life.

Level 4

The acute effects on mood and performance shown at Level 4 in Figure 6 are seen as resulting not only from the features of the work schedules, via the Level 3 disturbances, but also from work-related factors such as the job demands and workload. These latter factors will include the type of job being performed, the pacing and intensity of the work, and the predictability of the consequences of individuals' actions. A number of experimental studies of shift work and field studies using interpolated performance measures have examined the impact of various features of work schedules on both performance and mood. They have typically found, for example, that

both performance and alertness are lower at night than during the day, and lower on 12-hour shifts than on 8-hour ones (Rosa and Bonnet;²⁶ Bonnefond, Rogé and Muzet).²⁷ However, it is again the case that whereas it might seem reasonable to assume that these changes might mediate changes in the higher-level outcomes of safety and health, there is a paucity of evidence on this. It is also important to note that the acute effects on mood and performance may also feed back and exacerbate the Level 3 disturbances. For example, disturbed sleep may not only impair performance and mood, but may also be a consequence of such impairments.

Level 5

This is probably the level of the model for which there is the least evidence in the literature. The idea here is that individuals' coping strategies might moderate the impact of the lower levels (Levels 1–4) on the higher order outcome measures (Levels 6 and 7). While this suggestion is probably correct and is supported by a few studies in which individuals have been interviewed about their coping strategies (for example, Adams, Folkard and Young),²⁸ attempts to examine coping strategies by means of questionnaire scales have met with rather mixed results (for example, Spelten, Smith, Totterdell, Barton, Folkard and Bohle).²⁹ This probably reflects both on inadequacies in the coping strategy scales that have been used and on the potentially vast differences between individuals in the type of strategies that they adopt.

Level 6

The potential chronic effects of abnormal work schedule features on mental health are shown at a different level to those on physical health and safety, simply because they may serve to mediate some aspects of safety and physical health, and especially those for which 'stress' is considered a causal factor. Mental health effects are seen as stemming from the acute effects of work schedule features on mood, but also as feeding back and exacerbating the latter. Therefore, the well-known 'vicious circle' may develop in which bad mood may spiral downwards into depression. There is a reasonably consistent literature showing that abnormal work schedules, and especially those involving night work, may result in increased levels of anxiety and depression, and this includes at least one longitudinal study (Bohle and Tilley).³⁰ Our results from the VISAT study indicated that shift workers reported higher levels of chronic fatigue and that those who had quit shift work relatively early reported higher emotional reactivity and stress than those who had only ever worked days. We found that while quitting shift work led to a reduction in chronic fatigue, there was little evidence of similar improvements in emotional reactivity or stress. We also found that shift work was associated with impaired cognitive abilities, especially after a 10-year exposure, although our analyses indicated that these effects were temporary and reversible, with signs of impairment disappearing some years after the cessation of shift work (at least five years). Results from the longitudinal data (10-year follow-up) confirmed what was observed through the cross-sectional analyses of the t1 data by Rouch.¹⁹ It further extended these earlier findings by revealing that the effect of shift work on cognition was not only independent of sleep complaints (in line with the findings of Rouch *et al.*),¹⁹ but was also independent of metabolic dysfunction. This is despite the fact that we found evidence for an increased incidence of metabolic dysfunction in shift workers in our longitudinal analyses (see below). Clearly further research is needed to explore the mechanisms underlying this chronic effect of shift work on cognitive abilities.

Level 7

The final level of the model is concerned with what are arguably the most important factors, namely the physical health of the individuals concerned and the safety, not only of these individuals, but also of the general public and the environment. There is a considerable literature on the impact of abnormal work schedules on physical health and a rather smaller one on the relative risk of injuries and accidents.

With respect to health, a number of studies have indicated that shift workers whose schedules include night work show a generally higher prevalence of digestive disorders (from two to five times higher on average) than those whose schedules do not (Costa;³¹ Knutsson).¹³ In addition, a number of epidemiological studies have yielded data suggesting an association between shift work and cardiovascular diseases. More specifically it has been shown that there is: a prevalence of cardiovascular risk factors, of angina pectoris and hypertension among shift workers; a higher morbidity due to cardiocirculatory and ischaemic heart diseases with increasing age and shift work experience; and an increased relative risk of myocardial infarction in occupations with a high proportion of shift workers (Knutsson, Åkerstedt and Jonsson;³² Knutsson;¹³ Kristensen).³³ It is possible that these health problems are linked to the development of metabolic syndrome (a set of symptoms linked to increased risk of heart disease, obesity, peptic ulcers, gastrointestinal problems and poorly controlled blood sugar levels), with the current study identifying an association between exposure to shift work and increased risk of metabolic dysfunction, as mentioned above.

Although the evidence relating digestive disorders and cardiovascular disease to abnormal work schedules is probably the strongest, there is also some evidence for other physical health problems such as cancer (Knutsson;¹³ Schernhammer, Kroenke, Dowset, Folkard and Hankinson)³⁴ increased minor infections (Smith *et al.*, 2003),³⁵ and maternity problems in women (Knutsson).¹³

A number of authors have pointed to the fact that the headline hitting disasters of Three Mile Island, Chernobyl, Bhopal and Exxon Valdez all occurred at night (for example, Mitler, Carskadon, Czeisler, Dement, Dinges and Graeber).³⁶ However, although these were all at least partially caused by human error, determining the *a priori* risk for such disasters is fraught with problems. For example, if we found that air accidents were less frequent at night it would be very difficult to determine whether this was due to fewer planes flying at night (i.e. the exposure rate), or to less congested air space (i.e. the hazard level), or to improved flying skills on the part of the air crews (i.e. changes in performance capabilities). Unfortunately, most of the literature on the impact of work schedules on accident and injury rates suffers from similar problems of unknown exposure rates and hazard levels and it is therefore difficult to determine the risk associated with potential changes in performance capabilities.

There are, however, a few studies that have been published where exposure rates and hazard levels appeared to be constant, and where any variation in injury frequencies could be reasonably assumed to reflect on variations in the performance capabilities of those concerned. There is considerable agreement between these studies in showing that the risk of injuries is increased on 12-hour shifts relative to 8-hour ones (by about 25–30 per cent), is increased at night relative to the day (again by about 25–30 per cent), and increases in a fairly linear manner over at least the first four successive shifts, with the increase being larger on night shifts than on day shifts (see Folkard and Tucker).³⁷ These findings have been shown to be relatively consistent across studies and have been used to develop a risk index that can be used to predict the relative risk associated with any given work schedule (Folkard and Lombardi;³⁸ Folkard, Robertson and Spencer).³⁹ Nevertheless, there is a dire need for further, well-controlled studies in this area to assess, for example, the risk over longer spans of successive shifts.

Summary and conclusions

In summary, the conceptual model shown in Figure 6 can be viewed as comprising eight simple hypotheses, namely:

- Features of shift systems result in disturbed biological rhythms, sleep, family and social life.
- The extent of this disturbance is moderated by individual, organisational and situational differences (for example, age, gender, circadian type, commuting times, etc.)
- Disturbed biological rhythms, sleep, family and social life have acute effects on mood and performance.
- These acute effects feed back; they exacerbate the disturbances of biological rhythms, sleep, family and social life.
- The acute effects on mood and performance can result in chronic effects on health, mental health and performance.
- These chronic effects will be moderated by coping strategies.
- These chronic effects will also feed back; they exacerbate the acute effects on mood and performance.
- The acute effects on mood and performance and the chronic effects on mental health will jointly determine physical health and safety.

However, the primary purpose of this conceptual model is to suggest the manner in which the various variables might interact with one another in jointly determining the relationship between the features of work schedules and the health and safety of those concerned. There is a relatively extensive work schedule literature that generally supports the eight simple hypotheses (see review by Tucker and Knowles).²³ The ones that have received the least attention are those concerned with the more chronic effects, and the reason for this would appear to be that these are the most difficult to test. Therefore, simple cross-sectional studies can provide at least partial answers to the other hypotheses, while the chronic hypotheses require either a longitudinal design or at the very least some form of structural equation modelling (SEM). In general, it is also fair to say that the main shortcoming of the research literature is that almost all studies have failed to address more than two or three levels within the model.

Our analyses of the VISAT have addressed many of these failings. We have examined both acute and chronic effects in a relatively wide range of variables. We have identified chronic effects of shift work on both metabolic dysfunction and cognitive performance and further shown that these would appear to be unrelated consequences of abnormal work schedules. We have also examined how these adverse chronic consequences may increase with more exposure to shift work (for example, metabolic dysfunction, chronic fatigue and cognitive performance) and may subsequently reduce when individuals quit shift work. We have found evidence, that whereas some measures (for example, sleep complaints and cognitive performance) may recover when an individual quits shift work, others (for example, perceived stress and social isolation) show little evidence of recovery. In short, our analyses have thrown considerable light on the more chronic effects of exposure to shift work and their potential recovery after quitting shift work.

5 Practical recommendations*

The recommendations included in this report are based not only on our findings from the VISAT study, but also on the published literature. Unlike many previous authors we have divided them into three main categories, namely (i) sleep and fatigue, (ii) psychological (iii) physical health, and family, social and leisure problems. These have then been subdivided into recommendations aimed primarily at individual shift workers and those aimed at their employers. Although it is logically possible to further subdivide the three main areas, in practice, recommendations designed at improving, for example, family life are likely to also impact on social and leisure problems. It is also the case that further subdivision may overcomplicate things for many shift workers.

Sleep and fatigue

As far as we are aware no previous study has examined sleep complaints using longitudinal data from different age cohorts over such a long period (10-year follow-up) or has been able to distinguish between former shift workers, current shift workers and workers who have never worked on shift. One of our primary aims in this research was to examine how shift working affects sleep in later life and to determine whether poor sleep quality persists after giving up shift work. Our initial comparison of current and former shift workers ('shift workers') with those who had never worked shifts ('non-shift workers') confirmed previous findings that the shift workers tend to experience greater problems sleeping. It also provided evidence, for the first time, that premature awakening is a particular problem for shift workers. The effect of shift work experience appeared to be greatest among those in their forties and reduced as participants left shift work (i.e. when they transferred to day working or retired), suggesting that the effects of shift work did not persist once people quit shift work (Tucker *et al.*).¹² Similarly, chronic fatigue was higher in shift workers and tended to reduce once they quit shift work (Tucker *et al.*).¹⁰

We also found that former shift workers in the younger two cohorts (32 and 42 years old at t1) reported significantly more sleep problems than those who had never worked shifts, despite the fact that neither group worked shifts at the time that the measurements were taken (Tucker *et al.*).¹² The most likely explanation for this is that they were either poorer sleepers when they entered shift work or that they were especially vulnerable to the disruptive effects of shift work on sleep. Indeed, it may be because of this that they could not tolerate shift work and so gave it up quite quickly.

These findings, together with those in the general literature, suggest a large number of practical recommendations with respect to sleep and fatigue, both for the shift workers themselves and for their employers, namely:

* More information on the rationale underlying each recommendation can be found in the Health and Safety Executive guidance.⁴⁰

Recommendations for employees

- Avoid caffeine and alcohol before going to sleep.
- Avoid 'large meals' (more than 20 per cent of daily energy intake) one to two hours prior to your main daily sleep episode.
- Avoid eating, or at least restrict energy intake, on the night shift between midnight and 6 a.m. and try to eat at the beginning and end of the shift.
- Eat breakfast before your day sleep after a night shift to avoid waking due to hunger.
- Make sure that family and friends are aware of and considerate of your sleep hours and needs.
- Ensure you have a comfortable, quiet place to sleep during the day.
- Air conditioning, telephone answering machine, foam ear-plugs, eye masks and good blinds/curtains are examples of devices that may improve your sleep.
- Make time for quiet relaxation before bed to facilitate better sleep (i.e. reading, breathing exercises, muscle relaxation techniques).
- Sleep on a set schedule to help establish a routine and to facilitate sleeping during the day.
- Avoid strenuous exercise before sleeping because your body's metabolism will remain elevated for several hours and this makes sleeping difficult.
- If you fail to fall asleep after one hour, read a book or listen to quiet music for a while.
- If you still can't fall asleep, try again later in the day.
- Shift workers' sleep problems often get worse at around age 40 so to avoid these problems try to quit shift work by then.

Recommendations for employers

- Design shift schedules to allow adequate time between shifts for sleep, meal preparation; avoid quick returns.
- Schedule the most demanding work early in the shift when workers are most alert.
- Schedule shorter, more frequent breaks throughout the shift.
- Do not schedule more than five to seven shifts in a row.
- The workplace should be brightly lit.
- Night work should be reduced as much as possible.
- Only schedule work on one or two nights in a row.
- Avoid excessive overtime.
- Train workers need about the steps they can take to reduce negative effects of shift work.
- Rotate shifts forward (morning – afternoon – night).
- Starting the shift at 7 a.m. may be less disruptive than starting the shift at 6 a.m.
- Provide at least 48 hours between shift changes to allow the body to adjust.
- Take advantage of individual differences.
- Avoid split shifts.
- Avoid excessive 12-hour shifts.
- Have a room with facilities for workers to lie down and rest before and after a shift.
- Identify and treat workers who have sleep disorders.
- Evaluate shift schedule design such as length of breaks, start and finish times, etc.
- Evaluate sleep problems during the regular health checks.
- The health checks should become more frequent from age 40 and in those who have been shift workers for 10 years or more.
- Transfer those with severe sleep problems to day work.

Psychological and physical health

In our research, the perceived overall health of shift workers was similar to that of day workers, with both groups showing a decrease over the three measurement occasions (Tucker *et al.*).¹⁰ This could, however, simply reflect on shift workers having habituated to a poorer level of health. Indeed our recent analyses suggest that exposure to shift work is associated with an increased risk of metabolic dysfunction (Tucker *et al.*),¹⁶ a set of symptoms linked to increased risk of heart disease, obesity, peptic ulcers, gastrointestinal problems and poorly controlled blood sugar levels. While the link between shift work and metabolic dysfunction has yet to be fully understood, one of a number of possible mechanisms is that disrupted eating patterns cause shift workers to be unable to metabolise food in the normal way. The recommendations below include dietary advice designed to reduce symptoms associated with metabolic syndrome, such as increased insulin resistance and elevated cholesterol levels. We also found in the same study that shift work was associated with impaired cognitive abilities. The effect of shift work was significant after a 10-year exposure. However, our analyses also indicated that these effects were temporary and reversible, with signs of impairment disappearing some years after the cessation of shift work (at least five years). Shift workers who subsequently quit shift work also reported higher levels of emotional reactivity and perceived stress than those who only ever worked days, but there was little evidence that quitting shift work improved matters.

In the light of these findings, and those from a substantial literature in this area, a number of recommendations can be made, namely:

Recommendations for employees

- Try not to exceed working 10 consecutive years of shift work.
- Maintain a healthy lifestyle with exercise, regular meal times, and good sleeping habits when not working.
- Stick as closely as possible to a normal day and night pattern of food intake.
- Divide your 24-hour food intake into three satiating meals, each contributing 20–35 per cent to your overall 24-hour intake. The higher your energy needs, the more frequent your meals and snacks should be.
- Avoid over-reliance on (high-energy content) convenience foods and high-carbohydrate foods during your shifts. Instead, choose vegetable soups, salads, fruit salads, yoghurt, wholegrain sandwiches, cheese or cottage cheese (topped with slices of fruits), boiled nuts, green tea (promoting antioxidant activity), although this may not be palatable to some.
- Avoid sugar-rich products such as soft drinks, bakery items, sweets, and non-fibre carbohydrate foods (high glycemic load) like white bread.
- Use relaxation techniques such as deep and slow breathing.
- Try to get adequate sleep and exercise.
- Plan days off in advance if possible.
- Try to prioritise tasks and tackle one at a time.
- Afternoon/evening shift workers should have their meal in the middle of the day instead of in the middle of their work shift.
- Night workers should eat lightly throughout the shift and have a moderate breakfast.
- Relax during meals and allow time for digestion.
- Drink lots of water
- Cut back on foods that are high in salt.
- Reduce high in fat foods.

- Maintain regular eating patterns with well-balanced meals (avoid junk food and limit fat intake).
- Eat the usual balance of vegetables, fruit, lean meat, poultry, fish, dairy products, grains, and bread.
- Avoid excessive use of antacids, tranquilisers and sleeping pills.
- Minimise the intake of caffeine and alcohol.
- Avoid using fast food and vending machines.
- Try to incorporate regular exercise into your schedule.

Recommendations for employers

- Move people from shift work after 10 years of exposure.
- Plan shifts as far in advance as possible.
- Keep schedules flexible by allowing workers to trade shifts.
- Schedule time off over weekends.
- Provide workshops and information sessions on stress management.
- Make sure demands on workers are reasonable.
- Maximise worker autonomy.
- Include a mental health component to employee assistance programmes.
- Consider offering facilities for social activities such as recreation and staff social gatherings.
- Provide exercise facilities on site.
- Provide a 24-hour cafeteria where night workers can obtain a hot, nutritious meal and appropriate dining facilities that, for example, allow a meal to be eaten away from the workplace, with colleagues, in as pleasant a surrounding as possible.
- Provide a variety of food choices: complete or vegetarian meals and high-quality snacks are recommended. Avoid foods and beverages classified as low-quality snacks.
- Try to meet food guide nutrition requirements.
- Reduce the provision of foods high in salt.
- Reduce foods that are high in fat.
- Limit availability of caffeine and alcohol.
- Schedule regular meal breaks.
- For workers who can't work shift work for medical reasons, provide day employment.
- Provide regular (annual) health checks for shift workers and transfer them to day work if required.

Family, social and leisure problems

The original VISAT study concentrated on occupational health and only a single social measure, namely social isolation, was included in the analyses that we have performed. Indeed, there is a relative dearth of studies on the social impact of shift working compared to the relatively large literatures on sleep and fatigue and on psychological and physical health. Furthermore, perceived social isolation might, at least in part, reflect on psychological health rather than on a genuine absence of social contacts. In fact, our findings indicated that the level of perceived social isolation was no greater in shift workers than day workers.

Nevertheless, what literature there is on the social and family problems of shift workers indicates that there can be some serious problems that warrant a number of recommendations, namely:

Recommendations for employees

- Use a calendar to schedule events and activities.
- Establish good communication skills.
- Schedule at least one daily meal with the family; this helps to keep communication channels open and promotes a good eating habit.
- Socialise with other shift workers and their families; this helps to minimise the disruption that shift work can have on your social life.
- Keep in touch with partner and children daily.
- Set time aside for just you and your partner.
- Carefully plan family activities; family ties are a precious commodity (plan days off in advance if possible).
- Pay close attention to physical fitness; a regular exercise programme helps the body adjust to the negative effects of shift work and it can also help improve the quality and quantity of sleep.
- Practice stress reduction.

Recommendations for employers

- Provide an on-site day-care facility.
- Offer 24-hour day-care solutions.
- Offer activities for employees' children, such as sponsoring sports teams, etc.
- Provide transportation to events.
- Provide workshops on communication and conflict resolution.
- Organise hobby or interest groups within the workplace (for example, art classes, support groups).
- Sponsor employee sports teams and leagues (for example, company football league).

Appendices

The following appendices include abstracts of the different research projects we conducted under IOSH (Institution of Occupational Safety and Health) auspices. These abstracts refer to oral presentations made during international conferences or to articles published in leading academic journals or articles under review.

Appendix 1

Ansiau D, Marquié J-C, Tucker, P and Folkard S. Long-term effects of shift work on sleep quality as a function of age: Results from the VISAT longitudinal study. *XIXth Symposium on shift work and working time, Venice, Italy, 2009.*

Abstract

This study examined age-related changes in subjective sleep quality in an occupational setting, and tested the hypothesis of persistent sleep troubles in former shift workers. Data were taken from the VISAT longitudinal study (ageing, health and work), which allowed both cross-sectional and longitudinal aspects of age-related changes to be examined. The cohorts comprised male and female, employed and retired wage earners who were 32, 42, 52 and 62 years old at the time of the first measurement (t1, 1996), and who were seen again five (t2) and 10 (t3) years later. Most analyses were performed on the 1,257 participants who took part on all three measurement occasions, but some were based on the larger t1 and t2 samples. Subjective sleep quality, past and current experience of shift work, and perceived stress were recorded on all three measurement occasions.

The design of the VISAT longitudinal study allows an examination of three types of time-related effects: age effects, historical context effects and birth cohort effects.

Our preliminary analyses showed sleep troubles increased in workers in their thirties and forties and then stabilised over the next two decades. The results suggested that the stabilisation of sleep troubles in the older groups was due to decreased overall stress in those approaching retirement and in those already retired. Comparing within-person and between-person changes revealed an effect of cohort, with more sleep problems reported at a given age than 10 years ago at the same age. There was evidence of some persistent effects of sleep troubles in still-employed former shift workers, but not of permanent effects since no differences were found between older or retired former shift workers and their controls. These results support the view that still-employed former shift workers are typically those who have quit shift work because of their poor sleep quality and tolerance to shift work. In contrast, there is a higher proportion of good sleepers who have tolerated shift work better and longer, among the older and retired former shift workers.

Appendix 2

Ansiau D, Marquié J-C, Tucker P and Folkard, S. Effets liés au temps et au travail posté sur la qualité du sommeil: Résultats de l'étude longitudinale VISAT. *Cinquième symposium de psychologie ergonomique Epique 2009, Nice, France, 2009.*

Abstract

This study analysed cross-sectional and longitudinal features of age-related changes of subjective sleep quality and tested the hypothesis of persistence of sleep problems among former shift workers.

Analyses were based on the VISAT longitudinal study. The sample included active or retired employees, men and women, and who were 32, 42, 52, and 62 years old during the first data collection phase in 1996. Most analyses were conducted on the remaining 1,257 participants who took part in the three data collection phases (1996, 2001, and 2006). Subjective sleep quality, past and current shift work experience and perceived stress were measured during these three phases.

Sleep problems seem to increase among workers in their thirties or forties and tend to stabilise in workers in their fifties and sixties. Sleep problem stabilisation among older employees could be related to decreased stress in workers who are about to be retired or are already retired. Results indicate a persisting effect of sleep problems among older workers who are still working. Nevertheless, there is no permanent effect since no difference has been observed among older shift workers who are retired. These results support the hypothesis according to which, workers who are in the meantime former shift workers and still in activity, are those who, because of disturbed sleep or a lower tolerance to shift work, rapidly come back to normal working hours. However, results do not validate the hypothesis of irreversible sleep problems.

Appendix 3

Tucker P, Folkard S, Ansiau D and Marquié J-C. A longitudinal study of the combined effects of age and shift work on perceived health problems. *The International Association of Gerontology & Geriatrics Conference, Swansea University, UK, 2010.*

Abstract

Sleep disturbances are one of the most frequent complaints of shift workers. However, few studies have examined either the build-up of such sleep problems over time, or their potential amelioration following exit from shift work. With the workforces in industrialised countries getting older, the current study sought to determine how working shifts affects sleep in later life. Longitudinal data were collected from a large sample in 1996, 2001 and 2006 from employees who were 32, 42, 52, and 62 years old in 1996. The effects of shift work on sleep were most apparent in the early and middle years of working life, with little to suggest that shift working led to greater sleep problems later in life. Former shift workers reported more sleep problems than both current shift workers and those who had never worked shifts. This suggests that those who had exited shift work were a self-selected group who had experienced greater sleep problems than other shift workers, and as a result had given up shift work. Giving up shift work off-set the age-related accumulation of sleep problems, with the net result that former shift workers showed little or no change in sleep problems over the three measurement occasions. Those who had most recently given up shift work experienced more sleep problems than those who had given it up more than five years prior to baseline. It is concluded that the effects of shift work on sleep may persist for a long time after giving up shift work but that they are not permanent.

Appendix 4

Tucker P, Marquié J-C, Folkard S and Ansiau D. The effects of quitting shift work on perceived well-being. *Poster presentation given at the 20th international symposium on shift work and working time, Stockholm, Sweden, 2011.*

Objective

To examine the combined effects of age and shift work on longitudinal trends in five indices of well-being.

Method

Analyses were based on data from VISAT, a prospective study involving measurement of subjective well-being at three time points over 10 years. The sample comprised 680 male and female employees who were 32 or 42 years old at the first measurement occasion (t1, 1996), and who were seen again five (t2) and 10 (t3) years later. Participants were categorised in terms of whether they worked either shifts or regular day work on each of the three measurement occasions (t1-t2-t3) as follows: shift, shift, shift; shift, shift, day; shift, day, day; day, day, day (former shift worker, prior to t1); and day, day, day (never a shift worker).

Results

Higher scores reflect negative outcomes.

Chronic fatigue: Working shifts was associated with higher scores. There was an interaction between measurement occasion and work schedule reflecting decreased scores following cessation of shift work.

Emotional reactivity: There was an interaction between measurement occasion and work schedule, reflecting decreased scores following cessation of shift work. However, those who quit shift work before t2 showed a rebound in scores at t3.

Social isolation: There was an interaction between measurement occasion, work schedule and age cohort. Within the older cohort (42 at t1), those who quit shift work before t2 (i.e. between the ages of 42 and 47) showed a reduction in scores that was sustained at t3. Those who quit shift work after t2 (i.e. between the ages of 47 and 52) showed no reduction after quitting.

Perceived stress: Those who had never worked shifts scored lowest, while those who had quit shift work scored highest. Those working shifts on all three measurement occasions had relatively low scores, compared to those who had quit shift work. There was little indication that quitting shift work decreased stress.

Perceived health: Scores were higher among the older cohort but there was an interaction between age cohort and work schedule. The largest differences between cohorts were among those who had quit shift work before t2; the smallest differences were among those who had never worked shifts and those who worked shifts on all three measurement occasions.

Conclusion

Quitting shift work and transferring to day work was associated with only limited improvements in well-being, with the clearest beneficial effects seen in chronic fatigue. Those who remained in shift work until late middle age (i.e. 52) showed relatively little impairment of well-being, suggesting either a selection effect (the healthy worker effect) or relatively benign working conditions.

Appendix 5

Tucker P, Marquié J-C, Gentil C, Folkard S and Ansaïu D. Shift work, metabolic dysfunction and impaired cognition. *Oral presentation given at the 20th International Symposium on Shift work and Working Time, Stockholm, Sweden, 2011.*

Abstract

Objective

Previous research has identified associations between non-standard work schedules (for example, shift work) and the development of metabolic syndrome, and also between non-standard work schedules and impaired cognitive performance. This study was the first to explore the relationship between shift work, metabolic syndrome and cognitive performance within a single sample.

Method

Analyses were based on data from VISAT, a prospective study involving the measurement of physiological, subjective and cognitive performance outcomes at three time points over 10 years, from 3,237 participants at baseline. The sample comprised employed and retired wage earners, male and female, who were 32, 42, 52 and 62 years old at the time of the first measurement (t1, 1996), and who were seen again five (t2) and 10 (t3) years later.

Results

At t1, participants who were working, or had previously worked, non-standard schedules (i.e. schedules that involved either: rotating shifts; not being able to go to bed before midnight; having to get up before 5 a.m.; or not being able to sleep during the night) were more likely to exhibit symptoms of metabolic syndrome, after controlling for age, sex, socio-professional status, smoking, alcohol intake and perceived stress (odds ratio 1.81; 95 per cent confidence interval (CI) 1.05–3.12).

Participants exhibiting symptoms of metabolic syndrome at t1 showed a significant decline in cognitive performance between t1 and t3, while those without the syndrome showed no change. This interaction between metabolic syndrome status and measurement occasion was significant ($p < .01$) after taking into account effects on cognitive performance of age, gender, socio-professional status, sleep disruption, alcohol consumption, tobacco consumption, perceived stress and type of work schedule.

A partial replication of the second analysis (substituting type of work schedule with length of exposure to rotating shift work) identified an interaction between metabolic syndrome status and length of exposure ($p < .05$). Among participants who were free of the syndrome at t1, those with 0–10 years' exposure at t1 had higher cognitive performance scores than those with 10 or more years' exposure. Participants exhibiting symptoms of metabolic syndrome tended towards lower cognitive performance (non-significant), but there was no effect of length of exposure in this group.

Conclusion

Glucose is the main metabolic food for the brain and is therefore necessary for mental performance. Impaired glucose metabolism associated with metabolic syndrome may be responsible for reduced cognitive functioning. However the effects of metabolic syndrome on cognitive performance did not appear to be exacerbated by prolonged exposure to shift work.

Appendix 6

Tucker P, Folkard S, Ansiau D, Marquié J-C. The effects of age and shift work on perceived sleep problems: Results from the VISAT combined longitudinal and cross-sectional study. *Journal of Occupational and Environmental Medicine*, 2011; 53(7), 794–798.

Abstract

Objectives

With the workforces in industrialised countries getting older, this study sought to determine how shift-working affects sleep in later life.

Method

Longitudinal data were collected from a large sample in 1996, 2001, and 2006 from employees who were 32, 42, 52, and 62 years old in 1996.

Results

The effects of shift work were most apparent in the early and middle years of working life. Former shift workers reported more sleep problems than both current shift workers and those who had never worked shifts. Giving up shift work off-set the age-related accumulation of sleep problems, with the net result that former shift workers showed little or no change in sleep problems over the three measurement occasions.

Conclusions

The effects of shift work on sleep may persist for a long time after giving up shift work but they are not permanent.

Appendix 7

Marquié J-C, Ansiau D, Tucker P and Folkard S. Effects of age, gender, and retirement on perceived sleep problems: Results from the VISAT combined longitudinal and cross-sectional study. *Sleep*, 2012; 35(8), 1115–1121.

Abstract

Objectives

This study examined the effects of age, gender and retirement on the subjective frequency of various sleep problems in individuals on a normal work schedule.

Design

Data were taken from the VISAT study (ageing, health and work), which allowed both cross-sectional and longitudinal aspects of age-related changes to be examined.

Participants

The cohorts comprised 623 male and female, employed and retired, wage earners who were 32, 42, 52 and 62 years old at the time of the first measurement (t1, 1996), and who were seen again five (t2) and 10 (t3) years later.

Measurements and results

Subjective ratings of the frequency of sleep problems and hypnotic usage were recorded on all three occasions, as was the employment status of the individuals. After controlling for age and gender, a decade effect was observed for difficulty falling asleep and difficulty maintaining sleep, indicating that the frequency of these sleep problems was rated as higher in 2006 than in 1996. The perceived frequency of difficulty maintaining sleep, difficulty getting back to sleep and premature awakening was found to increase in individuals up to their mid-fifties but to then remain relatively constant, or even in the case of premature awakening to reduce, up to the age of 72. In contrast, the rated frequency of difficulty falling asleep and hypnotic usage increased fairly linearly over the entire age range.

Conclusions

Sleep complaints are reported early in the workers' lives, are more frequent with age, but some of them improve after retirement, especially for premature awakening.

Appendix 8

Tucker P, Marquié J-C, Folkard S, Ansiau D and Esquirol Y. Shift work and metabolic syndrome. *Chronobiology International*, 2012: 29(5), 549–555.

Abstract

Many of the health problems that are more prevalent among shift workers are thought to be linked to their heightened susceptibility to metabolic syndrome; the association of even moderate degrees of visceral obesity, dyslipidemia, abnormal blood pressure, and serum glucose levels in the same individual. Although previous studies have identified associations between shift work and metabolic syndrome, there is relatively little evidence to date of how the risk of developing it varies as a function of exposure to shift work.

This study seeks to confirm earlier findings of an association between shift work exposure and metabolic dysfunction and to examine the impact of exposure duration, while adjusting for a number of covariates in the analyses. The analyses were based on data from VISAT, a study involving the measurement of physiological, behavioural, and subjective outcomes from 1,757 participants, 989 being current or former shift workers. The sample comprised employed and retired wage earners, male and female, who were 32, 42, 52, and 62 years old. The first analysis sought to confirm previous findings of an association between exposure to shift work and the risk of developing metabolic syndrome. It indicated that participants who were or who had previously been shift workers (working schedules that involved rotating shifts; not being able to go to bed before midnight; having to get up before 5 a.m.; or being prevented from sleeping during the night) were more likely to exhibit symptoms of metabolic syndrome, after adjusting for age, sex, socioeconomic status, smoking, alcohol intake, perceived stress, and sleep difficulty (odds ratio 1.78; 95 per cent confidence interval (CI) 1.03–3.08).

The results suggest the association between shift work and metabolic syndrome cannot be fully accounted for by either higher levels of strain or increased sleep difficulty among shift workers, although it remains a possibility that either one or both of these factors may have played a contributing role. The second analysis addressed the issue of duration of exposure to shift work. Participants with more than 10 years' experience of working rotating shifts were more likely to exhibit symptoms of metabolic syndrome than participants without exposure to shift work, i.e., day workers, even after adjusting for age and sex (odds ratio 1.96; 95 per cent confidence interval (CI) 1.03–3.75).

The current study confirms the association between shift work exposure and metabolic syndrome. It also provides new information regarding the time course of the development of the illness as function of exposure duration, although this was only examined in relation to rotating shift work. It is concluded that those responsible for monitoring workers' health should pay particular attention to indices of metabolic dysfunction in workers who have been exposed to shift work for more than 10 years.

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