WORK-RELATED FATIGUE
SUMMARY OF RECENT INDICATIVE RESEARCH
2006

Australian Government
Australian Safety and Compensation Council

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Important Notice

Table of Contents

Executive Summary

1. In the last decade increasing pressure on Australian industries to become more competitive has resulted in the introduction of new technologies and significant labour market change. There has been a concomitant increase in the requirement for continuous or more flexible business operations, which have in turn increased the number of employees engaged in shiftwork, working irregular and or longer hours. This restructuring has often also resulted in increased job complexity and work intensification.

2. There is increasing recognition that these workplace developments may lead to increased rates of employee fatigue. It is widely acknowledged that fatigue can compromise health and safety. Employee fatigue has obvious implications for those safety critical industries where fatigue may cause or contribute to potentially dangerous or costly errors.

Scope

3. This paper provides a summary of activities underway in Australia and overseas addressing work-related fatigue, for the period January 2005 to July 2006. It provides an overview of recent developments in research and examines national and international approaches.

4. Searches for academic papers were conducted on a number of databases and search engines (confined to between 2005 and 2006, using various search terms including "workplace fatigue" and "fatigue"). Search engines included OSHROM, Scirus, EBSCO, Proquest, Google and Google Scholar.

5. There has been significant development in responses to fatigue management during this period, particularly in the context of regulation. Legislative responses have occurred mainly in the transport and health sectors. Consequently, an additional paper has been developed as an addition to this paper (the *Work-Related Fatigue Summary of Recent Regulatory Developments* paper).

Key Messages

Key Messages covered in this paper

During 2005-06, research on work-related fatigue has been focused on the transport and health sectors, due to the potential for significant impacts on the health and safety of workers and for major public safety consequences. Fatigue research has also been conducted in the construction and manufacturing industries, in response to the extensive use of extended hours and shift arrangements.

It is difficult to apply a broad based approach to fatigue management in the workplace. There is need to take into account the nature of the work performed, the skills and capacities required to perform the work, the effects of fatigue on performance and the potential consequences of performance decrements.

Fatigue research has not yet produced a significant body of evidence based data that clearly delineates the relationship between work patterns, job/task demands, sleep duration and worker performance. Many studies are poorly designed and controlled and use poorly defined measures. This results in difficulty in drawing conclusions from the existing literature that could serve as a guide to policy advice.

Definitions - The Nature and Determinants of Fatigue[1]

6. Management of the various kinds of risks that can arise from high levels of workplace fatigue is a complex and challenging process. The state of 'fatigue' is multidimensional and not fully understood; the terminology we use to describe it is inadequate and sometimes confusing; and the state of being "fatigued" can be difficult to disentangle from other states such as 'jetlag' and the equivalent state arising from working nightshifts ('nightshift-lag'?), 'boredom', and 'stress'.

7. There are varying definitions of fatigue. WorkCover NSW, in implementing regulations in 2006 on fatigue in long haul road transport, has described fatigue as the "feeling of weariness from bodily or mental exertion; and feeling tired, drained and exhausted. Fatigue influences an individual's physical, mental and emotional state, which may result in less alertness, accompanied by poor judgment, slower reactions to events and decreased motor skill"[2]. The Australian Civil Aviation Authority (CASA)

[1] Private correspondence with Associate Professor W. Macdonald of La Trobe University in May 2006.
[2] WorkCover NSW Driver Fatigue Management – A Guide to Managing Driver Fatigue in the Long Haul Trucking Industry (February, 2006)

defines fatigue in its Civil Aviation Orders (2004) as “exhaustion of the mind or body resulting from labour or exertion and/or a lack of sleep[3]”.

8. However, from a quick and informal review of such definitions it can be found that most are in agreement with a commonsense understanding that a centrally defining feature of fatigue is its cause. Based on this, and on more general knowledge of the area, Macdonald suggests that fatigue can be defined as a multidimensional state that entails a reduction in functional capacities due to the cumulative effects of physical and/or psychological effort expenditure in the absence of sufficient recovery time or rest; (rest needs to be commensurate with the nature and level of prior effort expenditure, and with level of sleep debt).

9. The above definition of fatigue is closely based on that of Job and Dalziel (2001) and is consistent with many other published definitions. These authors defined fatigue as follows:

> “Fatigue refers to the state of an organism’s muscles, viscera, or central nervous system, in which prior physical activity and/or mental processing, in the absence of sufficient rest, results in insufficient cellular capacity or systemwide energy to maintain the original level of activity and/or processing by using normal resources.” (p.469)

10. It follows from Job and Dalziel’s definition that major causes of fatigue are activities entailing: muscular exertion, prolonged attention, attention to a repetitive stimulus, prolonged performance of a complex or repetitive task, and combinations of such activities. It is important to note that the effects of ‘fatigue’ on performance, safety and health can be significantly influenced by interactions with states such as jetlag (or ‘nightshift-lag’), boredom, and stress resulting from a wide variety of factors. These latter states have some characteristics and effects in common with those of fatigue, so they are easily confused with it. However these states do not fall within the above, generally accepted kinds of fatigue definitions.

11. Table 1 (below) presents an analysis of the dimensions of fatigue in relation to their causal factors, along with a similar analysis of these related states.

[3] Civil Aviation Safety Authority, Civil Aviation Orders, Part 48, Section 48, Issue 7, December 2004, Amendment 28.

CAUSAL FACTORS		DIMENSIONS OF 'FATIGUE'			
		Physiological State	**Performance Ability**	**Subjective Experience**	**Performance Outcomes**
Levels of Effort/Energy Expenditure	**Physical**	various indicators of local and/or whole body fatigue	reduced muscular strength and/or physical energy	physical tiredness – discomfort, aches	possible reduction
	Cognitive	mental fatigue – lack of 'mental energy'	reduced mental energy	mental tiredness	possible reduction
	Emotional	emotional fatigue - reduced resistance to stressors	reduced emotional control, increased 'fragility'	emotional exhaustion	possible reduction
Inadequate time to recover from effects of the above factors		any of the above	any of the above	any of the above	possible reduction
Sleep debt (Sleep is needed for more general, systemic recovery from the fatiguing effects of simply being awake)		low energy – general	reduced – general	tired – general	possible reduction
CAUSAL FACTORS ARE DIFFERENT FROM THOSE OF FATIGUE (based on usual *definitions* of "fatigue")		**Dimensions of other states that are commonly confused with fatigue,** and that may *interact* with fatigue e.g. 'jetlag' (or **'nightshift-lag'**), **boredom**, **stress**			
Circadian disruption		Abnormal states	variable	tired but variable	possibly reduced
Monotony		low arousal	unaffected (or only brief reduction)	boredom, possibly stress	reduced
Inadequate mental challenge		low arousal	unaffected	low motivation, possibly stress	reduced
Stressors- i.e. factors that threaten coping ability – may include all of the above plus many others		a complex syndrome of indicators, including some of the above	likely to be reduced	various anxiety-related, negative emotions, possibly including the above	variable

Table 1. The top section of this table shows the set of personal states that comprise 'fatigue' in accord with most definitions; in the bottom (shaded) section of the table are some similar but – by definition – *non-fatigue* states. Causal factors and performance outcomes are shown for both sets of factors.

12. The need for 'sufficient' rest implies that periods of rest during performance may counteract the fatiguing effects of physical and mental activities. It also allows for the fact that the amount of rest that will be sufficient to avoid fatigue due to energy expenditure must take account of the nature and levels of effort expended, (which will be determined by a

very wide range of other variables as depicted in Figure 1). 'Sufficient' rest will also be determined by the individual's level of sleep debt.

13. As is made clear in Job and Dalziel's definition, increasing fatigue does not necessarily result in deteriorating performance, since it is often possible for an individual to invest additional "resources" (such as more effort) or to adopt different strategies (e.g. lowering their target level of performance quality), to compensate for reducing performance capacities. Or people may resort to chemical stimulants in an attempt to sustain the abilities they need to maintain satisfactory work performance. In accordance with this, the right-hand column in Table 1 shows "possible reduction" in performance as a result of fatigue states (top half of the table). In contrast, the bottom half of Table 1 shows states such as boredom or low morale, which stem from monotony or lack of sufficient challenge, to cause poorer performance. Another noteworthy feature of Table 1 is its suggestion that the subjective experience of states such as fatigue, circadian disruption, boredom and stress can be very similar, which means that they do not – at least when taken alone – provide a reliable means of identifying their various causal factors.

14. The focus of Table 1 is on fatigue itself. Figure 1 (below) provides a much broader perspective, depicting fatigue (the dimensions of which are detailed in Table 1) within the broader context of the overall work system; the arrows depict causal linkages between variables.

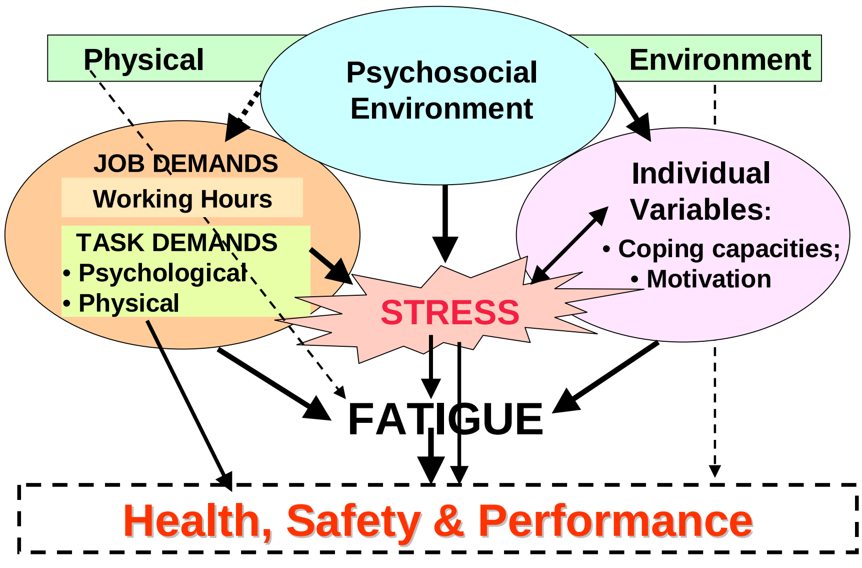

Figure 1. Relationships between job demands, physical and psychosocial environment factors, individual variables (relatively stable personal characteristics), more transient personal states such as stress and fatigue, and system outcomes such as work performance, health and safety.

15. In this figure, factors influencing fatigue are categorised as: Job Demands, incorporating the physical and psychological demands of performing specific work tasks as well as overall job demands and working

hours; Individual Variables which determine coping capacities and performance strategies; Psychosocial Environment variables such as Job Control (likely to influence the variety of fatigue management strategies available to individual workers) and Interpersonal Relationships, which can have a major influence on workplace stress levels; Physical Environment variables such as heat, vibration and noise, which can significantly affect individual vulnerability to fatigue, and Stress which, like fatigue, is a personal state intervening between workplace variables and health and safety outcomes.

16. Fatigue is often measured using subjective, performance and physiological indicators, each of which may reflect different combinations of sleep need and task demand and each of which may be affected by motivational and environmental factors. Hence the relationships between subjective, performance and physiological indicators of fatigue at any given point in time and across time are not straightforward. Different types of measures make different assumptions about how fatigue behaves across time[4]. Therefore it is difficult to apply a broad based approach to fatigue management in the workplace. There is need to take into account the nature of the work performed, the skills and capacities of the person to perform the work as matched against the requirements of the task, the effects of fatigue on performance and the potential consequences of performance decrements.

Data Analysis

17. An unpublished study completed for the National Occupational Health and Safety Commission (NOHSC) in 2004 indicated that little data on fatigue and work relatedness was available in Australia and what does exist was established largely to serve administrative purposes.

18. As part of the work to progressively improve occupational health and safety (OHS) data, the Office of the ASCC requested the Australian Bureau of Statistics (ABS) collect information on shift work and hours of work in its 2005 – 2006 work related injuries survey (WRIS). Information from this survey is expected to be available in mid 2007.

Recent Australian Research

19. In February 2006, the National Transport Commission (NTC) commenced a research project to examine culture and compliance in the heavy vehicle industry. The research will examine how culture and compliance have been influenced by the fatigue reforms and the compliance and enforcement reforms, to be implemented over 2006 -

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[4] Williamson A (2001) *Fatigue and Performance in Heavy Truck Drivers Working Day Shift, Night Shift or Rotating Shifts,* NSW Injury Risk Management Research Centre University of New South Wales

2007. The project will involve pre and post reform implementation interviews and focus groups with the parties in the chain of responsibility, including drivers, operators and loaders. The sample will also include short haul drivers. This project will assist in gauging the impact of these reforms on a national basis, not just within the transport industry, but within the wider supply chain. The Office of the ASCC is working collaboratively with the NTC on this project, and is a co-sponsor. The results of the first stage of the study are anticipated in October 2006.

20. The University of SA Centre for Sleep Research continued to work with the Australian Rail Consortium to develop fitness for duty programs, particularly focusing on fatigue management. The research developed risk assessment software to assist in quantifying fatigue measures. The final stages of the *Shiftwork and Workload Study* will extend on previous work done to understand the nature of train driver fatigue, using the software to assist in understanding the elements and interactions of risk factors. The next phase of the study aims to determine 'how much' fatigue makes a driver too fatigued to drive a train safely.

21. The group has also received a grant to examine how a risk management approach can be applied to the regulation of working hours more generally within industry. The aim of this project is to develop a scientifically validated tool to assist workplaces to manage job related fatigue associated with hours of work. The initial phase of the study has been completed in the mining industry and the next phase will continue in the rail industry. The Centre has continued various other projects examining fatigue and error management in aviation; the recognition, prevention and mitigation of fatigue in health workers; the effects of fatigue on road drivers, as well as fatigue management in the US rail industry.

22. Winwood, Winefield, Dawson and Lushington (2005) from the University of South Australia developed and validated a scale to measure work-related fatigue and recovery. This study was initiated in response to empirical studies that linked persistent failure to recover from acute fatigue to the evolution of chronic fatigue. Current measurement scales for fatigue do not adequately distinguish between the chronic and acute elements of fatigue and none included a measure of effective recovery from fatigue. This study produced a 15 item Occupational Fatigue Exhaustion Recovery (OFER) scale, which has been validated in study populations of nurses and quarry workers, specifically to measure work-related fatigue. The scale was found to possess robust psychometric characteristics and the three sub-scales identified and distinguished between chronic work-related fatigue traits, acute end-of-shift states and effective recovery between shifts. The OFER scale is likely to provide valuable information on understanding the role of between shift recovery in the evolution of persistent fatigue but requires further research in study populations from different industries.

23. The Minerals Industry Safety and Health Centre at the University of Queensland conducted research on the relationship between hours of work and incidents in the coal mining industry (Cliff 2006). The study aims to provide data to assist in the evaluation of the effectiveness of mining industry guidelines, regulation and risk management processes for addressing hours of work. The study analyses current mining rosters by time of day and day of roster, with the aim of identifying high incident periods. This research is still in progress, however preliminary results indicate that coal mining data appear to be at variance with incident reporting patterns experienced with classical roster patterns and hour of work data. It is commonly reported that higher incident rates occur on the night shift. However, the preliminary findings of this research show that night shift may have a lower incidence rate than day shift, suggesting that fatigue management systems may be effective in reducing risk or that the mining work force differs from urban work forces, making miners more resilient to the effects of fatigue.

24. Friswell, Williamson and Dunn (2006) from the University of NSW have undertaken research and produced three papers on the effects of fatigue on safety and performance in the short haul light trucking sector in NSW.

25. In their study *Road transport work and fatigue: A comparison of drivers in the light and long distance heavy vehicle road transport sectors*, the report suggests that the nature of fatigue-related incidents will be shaped by the types of demands that the driving environment places on the driver. Light truck drivers tend to work day time hours, but the hours can still be long, with significant numbers of stops for pick ups and deliveries (with associated manual handling) and heavy traffic in urban areas. The study found that fatigue is more likely to be manifested in impairments in their ability to deal with the demands of an urban driving environment, such as poor awareness of traffic and poor attention to signs, having near misses or colliding with something. The study noted that despite showing significant effects of fatigue both personally and on road safety, light truck drivers did not often have a good awareness of it as a problem for them. The study also found that heavy truck drivers often work at night, with a significant number working extremely long working hours. Demands for this group will include more monotonous rural highway driving and time spent waiting for loading and unloading. They were more likely to show impairments in dealing with the demands of a non-urban driving environment (failing to maintain speed and running off the road) and the demands of controlling a very large vehicle (poor gearing and poor steering).

26. In their study *Driver Perspectives On Work, Fatigue And Occupational Health And Safety In The Light And Short Haul Road Transport Sector*, views were sought from drivers operating short haul vehicles as couriers, taxis, express delivery and carrying mixed freight. Most time was spent driving, with 20% of time relating to freight preparation (average 26 stops per day) loading and unloading, with the average work week being 50

hours per week. The study found that driver fatigue was common, with around 40% of drivers reporting experiencing fatigue at least once per week. The risks for short haul drivers included workload and workload pressure and these played a greater role than circadian factors and sleep debt (which is one of the strongest predictors of fatigue in long haul drivers). The strongest predictors for short haul drivers were: long work hours, high workload and door to depot work. Stress was associated with fatigue. The report noted that workplace injuries associated with manual handling were common (40% in last year) for short haul drivers, and the strongest predictors of likelihood of injury were related to vehicle issues (design) and stress arising from workload pressure.

27. In their study *Company Perspectives On Work, Fatigue And Occupational Health And Safety In The Light And Short Haul Road Transport Sector*, representatives of companies who employed or contracted light and short haul drivers, and drivers themselves, were surveyed to examine the views and experiences of companies and drivers on work and safety issues and to compare them. The study found that drivers mainly worked day shifts and most worked 45 hours per week, although some worked up to 72 hours per week. Driving occupied around half of the time in a shift, with loading and sorting activities dominating the remaining time. Each shift involved around 35 freight stops on average. The study noted that companies and drivers reported different views on some aspects of driver fatigue. Unlike drivers, company representatives did not regard fatigue as a significant problem for the light trucking sector and were also more likely to attribute fatigue problems to individual behaviours than to organisational factors.

Recent International Research

Health Industry Related Research

28. Arnedt, Owens, Crouch, Stahl, and Carskadon (2005) from the University of Michigan assessed the effects of hours of work, workload and alcohol on the performance of 34 resident medical officers over a four week period. The residents attended a test session during the final week of a light call rotation and the final week of a heavy call rotation. During these sessions, residents were given either alcohol or a placebo for alcohol. The study examined four conditions: light call (defined as day clinics, averaging 50 hours per week); heavy night call (defined as intensive care work, averaging 90 hours per week, with every fourth night on call); light call with ingestion of alcohol (0.04g - 0.05g % per 100 ml of blood) and heavy call with placebo. All participants achieved the target blood alcohol concentration. Compared to light call duties, the alcohol affected reaction times were 7% slower and commission errors were 28% higher. On standardised driving tests, lane variability and speed variability were 27% and 71% greater respectively. Speed variability was 29% greater in the heavy call with placebo condition than in the light call with

alcohol condition. Reaction time, lapses and omission errors were not different. Residents' post heavy call performance was equivalent to or worse than the impairment observed at 0.04 – 0.05% blood alcohol concentration, as measured by sustained attention, vigilance and simulated driving.

29. During the study, residents were also asked to indicate their perception of performance. Results indicated that the residents' capacity to self assess their performance was limited and highly task dependent. The study concluded that resident performance impairment post heavy call is equivalent to or worse than the impairment observed at 0.05% blood alcohol concentration, as assessed by sustained attention, vigilance and simulated driving tasks standardised tests.

30. In January 2005, the National Institute of Occupational Safety and Health (NIOSH, USA) reported on a NIOSH funded prospective study into the association between extended shifts by medical interns and their risk of car crashes. The study, reported in the New England Medical Journal (Barger et al, 2005) found that medical interns who had worked shifts of longer than 24 hours were more than twice as likely to have a crash and five times as likely to have a near miss event, compared to a shift not of extended duration. The study recruited 2737 interns from across the USA, who recorded 17 003 self reported monthly surveys detailing work hours, frequency of shifts greater than 24 hours and driving safety records. The risk increased by 16% for those interns working five or more extended shifts in a month. NIOSH acknowledged that this study demonstrated that the impact of overly long work hours and fatigue extends beyond the hospital working environment and poses significant risks for other sectors of society.

Construction Industry Research

31. The effect of long work hours and work scheduling on the occurrence of work-related injuries has been examined in construction workers in the USA (Dong 2005). This study used data from the 1979 cohort of the National Longitudinal Survey of Youth. These subjects were interviewed annually from 1979 to 1994 and then bi-annually from 1996. The 1988 survey introduced a series of questions on work-related injuries and illnesses, enabling tracking of work histories in the construction study. The work hours were also drawn from the National Longitudinal Survey of Youth. Overtime was defined as working greater than 8 hours per day and greater than 40 hours per week. Workers working greater than 8 hours per day had higher injury rates than those working less than 8 hours per day (15% versus 10%). Among the production workers in all industries, including construction work, the injury rate increased steadily with increasing hours of overtime. A significant relationship was not demonstrated with construction workers alone, due to insufficient statistical power in the sample. Where hours increased above 50 hours per week, the risk of injury almost doubled.

32. The results of this study found that the risk of injury increases with long work hours when other variables are held constant. Construction workers working long hours were significantly more likely to be involved in a work-related injury. The study found that work schedules of construction workers differed from workers in other industries in that they started work earlier, worked longer days and fewer weeks and were more likely to hold multiple jobs and to change jobs. Given the higher risk for long work hours in construction observed in this study, it is more likely that it is the length and other dimensions of work hours in construction that contribute to safety risks, rather than the night shift work that has been the focus of much previous research. The findings from this study suggest that work hours should be limited to 48 hours per week.

Transport Industry Research

33. A study by Sabbagh-Ehrlich, Friedman and Richter (2005) in Israel aimed to identify occupational and individual predictors of fatigue, falling asleep at the wheel and involvement in crashes. Trucks represent 6% of all vehicles in Israel but represent 20% of road deaths, even though travel distances are usually less than 200 km and overnight travel is uncommon. Field interviews of 160 drivers examined driver characteristics, workplace and driving conditions, employment relations, sleep quality and fatigue. One day prior to the interviews, 38% of drivers had exceeded the 12 hour driving time limit. More than 30% reported falling asleep at the wheel recently and 13% had previously been involved in a sleep related crash. Forty two percent of drivers reported that their employers forced them to work beyond the legal 12 hour daily limit. Involvement in a crash with casualties was associated with poor sleep quality. Drivers' self assessment of fatigue underestimated fatigue levels measured using the Pittsburgh Sleep Quality Questionnaire. However fatigue occurred in many drivers without sleep problems and many crashes occurred without fatigue. The study concluded that self assessment of fatigue was an insensitive measure. Prevention measures were required to address work stress, to screen drivers for health related risk factors and to examine methods of speed control and shift arrangements in this sample of drivers.

34. Rail worker fatigue risks were examined in a study by Her Majesty's Rail Inspectorate in the United Kingdom (Dickinson 2005). The study reported on targeted inspections of 8 train and freight operating companies using the Fatigue Index developed by the UK Health and Safety Executive. The Fatigue Index is based on 5 main factors – shift start time, shift duration, time between successive shifts, breaks and number of consecutive shifts. The study used the Hidden limits[5] to assess compliance. The Hidden limits applied to safety critical workers are 12 hours shift, with a 12 hour rest period between shifts, a limit of 72 hours

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[5]From the UK Railway Group Standard GH/RT 4004 Changes in Working Hours – Safety Critical Work Appendix 1.

work time per week and a maximum of 13 consecutive duty days. These limits were developed on working hours that were achievable in the late 1980s rather than based on any scientific or technical evidence.

35. The study found that all rail operating companies had comprehensive arrangements for controlling hours of work and all drivers had been identified as safety critical workers. Shifts greater than 10 hours were consistently reported by drivers as too tiring. All drivers had been issued with a booklet on coping with shiftwork. Drivers from all companies reported it was impossible to follow some aspects of the guidance. The Fatigue Index indicated that risks usually resulted from successive, very early, long shifts where there were more than four consecutive early starts. Persistent late running trains were identified as a problem that impacted on managing fatigue, yet these patterns were not addressed in roster design. The study concluded that while there were high levels of compliance with the Hidden limits, drivers were frequently feeling fatigued.

General Fatigue Research

36. A Chinese study by Hsin-Chieh, Wen-Hsin and Toly Chen (2005) examined the effect of high intensity physical work on fatigue and recovery. The findings indicated that in high intensity work where the worker continues working until exhaustion, physiological recovery time was significantly longer than subjective recovery time. Participants felt they had achieved recovery while physiological measures indicated signs of strain. Heart rate recovery time was significantly longer than respiratory recovery time. The high intensity work was mainly attributed to lower limb muscular efforts and in adults in 20-30 years age group.

37. Folkard and Lombardi (2006) examined the risk of injuries and incidents associated with features of work schedules from published epidemiological studies. The study pooled the results of injury and incident reports using an additive model to form a “Risk Index”. Only studies that calculated a relative risk estimate were included. The estimated risk of an incident for various standard work schedules was examined using the proposed model. The model is restricted to providing estimates of risk for injuries and incidents, acknowledging the various methodological difficulties in attempting to examine impacts on health measures. These challenges have been illustrated in a survey of more than 2000 aircraft engineers, which measured normal hours worked per week and the reported prevalence and incidence of health problems and illnesses. The survey found that the frequency of cardiovascular symptoms decreased with increasing work hours. It is probable that this finding reflected a self selection bias of the fittest workers into longer working hours.

38. Additionally, the data indicated that age was negatively correlated with normal work hours, such that on average, older workers worked fewer hours per week. Thus any relationship between chronic (or long

term) health effects may be confounded by age and in many cases, these chronic health outcomes required long induction and latency times to emerge. Ideally any examination of the impact of long hours on health needs to control for both age and years of experience, which typically are highly correlated.

39. While many studies report that fewer injuries are sustained during the night, the results of this study suggest that the reported night injuries tended to be more serious. The study found that the risk of injury varies substantially depending on how the work hours are comprised. The risk depends on the length and type of shift, as well as the frequency of rest breaks. The authors concluded that placing a limit on the risk associated with a particular work schedule is likely to be more effective than setting daily, weekly or monthly work hour regulations in keeping workplace safety within acceptable limits.

40. The efficacy of naps as a fatigue counter measure was examined by Driskell and Mullen (2005) in a meta-analysis study that aimed to identify the strength and significance of the effects of naps on performance and feelings of fatigue. The study used data from 23 studies that met inclusion criteria. The results of the analyses may be useful in predicting nap efficacy as a function of length of the nap and post nap interval. This information may assist in designing jobs and optimal work schedules to minimise the effects of fatigue, particularly in those jobs where tolerance for error is low and consequence of error is high.

41. The analysis found that performance improved after longer naps and the beneficial effects of naps deteriorated after longer post nap intervals. One of the perceived disadvantages of napping is the potential for post nap inertia, characterised by disorientation and performance decrements immediately following a nap. This study found no variation in fatigue or performance within the one hour period immediately following the nap. The study acknowledges that the nature of task demands and number of hours of wakefulness prior to baseline assessments were important variables which may influence performance but were not addressed during this study. The study concluded that naps are not a solution to the problem of fatigue; however they may provide an effective countermeasure as part of an integrated fatigue risk management program.

42. Further studies from the Maastricht Cohort Study on Fatigue at Work were published during 2005. The series of epidemiological studies are based on a cohort drawn from the Dutch general working population, and commenced in May 1998. A sample of this cohort was selected to study the relationship between psychological distress, fatigue and long-term sickness absence (Bultmann, U., Huibers, M., Ludovic, P., van Amelsvoort, M., Kant, I., Kasl, S. and Swaen, G. 2005). The study sample consisted of 8840 men and 3255 women, recruited from 45 different companies. Fatigue was measured on a scale that examines various aspects of

fatigue, including severity, concentration, motivation and physical activity level and was validated in the working population.

43. To examine the role of fatigue in this study, subjects were allocated into four mutually exclusive categories: the reference group, cases of psychological distress only, cases of fatigue only or cases with both psychological distress and fatigue. The findings indicated that for men, having psychological distress alone or having psychological distress combined with fatigue was associated with future long-term sickness absence. However, in women, it appears that psychological distress and fatigue act additively to produce an effect because only the combination was strongly associated with long-term sickness absence. This study points to the need for workplaces to manage the psychosocial elements of work, including job and work organisation to minimise the risk for fatigue and psychological distress.

44. The Scandinavian Journal of Work, Environment and Health ran a series of papers on fatigue in 2005. In an editorial comment, Kecklund stated that it is common for many workers to like to maximise their daily work hours to increase their days off. Thus many workers do not regard long hours as harmful to their health and safety. Kecklund felt that the public's awareness of the risks of long work hours should probably be increased.

45. The results of Dong's construction study, which appeared in the same edition, indicated that at least for industrial workers, the European work hour directive is not a safe limit for preventing work-related injuries. These results, along with other studies suggest that the maximum shift duration should not exceed 12 hours and should probably be shorter for certain shifts, such as nights. It also suggests that work weeks of longer than 48 hours are likely to be associated with a considerable increase in injury risk.

46. A prospective study of the effect of shiftwork experience on age and cognitive performance by Rouch, I., Wild, P., Ansiau, D., and Marquie, J. in 2005 examined a cross-sectional sample of 3237 French workers aged 32, 42, 52 and 62 years of age. Data on working hours, shift work and sleep patterns was collected by questionnaire. Cognitive abilities were tested using memory, retrieval and information processing tests. Current shift-workers were found to have lower cognitive performance than workers never exposed to shift work. In the same population, memory performance also declined with increasing shift-work duration. Among former shift-workers, the cognitive performance of those who had ceased shift-work more than four years ago suggested a reversibility of effects.

47. The study concluded that cognitive functioning tends to be impaired by long-term exposure to shift-work. The results of this study showed no interaction between age and shift-work, indicating that shiftwork had the same effect on cognitive performance at every age.

48. Holland (2006) examined the effect of shiftwork related fatigue on the family life of train operators. The study used semi-structured interviews of train operators employed within one large transportation company. The study used naturalistic inquiry methods to identify common themes emerging from interviews and examined these further in focus groups to identify relationships. Participants described fatigue as the inability to function optimally both physically and mentally.

49. The study found that family support represented an important mechanism for managing and coping with fatigue. In this study, family support was considered to comprise understanding of the physiological and emotional issues arising from shiftwork and erratic work schedules. Workers reported that fatigue impacted every facet of their lives. They placed greater weight on the impact of fatigue on their family and personal relationships than they did on their own health and safety.

50. The study recommended strategies for health and safety professionals to intervene to reduce the impact of fatigue on shiftworkers. In achieving effective fatigue management programs, the study recommends that the enterprise share responsibility with the workers for managing fatigue. Such strategies should include educating families and including them in the decision making process on shift arrangements to improve support and participation.

51. A two year longitudinal study of 526 Dutch truck drivers and 144 nurses examined workers' capacities to recover from work related fatigue due to long working hours (De Croon, E., Sluiter, K. and Frings-Dresen, M. 2006). Their Need for Recovery (NFR) Scale was used to assess participants' state of recovery at two weeks, one year and two year intervals. Participants were classified according to the 'stability' of their work environments.

52. The degree of stability was quantified by four events that may have occurred during the follow up period. These events were – reorganisation or merge; a change of supervisor or management; a change in working hours or schedule; or a change in work activities. The four scores constituted a work stability index. The NFR scale was able to discriminate between groups whose hours of work increased and those whose hours had not changed. The average increase in working hours was 5 hours per week.

53. The study concluded that the test and retest reliability of the NFR scale indicates it could be used to safely monitor difficulties workers may have recovering from work related exertions over time or to make inferences over longer periods of time. Therefore this measurement scale may be useful in evaluating interventions aimed at reducing fatigue related to work.

Consultation and Collaboration

54. In preparing this paper, a range of researchers, jurisdictional representatives and road transport authority representatives responsible for commissioning research were consulted on current developments.

Conclusion

55. Fatigue research has not yet produced a significant body of evidence based data that clearly delineates the relationship between work patterns, job/task demands, sleep duration and worker performance (Dawson, D. and Zee, P. 2005).

56. Many studies are poorly designed and controlled and use poorly defined measures. This results in difficulty in drawing conclusions from the existing literature that could serve as a guide to policy advice. Hence there is a need to develop more specific multi-method exposure assessment tools to minimise the variability of measures and definitions used in fatigue research in general. This lack of specificity creates difficulty in drawing comparisons and meta-analysis for epidemiological purposes.

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