Shiftwork, sleep, fatigue and time of day: studies of a change from 8-h to 12-h shifts and single vehicle accidents

Vitale Di Milia
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SHIFTWORK, SLEEP, FATIGUE
AND TIME OF DAY: STUDIES OF A CHANGE
FROM 8-H TO 12-H SHIFTS AND SINGLE VEHICLE ACCIDENTS

A thesis submitted in fulfilment of the
requirements for the award of the degree

DOCTOR OF PHILOSOPHY

from

UNIVERSITY OF WOLLONGONG

by

VITALE DI MILIA
BA (Hons); M. Ed. Studies

DEPARTMENT OF PSYCHOLOGY

1999
I, Vitale Di Milia, declare that this body of work has not been submitted for a degree to any other university or institution, and that the work contained within is my own.

Signed: 

Dated: 
I dedicate this thesis to my parents: Rocco and Antonia Di Milia.

I cannot begin to understand the sacrifices that they endured in order to provide me with every opportunity for a better quality of life. I hope that this thesis is a small reward for their love and support.

My father was a shiftworker and I do not recall him much in my life.
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ABSTRACT

The thesis presents the findings from three separate studies. The first two studies (chapter two) are concerned with the impact of the compressed workweek (CWW) on the well-being of shiftworkers. One study was based in a Coal mine and the other, in a Steelworks. The Steel study also included an interview of the shiftworkers (Chapter three), an analysis of absenteeism (Chapter four) and safety (Chapter five). The third study (Chapter six) made use of a road accident database to demonstrate the effect of time of day on the distribution of single vehicle accidents (SVA). In addition this database also allowed an investigation of the omission recording errors by shiftworking policeman as a function of time of day (Chapter seven).

The Coal and Steel studies used a longitudinal repeated measures design to examine the impact of a change from a continuous weekly 8-h shift to a continuous fast rotating 12-h shift. In both these studies, survey and sleep data served as dependent measures. The survey material was primarily based on scales from the Standard Shiftwork Index (Barton et al. 1995). Sleep data was obtained across complete shift cycles using sleep diaries. The sleep data were examined in terms of the expectations from the Sleep Deprivation Model (Tepas & Mahan, 1989). The quantitative analysis of these data were supported by some qualitative analysis of changes in sleep pattern. Specifically, changes in the daily deviation from mean sleep and cumulative sleep gain/loss across the shift cycle, between 8-h and 12-h shifts were examined.

In the Steel study, the effect of the change to 12-h shifts was further supported by additional studies. The interview study (chapter three) had two primary aims. The first was to gain a more comprehensive understanding of the change in rotation speed and shift length by interviewing the shiftworkers. The second was to explore the changes in sleep strategies as a result of the change to a faster rotation. Shiftworkers
completed 'estimated' sleep durations based on a number of hypothetical shift patterns and provided a rationale for these choices.

Consistent with many studies, strong support was found for 12-h shifts and this was attributed to the increased time away from work and the reduced number of consecutive night shifts. In general, a number of SSI measures showed improvements but few were significant.

Self report and interview data both recorded shiftworker awareness of trading sleep loss for social gain. The intent to leave shiftwork was reduced but nonetheless present on 12-h shifts. This suggested that 12-h shifts do not solve, but reduce the problems associated with shiftwork. In the Coal study, shiftworkers reported a willingness to 'slow' their 12-h shifts to provide more rest days between work periods. Other indicants of fatigue were self reported increases in sleep need and changes in napping behaviour.

No main effects for total sleep time (TST) were found between 8-h and 12-h shifts. Mean TST was achieved by a marked redistribution of sleep on 12-h shifts. In particular, 12-h shifts were associated with significant reductions in sleep for night shifts and increased sleep on day shift and days off. These findings need to consider the high probability of a type II error due to the low power findings associated with the small sample size, expected effect size and choice of alpha.

While the changes in mean TST were of interest, the sample size also allowed for an extensive analysis of complete sleep records as a function of the change in shift schedules. In particular, it was suggested that changes in mean distribution of TST may be a more important indicant of fatigue than simply using the mean as the marker.

The effect of the faster rotation on cumulative sleep gain/loss across the shift cycle provided mixed results. In the Coal study, the number of shifts worked and the total number of days in the cycle when mean daily sleep was below the cycle mean
sleep average, decreased on 12-h shifts. In the Steel study, the number of shifts worked increased when mean TST was below the mean for the cycle but an improvement was found for the total number of days. These differences may be attributed to the different forms of the 12-h shifts in the two studies.

Absence (chapter four) in the Steel study was significantly less on 12-h shifts but this was best explained by a remuneration policy that no longer provided overtime payment. A case study analysis of absence suggested that absence was used in combination with other factors to redesign the shift schedules.

During 8-h shifts absence was used to 'compress' the workweek and overtime was used to increase mean earnings. On 12-h shifts, absence was augmented by examining when single days of annual leave and small periods of annual leave, were taken across the shift cycle (non-attendance). This analysis suggested non-attendance was used to reduce exposure to three consecutive shifts, especially night shifts. This strategy also served to increase the number of days off from two to three days. The interview data also reported three night shifts were problematic and that two days off were insufficient.

The change to 12-h shifts in the Steel study had no effect on safety (chapter five). This is most likely due to the fact that accidents are rare events and that too short a time period for comparison had elapsed. Nonetheless, some indication of increased accident frequency was found for the same time of day on 12-h shifts.

The methodological and practical difficulties of examining performance in the Coal and Steel studies, led to the use of a road accident database to demonstrate the performance implications by time of day. This database was used to conduct two studies. Chapter six examined the time of day distribution in single vehicle accidents by driver age, gender and day of the week. Chapter seven examined the time of day variability in omission errors by shiftworking police officers.
The time of day accident distribution for SVA was in line with international findings (Horne & Reyner, 1995a, 1995b). Correcting the accident rate for traffic density suggested the greatest accident risk was at 03.00, with a secondary peak at 14.00. The effect of age, gender and day of the week on accident frequency was also demonstrated. These data were also used to develop an alternative method to using traffic density to adjust accident frequency. The Driver Characteristics Model may provide a better measure for examining the effects of sleepiness. The timing of these single vehicle accidents suggested the influence of the sleepiness rhythm on performance, after a number of other accident causation factors were removed from the analysis.

This database also reflected the accuracy in accident form completion of shiftworking policemen. Performance was lowest at 02.00 but a clear afternoon peak was not obtained. The error rate was found not to be related to accident severity or workload. This analysis also suggested that night time performance is sensitive to task differences.

The final chapter seeks a synthesis of the studies presented in this research. In particular, it makes some additional comments concerning methodology and some recommendations for designing 12-h shifts. Key limitations to these results and suggestions for future study are also made.

While 12-h shifts are clearly supported by employees, it is reasonable to suggest they are superior in comparison to poorly designed 8-h shifts (Lowden et al. 1998). Therefore, innovative shiftwork solutions need to be developed and tested, in order to provide flexibility and a safe working environment. A key message is that 12-h shifts may reduce chronic exposure but not the total exposure to night work. Therefore, innovative shift systems need to reduce the number of night shifts and not repackage the same number of night shifts into smaller blocks.