Shift work, sleepiness and long distance driving

Article *in* Transportation Research Part F Traffic Psychology and Behaviour · July 2006

DOI: 10.1016/j.trf.2006.01.006

1 author:

Lee Di Milia
Central Queensland University

Available online at www.sciencedirect.com

SCIENCE DIRECT®

Transportation Research Part F 9 (2006) 278–285

TRANSPORTATION RESEARCH PART F

www.elsevier.com/locate/trf

Shift work, sleepiness and long distance driving

Lee Di Milia *

Department of Psychology, University of Connecticut, Storrs, CT 06269, USA

Received 30 May 2005; received in revised form 23 January 2006; accepted 25 January 2006

Abstract

A structured interview was used to collect data from 1579 passenger vehicle drivers over a 10-week period. Approximately 11% of these drivers were shift workers (SW) who had completed night shift and the balance were non-shift workers (NSW). The mean one-way driving distance was 211 km (SD = 84) and 213 km (SD = 162) for SW and NSW respectively. The majority of SW (76%) did not plan to take a driving break and some intended driving up to 600 km. SW reported taking approximately 6.5 h of sleep the day before the drive compared to NSW who had a full nights sleep. Mean sleepiness ratings based on the Karolinska Sleepiness Scale (KSS) suggested SW were significantly more sleepy ($M = 4.64$) than NSW ($M = 2.98$). Approximately 19% of SW were classified with severe sleepiness (KSS $\geqslant$ 7) compared to 1% of NSW and this suggested SW had a greater incidence of safety relevant sleepiness. Severe sleepiness has been linked to driving impairments and is therefore, of concern for the safety of the individual and the wider community.

Keywords: Driving; Road safety; Shift work; Sleepiness; Extended shifts

1. Introduction

The safety and well-being of workers is of paramount importance. Shift work including night work, is considered a key risk factor with recent studies highlighting workers are exposed to an increased accident risk across consecutive night shifts (Folkard & Tucker, 2003). In addition to on-shift exposure to possible harm, driving home following night shift is an additional safety risk faced by workers (Costa, Tieghi, & Chiesi, 1986). The literature has consistently reported increased levels of fatigue and sleepiness in night workers (Åkerstedt, 2003), and both are regarded as major risk factors in vehicle accidents (Horne & Reyner, 1995; Philip, 2005). There are few direct studies of shift workers and driving risk but the available literature suggests working night shift is linked with increased driver sleepiness and self-reported driving impairments (Heslegrave, Rhodes, & Gil, 2000; Rogers, Holmes, & Spencer, 2001).

* Permanent address: School of Management and CRC for Integrated Engineering Asset Management, Central Queensland University, Rockhampton, QLD 4702, Australia. Tel.: +61 7 4930 9422; fax: +61 7 4930 9700.
E-mail address: v.dimilia@cqu.edu.au

1369-8478/$ - see front matter
doi:10.1016/j.trf.2006.01.006

Sleepiness refers to the degree of difficulty in staying awake while completing a task (Carskadon & Dement, 1982). One of the strongest findings in the literature is that night workers typically report high levels of both subjective (Åkerstedt, 2003) and objective sleepiness (Kecklund & Åkerstedt, 1993). The mechanism that best explains sleepiness is the combined influence of circadian factors and sleep's homeostatic function (Folkard, Åkerstedt, Macdonald, Tucker, & Spencer, 1999). Night shift is routinely associated with chronic sleep loss (Tepas & Mahan, 1989) and a number of laboratory studies have linked sleep loss with impaired performance on a number of monotonous and passive tasks that are relevant to long distance driving. These include reaction time (Philip et al., 2003), mental performance (Van Dongen, Maislin, Mullington, & Dinges, 2003), vigilance, hand–eye co-ordination and visual discrimination (Williamson, Feyer, Mattick, Friswell, & Finlay-Brown, 2001).

Estimates of sleep related road accidents are of some magnitude and therefore, sleepiness is a concern for the safety of the wider community. Horne and Reyner (1995) estimated sleep related accidents accounted for some 15–20% of accidents attended by police on urban roads and motorways in the UK. Estimates from the USA suggest that sleepiness is responsible for 1–3% of highway crashes and that some 96% of crashes involve passenger vehicles (Knipling & Wang, 1994). Sleep related road accidents typically result in death or serious injury due to the high speed of vehicles on impact (Horne & Reyner, 2001).

Survey studies suggest that working arrangements and sleep loss are implicated in driving accidents. Stutts and her colleagues (2003) concluded sleep related accidents were more likely in drivers with multiple jobs, had worked night shift and had taken insufficient sleep prior to the accident. Similarly, 43% of drivers cited night work, working overtime, shift work and working more than one job as factors for being 'drowsy' when driving (McCartt, Ribner, Pack, & Hammer, 1996). Fell and Black (1997) also reported the majority (57%) of accident drivers did not have a full night sleep prior to the accident.

Sleep truncation resulting from the need to rise early to travel to work is another factor associated with road accidents. The amount of truncation is a function of the time needed to travel to work (Folkard & Barton, 1993). Di Milia and Bowden (2006) reported some workers left home at 03:00 and drove some 230 km to commence day shift. Approximately 13% of these drivers indicated falling asleep at the wheel in the previous twelve months and this resulted in a number of lane drift incidents including running off the road. Drivers involved in these incidents reported sleep durations of up to 5 h. Independent of shift work per se, driving during the early morning hours is associated with the greatest accident risk for single vehicle accidents due to circadian influences (Garbarino, Nobili, Beelke, De Carli, & Ferrillo, 2001).

Shift length and journey time are other variables that may influence driver safety. Rogers et al. (2001) concluded workers on 10 h and 12 h shifts were more tired driving to and from work, and at greater risk of falling asleep following night shift. More specifically, reduced sleep durations ($\leqslant$6 h) and long travel times (>35 min) were associated with increased sleepiness and impaired driving performance. Heslegrave et al. (2000) compared the driving behaviour of miners changing from 9 h to 12.5 h shifts with a 30-min commute. The longer shifts were associated with increased attention lapses, falling asleep at the wheel, near misses and accidents for both day and night shift. One limitation of these studies is that they did not examine sleepiness as a function of the number of consecutive night shifts. While extended shifts per se are considered to increase fatigue (Rosa, 1995), their combination with long distance driving suggests they may be a cause for greater concern.

The literature suggests that driving after the night shift is linked with increased sleepiness and one may assume this relationship even more problematic in the context of long distance driving. However, with the exception of Di Milia and Bowden (2006), there appear to be no published field studies of shift workers that have directly examined the impact of extended shifts and long distance driving on sleepiness and driver behaviour. It may be possible that workers recognise the risk of extended wakefulness and take some sleep before the journey. Do drivers plan to travel directly to their destination or do they factor rest breaks into the journey? Does the number of days off in the work schedule influence the return journey?

The opportunity arose to examine these questions by collecting data from shift workers living in a rural coal-mining district located some 2–3 h drive from the east coast of central Queensland (Australia). Anecdotal reports indicate some workers regularly travel these distances during breaks in the work schedule. The aim of this study is to provide empirical support for the distances driven following night shift and the timing of the journey. In addition, the study will provide an estimate of the driver's sleepiness, their planned driving strategy and return travel plans. Furthermore, the study will also examine sleepiness ratings as a function of the number of consecutive night shifts worked.

2. Method

2.1. Setting and procedure

Driver sleepiness is a key road safety issue in central Queensland and police requested the author to design a brief structured interview form to collect data from passenger vehicle drivers. Police indicated the results would inform a subsequent driver education campaign.

Two data collection sites were established in the ‘Northern’ and ‘Central’ coal districts. The sites were approximately 350 km apart and were located on the highway to the coast. Data were collected over a 10-week period and covered weekdays only: week one began on Monday, week two on Tuesday and so on. Vehicles were randomly stopped in blocks of 2–5 cars between the hours of 08:00 and 10:00. These times were selected as estimates of when night workers may pass through the sites given that the majority of night shifts ended at approximately 07:00.

Police followed a standard procedure. All drivers underwent a blood alcohol concentration test (BAC, <0.05) followed by a licence check. Drivers were then asked to volunteer for a brief study concerning their recent work, sleep and travel plans. Personal and vehicle registration details were not recorded. Ten police officers completed a training session that focussed on accuracy in data collection and role-playing to calibrate their sleepiness ratings.

2.2. Measures

The following data were collected from driver’s: age, gender, work status, distance to be travelled, driving strategy (break vs. no-break), and details concerning their return trip. Those identified as shift workers were asked to indicate their industry grouping, basic details concerning the work schedules and an estimate of their last sleep duration. At the completion of the interview, police estimated the driver’s sleepiness using the Karolinska Sleepiness Scale (KSS; Åkerstedt & Gillberg, 1990). The KSS is anchored with the following descriptors; 1 = extremely alert; 9 = extremely sleepy. Severe sleepiness was defined as a KSS rating of 7 (sleepy, but not yet fighting sleep) or higher (Härmä, Sallinen, Ranta, Mutanen, & Müller, 2002). Pilot testing suggested approximately 3 min to complete the interview.

2.3. Data analysis strategy

The data were examined by the two sites (Northern and Central) since they varied in their distance to the coast. In addition, the data were divided into two driver groups. The shift worker (SW) group comprised of participants who reported having worked a minimum of 8 h during the night prior to the interview and worked day shift elsewhere in their schedule. All remaining drivers were categorised as non-shift workers (NSW).

To examine the impact of consecutive night shifts on sleepiness ratings, male miners working 12 h shifts were divided into two groups: (a) those working up to three consecutive night shifts ($n = 62$), and (b) those working four to seven consecutive night shifts ($n = 61$). In addition, a random group of NSW male drivers was also selected ($n = 61$) for comparison.

3. Results

3.1. Details of sample

Police interviewed 1581 drivers. Two drivers were excluded for failing the BAC test and the balance volunteered to participate (Northern = 682; Central = 897). Records from Queensland Transport suggested these drivers accounted for some 21% of the traffic volume between 08:00 and 10:00.

Of the drivers, 180 were categorised as SW (11.4%), 1375 (87.1%) were NSW and 24 could not be coded. Of the SW, 121 were from the Northern site and 59 from the Central site. Males accounted for 97% of all SW and 67% of NSW drivers. Mean age was 42.56 years (SD = 13.05) and there were no significant differences by site and group. The age range for the entire sample was 17–89 years.

3.2. Working arrangements

Miners accounted for 93% of all SW and the balance were nurses, train and truck drivers. Eighty-nine per cent of SW reported driving immediately following their last night shift and 11% were driving between night shifts. The mean number of completed night shifts before driving did not significantly differ by site (see Table 1). The most common arrangement was working four consecutive night shifts (30%) followed by two consecutive night shifts (29%). The range was from one to 14 night shifts. Shift durations were primarily 12–12.5 h (87%) but a small number of 8 h shifts (2%) were reported. The maximum shift length was 13.5 h.

3.3. Distance travelled and driving strategy

Mean one-way distance travelled did not significantly differ between SW ($M = 211.12$ km, SD = 84.41 km) and NSW ($M = 213.31$ km, SD = 161.97 km). A significant difference was obtained for the distances driven between SW from the Central ($M = 249.17$ km, SD = 105.70 km) and Northern site ($M = 192.56$ km, SD = 64.58 km) $t(178) = 4.44$ $p = 0.01$.

No significant differences were found for mean distance travelled by site, group and driving strategy (see Table 2). However, the large standard deviation underlines the variability in the driving distances for both groups. Of the SW, 76% reported not taking a break and the maximum distance driven was 600 km. The SW taking a driving break (24%) reported a maximum distance of 655 km. Some 11% of SW ($n = 19$) indicated they were travelling between night shifts and the maximum mean distance driven in these cases was 581 km.

The majority of SW (54%) indicated returning home in three to four days compared with 61% of NSW who reported returning home on the same day. Mean return time for SW was 13:15 (SD = 4.69) but the distribu-

Table 1
Working arrangements for shift workers in the Northern and Central sites

Working arrangements	Northern ($n = 112$)		Central ($n = 59$)	
	Mean	SD	Mean	SD
Number of completed night shifts	3.57	1.78	4.12	2.45
Night shift start time[a]	18:61	1.95	18:42	2.95
Night shift end time[a]	06:71	1.20	06:69	1.23
Shift length (h)[a]	11.89	0.83	11.86	1.04

[a] Decimal time.

Table 2
Distance, travel time, sleepiness and sleep between shift workers and non-shift workers by site

	Northern site				Central site			
	Shift workers		Non-shift workers		Shift workers		Non-shift workers	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Drive direct (km)	190.16	66.70	133.21	100.23	230.18	82.65	182.14	94.12
Drive break (km)	207.24	48.73	233.46	190.89	273.27	126.87	367.10	232.36
Same day round trip (km)	281.63	102.01	239.40	165.84	581.50	318.27	343.57	152.97
Return day departure time[a]	13:45	4.51	13:69	3.46	12:33	5.11	13:85	3.66
Sleepiness rating (KSS)	4.92	1.74	3.27	1.06	4.07	1.32	2.78	1.09
Sleep length (hours)[a]	6.61	2.24	NA	NA	6.29	2.27	NA	NA

[a] Decimal time.

Table 3
Sleepiness ratings by percentile scores for shift workers and non-shift workers

Percentile	Shift workers	Non-shift workers
5	3	1
10	3	2
25	3	2
50	5	3
75	6	3
90	7	4
95	7	5

tion was bimodal: 14% indicated returning between 02:00 and 05:00, and 54% between 14:00 and 16:00. The mean return time for NSW was 14:00 (SD = 3.57).

3.4. Sleep and sleepiness

Mean self-reported sleep durations in SW did not significantly differ between the Central ($M = 6.29$ h, SD = 2.27 h) and Northern site ($M = 6.61$ h, SD = 2.24 h). This sleep was taken during the preceding day compared to NSW who reported a full night's sleep before the journey. A significant mean difference (see Table 2) was found between SW ($M = 4.64$, SD = 1.66) and NSW ($M = 2.98$, SD = 1.11) for perceived sleepiness ratings ($F(1, 1554) = 228.55$, $p = 0.01$). The KSS ratings expressed as percentile scores indicated SW to consistently record higher sleepiness ratings (see Table 3). Severe sleepiness ($\geqslant 7$) was identified in 19% of SW compared to 1% in NSW.

One-way ANOVA indicated no significant differences in sleepiness between miners working 4–7 consecutive night shifts ($M = 4.82$, SD = 1.74) and those working 1–3 night shifts ($M = 4.61$, SD = 1.62). A Scheffe post hoc test indicated the NSW group was significantly less sleepy ($M = 2.97$, SD = 1.02) ($F(2, 181) = 28.24$, $p = 0.001$) than the two other groups of workers. The mean age between the three groups was not significant ($M = 40.03$, SD = 11.04).

4. Discussion

This field study is arguably the first to have used a large sample to examine the relationship between night work and sleepiness in the context of long distance driving. The results make a useful contribution to the literature by: (a) providing an estimate of the number of workers undertaking long distance driving and the distances travelled, (b) sleepiness levels, and (c) noting the role of the work schedule in the worker's travel plans. These findings have implications for employers, employees, work schedule design and the road safety of the wider community.

Approximately 11% of SW planned to drive mean distances of 211 km (Northern site) and 249 km (Central site) after having worked a series of 12 h night shifts. However, there was much variability in the mean and the maximum one-way distance at both sites was approximately 650 km. The mean distances were similar to those reported in a study describing the emergence of a 'drive-in, drive-out' workforce in the coal districts (Di Milia & Bowden, 2006). Of concern is that these journeys are attempted in conjunction with a number of road accident risk factors. These include chronic sleep loss following night shifts (Tepas & Mahan, 1989), fatigue from the job demands (Rosa, 1995) and extended wakefulness (Åkerstedt, 2003). Given the SW had been awake since approximately 15:00–16:00 the day before the survey, the minimum amount of wakefulness in workers was about 17 h. A number of studies have concluded 17–19 h of wakefulness impairs simulated performance akin to a BAC of 0.05% and 21–24 h of wakefulness is equivalent to a BAC of 0.10% (Arnedt, Wilde, Munt, & MacLean, 2001; Dawson & Reid, 1997).

Other factors compounding the accident risk include the nature of the drive and long distance driving per se. The highways between the coal-mining district and the coast have long sections of straight roads with little interesting features in the landscape. Monotonous highway driving has been linked to an increased accident risk (Horne & Reyner, 1995; Thiffault & Bergeron, 2003). Long distance driving is also problematic since reaction time is demonstrated to decrease with each hour of driving (Philip et al., 2003) and sleep loss has been shown to degrade simulated driving performance (Williamson et al., 2001). The reported sleep lengths of the SW were similar to those obtained in laboratory studies demonstrating impaired reaction times (Van Dongen et al., 2003).

The finding that sleepiness was significantly higher in SW was consistent with the literature (Rogers et al., 2001). A much greater proportion of the SW (19%) were rated as having 'severe' sleepiness compared to NSW (1%) and this suggests SW face a greater road accident risk than NSW. Sleepiness ratings of 7 have been linked with objective indicators of sleep such as slow eye movements and elevated alpha and theta activity (Åkerstedt & Gillberg, 1990; Gillberg, Kecklund, & Åkerstedt, 1994). In turn, these sleep indicators are associated with performance decrements and vigilance lapses (Gillberg et al., 1994).

A number of driving simulator studies have demonstrated the relationship between high levels of sleepiness and impaired driving (Otmani, Pebayle, Roge, & Muzet, 2005; Van der Hulst, Meijman, & Rothengatter, 2001). Drivers with a KSS of $\geqslant 7$ drove for an average of 43 min before an accident (all wheels outside the lane; Reyner & Horne, 1998). There are consistent findings linking high levels of sleepiness with elevated levels of alpha and theta activity. These EEG indicators have been associated with excessive lane drifting (Horne & Baulk, 2004; Horne & Reyner, 1996). Of more relevance to this study, Åkerstedt and his colleagues (2005) examined the driving performance of 10 SW following a night shift and after a normal night sleep. Driving after the night shift was associated with nine times more accidents, less time before the first accident (83 min compared to 116 min), greater variation in lane drift and longer periods of eye closure (0.10–0.14 s). KSS ratings were significantly higher following night shift and increased with time on task. Ratings of 7 were achieved within 15 min of driving following the night shift compared to 5.5 after 65 min of driving after a normal night sleep.

It is important to note that 'crashing' in a simulator does not hold the same real-world consequences compared to driving in the field. Therefore, driver motivation to avoid an accident between simulated and actual driving may differ. This suggests that while simulator studies are useful in linking sleepiness with driving impairment, they may provide conservative estimates of the problem (Reyner & Horne, 1998).

The results also provided some support for studies suggesting that additional night shifts are associated with an increased safety risk (Folkard & Tucker, 2003). Sleepiness ratings were higher in SW that completed 4–7 night shifts but their means were not significantly greater than workers completing 1–3 night shifts. The inability to find a significant difference may be due to these estimates being made in the early to mid stages of the journey (Philip et al., 2003). In conclusion, in the absence of significant differences between age or journey length, a plausible explanation for the higher sleepiness ratings in SW is the combination of the work schedule and wakefulness prior to the journey.

The results also suggested the work schedule governed the SW travel agenda. The majority of SW indicated returning home in three to four days and this coincided with the number of days off. The bimodal timing of the SW return journey signalled a strategy of maximising time away from work. The majority planned to return between 14:00 and 16:00 and it is possible that some of these workers timed their arrival to coincide with the commencement of night shift. Estimates suggest 50% of shift workers do not sleep before the first night shift (Knauth & Rutenfranz, 1980). Alternatively, it may be these workers planned to rest before commencing work on the following day. The other key period for travel was 02:00–05:00 and this suggesting driving direct to commence day shift. One possible reason to explain the long distance driving of SW is that some workers have second homes located on the coast (Queensland Planning Information & Forecasting Unit, 2001).

The results from this study while useful should be treated with some caution. In order to minimise driver inconvenience, only basic information was collected. Data were not screened for sleep disorders or recent accident history in travelling to and from work. Secondly, police officers were aware of the study aims and this may have influenced their ratings. Thirdly, the KSS is a self-assessment tool and there are no data to suggest its reliability and validity when used by observers. The rationale for using observers is that drivers are known to be 'optimistic' concerning their driving ability when fatigued (Dalziel & Soames Job, 1997).

The findings from this study have a number of implications. The design of work scheduling is dominated by discussion concerning shift length and rotation speed (Knauth & Hornberger, 2003). While these are important features, work scheduling systems must consider their total impact on worker safety. A second implication is the need for driver sleepiness to be included in fatigue management training programs (Gander, Marshall, Bolger, & Girling, 2005; Philip, 2005) so that employees are aware of the safety risk in driving immediately following night work. A third implication is for employers to consider ways of eliminating the driving risk after night shift. Some possibilities include chartering a bus to transport employees or requiring employees to sleep for a minimum period before driving. The finding that some 20% of the SW drove with severe levels of sleepiness is of concern for the safety of the driver and the wider community. From a road safety perspective this requires socially acceptable solutions to driver sleepiness to be considered.

References

Åkerstedt, T. (2003). Shift work and disturbed sleep/wakefulness. *Occupational Medicine, 53*, 89–94.

Åkerstedt, T., & Gillberg, M. (1990). Subjective and objective sleepiness in the active individual. *International Journal of Neuroscience, 52*, 29–37.

Åkerstedt, T., Peters, B., Anund, A., & Kecklund, G. (2005). Impaired alertness and performance driving homing from the night shift: a driving simulator study. *Journal of Sleep Research, 14*, 17–20.

Arnedt, J., Wilde, J., Munt, P., & MacLean, A. (2001). How do prolonged wakefulness and alcohol compare in the decrements they produce on a simulated driving task? *Accident Analysis and Prevention, 33*, 337–344.

Carskadon, M. A., & Dement, W. C. (1982). Nocturnal determinants of daytime sleepiness. *Sleep, 5*(Suppl. 2), S73–S81.

Costa, G., Tieghi, S., & Chiesi, A. M. (1986). Interferences between commuting and shiftwork. In M. Haider, M. Koller, & R. Cervinka (Eds.), *Night and shiftwork: Longterm effects and their prevention* (pp. 311–318). Frankfurt am Main: Peter Lang.

Dalziel, J. R., & Soames Job, R. F. (1997). Motor vehicle accidents, fatigue and optimism bias in taxi drivers. *Accident Analysis and Prevention, 29*, 489–494.

Dawson, D., & Reid, K. (1997). Fatigue, alcohol and performance impairment. *Nature, 388*, 235.

Di Milia, L., & Bowden, B. (2006). Unanticipated safety outcomes: shiftwork and drive-in, drive-out workforce in Queensland's Bowen basin. *Asia Pacific Journal of Human Resources, 44*, 34–45.

Fell, D. L., & Black, B. (1997). Driver fatigue in the city. *Accident Analysis and Prevention, 29*, 463–469.

Folkard, S., Åkerstedt, T., Macdonald, I., Tucker, P., & Spencer, M. B. (1999). Beyond the three-process model of alertness: estimating phase, time on shift and successive night effects. *Journal of Biological Rhythms, 14*, 579–587.

Folkard, S., & Barton, J. (1993). Does the 'forbidden zone' for sleep onset influence morning shift sleep duration? *Ergonomics, 36*, 85–91.

Folkard, S., & Tucker, P. (2003). Shift work, safety and productivity. *Occupational Medicine, 53*, 95–101.

Gander, P., Marshall, N., Bolger, W., & Girling, I. (2005). An evaluation of driver training as a fatigue countermeasure. *Transportation Research Part F, 8*, 47–58.

Garbarino, S., Nobili, L., Beelke, M., De Carli, F., & Ferrillo, F. (2001). The contributing role of sleepiness in highway vehicle accidents. *Sleep, 24*, 203–206.

Gillberg, M., Kecklund, G., & Åkerstedt, T. (1994). Relations between performance and subjective ratings of sleepiness during a night awake. *Sleep, 17*, 236–241.

Härmä, M., Sallinen, M., Ranta, R., Mutanen, P., & Müller, K. (2002). The effect of an irregular shift system on sleepiness at work in train drivers and railway traffic controllers. *Journal of Sleep Research, 11*, 141–151.

Heslegrave, R. J., Rhodes, W., & Gil, V. (2000). A prospective study examining the changes to worker health and safety after shifting from 9 to 12.5-hour shifts. In S. Hornberger, P. Knauth, C. Costa, & S. Folkard (Eds.), *Shiftwork in the 21stCentury* (pp. 175–180). Frankfurt am Main: Peter Lang.

Horne, J. A., & Baulk, S. D. (2004). Awareness of sleepiness when driving. *Psychophysiology, 41*, 161–165.

Horne, J. A., & Reyner, L. A. (1995). Sleep related vehicle accidents. *British Medical Journal, 310*, 556–567.

Horne, J. A., & Reyner, L. A. (1996). Counteracting driver sleepiness: effects of napping, caffeine and placebo. *Psychophysiology, 33*, 306–309.

Horne, J. A., & Reyner, L. A. (2001). Sleep-related vehicle accidents: some guides for road safety policies. *Transportation Research Part F, 4*, 63–74.

Kecklund, K., & Åkerstedt, T. (1993). Sleepiness in long distance truck driving: an ambulatory EEG study of night driving. *Ergonomics, 36*, 107–1017.

Knauth, P., & Hornberger, S. (2003). Preventive and compensatory measures for shift workers. *Occupational Medicine, 53*, 109–116.

Knauth, P., & Rutenfranz, J. (1980). Duration of sleep related to the type of shiftwork. In N. Vieux & N. Andlauer (Eds.), *Night and shiftwork; biological and social aspects* (pp. 161–168). Oxford: Pergamon.

Knipling, R., & Wang, J.-S. (1994). *Crashes and fatalities related to driver drowsiness/fatigue*. Washington, DC: Office of crash avoidance research, US Department of Transportation. Research Note.

McCartt, A. T., Ribner, S. A., Pack, A. I., & Hammer, M. C. (1996). The scope and nature of the drowsy driving problem in New York state. *Accident Analysis and Prevention, 28*, 511–517.

Otmani, S., Pebayle, T., Roge, J., & Muzet, A. (2005). Effect of driving duration and partial sleep deprivation on subsequent alertness and performance of car drivers. *Physiology and Behavior, 84*, 715–724.

Philip, P. (2005). Sleepiness of occupational drivers. *Industrial Health, 43*, 30–33.

Philip, P., Sagaspe, P., Taillard, J., Moore, N., Guilleminault, C., Sanchez-Ortuno, M., et al. (2003). Fatigue, sleep restriction, and performance in automobile drivers: a controlled study in a natural environment. *Sleep, 26*, 277–280.

Queensland Planning Information and Forecasting Unit (2001). *Bowen basin localities*. Mackay: Queensland Government.
Reyner, L., & Horne, J. (1998). Falling asleep whilst driving: are drivers aware of prior sleepiness? *International Journal of Legal Medicine, 111*, 120–123.
Rogers, A. S., Holmes, S. R., & Spencer, M. B. (2001). The effect of shiftwork on driving to and from work. *Journal of Human Ergology, 30*, 131–136.
Rosa, R. R. (1995). Extended workdays and excessive fatigue. *Journal of Sleep Research, 4*(Suppl. 2), 51–56.
Stutts, J. C., Wilkins, J. W., Osberg, J. C., & Vaughn, B. V. (2003). Driver risk factors for sleep-related crashes. *Accident Analysis and Prevention, 35*, 321–331.
Tepas, D. I., & Mahan, R. P. (1989). The many meanings of sleep. *Work and Stress, 3*, 93–102.
Thiffault, P., & Bergeron, J. (2003). Monotony of road environment and driver fatigue. *Accident Analysis and Prevention, 35*, 381–391.
Van der Hulst, M., Meijman, T., & Rothengatter, T. (2001). Maintaining task set under fatigue: study of time on task effect in simulated driving. *Transportation Research Part F, 4*, 103–118.
Van Dongen, H. P. A., Maislin, G., Mullington, J. M., & Dinges, D. F. (2003). The cumulative cost of additional wakefulness: dose–response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep, 26*, 117–126.
Williamson, A. M., Feyer, A.-M., Mattick, R. P., Friswell, R., & Finlay-Brown, S. (2001). Developing measures of fatigue using an alcohol comparison to validate the effects of fatigue on performance. *Accident Analysis and Prevention, 33*, 313–326.