The underlying causes and incidence of driver fatigue in a shiftwork and non-shiftwork population

A Report to
Coal Services Australia - Health and Safety Trust

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The views expressed in this report are those of the authors and they are solely responsible for the content of the report.

Chapter 1 Executive Summary

The introduction of extended working shifts (in excess of 8-h) and the increased use of contractors has produced an occupational health and safety (OHS) issue that had not been considered in detail in risk assessments at the time; the impact of driver fatigue in addition to the work shift. This research comprised three separate studies that provided data on the impact of driver fatigue in both short and long distance driving and the driving patterns of shiftworkers on days off.

The greatest benefit of extended work shifts is that they provided better utilisation of leisure time. In turn, this allowed some workers to leave the Bowen Basin over long roster breaks and travel to the coast. Since long roster breaks usually follow a series of night shifts, it was argued that: 1) night shifts are associated with an accumulating sleep loss, 2) working nights is more tiring than days, and 3) this mounting level of impairment is compounded by driving. From a risk management perspective driving after working night shift is considered problematic irrespective of distance. Longer distances however serve to potentially increase the risk.

A second factor that requires an examination of driver fatigue is the increasing use of contractors. This workforce does not in the main live in local towns. The majority of employees may be considered as drive-in drive-out (DIDO) workers. These employees drive long distances to reach the mine locality, make use of local accommodation for the work period and then return home. It is also the case that mine employees may also be DIDO workers. These workers have made the coastal region their permanent home and make use of local accommodation during the work period. For example, one employee lived at Hamilton Island and travelled to the Basin for the work period.

The study in chapter five was concerned with driver fatigue in employees who lived closer to their workplace. The study involved three groups, shiftworkers, day-workers in the mining industry (DWM) and day-workers who worked a standard work arrangement and employed at a regional university (DWU). Each of these groups travelled a similar distance to work. Shiftworkers reported working in excess of 12-h shifts (82%) while the balance reported 10-12 hours per day. Some 36% of the DWM group also worked in excess of 12-h per day and 51% worked 10-12 hours per day.

The shiftworkers and DWM began work on day shift between 6.00 and 7.00 am. In contrast, the DWU group commenced work at least 2-hours later and work shifts were mostly 8-h with 11% reportedly working 10-12 hours. The critical difference between the groups was shift start times in the morning and shift length.

While the mean distance from work was similar for the three groups (38-47 km), the upper range was higher in shiftworkers (150 km) and DWM (90 km). In line with the literature, shiftworkers recorded less sleep duration than the other two groups. In shiftworkers, mean sleepiness and driving impairment was greater at the end of day and night shift. Night shift was most problematic with 59% reported being more sleepy than alert. Falling asleep at the wheel was reported in 13% of shiftworkers when driving to night shift and 43% when driving home from night shift. Approximately 3% of shiftworkers reported incidents as a result of falling asleep and these included various manifestations of lane drift including run-off road but no serious accidents were noted.

Sleepiness and driving impairment also increased at the end of day shift for both day-worker groups. The greatest increase was in the DWM group and this suggested that the earlier start time and longer shift may explain the difference. Falling asleep at the wheel was less likely in the DWU group when going to day shift but greatest in the DWM group at the end of night shift (19%). In addition, to earlier start time and shift length, the DWM group also indicated overall greater weekly working hours than the DWU.

Chapter six is a pilot study that examined driver fatigue in DIDO workers. Workers reported leaving home as early as 3.00 am to attend day shift and drove up to 230 km. Results showed that the earlier in the day the drive commenced and the greater the distance to be driven, the higher were sleepiness and driving impairment values. In addition, a separate group of DIDO employees left home at 2.00 am but these workers drove up to 1300 km to attend day shift on the following day. Others in this group left home at various times the day before day shift but travelled hundreds of kilometres. This group recorded the highest levels of sleepiness and driving impairment.

Falling asleep at the wheel was reported in 13% of DIDO workers when driving to day shift. There seemed no real pattern to the number of times a driver fell asleep and the distance driven but this may be due to the small sample size and corresponding

small number of incidents. Nonetheless each of the incidents was associated with less than 5-h of sleep prior to the incident.

Driving home from the work spell (whether end of day or night shift) was linked to greater sleepiness and driving impairment compared to going to work. Some 23% of DIDO's reported falling asleep driving home but this figure was a little higher for this driving after night shift. The night shift incidents were associated with having had less than 5-h sleep but it is important to note this sleep was taken well before the drive since the employee had also worked a 12-h night shift. Sleep related incidents for DIDO day-workers were linked to 6-8 hours of sleep.

Post shift driving strategies were also examined. Shiftworkers (54%) were more likely to take a driving break than day-workers (38%). However, shiftworkers indicated driving 75-550 km without a driving break and the range in day-workers was 106-500 km.

Chapter seven provided data to support the suggestion that some shiftworkers spent time away at the coast after completing a block of night shifts. In both the Westwood and Eaton sites, shiftworkers were found to have undertaken a long drive (approximately 200 km) after having completed four night shifts on average. Some were planning to drive more than 600 km without a driving break. The shiftworkers reported having had between 6.18-h and 6.36-h of sleep prior to working the night shift and then driving. At the time of the survey, shiftworkers at both sites were rated a significantly more fatigued than other drivers.

Drivers were also asked about their return trip. Shiftworkers planned to return in 3.5days. This suggested spending the full rostered days off away from the local town. When asked about the return time a bi-modal distribution was observed. Some planned to leave early morning in order to arrive for day shift while others planned to leave in the early afternoon.

Overall these findings suggest that driver fatigue is an issue in the coal industry. While major incidents were not found in this study, we suggest this was under reported. Workers compensation data suggested that journey accidents are a significant contributor to overall costs in the industry.

Some limitations to these studies were noted (see chapter 8). However, in the main these limitations do not reflect poorly on the findings. It may well be the case, that our strategy has under reported the problem of driver fatigue. It is important to note that reporting the 'mean' (or the average) value in studies hides the variability in

the data. When dealing with the lives of individuals, if small percentages of workers are at risk, it is important to identify these workers. This is why in some cases we have highlighted extreme scores.

In addition we suggest further research in this area to verify or counter our findings. It is likely that driver fatigue may be more of an issue in some mines than others based on differences in work/rest balance, distance from home, daily and weekly hours worked and shift start/end times.

We recommend two broad strategies. One is an educational campaign across the industry and the second is to review the effectiveness of offering a sleep facility to employees. These recommendations are deliberately broad so that the industry best considers how to address the issue given local circumstances.

In summary, the underlying causes of driver fatigue appear to be associated with driving during the early morning period, working long shifts and driving after having worked a series of night shifts. Night shift is especially tiring for shiftworkers and driving long distances is not recommended prior to a recovery sleep.

Chapter 2 Introduction

Labour reform in the Australian coal mining industry since the early 1990s has played a significant role in raising the productivity of the industry (Bowden, 2003). This reform included changes to working practices and the extensive use of extended working shift arrangements (i.e. shift lengths in excess of 8-h). The majority of mines in the Bowen Basin operate some form of continuous 12-h shift operations (Helier, 2001).

There is general acceptance that continuous rotating shiftwork including extended shifts, is a genuine occupational health and safety (OHS) hazard. Shiftwork has been linked to a number of physical, psychological and social impairments (Waterhouse, Folkard & Minors, 1992). The effects of shiftwork are also apparent at the organizational level. Night work is associated with an increased accident risk (Smith, Poole & Folkard, 1994) and impaired performance (Rosa & Bonnet, 1993). The cost of shiftwork to organizations includes but is not limited to:

- absenteeism and the associated overtime costs.
- Repair/replacement of plant and equipment damaged as a result of 'human error'.
- Downtime caused by damage to plant and equipment.
- Workers compensation insurance and claim costs.

The health and safety of coal miners is paramount in the industry. The industry has recognised the problems associated with working extended shifts and has responded by funding a number of initiatives into OHS. These include a number of annual safety conferences and various research projects. At the mine site level, management has establishing fatigue management committees to oversee the issue. Fatigue concerns are usually addressed by making modifications to the roster design and by providing fatigue management training to ensure workers are not exposed to unsafe levels of fatigue. The mantra in the industry is that the 'shiftworker is fit-for-duty' and this implies on-shift.

Employee health and safety is however more than fitness-for-duty; safety is also important away from work. Of importance in the 'non-work' period is the drive to and

from work. There is scant data on the effect of working extended shifts and its impact on driver fatigue and safety. However, workers compensation data suggest that journey accidents are a significant cost to the coal industry (Armour, 2003).

The issue of extended shifts and driver fatigue is arguably an even greater issue in the Bowen Basin as a result of changes brought about by extended shifts and living/recreational arrangements. Extended shifts provide for regular blocks of rostered days off. Anecdotal evidence suggests that this allows for regular travel away to the coastal regions. Driving long distances in the morning following a spell of extended night shifts may place a driver at an increased accident risk (Di Milia, 1999; Fell and Black 1997). Night shift is associated with increased fatigue which is then compounded by the driving demand.

The proximity to the coast of the Bowen Basin mines has also resulted in some families choosing to live on the coast. This requires the employee to travel longer distances to work, reside in local accommodation and return home at the end of the work period. These workers may be regarded as drive-in/drive out (DIDO) employees. While some DIDO employees live locally during their work commitments, anecdotal evidence suggests that others drive up to 2-h to attend work, complete a 12-h shift and then return home on a daily basis. Such practices are risky in the long term.

The increased use of contractors in the industry (Bowden, 2003) is another factor to examine driver fatigue. Anecdotal evidence suggests that while some live locally, others also come from the coastal regions and others come from far further regions. Arguably contractors may make up the greater number of DIDO workers but these is no independent evidence to support this position.

The aim of this research program is to examine driver fatigue in the Bowen Basin. A number of studies have documented the involvement of shiftworkers in vehicle accidents and increased fatigue (Richardson et al. 1990; Fell & Black, 1997; Rogers et al. 2002). However, these studies are not directly comparable since they differed on a number of characteristics.

Three studies are planned to investigate the issue of driver fatigue in the coal industry. The first study (chapter 5) is a direct survey of shiftworkers who drive shorter distances to work and to compare these results with two other groups: a) day workers in the coal industry that commence work at approximately 07.00 and work long hours, and b) day workers that commence work later in the day and work a

standard day length. This study will allow for a number of comparisons between shiftwork and day work in terms of driver fatigue.

The second study (chapter 6) is a pilot study that will examine driver fatigue in shiftworkers who are described as DIDO shiftworkers. This data will provide preliminary data concerning the health and safety of long distance commuting in the coal industry.

The third study is a roadside survey of drivers during the mid morning period. This study will provide preliminary data on road use by shiftworkers on completing night shift. The study seeks to document the additional risks undertaken by shiftworkers by travelling after having completed a series of 12-h night shifts.

The three studies will provide direct data on driver fatigue in the Bowen Basin region. These data will be made available for the industry to consider the ongoing health and safety of its employees.

Chapter 3 Literature Review

3.1 Introduction

Rotating shiftwork is not necessarily problematic for all employees due to biological differences but there is a strong body of evidence linking shiftwork to a number of physical, psychological and social impairments. A key complaint among shiftworkers is gaining sufficient sleep (Akerstedt, 1991) and while estimates vary, some 70% of shiftworkers complain of sleep disruption. Concerns regarding sleep duration and quality are critical since sleep has been recognised as a major factor in fatigue and subsequent performance (Tepas, 1999).

There are sound biological grounds to expect health and performance impairments in shiftworkers. However, direct evidence linking shiftwork and impairment is limited. Interpreting causality from most studies is problematic due to methodological limitations in study design. These include; a reliance on cross sectional studies (Akerstedt & Torsvall, 1978), the inability to use matched control groups (Knauth, 1995), the health worker effect (Frese & Semmer, 1986) and finding a workplace that has constant operation and manning over the 24-h period. In addition, demonstrating performance impairment requires a large dataset in which accidents are reliably recorded. These features are seldom available in industrial settings.

3.2 Shiftwork and fatigue

It has been said that there are only two problems with shiftwork; working when you should be asleep and sleeping when you should be awake (Folkard & Monk, 1992). Human biology displays a diurnal pattern and is governed by a circadian pacemaker that resists phase shifting of our biology to accommodate working at nights. The tension caused by attempting to phase shift human biology is considered the primary mechanism that explains a number of impairments in shiftworkers (Folkard, 2000).

The disruption of circadian function is but one component of human fatigue. A second biological component, ‘time of day’ also plays key role. Time of day refers to a sleepiness/alertness pattern that predisposes individuals to feel tired due to time of day. These times are associated with the greatest propensity for sleep; typically during the early morning hours (2.00 – 4.00 am) and the mid afternoon (2.00 – 4.00 pm). In

the absence of interesting work, these time periods are associated with poor performance. For example, the greatest number of single vehicle accidents (Di Milia, 1999; Horne & Reyner, 1999). A third component is considered to be 'time on task'. This factor suggests that continuous work without adequate rest results in fatigue. In particular, extended working hours (shifts beyond 8-hours) have been linked with excessive fatigue. Therefore, the basic fatigue model is made up of biological and physical components. In addition to these factors, working during the night shift adds additional fatigue components. The first night shift is typically worked with little or no prior sleep in the previous 24-hours (Di Milia, 1999). This poor prior sleep to commencing work is then compounded by an accumulating or chronic sleep loss due to day sleep being of shorter duration than night sleep.

While the discussion has focussed on night work, there is also evidence to suggest that day working is also subject to high levels of fatigue. Truncated sleep (Barton & Folkard, 1993) and a large number of consecutive long working days with insufficient rest breaks also results in increased sleepiness.

The impact of shiftwork is most clear on sleep and psychological health. The most robust finding in shiftwork studies is the reduced sleep quantity and quality following night shift (Wilkinson, 1992). Day time sleep is typically two to three hours less than night time sleep. Sleep is especially reduced following night shift primarily due to circadian factors and further exacerbated by environmental and social factors.

Reduced sleep is associated with a number of psychological, performance and safety impairments. A common complaint among shiftworkers is a general malaise of feeling tired and irritable (Smith, 1992). These feelings of malaise carry over into disturbed social and family lives for the individual and their families (Smith & Folkard 1993).

A number of laboratory studies have demonstrated that sleep reductions of 2-hours are associated with performance decrements (Pilcher, 1997). There are an increasing number of studies that have demonstrated that being awake for 17-hours results in performance similar to a blood concentration of 0.05% (Dawson & Reid, 1997; Williamson et al., 2002).

In terms of workplace safety, there are few well designed studies that are able to demonstrate the link between night work and increased accident risk. Smith et al. (1994) demonstrated that when production and support services were constant, and employees did more than mind the production process, night shift recorded an

accident risk of 1.4 compared to day shift (1.0). More recently studies of single vehicle accidents in a number of countries have consistently reported increased accident risk during the early morning and afternoon periods (Bruno, 2004; Di Milia, 1999; Horne & Reyner, 1995)

3.3 The coal industry and driver fatigue

There are a number of factors that suggest driver fatigue may need to be monitored in the coal industry. These include the changes in working hours, the increased use of contractors and the cost of workers compensation for journey accidents. Armour (2003) reported that one-half of all vehicle accidents were journey accidents. The most expensive workers compensation claim ($77,400) and days claimed (1,000 days) were for vehicle accidents.

One contributor to the productivity gains in the coal industry has been the introduction of extended shiftworking systems. These shifts have had provided benefits to both employers in terms of cost savings and to employees. Extended shifts have provided a number of benefits to shiftworkers.

In principle the faster rotations provide a reduction in accumulated sleep loss since a smaller number of consecutive night shifts are worked. However, evidence does suggest that too rapid a rotation is also associated with acute sleep loss (Di Milia, 1999). A number of studies have concluded that extended shifts require close monitoring as they can cause greater amounts of fatigue dependant upon the nature of work, the shift system design including shift timing and the pattern and length of rest breaks (Di Milia, 1999; Rosa, 1993).

A second benefit of extended shifts is that they provide greater blocks of time away from work. Another robust finding in shiftwork studies is that extended shifts are highly popular with shiftworkers in terms of leisure time (Di Milia, 1999; Rosa, 1993; Smith et al. 1998). This time allows shiftworkers to recover from the work spell and maintain their social links with family and friends.

The increased free time from work has arguably provided an unintended but potential OHS issue for the coal industry; well being driving to and from work. The concern with driver fatigue applies to all workers despite their actual residence since long working hours and driving at particular times of the day can be hazardous. However, driving longer distances is associated with an increased accident risk (Stutts et al, 2003)

Anecdotal evidence suggests that the leisure time associated with extended shifts has resulted in some shiftworkers travelling away from the Bowen Basin to the coast on a regular basis. The distances between the Basin and the coast vary between 250 and 350 kms, but the final destination of workers is not known. Indeed the aim of chapter seven is to examine the frequency of long distance travel in shiftworkers generally. Some support for the regular absence of shiftworkers from local towns in the Bowen Basin can be found in the Census data (ABS, 2001). This data suggested between 18-25% of homes were unoccupied on census night. In addition to this practice, there is also anecdotal evidence that some families have relocated to the coast. This would require the shiftworker to drive a long distance to attend work, reside in local accommodation during the work period only and travel back home on completion of shift.

The increased use of contractors in the Bowen Basin coal fields is another vehicle that adds to the concern with driver fatigue. The use of contractors in all Queensland mines increased from 856 to 3081 while employees of the mine operators decreased from 10,483 to 7,124 during the period 1996-2002 (Bowden, 2003). While some contract employees reside in local towns, major contract firms are located on the coast. These firms supply local accommodation to their employees during work periods only. This requires employees to drive to the coal fields form the coast.

The discussion so far implies that shiftworkers and long distances may be most problematic. However shorter driving distances in shiftworkers and day-workers may also be problematic. Early start times are associated with significant sleep truncation and combined with a monotonous task such as driving may increase accident risk.

3.3.1 Sleep loss and its impact on driving

Sleep loss is a major contributor to fatigue and feeling tired has been estimated to be the cause of approximately 10% of road accidents and some 20% of highway accidents (Maycock, 1996). Laboratory studies routinely conclude that mental performance and alertness is impaired when night sleep is restricted to less than 5-hours (Dinges et al. 1997; Pilcher & Huffcutt, 1997).

The effects of sleep loss are most commonly found in tasks that are routine, require sustained attention and are of long duration; characteristics that describe long distance driving. Sleep loss may not necessarily result in dangerous driving but it is associated with slower reaction times. Other outcomes from sleep loss include,

attention lapses, an inability to consider all environmental information, lane drift and actual crashes.

The literature on driver accidents consistently implicates sleep loss as a central factor. Fell and Black (1997) reported 57% of accident drivers did not have a full night sleep prior to the accident. The key factors associated with sleep loss in this study included long working hours, working night shift and leaving home in the early morning to attend work. Richardson et al. (1990) found that 22% of shiftworkers reported at least one vehicle accident or near miss that they attributed to sleepiness in the previous 12 months compared to 7% of day-workers. In a telephone survey of 1000 drivers, 43% reported driving in a 'drowsy' state and cited night work, working overtime, shiftwork and working more than one job as the key factors (McCartt et al. 1995).

More recently Rogers, Holmes and Spencer (2001) examined the effect of shiftwork on driving to and from work. They concluded that shiftworkers compared to day-workers were more tired on the drive to and from the work place and more at risk of falling asleep behind the wheel. For shiftworkers, the drive home post night shift was associated with higher levels of sleepiness and driving impairment. Other factors that were associated with higher levels of sleepiness and driving impairment were prior sleep length and travel time. Sleep durations of less than 6-hours were associated with impaired performance compared to sleep durations of ≥ 7-hours for journeys to and from work. Individual with shorter travel times (< 15 minutes) reported lower levels of sleepiness and driving impairment than those with longer travel times (> 35 minutes). Shiftworkers after night shift were more likely to report higher sleepiness and driving impairment but more so after longer distances. Twenty five per cent of shiftworkers and 22% of day-workers reported falling asleep at the wheel in the previous 12 months. The greatest number of falling asleep incidents occurred after night shift. However, employees in this study were not coal miners and they lived no more than 35 minutes from the workplace.

Heslegrave et al. (2000) looked at the changes associated with a move from 9-h to 12.5-hour shifts on a number of indicators including commuting. Day shift start times were 7.30 am on both shift systems and night shift ended at 8.00 am on the extended shift (30 minutes earlier than the shorter shift system). The frequency of lapses in attention, falling asleep at the wheel, near misses and accidents were all higher on the

extended shift schedule for both shift types. Again, employees in this study were not coal miners and shift start times differed to those worked in the Basin.

3.4 A risk management approach

A risk management approach of the interaction between shiftwork and driving, including long distances would suggest that driving increases the risk factor. Employees' level of risk may vary by the following criteria:

- The patterning and number of consecutive shifts
- Shift start and end times
- Shift length and shift duties
- Time of departure to attend shift and the timing of the return journey
- Accumulating sleep loss over consecutive night shifts
- Amount of rest on-shift and off-shift
- The monotony of driving task over long time period

Each of these factors plays a significant role in the level of driver fatigue for both shiftworkers and day-workers. The goal for the coal industry is to understand that fitness for duty is more than on-shift duty. The health and safety of employees is critical outside of work for human and financial considerations.

Chapter 4 Research Questions

The design of this study will allow for a number of comparisons to be made. The first study (chapter 5) provides some evidence for answering the following questions:
Shiftworkers:

1. Are there differences in driver fatigue and driving impairment by type of shift?
2. Are there differences in the frequency of 'falling asleep' by shift type
3. The amount of sleep prior to a road related accident or incident in shiftworkers.

Shiftwork versus day-workers:

1. Are there differences in driver fatigue and driving impairment in day work as a function of start/end time and shift length
2. Are there differences in the frequency of 'falling asleep' as a function of start/end time and shift length
3. The amount of sleep prior to a road related accident or incident when working on days.

Chapter 6 describes and reports on a pilot study of DIDO shiftworkers. It will allow an exploration of the following questions:

1. Are there differences in driver fatigue as a function of travel time?
2. Are there differences in driving impairment as a function of travel time?
3. The frequency of falling asleep in the previous 12 months and whether falling asleep was more likely driving to work or from work.
4. The amount of sleep prior to a road related accident or incident.

The aim of chapter 7 is to provide preliminary data on the travel patterns of shiftworkers after completing night shift. It has been argued that shiftworkers may take the opportunity of travelling to the coast after a spell of night shift which is when a long break is usually placed. This study will provide preliminary data to the following questions:

1. Are there differences in driving distances between shiftwork and non-shiftwork drivers?

2. Are there differences in driving strategy between shiftwork and non-shiftwork drivers?
3. Are there differences in sleep duration for the previous 24-h between shiftwork and non-shiftwork drivers?
4. Are there differences in sleepiness rating between shiftwork and non-shiftwork drivers?

Chapter 5 Survey of Shiftworkers and Non-shiftworkers

5.1 Introduction and method

The self report survey was designed to collect the following data: biographical, work and travel details, sleep duration, estimates of sleepiness and driving impairment when travelling to and from work, and accident/incident involvement. The sleepiness scale was anchored (1 = very alert; 3= alert; 5 = neither alert nor sleepy; 7 = sleepy (but not fighting sleep); 9 = very sleepy, fighting sleep). The driving impairment scale was anchored (1 = never; 3= sometimes; 5 = always). The survey was designed to identify DIDO workers and workers who reside in closer proximity to their workplace.

The senior site executives from four mines were approached to participate in the study and three consented. A fourth mine had agreed to be involved but later declined for industrial relations issues. Each mine was located approximately 30 km from a local town. The mining sample provided data from shiftworkers and day-workers.

Permission was also obtained to conduct a similar survey with workers from a large regional university where all employees are day-workers. The sample was chosen so that each person lived a minimum of 20 km from their work place. The three groups allow for a number of comparisons that may be sensitive to work start and end times and by shift versus non-shift.

A package containing a note describing the purpose of the survey, the survey and a return addressed envelope were supplied to each individual. The survey was voluntary and confidential. Surveys at two of the mines were distributed by mine staff. At the third mine, the surveys were completed in small groups in the presence of the researchers who explained the purpose of the study. University staff were mailed a package containing background details, the survey and reply paid envelopes.

5.2 Response rate and working arrangements

Mine site A:

The workforce comprised of approximately 290 contract employees working for three main employers. Responses were received from 73 employees (25%). All responses were from shiftworkers. Two different rosters were worked; 1) Four on/four off, with

both shifts being 12.15h. Day shifts were 07.15 – 19.00 and night shifts were 19.00 – 07.15; and 2) Six on/three off. Day shifts were 07.00 – 17.30 (10.5h) and night shifts were 19.00 – 07.15 (11h).

Mine site B:

201 responses were received from approximately 425 shiftworkers (47%). Shift length was 12-h with changes at 06.30 and 18.30. The shift pattern comprised two days, one off, two nights, one off, two days, one off, two nights, followed by five off. In addition, 37 day-workers completed the survey. These employees commenced work at approximately 07.00 and reported shift lengths of up to 12-h.

Mine site C:

The mine employed approximately 150 shiftworkers belonging to two major contractors. A total of 30 responses (88%) were received from the earthworks contractor. Shift length was 11.5-h with shift changes at 06.30 and 18.30. Shift patterns were five day shifts with two days off, followed by five night shifts and two days off. Permission to survey the remaining shiftworkers was not granted due to EBA negotiations.

In addition, 50 day workers (90%) completed the survey. These employees worked for a number of different contractors and the mine owners. Consecutive workdays ranged between 4.5 to 7 days and the type of work performed included management, office work, maintenance and drilling. Day shift commenced between 06.30 and 07.00 and shift lengths were between 10-h and 12-h. Some day-workers reported working shifts in excess of 12-h

University employees:

A total of 78 surveys were completed (28%). All respondents worked at least four days per week. Start times varied between 08.00 and 09.00. Academic staff (approximately 30%) reported working up to 10-h. Overall, most staff worked about 8-h.

5.3 Data analysis strategy

A number of different shift work rosters were identified across the three mines and some were worked by relatively few workers. Small samples prevent reliable data analysis and it was decided to combine all the shiftwork arrangements into a single group (n=304). The day-workers were divided into two groups to reflect differences

in start time. The day-workers at the mines were named ‘DWM’ (day work mine; n = 87) and the balance were identified as ‘DWU’ (day work university; n = 78).

To ensure that respondents were actual drivers, responses were screened for how people travelled to work. Only respondents who drove themselves or car pooled were retained. This reduced the sample to 217 shiftworkers, 72 DWM and 75 DWU (overall n = 364).

Differences in shift length were also identified. Three groups were created to facilitate data analysis. These were: ≥ 12-h, b) 10 ≤ 12-h, and c) < 10-h. The typical working hours in the DWU group was approximately 8-h but these were grouped in the ‘<10-h’ category.

A series of repeated measures ANOVA and one way ANOVA tests were conducted to examine for differences between groups on a number of variables.

5.4 Results

A total of 364 surveys were received from individuals that either drove directly to work or that regularly drove as a member of a car pool. Of these responses, 217 were shiftworkers (96% male), 72 were DWM (90% male) and 75 were DWU (41% male). Compared to both day work groups, the shiftworkers were slightly younger, weighed more, reported needing less sleep per day and had a greater length of service. These background details can be found in table 5.1.

See table 5.1

The mean travel time (33 minutes) to commence day work was similar for the three groups. The mean travelling distance ranged from 38 km (DWU) to 47 km (shiftworkers). However, 9% of shiftworkers drove between 70 and 150 km to attend work, and 13% of DWM drove between 70 and 90 km to attend work on a daily basis.

The start of day shift for the majority of shiftworkers and DWM was between 6.00 - 7.00 am. The DWU group began work at approximately 8.30 am. The DWU group left for work at approximately 7.50 am compared to 5.30 am for the other groups. However both the shiftworkers and the DWM group left home as early as 4.00 am. Night shifts commenced between 6.30 pm and 7.15 pm and ended between 5.30 am and 7.00 am. The mean departure time from home to commence night shift was 5.33 pm.

Table 5.1: Travel Distance and Background details for the three groups.

	Shiftworkers			DWM			DWU		
	Mean	Min. value	Max. value	Mean	Min. value	Max. value	Mean	Min. value	Max. value
Travelling distance (kms)	46.5	20.0	150.0	45.5	25.0	90.0	38.2	20.0	50.0
Age (years)	39.5	18.0	69.0	39.7	18.0	62.0	44.9	21.0	64.0
Weight (kgs)	89.0	48.0	200.0	85.2	55.0	140.0	73.6	47.0	113.0
Sleep need per day (hours)	7.3	4.5	12.0	7.6	5.0	9.0	7.7	5.0	10.0
Length of service (years)	13.8	0.1	40.0	9.5	0.1	31.0	8.5	0.3	33.0

The majority of shiftworkers (82%) reported working more than 12-h and the balance between 10 and 12-h. The most common working hours for the DWM group was between 10 and 12-h (51%), followed by more than 12-h (36%) and less than 10-h (13%). The working day for 89% of the DWU was approximately 8-h group and the balance reported working between 10 and 12-h.

Sleep:

In shiftworkers, the amount of sleep before the first day shift (7 hours 6 minutes) was 2 hours and 30 minutes more than sleep before the first night shift ($p < 0.001$). Sleep between day shifts (7 hours 19 minutes) was 24 minutes longer than for sleep between night shifts ($p < 0.001$). There were no significant mean differences by shift length but in each case mean sleep was lower for shift length beyond 12-h.

Sleep disturbances were significantly less ($p < 0.001$) on days off (6.51) followed by day shift (7.82) and night shift (9.30). The range for sleep disturbance scores was 3 – 15. There were no significant mean differences for sleep disturbances by shift length for day and night shift but for each shift, sleep disturbance values were higher as shift length increased.

In the day work groups, DWU reported the highest sleep need (7 hours 42 minutes) compared to DWM (7 hours 31 minutes). Sleep disturbance on day shift was highest in the DWM group (9.17) and lower in the DWU (8.45). Sleep disturbances on days off were also higher in the DWM group (8.13) and lower in the DWU (7.57). The sleep disturbance values for both day shift and days off in both the DWM and DWU groups were higher than those reported by shiftworkers.

Fatigue (sleepiness) and driving impairments:

For shiftworkers, sleepiness significantly increased at the end of day shift and night shift compared to the start of shift ($p < 0.05$). Sleepiness at the end of night shift was significantly higher than all other start and finish times ($p < 0.05$) and some 59% of shiftworkers reported sleepiness levels above the mid point for the scale (5 = neither alert nor sleepy). Driving impairment was rated significantly higher for the end of night shift ($p < 0.001$). The data on sleepiness and driving impairments by shift for the three groups can be found in table 5.2.

See table 5.2

Table 5.2: Self-rated Sleepiness and Driving Impairment values for Day and Night Shift.

	Shiftworkers			DWM			DWU		
	Mean	Min. value	Max. value	Mean	Min. value	Max. value	Mean	Min. value	Max. value
Sleepiness - to day shift	3.45	1 (12%)*	8 (1%)	3.78	1 (7%)	7 (3%)	2.92	1 (20%)	7 (1%)
Sleepiness - from day shift	3.81	1 (8%)	9 (1%)	4.46	1 (3%)	8 (2%)	3.95	1 (4%)	8 (1%)
Sleepiness - to night shift	3.67	1 (9%)	8 (1%)	--	--	--	--	--	--
Sleepiness - from night shift	6.02	1 (2%)	9 (18%)	--	--	--	--	--	--
Impairment - to day shift	1.82	1 (41%)	5 (1%)	1.87	1 (25%)	3 (12%)	1.79	1 (35%)	3 (13%)
Impairment - from day shift	1.91	1 (35%)	5 (1%)	2.13	1 (21%)	4 (2%)	2.13	1 (25%)	4 (4%)
Impairment - to night shift	1.91	1 (36%)	5 (1%)	--	--	--	--	--	--
Impairment - from night shift	2.66	1 (15%)	5 (6%)	--	--	--	--	--	--

NB: Sleepiness values range 1 (very alert) - 9 (very sleepy); Impairment values range 1 (never) - 5 (always).

* Number in brackets identifies the percentage of respondents that assigned the rating.

In comparing the three groups for driving to day shift, mean sleepiness was significantly lower in shiftworkers and the DWU ($p < 0.003$) and highest in the DWM. Each group recorded higher sleepiness ratings at the end of day shift. The DWM group recorded a significantly higher sleepiness ratings compared to the other groups. The DWU group also showed the greatest difference between pre and post shift sleepiness.

In percentage terms, 8.4% of shiftworkers reported sleepiness levels above the scales mid point on driving to day shift, compared to 7.3% in DWM and 2.3% in DWU. On driving home from day shift some 17% of the day work groups rated sleepiness above the mid point compared to 12% of shiftworkers.

Self rated driving impairment for driving to and from day shift showed a similar pattern to sleepiness. For all groups, driving impairment was highest when driving home after day shift. The DWU group reported the highest impairment at the end of day shift. However there were no significant differences for driving impairment between the groups for either to/from day shift.

Falling asleep at the wheel:

Approximately 13% of shiftworkers reported falling asleep on the drive to night shift compared with 43% on the drive home from night shift. There were no significant differences between the three groups in falling asleep on the drive to or from day shift. However, shiftworkers and the DWM group seemed more likely to report falling asleep. The results are shown in table 5.3.

Table 5.3: Percentage of Drivers Falling Asleep when Driving to and From Day Shift.

	Frequency of falling asleep							
Group	Never		Once or twice		Three / four		More than four	
	To	From	To	From	To	From	To	From
Shiftworker (n=212)	90.6	87.2	7.5	10.9	0.9	0.9	0.9	0.6
DWM (n=68)	89.7	80.9	8.8	13.2	0.0	1.5	1.5	4.4
DWU (n=75)	97.3	90.5	2.7	8.1	0.0	1.4	0.0	0.0

Ten drivers reported involvement in a small number of incidents on driving to work in the previous 12 months. Of the six shiftworkers reporting incidents the most common events were running off the road and crossing the centre line. In addition, two events of braking for no reason were also recorded. Three DWM workers reported incidents; these were crossing the centre line and run off shoulder. Crossing the centre line was the only incident in the DWU group

Twenty-four drivers reported incidents on driving home from work in the previous 12 months. The number (expressed as a percentage) of incident involvement is shown in table 5.4. No significant differences for the number of incidents was found between the three groups but it seemed that the shiftworkers and DWM groups were more likely to be involved in more than two incidents in the previous 12 months. Incidents common to all groups were running onto the shoulder or off the road and crossing the centre line. Most of these incidents were associated with having had less than 6-hours of sleep.

Table 5.4: Percentage of Driving Incidents when Driving Home from Shift.

Number of incidents	Shiftworker	DWM	DWU
One	31	20	33
Two	50	20	67
More than two	19	60	--

5.5 Discussion

The key differences between the three groups of employees were work start times and shift lengths. In addition, although mean travel distances were similar for the groups, some 10% of the shiftworkers and DWM group drove up to 150 km to attend work.

Sleep duration among shiftworkers was in keeping with the literature with sleep reductions observed for day sleep and sleep disturbances were greatest on the night shift. Sleep duration was not significantly impacted by shift duration but the data suggested that as hours worked increased, sleep duration decreased. A possible reason

for this is that longer shifts allow less time for non work activities and sleep duration is one activity that is curtailed.

Sleep duration for day shifts was highest in the DWU group by 20 minutes (7 hours 42 minutes). Although this difference is not large, the DWU employees worked shorter shifts and awoke later in the morning. This allowed a greater opportunity for sleep. Interestingly sleep disturbances were greatest in the non-shiftwork groups for both day shift and days off.

Mean ratings for sleepiness and driving impairment were highest for each end of shift for all groups. In the day shift groups, the increase in fatigue ratings suggested that driving after completing a work period is an additional demand irrespective of shift length and start time. The increases across day shift may not be reason for concern but it is important to point out that the mean value does hide the variability in each group. Although small in percentage terms, a small number of employees in all groups reported being 'very sleepy'. It is important to point out that individuals at risk need to be identified and some form of assistance be made available.

The benefit of driving to work later in the day and gaining more sleep were demonstrated in the DWU group who recorded the lowest ratings for sleepiness and driving impairment for day shift start. The highest impairment ratings were recorded for driving at the end of night shift. The mean for sleepiness suggested some reason for concern but of more alarm was that 18% recorded a rating of 'very sleepy; fighting sleep.' Some 6% indicated that driving after a night shift was 'always' impaired. The most likely explanation for the end of night shift impairment was sleep loss and shift length.

The post shift increases for sleepiness and driving impairment were further supported by the results concerning the number of fall asleep incidents in the previous 12 months. Of concern was that 43% of shiftworkers reported some level of falling asleep at the wheel when driving home after night shift. In addition, some 13% reported falling asleep when driving to night shift. It is not known whether this was for the first or subsequent night shift but it does suggest that workers are not gaining sufficient rest. Under 'normal' circumstances, driving in the mid evening is associated with increased alertness. The fact that employees are reporting falling asleep may reinforce the suggestion of inadequate preparation for working night shift.

In the day-workers, falling asleep incidents were also higher at the end of day shift for all three groups but this was least for DWU and highest in DWM. Some 19% of

DWM employees indicated falling asleep and more than half reported having more than two sleep related vehicle incidents. There may be two reasons to explain the degree of falling asleep in the DWM group; sleep truncation and extended shifts. Employees are reducing sleep in the early morning to travel to work on time and over a third of the employees worked in excess of 12-hours per day and over one-half worked 10-12-hours per day. Some of these employees also reported working in excess of five consecutive day shifts per week.

For all groups the sleep related incidents resulted in various degrees of lane drifting. These included crossing the centre line, running onto the shoulder and off the road, and braking for no reason at all. These behaviours are consistent with the effects of sleep loss. Driving under conditions of high sleep loss is associated with difficulty in staying awake and the intrusion of microsleeps into consciousness. There were no reported serious incidents as a result of falling asleep at the wheel.

In summary, this study has demonstrated that shiftworkers and DWM employees were more tired than 'standard' day-work employees. All three groups recorded increased sleepiness and driving impairment post shift, but the largest increases where for the end of night shift and the end of day shift in the DWM group. In addition, these two groups reported the highest frequency of falling asleep at the wheel and sleep related vehicle incidents. The key distinguishing features between the shiftworkers and the DWM group compared to the DWU group is that they commenced work earlier in the day and worked more hours per day and per week. There was also some indication that the shiftworkers and DWM drove longer distances for work. These results suggested that driving too early in the day, driving long distances and working long daily shifts contribute to increased driver fatigue ratings and recorded road incidents.

Chapter 6. Drive In Drive Out Shiftworkers and Day-workers

6.1 Introduction and method

Discussions with mine management at sites 'B' and 'C' indicated that some shiftworkers lived outside the immediate local area during their days off. This provided the opportunity to conduct a pilot study to examine fatigue and driving impairment in DIDO shiftworkers.

Surveys were screened to ensure that employees travelled a minimum of 50 km by either driving direct to work or as a regular driver in a car pool. This resulted in 48 employees meeting these criteria. The sample contained an equal number of shiftworkers and day-workers.

6.2 Working and living arrangements

Eleven shiftworkers reported working between 10-h and 12-h shifts and 12 indicated working 12.5-h shifts. Shift changes occurred at about 06.30 and 18.30. The shift patterns were described in 5.2. Employees returned 'home' on days off.

The day-workers worked for a number of companies and the typical working arrangements consisted of five consecutive day shifts with weekends off. Work commenced at approximately 7.00 am. Nine reported working between 10 and 12-h shifts and 15 recorded working longer than 12-h per day.

All DIDO workers lived in temporary accommodation in proximity to their workplace. One day worker indicated going home (approximately 150 km one-way) at the completion of a 12-h day mid week and returned for a 07.00 am shift the next morning.

6.3 Data analysis strategy

Preliminary analysis of the time at which employees left to travel to work showed much variability. To account for this variability, three groups were formed for data analysis: a) those leaving immediately before day shift from 03.00 – 04.15 am, b) those leaving immediately before day shift from 04.30 – 05.30 am, and c) 'all others' - those travelling outside these time periods. The driving distances for these groups also showed large differences and therefore, analyses of sleepiness and driving impairment were weighted by driving distance.

Analyses in section 6.4 did not discriminate between day workers and shiftworkers since 'driving' to day shift' start times were similar. In section 6.5 analyses for DIDO employees were separated since they travelled home at different times of the day and because their working conditions may also differ.

6.4 Results for driving to work

The 24 shiftworkers were all male and the day workers comprised 22 males and two females. The mean age for all workers was 40 years old and the age range was 19-62 years.

The overall mean distance travelled to attend work was 238 km. The distances and travel time to work are shown in table 6.1. These data suggest that the further the distance to work, the earlier the drive commenced. The 'all others' group (see 6.3.) left as early as 02.00 the day before the shift and drove up to 1300 km to attend work. Others in this group left home from 08.00 and drove up to 1000 km. In both cases, employees aimed to reach the mine the evening before day shift commenced. An additional three employees who live outside of a local town to the mine travelled to work by bus. The distances travelled by these employees ranged from 100 to 2000 km. These employees were not considered for data analysis.

Table 6.1: Mean Distance Travelled and Travel Time from Home to start Day Shift.

	Distance (km)			Travel time (hours, minutes)		
Group	Mean	Min Value	Max Value	Mean	Min Value	Max Value
3.00 – 4.15	154	100	230	1.40	1.18	2.18
4.30 – 5.30	136	50	200	1.43	0.45	5.00
All others	454	90	1300	4.52	1.00	14.00
Overall	238	50	1300	2.39	0.45	14.00

The values for sleepiness and driving impairment whilst driving to work are shown in table 6.2. A significant difference was found between the means for the

groups ‘4.30 – 5.30’ and ‘all others’ (p=<0.05). This suggested that driving earlier and longer distances was associated with increased sleepiness and driving impairment. The overall unweighted mean for sleepiness and driving impairment ratings were 4.22 and 2.17 respectively.

Table 6.2: Mean Sleepiness and Driving Impairment by Time of Departing Home to commence Day Shift.

	Sleepiness			Driving Impairment		
Group	Mean*	CI Range**		Mean*	CI Range**	
3.00 – 4.15	4.14	3.07	5.21	2.26	1.69	2.83
4.30 – 5.30	3.66	2.33	4.98	2.10	1.40	2.81
All others	5.63	4.90	6.35	2.46	2.07	2.84
Overall	4.48	3.86	5.09	2.27	1.95	2.60

* Estimated mean weighted by distance travelled.

** Confidence Interval range

Six workers (13%) reported falling asleep while driving to day shift in the previous 12 months. The number of fall asleep incidents and distances travelled were: a) ‘once or twice’; 120 – 1300 km, b) ‘three / four’; 500 – 1000 km, and c) ‘more than four times’; 150 km. The details are shown in table 6.3. The type of accidents or incidents associated with falling asleep whilst driving to day shift included: run off road and shoulder, crossed the centre line and braked the car for no reason. These incidents were associated with getting up to 5-h of sleep.

See table 6.3

Table 6.3: Frequency of Falling Asleep when Driving to Day Shift

	Frequency of falling asleep			
Group	Never	Once or twice	Three / four	More than four
3.00 – 4.15	16	2	0	1
4.30 – 5.30	13	0	1	0
All others	12	2	0	0
Overall	41	4	1	1

6.5 Results for driving from work

The mean home arrival time was 09.48 (range 07.48 – 20.00) and 17.00 (range 03.00 – 23.00) for shiftworkers and day-workers respectively. The mean arrival time for day-workers suggested that employees left work earlier than normal on the last day since 63% of the day-workers reported working more than 12-h.

The values for sleepiness and driving impairment whilst driving home are shown in table 6.4. For shiftworkers, mean sleepiness was higher (p=<0.05) after night shift (5.50 versus 3.78) compared to driving to day shift. Driving impairment was also higher (p=<0.05) when driving home after night shift (2.67 versus 1.92).

Table 6.4: Mean Sleepiness and Driving Impairment by Shift Type when driving to distant Home.

	Sleepiness			Driving Impairment		
Shift Type	Mean	CI Range*		Mean	CI Range	
Night	5.50	4.88	6.12	2.67	2.32	3.01
Day	4.50	3.91	5.27	2.25	1.85	2.65

* Confidence Interval range

The number of times the employee fell asleep when driving home in the previous year is shown in table 6.5. Overall 23% reported some degree of falling asleep. Shiftworkers were involved in more fall asleep events than day-workers. The type of accidents or incidents associated with falling asleep whilst driving home included: run off road and shoulder, crossed the centre line and braked the car for no reason. These events were associated with getting up to 5-h of sleep for shiftworkers whereas DWM reported 6-8-h of prior sleep.

Table 6.5: Frequency of Falling Asleep when Driving Home

	Frequency of falling asleep			
Shift Type	Never	Once or twice	Three / four	More than four
Night	18	4	2	0
Day	19	4	1	0
Overall	37	8	3	0

The shiftworkers (54%) were more likely to take a break during the drive home compared to the day-workers (38%). A driving break was taken by shiftworkers when travelling 50 – 230 km. Driving breaks were taken when travelling 100 – 1300 km for day-workers. For shiftworkers not taking a driving break, the distances ranged from 75 – 550 km and for day-workers, the range was 106 – 500 km.

Strategies for staying awake were similar between the two groups. The most common was using the radio, open window/air conditioning and taking a break.

6.6 Discussion

The pilot study of DIDO workers provided some insight into the travel patterns and associated fatigue and accident risk. On at least one occasion for each work period, employees are leaving home as early as 3.00 am in the morning to drive directly to work. These employees travelled a maximum of 230 km to attend work. A separate

category left home as early as 2.00 am to arrive for day shift on the following day (approximately 29-hours later). These drivers covered distances of up to 1300 km.

Both these groups are of interest because they demonstrated that driving earlier in the morning and driving longer distances were associated with higher levels of fatigue and driving impairments than the group that left for work between 4.30 – 5.30. The most likely explanation for these results is that the drive coincided with the greatest drive for sleep (early morning hours), sleep inertia in truncating sleep too early and the demands of sustained attention in driving long distances in sometimes poorer environmental conditions.

The '4.30 – 5.30' group also reported that higher sleepiness and driving impairment ratings than the sample in chapter 6. This finding lends further support for the argument that early morning driving and driving longer distances driven were associated with greater impairment.

The frequency of falling asleep at the wheel seemed to be linked to the distance driven. Workers driving 500 – 1000 km reported falling asleep three-four times in the previous 12 months. Consistent with the results in chapter 5, the type of sleep related incidents were also a number of manifestations of lane drift. These incidents were associated with having had less than 5-hours of sleep.

In line with the results for end of night work in chapter 5, sleepiness and driving impairment were significantly higher on the return journey compared to end of day shift values. Overall 23% of DIDO workers reported some degree of falling asleep at the wheel. There did not appear to be differences by shift but the point is that falling asleep did occur and the frequency was higher when driving home. This suggested that employers need to investigate strategies to better protect workers from the risk of driving long distances post shift. These may include providing sleep facilities and/or assisting with transport. It is the case that sleep facilities are available for some workers but there is no requirement to make use of the facility.

It is also arguable that DIDO workers take greater responsibility when returning home since OHS is a joint responsibility. Some 54% of shiftworkers and 38% of day-workers reported taking a break when driving home after shift. While this may be generally good practice, it was disturbing to find those not taking driving breaks were up to 550 km.

This study has a number of limitations. The sample size was relatively small but this does not diminish the actual results. A larger sample may provide a better

estimate of the situation. Secondly a number of different work systems were combined for data analysis and this may have contributed towards minimising any differences between different forms of shiftwork and between shiftworkers and day-workers.

In summary, this pilot study provided preliminary results concerning the impact of DIDO working operations on fatigue and driving impairment. The results suggested that driving early in the morning and driving long distances were associated with fatigue and driving impairment. Although the self reported levels were not necessarily of major concern, 13% of DIDO workers reported falling asleep at the wheel when driving to day shift. End of shift data suggested significantly higher sleepiness and impairment values and especially for night shift. Falling asleep at the wheel did not show any differences by shift but nevertheless, 23% of DIDO workers reported falling asleep on the long drive home. A high number of DIDO workers drove home without a driving break. These findings suggest that employers may need to consider strategies to assist DIDO workers. Alternatives include providing a post shift sleep facility, transport assistance and educational solutions. Future follow up studies using larger sample sizes will provide more definitive data to guide the coal industry.

Chapter 7. Driver Survey

7.1 Introduction and method

A brief survey was developed to collect data from motorists travelling east from the Bowen Basin. Two separate sites were established. Westwood was chosen to collect data from traffic leaving the Blackwater and Middlemount districts. The second site at Eton was chosen to collect data from traffic leaving the northern Bowen Basin districts.

The survey was administered by police officers as part of a planned Random Breath Testing (RBT) and licence check initiative. Drivers were stopped in blocks of between 2-5 cars at each site between the hours of 8.00 am and 10.00 am. Police first completed the RBT, licence checks and asked permission of the driver to complete a brief survey. Pilot testing showed the survey would take approximately three minutes to complete. The survey collected biographical data, industry and work details, driving distance and strategy, and an estimate of sleepiness (rated by the police officer). The sleepiness scale was described in section 5.1.

Due to the many different shift rosters in operation, data was collected over a ten week period and covered the week days only. Week one began on Monday, Week two was a Tuesday and so on.

7.2 Response rate

The Westwood driver survey resulted in 897 responses. Data from Main Roads department suggested that the survey was completed by approximately 21% of passing traffic during the period 8.00 am – 10.00 am. The Eton survey was completed by 688 drivers and this represented some 20% of the traffic flow for the time period.

7.3 Westwood driver study

Responses to the 'industry' classification variable resulted in the establishment of three categories to guide the data analysis. These were: a) non-shiftworkers (NSW), b) shiftworkers at work or who had just completed work (SW), and c) shiftworkers who were on days off (SWNAW).

Overall, shiftworkers either at work or on days off accounted for 16% of the sample. Mean age for each group was between 41 and 44 years of age. Of the 142

shiftworkers, 133 were male and nine were female. Of the shiftworkers, 85% worked in the coal industry, 5% in rail and 3% in nursing. The most common shift lengths were 12-h (68%), followed by 12.5-h (9%) and 8-h (6%). Working three or four consecutive night shifts was most reported with one worker indicated having worked 12 consecutive night shifts.

There was no significant difference between the three groups for one way distance to be travelled for the day. The average for the groups was 242 km. However, the upper range for the SW group was 655 km. No significant differences in distance travelled were found for driving direct or taking a break to reach their destination for the SW group. The maximum distance to be driven direct following night shift was 380 km. Approximately 47% of the SW group indicated returning to their home between three and four days. The 53% of the SWNAW groups planned to be away for an average of three days. Of note, eight SW (14%) reported returning home on the day of the survey. This resulted in an average travel for the day of 507 km (maximum = 880 km) following the completion of night shift.

Drivers were asked how long they intended to be away from their home. The average time away was 3.5 days. This length of time corresponds with the length of rostered time off between work periods on extended shifts (Heiler, 2001). When asked about the return time of their journey, a bi-modal distribution was observed. Travel times were either early in the morning (between 2.00 and 3.00 am) or in the mid afternoon from about 2.00 pm.

A significant difference ($p=<0.01$) in sleep duration for the previous 24-h between SW (6.18-h) and SWNAW (7.12-h). Police ratings of driver sleepiness also showed a significant difference ($p=<0.01$). Mean SW sleepiness ratings were 4.07 compared to less than three for the other two groups.

7.4 Eaton driver study

Overall, 30% of the sample was reported as shiftworkers either at work or on days off. Mean age for each group was between 38 and 41 years of age. Of the 207 shiftworkers, 199 were male and eight were female. Of the shiftworkers, 92% worked in the coal industry and 4% in transport. The most common shift length was 12-h (74%) with most between 11-13-h (86%). Working three or four consecutive night shifts was common with ten nights being the upper limit.

A significant difference was found for one way distance travelled in the day (p=<0.01). SWNAW drove the furthest (223 km), followed by SW (193 km) and NSW (166 km). The upper range for the SW group was 600 km without intending to take a break. No significant differences in distance travelled were found for driving direct or taking a break to reach their destination for the SW group. Approximately 58% of the SW group indicated returning to their home between three and four days. The 48% of the SWNAW groups planned to be away for an average of two days. Of note, eleven SW (9%) reported returning home on the day of the survey. This resulted in an average travel for the day of 282 km (maximum = 410 km) following the completion of night shift. The time of return to the town showed the same bi-modal distribution with early morning and afternoon departures.

A significant difference (p=<0.01) in sleep duration for the previous 24-h between SW (6.36-h) and SWNAW (7.12-h). Police ratings of driver sleepiness also showed a significant difference (p=<0.01). Mean SW sleepiness ratings were five compared to 3.3 for the other two groups.

7.5 Discussion

The aim of this study was to provide preliminary data on road use by shiftworkers on completing night shift with the aim of identifying the additional risks undertaken by driving long distances.

The two studies identified that some 16 to 30% of drivers between the hours of 8.00 am and 10.00 am were either shiftworkers at work or on days off. There were minor differences in the mean distance to be travelled between the two sites (193 versus 242 kms). However the key point is that these distances were driven after the completion of three to four 12-hour night shifts on average and some worked up to 12 consecutive night shifts. Also of concern was that some shiftworkers indicated driving up to 600 km without taking a break.

While this survey did not collect accident related data, it did collect some data that suggested shiftworkers were increasing their accident risk. In both studies shiftworkers reported getting less sleep than the two comparison groups. In addition to consecutive sleep loss across the spell of night shifts and the physical demands of working nights, shiftworkers are undertaking a long duration monotonous task such as driving. The results from chapter six supported an argument that falling asleep at the wheel was associated with completing night shift and driving long distances. Finally,

at both sites, shiftworkers were assessed by the police officer as being less alert than the two groups that had taken night sleep.

There are some limitations to this study. First it was designed to be a brief survey and therefore it would have benefited from collecting additional data concerning work, sleep and rest prior to the journey. The police officers were not trained in administering the survey and it may be possible that the intent of some items were misinterpreted and contributed to biased or incorrect data being collected. It is also a possibility that sleepiness were biased by the fact that the ratings were collected at the end of the survey and after the officer had formed an impression of the driver's history and driving intention. However, rating sleepiness prior to other data collection may also have biased the rating. A number of officers commented on how 'alert' the driver was when first stopped and then relaxed when it was clear they were not being stopped for an offence. Another limitation was that all forms of shiftwork were treated in a homogeneous manner since data on actual shift systems were not collected

In summary, this driver survey identified that some 16-30% of drivers were shiftworkers in the Bowen Basin. Of these the significant majority worked 12-hour shifts in the coal industry. The study achieved its aim of recording the post night shift activity of shiftworkers. It seemed shiftworkers do indeed leave their local town for the long rostered block of days off to spend time at the coast. These shiftworkers undertook the drive after significantly reduced sleep loss and planned to drive on average between 193 and 242 km. Some recorded driving up to 600 km without a driving break. In each study, those having completed night work were rated as significantly sleepier than the other two groups. A number of limitations to these studies were discussed.

Chapter 8. Epilogue

The aim of this research was to investigate differences in driver fatigue between a shiftwork and non-shiftworking group. In addition, the non-shiftwork group were examined for differences in start times and shift duration. Each of the three studies provided evidence for the contribution of shift start/end times and shift length on driver fatigue. These findings need to be considered in light of some limitations in each of the studies.

In general, the earlier in the morning and the greater the distance to be driven to work, the more sleepiness and driving impairment was observed. The DWU group recorded the lowest level of sleepiness and driving impairments. This group arose later in the morning than the shiftworkers or the DWM group and worked shorter shifts.

The results demonstrated clear end of shift effects. For day shift, the greatest impairments were found in DWM and not shiftworkers. While this may suggest that shiftwork per se is not problematic, it may be more likely that the difference is due to the work differences between the shiftworkers and DWM. The DWM group began work at the same time as shiftworkers, worked similar shift lengths and in some cases worked longer weekly hours. This may best explain why DWM recorded greater sleepiness and driving impairment after day shift.

Increases in sleepiness and driving impairments were most marked for night shift. It was also the case that just under half of the shiftworkers reported falling asleep at least once when driving after night shift. However, falling asleep at the wheel occurred in about 10% of cases for shiftworkers and the DWM group compared to 3% in the DWU group. This suggested that early start times and longer working days may explain this difference.

Falling asleep did not seem to result in a serious accident or incident. Most commonly incidents were manifestations of lane drifting including run off road. Most of these incidents were reported to have occurred when workers had had less than 6-hours sleep.

The findings from chapter six confirmed the practice of DIDO workers. The results for DIDO workers showed a greater degree of impairment compared to the workers living in local towns and driving daily. This difference can best be explained

by the earlier departure time from home, the time of day that the drive occurs, the distances covered and the amount of hours worked. Of greater concern where the employees who left in the very early morning and drove up to 1300 km to attend day shift on the following day. These workers recorded the greatest deficits.

Driving long distances after completing night shift is not recommended. This suggested that employers and employees consider strategies to avoid this practice. Some employers do offer sleeping facilities post shift. However, there is a gap between a bed being offered and the offer being accepted. It is recommended that employers consider educational interventions to raise the awareness of driver fatigue in the industry.

The driver survey in chapter seven provided some support for the argument that extended shifts have allowed some shiftworkers to journey away from the mine area after completing a spell of night shift. It was argued that from a risk management perspective, driving long distances after a spell of night shift would be hazardous. The results confirmed, that shiftworkers had less sleep compared to non-shiftworkers, planned to drive on average approximately 200 km but some were planning to drive about 600 km. In addition, shiftworkers were rated by police officers as being sleepier than non-shiftworkers.

The three sets of studies however, have some limitations and these were outlined in each discussion section of chapter's five to seven but it worth highlighting two difficulties in particular. The various shiftwork systems and the small numbers worked in each led to a decision to collapse all shift systems into a single variable. While this helped to create a larger sample for statistical analyses, it may also be the case that this may have over or under played the impact of each shift system on driver fatigue.

The second limitation is that of common method variance. Each study made use of self report data and it is possible that each study may be biased in some way. It was not possible to collect independent data from each study to provide another vehicle for analyses of driver fatigue in shiftwork and non-shiftwork samples.

While these studies have some limitations it is also the case that they have demonstrated that:

1. Driving too early in the morning and driving long distances are associated with higher levels of driver fatigue.

2. Driving after a work shift is linked to greater fatigue and more so after night shift.
3. DIDO workers reported the highest level of impairment and more so after night shift. Some of these workers drove up to 1300 km to reach home.
4. Some night shift workers immediately depart for leisure time at the coast. This practice should be avoided since chronic sleep loss and driving long distances may combine to increase accident risk.

Finally, it is recommended that additional studies be conducted to verify or challenge the studies presented in this report. The coal industry has always worked towards maintaining excellence in OHS and driver fatigue is an area that warrants further examination.