A study of the health and safety aspects of shiftwork and rosters at the PCML

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ABSTRACT

This paper reports the conclusions of a study that was undertaken to assess the safety risk and health aspects of shiftwork and rosters at the Pasminco Century Mine Limited (PCML). PCML has guidelines in place to manage fatigue and wished to assess their effectiveness and the need for any changes. In part, this recognition was catalysed by the paucity of relevant data and studies on shiftwork and commute rosters in the metalliferous mining industry

The health and safety performance at PCML is among the best in the Australian Mining Industry. The system for managing fatigue is an integral part of the overall health and safety management system at PCML.

In conclusion, the data show that sleep quality and quantity does not deteriorate over multiple 24-hour periods, and that a commute workplace that supports and promotes a recovery environment will be less impacted by fatigue than a community based workplace where the recovery off-shift may be more difficult and may lead to an accumulated sleep debt.

In addition, there is no evidence from this study to indicate that fatigue as a result of the work rosters and shift cycles worked is a significant contributor to accidents and incidents at PCML.

INTRODUCTION

The study was commissioned by PCML to evaluate the effectiveness of the fatigue management initiatives that have been implemented at the Mine. Unlike other studies this project focuses purely on the safety risk and health aspects of fatigue whilst employees are on site. The study does not cover social and economic aspects of shiftwork and roster influences off site or in the domestic setting.

This distinction was principally made because PCML, in common with all fly in fly out operations has a strong influence over site conditions both during working hours and during rest and recreation between shifts. This degree of control obviously does not exist with a conventional residential based workforce.

OVERVIEW OF CENTURY OPERATION

PCML is one of the largest zinc mines in the world, producing 880,000 tonnes of zinc concentrate and 70,000 tonnes of lead concentrate annually.

Century's operations comprise two sites being the open-cut mine site located at Lawn Hill and the port site at Karumba, both in north west Queensland, Australia. Mining zinc, lead and silver, the open cut mine is expected to operate until 2018.

PCML was the recipient of last years MINEX Award presented by the Minerals Council of Australia in recognition of excellence in the field of safety and health in the mining industry. The fatigue management initiatives in place at Century were recognised as providing an industry benchmark for best practice.

Commute Roster Arrangements

Century employs approximately 570 personnel on a fly-in, fly-out basis who commute from a number of regional centres in far north Queensland. These include Townsville, Mt Isa, Normanton, Doomadgee, Burketown and Mornington Island.

There are four main roster cycles of twelve-hour shifts that are worked at Century Mine. These rosters reflect the different operational requirements at the Sites. These include:

- A six week cycle of five days on followed by two days off for four weeks, followed by seven days on and then seven days off;
- 9/5 roster – nine days on followed by five days off (providing four day overlap with opposite shift within two week period);
- 14/7 – fourteen days on followed by seven days off (providing one week overlap with another shift);
- 21/7 - twenty-one days on followed by seven days off (one week on day shift followed by two weeks on night shift, or two weeks on day shift followed by one week on night shift).

Personnel employed at the Port facility at Karumba live in the town in purpose built rental accommodation and being residential, their responses are not included in this paper but were included in the overall study.

Lifestyle at Darimah Village, Century Mine

The lifestyle at Century promotes a well-balanced approach to food, diet, exercise, sleep and social activities. All personnel live at the Darimah Village, and are provided with the following facilities

- Air-conditioned rooms with pull-down shutters to exclude noise and light.
- Room cleaning service with full linen change once a week
- Access to free laundry facilities
- Sporting facilities including 25 metre heated swimming pool, gymnasium with state-of-the-art equipment, tennis/basketball/netball court, indoor cricket pitch, oval for touch rugby, golf, walking tracks, bicycles and a yoga space
- Exercise instructor who is also responsible for maintaining the sporting facilities
- Recreation facilities including TV rooms, pool tables, darts, movie channels, Bacchus Club and Century Community Club social nights
- Dining facilities and menu options that promote a healthy and balanced diet that are also approved by a qualified dietician (and endorsed by the health promotion character 'Ernie')
- Two bars with limited bar hours and restricted purchase of 'take-away' alcohol
- Shop, phones in rooms, public phones and mobile phone coverage
- Outdoor barbeque and recreation area located away from residential area
- Village Medical Clinic and on-site Medical Centre staffed by Registered Nurses
- Village noise abatement policy that restricts noise after 9.30pm at night and 9.30am in the morning
- Fatigue Management Guidelines
- 'Working in the Heat' Guidelines and scheduled monitoring programme
- Workplace Drug and Alcohol Policy and procedures that promote education and awareness programmes including self-testing, and monitoring via random testing
- Transport to and from the Village, and chartered aircraft to move personnel to and from the operating sites
- Access to a subsidised Employee Assistance Programme

STRATEGIC DEVELOPMENT OF PCML FATIGUE MANAGEMENT GUIDELINES

Most of the initiatives and facilities listed above were adopted during the start-up of the PCML in November 2000. Pasminco and their contractors recognised that they need to continually evaluate shiftwork and rosters to ensure that the variables that may contribute to fatigue were identified, and the risk of fatigue minimised and/or mitigated.

In early May 2001, a number of workshops were held on site with supervisory and operational personnel to review current arrangements with regard to shiftwork and rosters, and identify any issues with regard to fatigue.

The Workshops looked at:

- What is fatigue and contributing factors
- Standards & Legislation
- What's in place now
- Latest fatigue management approaches
- Management Plan framework
- Current rosters & shift arrangements
- Issues emerging

The workshop participants identified the critical work related variables that may contribute to someone suffering from fatigue, these include:

- Work schedules and shift rotations eg. Night shift
- Type of work being carried out eg. Physically demanding, mentally demanding, monotonous, repetitive types of work
- Work environment eg. Exposure to noise, heat, dust etc

An extension of this assessment was to 'risk rate' various roles on Site to identify those where the employee was more at risk as a result of being fatigued.

For example, in the mining area the higher risk roles were identified as follows:

ROLE	DESCRIPTION	FATIGUE RISK FACTORS PRESENT	LIKELIHOOD	CONSEQUENCE	RISK RATING
Mobile equipment operators, includes truck drivers in the Pit, transport drivers and lead truck drivers	Responsible for operating mobile equipment such as trucks, graders, dozers, loaders, water carts and service vehicles in the Pit.	▪ Monotonous ▪ Duration of work (12 hours) ▪ Roster length (3:1) ▪ Shift work ▪ Working in isolation (transport truck drivers)	Almost Certain	Catastrophic	High
Non-mobile equipment operators, includes drill operators in the Pit	Responsible for operating non mobile equipment such as drills, shovels, excavators in the Pit.	▪ Duration of work (12 hours) ▪ Roster length (3:1) ▪ Shift work	Possible	Minor	Moderate
Blast crew and cable crew in the Pit	Responsible for charging drill holes with explosives and tying in shots. Cable crew responsible for laying and moving of heavy duty 11kV electric cable	▪ Physically demanding ▪ Duration of work (12 hours) ▪ Roster length (3:1) ▪ Night shift work (cable crew) ▪ Extreme work environment (heat & humidity)	Almost Certain	Catastrophic	High

For the higher risk roles, such as those described above, a number of additional fatigue management opportunities were identified and implemented. These include:

- Controlled shift length and roster design (including rotating shift cycles) eg. Minimum rest breaks between shifts; Maximum shift length; restricted roster length and hours per week (*Hours of Work and Rostered Time Policy);*
- Access to self-select work breaks via the mobile equipment dispatch system in each truck;
- One-on-one interview before commencing night shift for the first time, including the requirement to complete a Fatigue Management Questionnaire to assess experience with commute rosters and shiftwork.

The workshops also identified opportunities to better manage fatigue largely through educating and empowerment of personnel to improve self-detection and response to fatigue symptoms, as well as an understanding of practices to avoid the onset of fatigue. Some of the improvements were:

- Provision of information and education regarding fatigue management as part of the General Induction including presentation, booklet, and site specific video
- Return from R&R and tool box presentations on diet, exercise and lifestyle choices
- Posting of 'Stay alert, Stay safe' fatigue management posters in all rooms
- Evaluating the need to carry out non-standard work at night eg. One-off or non-routine jobs carried out during day
- Job or task specific fatigue management plan eg. Confined Space Entry in summer
- Determining requirements for stand-by and on-call duty in addition to normal role eg. Rotate through a team/crew

EVALUATION OF FATIGUE MANAGEMENT IN RELATION TO SHIFTWORK AND COMMUTE ROSTERS

The PCML Fatigue Management Guidelines address all the major potential issues identified in the technical literature. The Guidelines will be extended to include the synergistic effects of heat and fatigue in the future.

The Study indicates that there is good evidence to indicate that in general the Fatigue Management Guidelines are properly implemented across the site. There is some comment that there may be a need to be a reinvigoration of the process in some work areas.

Effectiveness of Fatigue Management

Accident And Injury Statistics

Century currently has a Lost Time Injury frequency rate of 0.5 per million exposure hours. All medically treatable incidents are logged in the ACCstat database together with information on when the incident occurred, time of day and day into roster.

Figure 1 outlines the relative frequency of accidents and incidents over the 12-hour day and 12-hour night shift for workers who work both day and night shifts.

The data indicate that there is no clear increase in the frequency of accidents or incidents relative to the number of hours spent at work as is predicted by the literature.

Figure 2 repeats this analysis for number of days into roster for the 28-day roster cycle (three weeks on shift; one weeks rest and relaxation). For comparison the predicted increased relative risk values from the literature (Folkard , 2002) and a US mining study (Wagner, 1988) are shown.

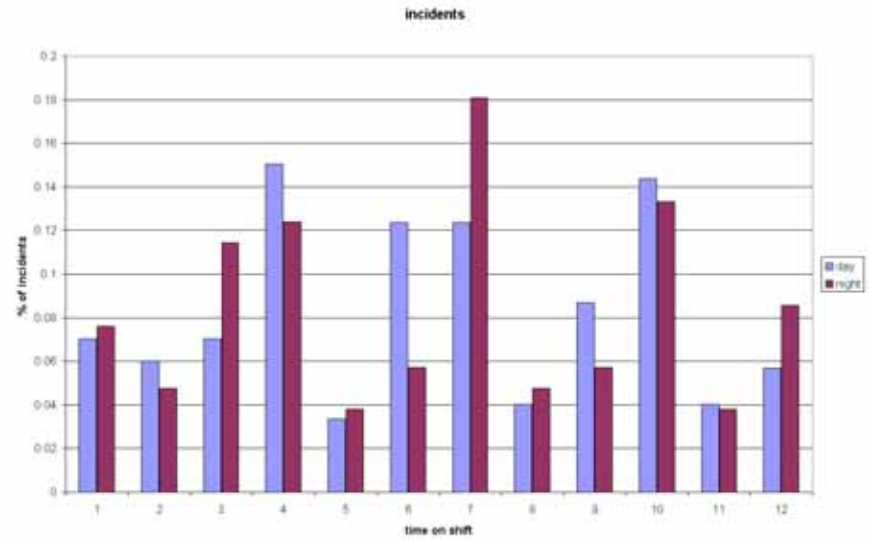

Figure 1 Relative frequency of all incidents for shift workers

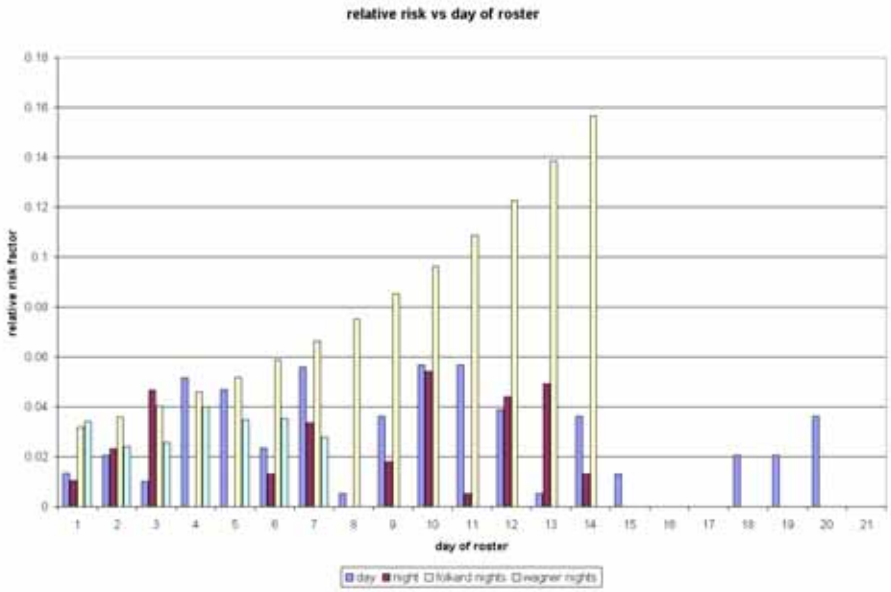

Figure 2. Analysis of incidents against day of roster for 28-day roster cycle

The data from Century and the US study do not conform to the standard literature predictions. Similar data was obtained from workers on the 21 day roster cycle.

Analysis of self-select breaks

All operators of mobile equipment in the Pit can request to have an unscheduled break that is managed via the on-board truck computer system. This break is called a Code 40 self-select break.

The Code 40 data was analysed in an effort to establish any temporal trends.

The data would seem to indicate that the greatest percentage of Code 40 breaks are taken on the first few night shifts.

The data also show that compared to the first two night shifts, there is no significant increase in the number of Code 40 breaks taken as the number of shifts increases. This absence of any trend towards taking an increasing number breaks would suggest that fatigue is not incremental or carried over with the number of night shifts worked.

This is consistent with previous studies in the off-shore oil industry where personnel actually sleep better once they are in the pattern of sleeping for night shift.

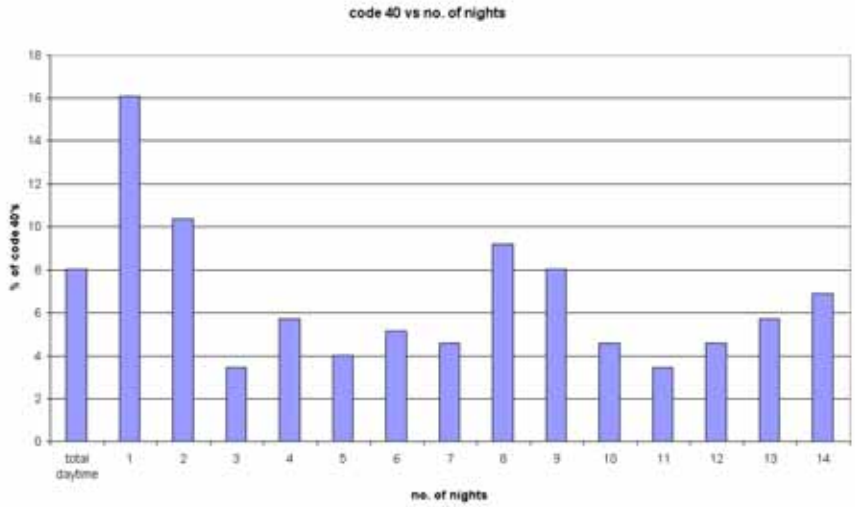

Figure 3 Code 40 breaks taken as a percentage of total number of personnel on night shift

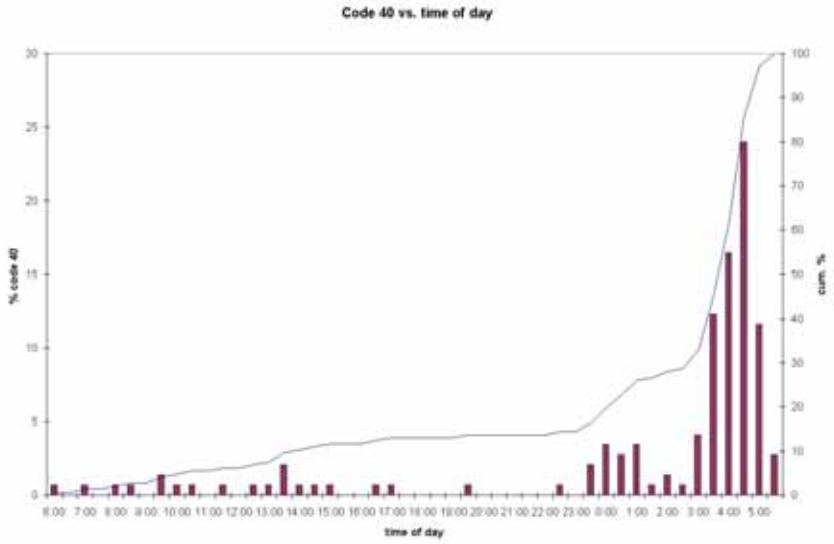

Figure 4 Code 40 break as a function of time of day

Figure 4 indicates that the self-select breaks are mainly taken between 3am and 5am.

This graph is a classic reflection of the influence of circadian rhythm, experienced as a dip in alertness between 3am and 5am. It also reinforces the validity of the data as a true reflection of the reporting of the breaks.

The widely documented circadian 'afternoon' dip (in alertness) would appear to be masked by the scheduled meal break that is taken by all operators so that blasting can be carried out.

Self Evaluation Questionnaires

The standard Survey of Shift workers (SOS) (Folkard, 1995) was handed out to the workforce of 570 and 240 were returned. Personnel were asked to subjectively rate a wide range of issues that may relate to shift work as well as specify their sleep patterns both at home and at work under the various shift patterns.

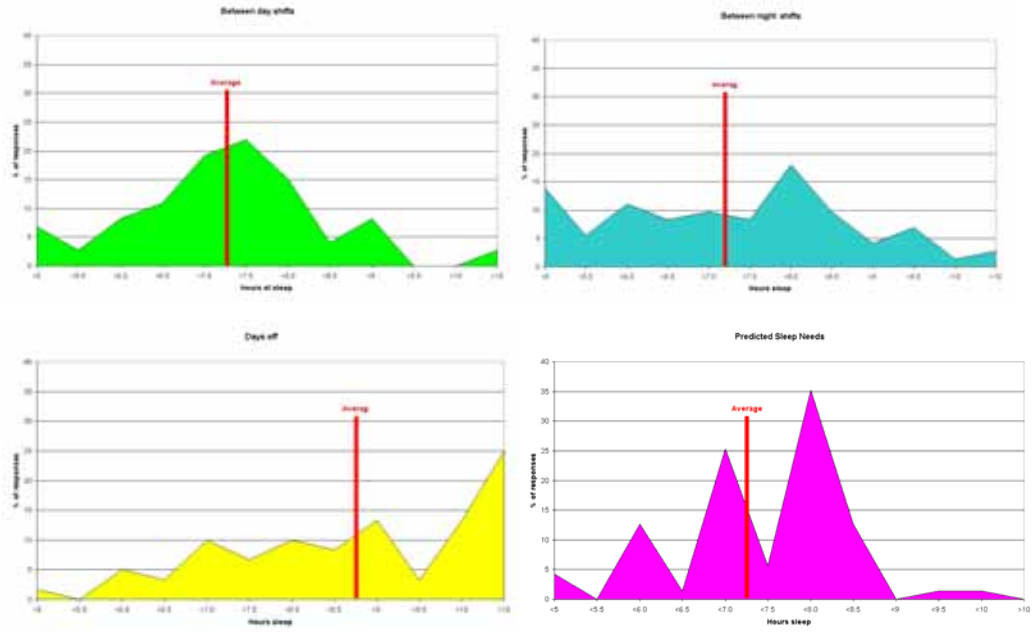

Figure 6 Distribution of hours of sleep for between day shifts, between night shifts, days off and predicted sleep needs

These data indicate that the average amount of sleep obtained does not vary between day shifts and night shifts though the standard deviation does increase. This indicates that some people sleep better on night shift and some sleep worse.

Sleep And Alertness Logs

Sleep and alertness logs, as used in the ACARP funded research project 'Development of a risk management tool for shiftwork in the mining industry' (Bofinger et al 2002), were distributed to the workforce. A relatively small number were returned. The hours of sleep defined by these were consistent with the hours of sleep obtained from the Survey of Shift workers. It is suggested that the low return rate was in part due to the length of time (up to 28 days) that personnel would have to fill them out over.

Comparison with other mining studies

There are three other reported studies on sleep habits in the Australian Mining Industry:

Study	Author & Date	Commute or residential	Shift length
Burton Open Cut Coal Mine	Esson et al, 2000	Residential	Rotating 12 day and night
ACARP	Bofinger et al 2002	Mixed Residential	Rotating 12 hour day and night Rotating 8 hour day, afternoon and night
Tasmanian Mining Industry	Heiler, 2002	Residential	Mixed
This study:			
Century	2003	Commute	Rotating 12 day and night

These studies report sleep habits in varying ways. Figure 7 compares the PCML average hours of sleep during days on shift with the ACARP and Burton studies.

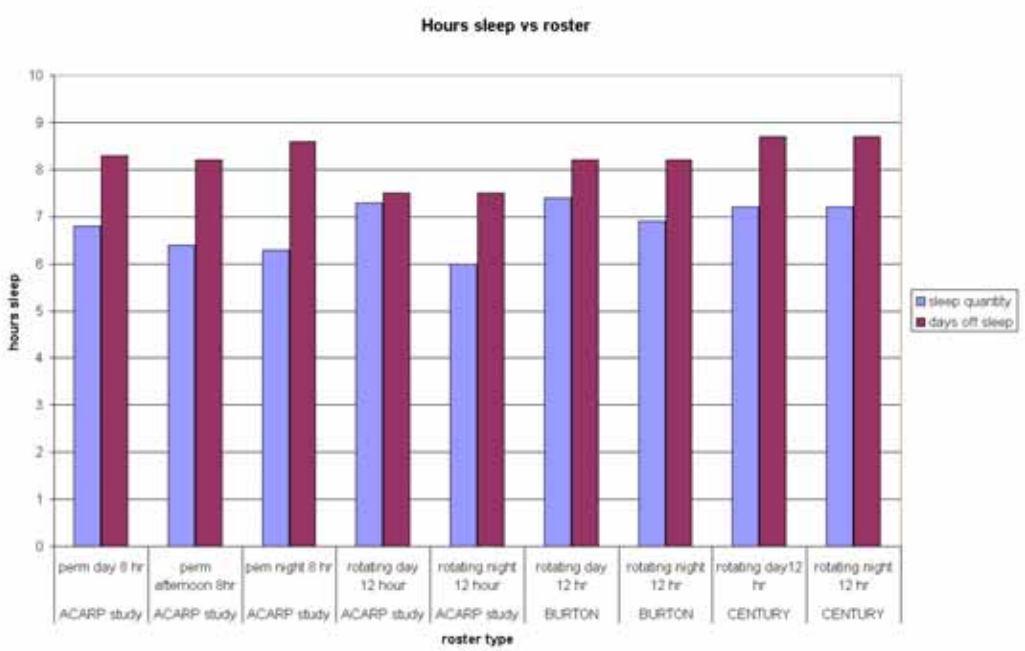

Figure 7 Average hours of sleep comparison for three studies

Generally, personnel at Century average over seven hours sleep between shifts, which is amongst the best reported. This result would suggest that the controlled sleep environment (commute roster) does significantly influence the hours of sleep compared to a residential community based workplace.

Figure 8 reports the standard deviation of hours of sleep for the same studies.

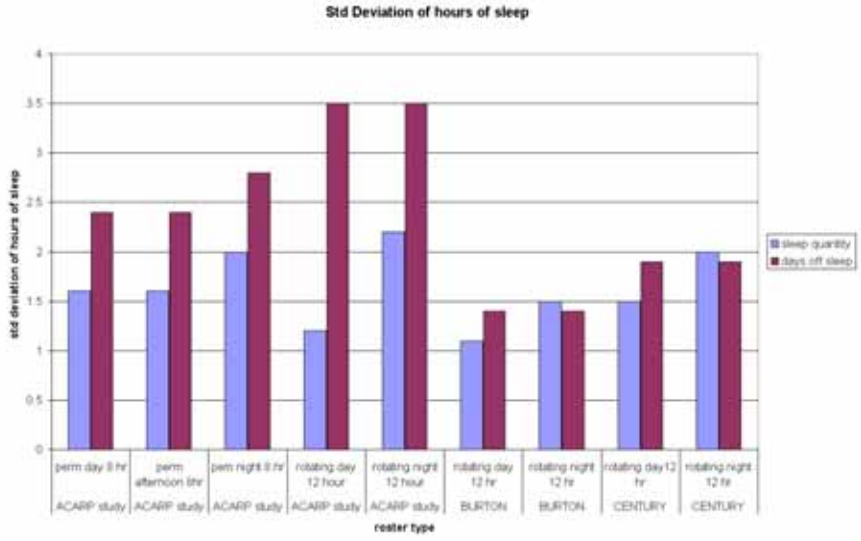

Figure 8 the standard deviation in hours of sleep while on shift for the three studies

Consistent with the results reported above, the standard deviation for night shifts for all studies is significantly higher than on day shift. This is consistent with individual sleep patterns.

The Tasmanian study reported sleep in three groups, 5 hours, 6 - 7 hours and 8 hours or more.

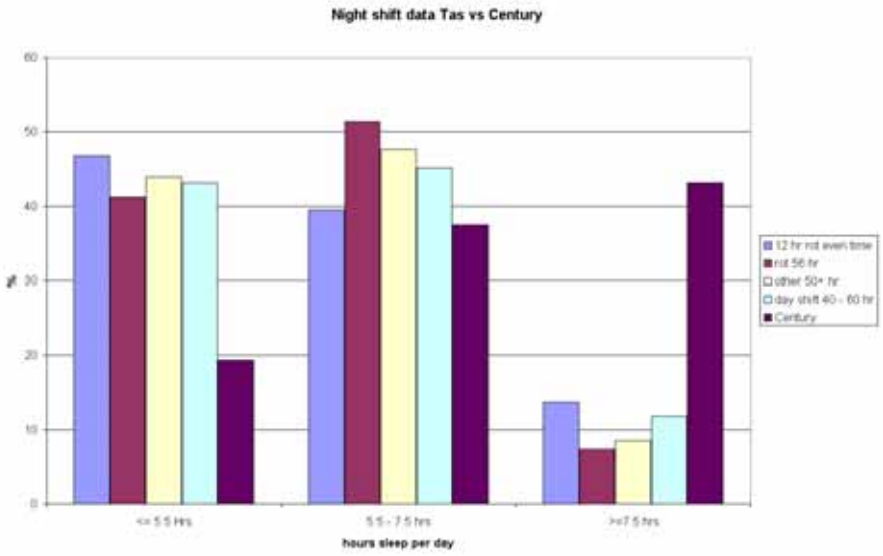

Figure 9 Night shift hours of sleep comparisons - Tasmania vs Century

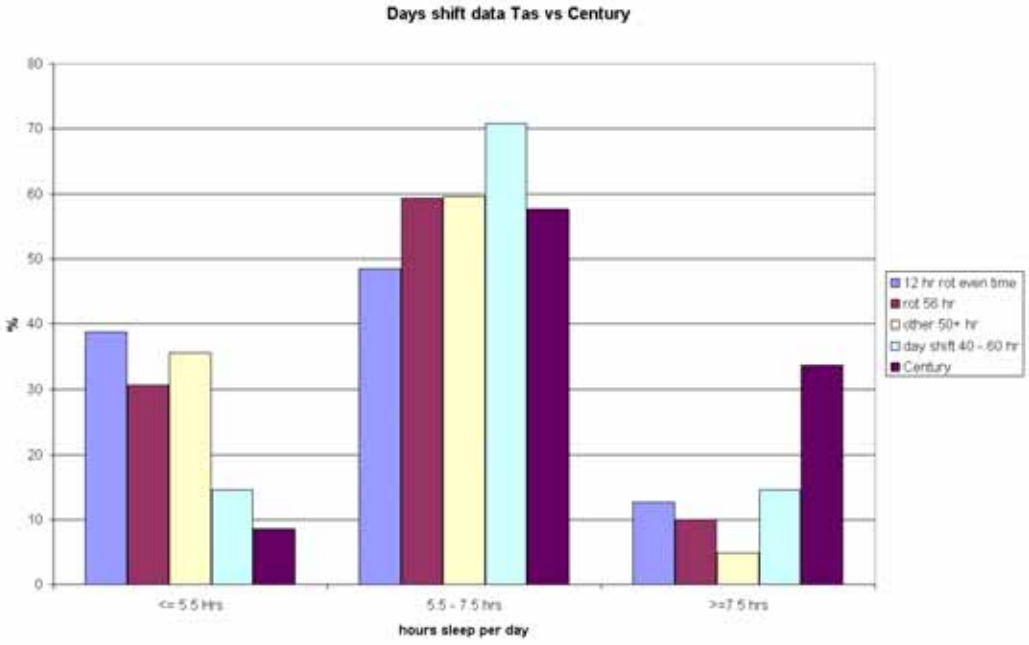

Figure 10 Day shift hours of sleep comparisons - Tasmania vs Century

The Century data reports favourably when compared to the Tasmanian data, indicating better length of sleep, both for day and night shift (Figures 9 and 10).

The same comparisons between the Tasmanian Study and Century were made with respect to sleep quality and similar trends were observed.

In general sleep quality after night shift is lower than after day shift, the average is still satisfactory but with a wider scatter.

These comparisons of the hours of sleep recorded by personnel working a commute roster compared to those who are residential are significant. While the influence of other variables warrants further study, this data supports a key hypothesis that the ability to manage the full 24-hour cycle in a commute operation (along with minimal domestic and other influences) is a significant positive factor in managing fatigue compared to a 'residential' community setting.

CONCLUSIONS FROM THE STUDY:

The core conclusion from this study is that after an initial adjustment to night shift, there is no evidence to indicate that fatigue increases. The data shows that sleep quality and quantity does not deteriorate over multiple 24-hour periods, and that a commute workplace that supports and promotes a recovery environment will be less impacted by fatigue than a community based workplace where the recovery off-shift may be more difficult and may lead to an accumulated sleep debt.

It can be concluded from the Study that there is no demonstrated link between shift cycle, rosters and accidents and incidents at PCML. The data shows a relatively even spread of accidents and incidents that does not differentiate between day shift and night shift, or the time of day or night.

A significant finding from the Study is that compared to other shift length and rotations, roster arrangements and residential operations, there is very little variation between the quantity and quality of rest between shifts recorded at work and at home. This is in direct comparison with other published studies that show wide variations between the quality and quantity of sleep recorded at work and at home. It is also of significance to note that Century employees recorded the greatest numbers of hours of rest between shifts compared with the other published studies. Again this reinforces the positive aspects of a commute environment that supports and promotes a recovery environment where each 24-hour cycle is managed.

The Study also confirms the notion that there is significant variability in quality and quantity of sleep on night shift between individuals. This is not unexpected and reinforces the place that education and awareness have in promoting self-awareness of fatigue symptoms, and promoting the understanding of practices to avoid the onset of fatigue. In addition, it qualifies the place that initiatives such as the Fatigue Management Questionnaire have in assessing and managing a workers potential to suffer from fatigue.

It can also be concluded from this Study that there may be some potential issues with fatigue on the first few night shifts, due to incomplete adaptation of circadian rhythms or wakefulness and sleep cycles. This is consistent with scientific literature on this subject, and the classical 3am – 5am alertness dip was evident. This is currently managed and monitored via the self-select work break procedure, however, there exists an opportunity to further investigate this phenomenon via continuous monitoring initiatives.

In conclusion, the observations that we have made, and the interpretations of the data that we recorded at Century may not apply elsewhere. However, it is a benchmark study into the health and safety aspects of shiftwork and commute rosters in the metalliferous mining industry, and has provided some alternative conclusions that warrant further investigation.

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