EVOLUTION NOT REVOLUTION,

RISK MANAGEMENT OF SHIFTWORK

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1 Abstract

The new mining legislation and regulations in both Queensland and New South Wales are based on risk management frameworks. The management of risks associated with shiftwork has not been systematically investigated and controls need identification. This paper outlines the development of a risk management tool for shiftwork resulting from extensive research in the mining industry.

The research has built on the current limited available knowledge by undertaking a study of current practice to identify processes for risk management and control. This has included the use and evaluation of sleep and alertness logs, and lifestyle questionnaires to identify the work and non-work factors affecting the management of shiftwork. Accident and incident data has also been evaluated. A matrix for assessing risks associated with shiftwork and fatigue has been developed and trialed at a number of sites. This matrix is based on risk management processes outlined in AS4360 and allows for site-specific variations in terms of people, equipment and environment.

2 Introduction

As part of the process to manage the risks associated with shiftwork, Simtars is completing an Australian Coal Association Research Program (ACARP) funded research project to develop a risk management framework for the mining industry. The risks associated with shiftwork are multifactorial and include fatigue, exposures to hazardous substances and health issues. Of these, fatigue is the focus of the project.

Mining regulations for coal, mining and quarrying industries in Queensland require the risk management of hazards associated with mining. One area that is covered in both sets of regulations is fitness for work. This is covered within the *Coal Regulations* **Part 6 Division 1**, and the *Mining and Quarrying Regulations* **Part 9 Division 1** which require the development of a safety management system to manage fatigue. Risks associated with fatigue cannot be effectively managed unless they are identified and understood.

The fundamental and interrelated causes of fatigue in workplaces are:

- The time of day that work takes place
- The length of time spent at work and in work related duties
- The type and duration of a work task and the environment in which it is performed
- The quantity and quality of rest obtained prior to and after a work period.

Symptoms of fatigue include tiredness even after sleep, psychological disturbances, disinclination to work and general loss of vitality. This may lead to chronic disruptive sleep patterns and body systems alterations (gastric ulcers etc).

From a safety and health perspective, fatigue is most appropriately conceptualised as either work-related or non-work-related.

(a) Work related fatigue

Examples of work related fatigue might arise from situations requiring concentrating for extended periods during work hours, working in temperature extremes or working in high-risk situations.

Levels of work-related fatigue may be considered to be more similar across different individuals performing the same tasks than non-work related fatigue. This follows because there are fewer variables for individuals doing the same task in the same environment than in a non-work situation. Work-related fatigue can be managed at an organisational level.

(b) Non-work related fatigue

Examples of non-work related fatigue include sleep disruption due to ill family members, stress associated with financial difficulties or domestic responsibilities, or many other factors.

Non-work-related fatigue, because of all the different circumstances, will be highly variable between individuals and is dependent on a person's environment in addition to their physical and mental attributes. Non-work-related fatigue is best managed at the individual level.

One of the difficulties of establishing the risk associated with fatigue in the mining industry has been the lack of data and information available on the work related and non-work related factors affecting fatigue.

3 Risk assessment process

3.1 Objectives

As shown in Figure 1, the objectives of the project are to identify and control the factors leading to fatigue in the workplace and to identify and control the risks associated with fatigue within the workplace.

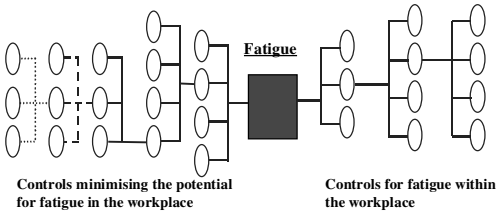


Figure 1 Objectives of ACARP project

The first step of the process involved the development of an acceptable definition of fatigue. Definitions of fatigue range the very simple to the overly complex. The following definition has been agreed upon by all participating mines in the project.

'Fatigue is caused by physical or mental exertion or insufficient sleep that results in a markedly reduced performance or reduced ability to carry out a task'

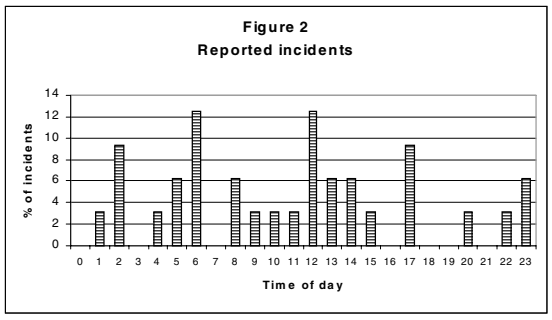
3.2 Methodology

(a) Data gathering

(i) Site information

One of the first steps of the project was to identify issues currently present at the mine eg:

- roster details
- production techniques
- accident and injury information related to shiftwork - an example is shown in Figure 2 which shows the percentage of reported incidents related to the time of day.



(ii) Worker information

Due to the limited available information on the factors leading to fatigue in the mining industry, the other major data gathering method was to identify and quantify work and non-work related factors leading to fatigue. This data involved two major parts.

Part one involved the distribution of a 38 point lifestyle questionnaire to all persons involved in the project (in the majority of circumstances this involved nearly every person on site, workers and management).

The questionnaires were distributed prior to the fatigue training. The questionnaire was divided into five main sections:

1 General demographic data (age, sex, marital status etc)
2 Diet and alcohol
3 Physical activity and exercise
4 Cigarette smoking and other drug use
5 Work environment (overtime, tasks etc).

Part two of the project introduced the sleep and alertness log books. The log books were designed to be kept for a minimum period of 14 days. During this time individuals were required to keep track of sleep quantity and quality, alertness and tasks performed during work periods. These log books were able to be modified to suit the roster rotation at different mine sites.

The sleep log comprised two sections:

- sleep ruler - a 24 hour visual analogue scale on which the subjects were asked to indicate with an X the time they went to sleep and with a U the time that they woke from the ***major sleep*** of the day
- sleep scale - Sleep quality was assessed using self-assessment. Participants were asked to rate the sleep quality on a scale of one through 10.

The alertness log was designed as a tool to measure the subjective alertness levels of the subjects on an hourly basis during work time only. In addition to the alertness levels individuals were also asked to record the ***main*** task performed during that hour.

(b) Fatigue training

A one-hour fatigue management training session was delivered to all persons participating in the project. The training session was designed to assist the individual to self manage fatigue and identify fatigue in others. This training provided participants with the following information:

- what is fatigue
- identification and management of the work related causes of fatigue
- identification and management of the non-work related causes of fatigue
- legislative obligations.

(c) Risk assessment

The results from the data gathering were used as supporting data for the risk assessment.

The risk assessment matrix was based on AS/NZS 4360:1995 – Risk Management. The risk assessment process was divided into:

- risk analysis – the systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences
- risk evaluation – the process used to determine the risk management priorities by comparing the level of risk.

Site representation at the risk assessment comprised:

- a minimum of two persons from each roster cycle on site
- management representative
- union representative.

The assessment of the factors causing fatigue covered the following areas:

(i) Work related

- the work arrangement, equipment and work environments likely to cause fatigue. These included tasks, breaks, work conditions and schedules.

(ii) Non – work related

- the human factors likely to cause fatigue.

These were in terms of lifestyle, health, awareness and culture

- the environmental factors likely to cause fatigue. These included accommodation conditions, time of day and community factors.

The following classifications were used for the risk assessment. These classifications are based on AS/NZS 4360:1995, Risk Management and were modified to suit the project. Modifications to the basic matrix occurred after initial trials at two mine sites. The modifications involved the removal of the descriptives for the consequences and likelihood. After the modifications were made participants in the risk assessments found it much easier to appoint a consequence and likelihood.

Consequences

1 = no fatigue resulting
2 = low levels of fatigue not affecting activity
3 = level of fatigue will cause moderate level of impairment
4 = high level of fatigue causing significant impairment
5 = very high level of fatigue causing serious impairment and/or leading to sleep

Likelihood

A = fatigue is expected to occur in most circumstances
B = fatigue will probably occur in most circumstances
C = fatigue should occur at some time
D = fatigue could occur at some time
E = fatigue may occur only in exceptional circumstances

Table 1 demonstrates the risk analysis matrix used.

The analysis was based on information supplied by workers and management during the risk assessments. This allowed a 'raw' ranking of the factors causing fatigue based on the understanding and knowledge of the participants of the risk assessment. It did not take into account current controls nor the information available from other sources.

The next step involved an assessment of the current controls (both formal and informal) in place to manage fatigue. This allowed identification of 'residual' risk.

The information available from the questionnaires and logs was taken into account. This allowed the ranking of the risks to be confirmed or re-evaluated as necessary.

(d) Risk management

Using the results of the risk assessment, potential controls to manage the risks were identified. Where contributory factors were analysed to be of low or moderate risk, additional control options were not considered.

Risk treatment options were identified at the:

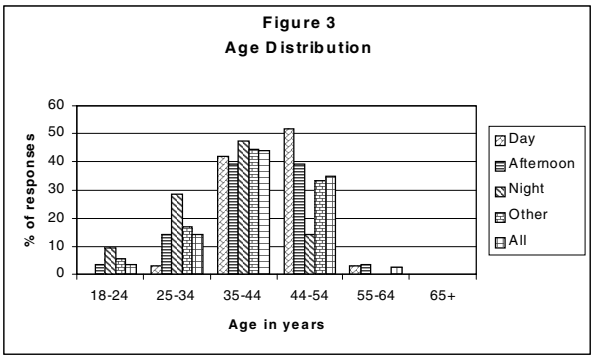
- corporate level
- site level
- shift level
- individual level.

Four of the project sites proceeded with the development of draft standard operating procedures and an additional mine went on to complete a roster redesign workshop.

3.3 Results

A total of six mines in Queensland and New South Wales have participated in this project. The number of questionnaires distributed across these four sites totalled 459. Some examples of the results of the questionnaires are shown in Figures 3 to 10.

Figure 3
Age Distribution



The age distribution as shown in Figure 3 was fairly consistent across sites. The time spent in the coal industry demonstrated the experience of most workers as shown in Figure 4.

Figure 4
Years in Coal Mining Industry

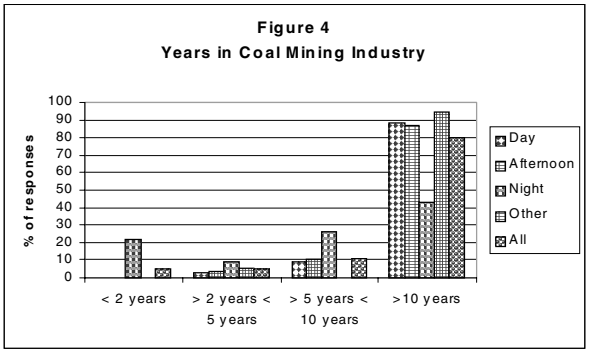


Table 1
Qualitative Risk Analysis Matrix

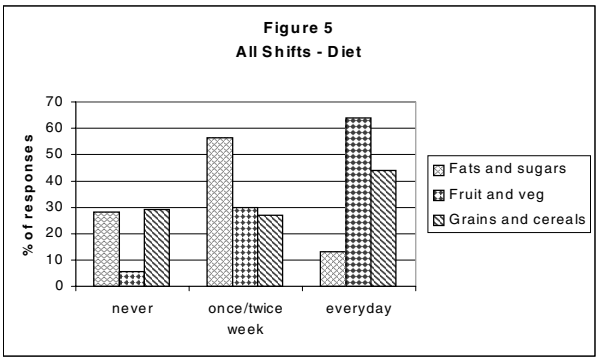
Likelihood	Consequences				
	1	2	3	4	5
A	S	S	H	H	H
B	M	S	S	H	H
C	L	M	S	H	H
D	L	L	M	S	H
E	L	L	M	S	S

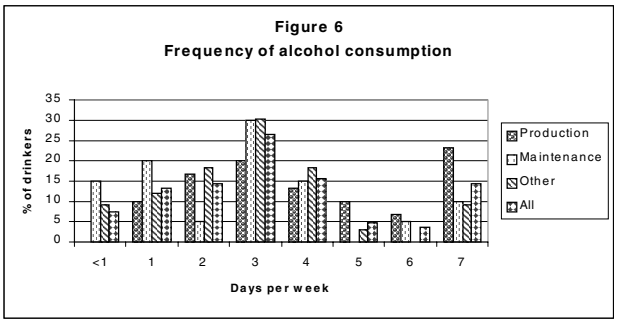
H = high risk in terms of contributing to fatigue, research and planning required at high level
S = significant risk in terms of contributing to fatigue, attention needed
M = moderate risk in terms of contributing to fatigue, responsibilities must be specified
L = low risk in terms of contributing to fatigue, manage by routine procedures

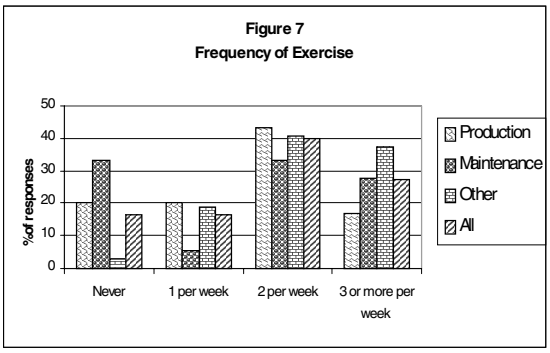
Dietary intake across the six project sites were generally within the National Guidelines for Australians however, intake of saturated fat was for some sites consumed in excess. Alcohol consumption varied across sites and workgroups.

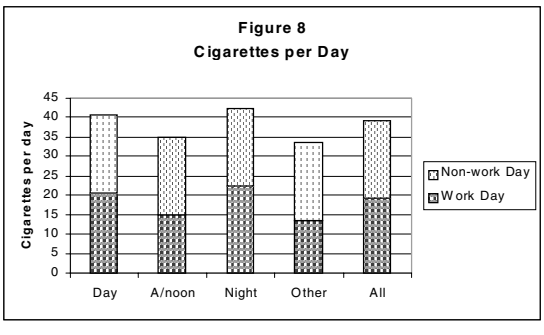
The majority of respondents indicated that exercise was difficult to find time for when trying the balance the needs of work and home life when on shift work.

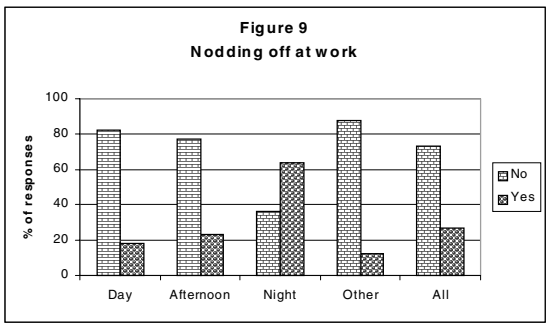
However, for those that were able to make time to exercise all were within the recommended guidelines for exercising. Cigarette smoking across all project sites varied but overall was consistent with the industry average of 27 percent.

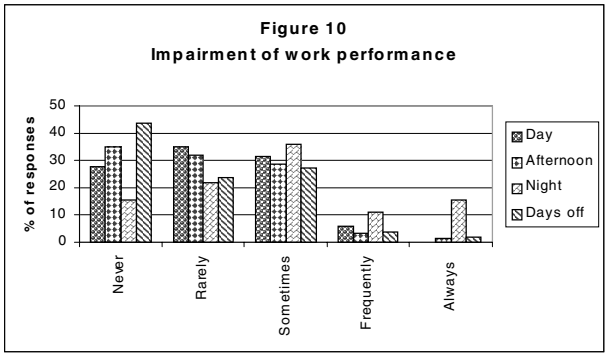


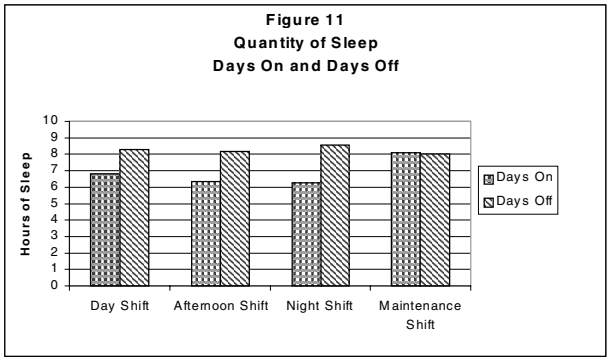












By far some of the most disturbing statistics came from the questions which asked 'Do you ever nod off at work' and 'Does tiredness effect your work performance' as seen in Figures 9 and 10. Approximately 65 percent of night shift workers at one mine (Figure 9) stated that they nod off regularly while at work.

Of these, 25 percent stated that they were operating either mobile or stationary equipment at the time. Results from one mine indicated by Figure 10 show that often on afternoon and night shift workers feel as though their work performance is impaired by tiredness.

The results from the Sleep and Alertness logs are shown in Figures 11,12 and 13. Completed sleep and alertness logs over the four sites were 73. Modifications to the sleep and alertness diaries have been made after a low response rate from initial trials. Participants were given the option to implement the sleep log only or use the combination of sleep and alertness.

Sleep diaries are analysed in terms of quality and quantity of sleep. Figure 11 displays quantity of sleep results comparing on and off roster averages across all shift types. Results can be displayed as the differences in alertness levels between first and last shift as shown in Figure 12 and as an overall average across all shifts as shown in Figure 13

Examples of the results of the risk assessments for two mines are shown in Tables 2 and 3.

Although there was some variation from mine to mine, generally, the high and significant risks for work related factors fell under the following areas:

- work arrangements
  - roster
  - overtime

- breaks
- time of travel
- change to roster
- work conditions
- tasks
- physical work environment
- stress.

Examples of this are shown in Table 2.

Table 3 shows some examples of the non-work related factors that were rated high or significant risk. Again there was variation from mine to mine but generally there was a level of consistency.

Tables 2 and 3 show the residual risks once the current formal and informal controls were taken into account. In some instances the informal controls that were identified were significant in controlling fatigue but the mines did not appreciate their importance.

The information from the questionnaires was taken into account to confirm or indicate the need for re-evaluation as necessary. Where contributory factors were analysed to be of low or moderate risk, additional control options were not considered.

These risks were supported by the information gained from the data sources or the experience and knowledge of the risk assessment team. Some of the risks are associated with any 24 hour operations eg time of day and associated circadian rhythms.

Additionally, some of the controls identified were put in place to control other workplace hazards eg road maintenance. Consequently, the control of fatigue is a side issue. The limited effectiveness of some of the controls identified results from the original reasons the control was initiated.

This means that even if controls minimising the potential for fatigue are in place, there is a residual risk that workers will become fatigued during work operations. Therefore, controls need to be put in place in two areas as shown in Figure 1.

Some risks can be addressed only by information and training. Employers need to provide access to information that allows their employees to make informed lifestyle choices. By providing relevant and accurate information, employers are more likely to minimise the impacts of non-work related fatigue on work activities.

Results varied from site to site with consideration of the following variables:

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Table 2
Work Related High Risk Factors

Mine A	Mine B
Body clock versus work pattern	Night - body clock including start and finish time
Shift time – length of time at work	Afternoon Finish 12 am
Overtime – running on other shifts	Day Start 6am/finish time 1pm+ travel time
Noise and vibration	Working in excess of specified max overtime (in conjunction with production targets)
Cabin conditions	Timing and unpredictability of overtime –pre or post shift
Work postures	
Number of shifts in a row	
Heat and humidity	
Time of start/finish of shift	

Table 3
Non-Work Related High Risk Factors

Mine A	Mine B
Lack of sleep – mental state eg worry	Second job (10% of workforce)
Sleep disorders – physiological Eg Sleep apnoea	Sleep disorders
Other medical problems	Family understanding/ management of shiftwork
Drugs and medication	
Travel time	Family commitments
Use of alcohol	

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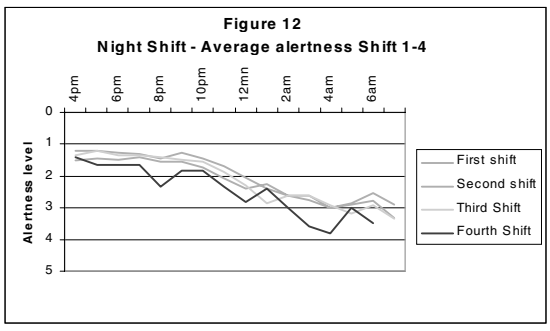
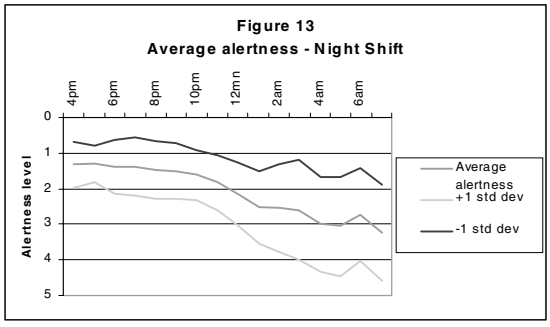
Results varied from site to site with consideration of the following variables:

- community, commuter or site based operation
- age of operation (older mines tended to have older workers).

Two of the participating mine sites proceeded with the development of draft standard operating procedures for fatigue and shiftwork, based on the results of the risk assessment. The major headings for the SOPs included:

- definition of fatigue
- accountabilities for fatigue management for SSE, supervisor, employee, contractors and visitors
- hours of work and rostering arrangements
- maximum hours of work
- number and length of rest breaks (both within and between shifts)
- maximum number of hours to be worked in a week or roster cycle
- maximum number of extended shifts in a row
- shift start time
- roster details
- overtime
- rotation of tasks





- physical environment
- education and awareness
- employee assistance program
- personal fatigue critical tasks
- administrative controls
- management of the fatigued worker
- audit and review

One site proceeded with a roster design workshop. The roster design process was divided into:

1 Background
- identification of health and safety requirements
- identification of operational requirements including different workgroups;
- identification of other worker requirements.

2 Roster design concepts
- shift length
- total hours
- shifts in cycle;
- overtime arrangement
- other factors impacting.

3 Evaluation of existing roster
The rosters are evaluated considering the following aspects.
- fatigue
- breaks between and within shifts
- travel time
- financial aspects of change to hours of work and overtime
- social impacts
- community
- operational requirements

4 Recommendations for new roster
The results of the risk assessment were used to underpin the changes to the rosters at this site.

4 conclusion

The results of the risk assessments undertaken at the mines have shown the value of using a risk assessment framework to identify the risk factors leading to fatigue. It allows the residual risks to be estimated and consequently additional controls to be implemented.

Development of shiftwork and fatigue management systems has been made easier by using the risk assessment process. The current risk assessment framework needs adjustment to allow for the synergistic effects of the inter-relationships of many of the factors leading to fatigue.

The risk assessment process is able to be tailored to suit mine specific needs or already existing systems. The nature of the subjective data gathered from the questionnaires and the sleep / alertness diaries are able to easily fit in with any risk assessment methodology.

Although still in development, the risk assessment framework will improve the process of complying with the new health and safety mining legislation to control the effects of shiftwork and fatigue at minesites in the Coal, Metalliferous and Extractive Industries.

5 References

1 Queensland Government (2001), *Mining and Quarrying Safety and Health Regulation 2001.*

2 Queensland Government (2001), *Coal Mining Safety and Health Regulation 2001.*