What works best at improving mine worker safety and why does it work

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ABSTRACT

This paper reports on the results of an ACARP funded project that investigated the effectiveness of safety programs at coal mines by determining the factors that lead to success.

There were two parts to the project. One investigated the strategies used throughout the industry to plan and implement safety programs. As part of the definition of what is happening industry-wide, a questionnaire investigating programs at all levels from individual to corporate was distributed. To compensate for the low response rate to the questionnaire, the conference proceedings for New South Wales and Queensland for the past five years were scanned. This information was combined with the results of the survey to give a reasonable picture of what was happening in the industry.

The second part considered five different programs in place at minesites. Investigations and evaluations on individual projects were undertaken at mines in Queensland and New South Wales. These programs include training, health interventions, audit, risk assessment and behavioural and attitudinal change and cover basic safety programs through to fitness for duty programs. The programs were analysed using a program evaluation model.

The factors identified as the three most important for success were the identification of the need for the program, actual and perceived commitment by management and allocation of adequate resources.

INTRODUCTION

How do we know if a safety program is working? Traditionally, the coal industry has tended to look at the downstream outcomes of safety programs such as accident statistics to ascertain the success or failure of a safety initiative. The limitations of these statistics as measures of program effectiveness are recognised, however, such injury statistics and compensation data may be of benefit in prioritising workplace intervention strategies. When it comes to safety, the mining industry is not plagued by new injuries, but rather finding effective solutions to existing problems.

Program Drivers and Motivators

Understanding what drives a program is one of the most important factors when determining a successful outcome. Drivers assist in shaping a program's goals and objectives. At least five factors may motivate the decision to implement programs to address safety issues and these have been identified in one form or other as the drivers of safety programs. These five include:

1. Employer's enlightened self-interest;
2. Information on hazards and controls;
3. Injury costs and workers compensation;
4. Worker or Union pressure;
5. Legislation and Regulation.

Additionally we are now seeing an increasing awareness of tort liability due to the growth in the number of cases involving litigation for injury and associated large payouts.

Once the drivers have been identified, it is important to identify both intrinsic and extrinsic motivating factors. Four types of factors have been identified as determinants of workers' safety motivation:

- Safety climate of an organisation - safety climate refers to workers' interpretations of features, events and processes in the work environment that are relevant to their safety;
- Task feedback - the rarity and delay of adverse effects from single tasks can lead workers to engage in increasingly unsafe acts as workers develop a sense of "unrealistic optimism" based on experience of innocuous outcomes of unsafe acts;
- Workgroup norms - these norms are informal rules the groups adopt to regulate and regularise group members behaviour. Workgroup norms are most likely to have reached a high degree of consensus and intensity when there are common goals and interdependent within the team.
- Organisational control systems – formal processes by which the organisation directs the members to action and monitors behaviour and results to ensure organisational goals are accomplished.

Evaluation Techniques

To effectively assess the success of a safety program, the evaluation must match the objectives of the program being evaluated. The reasons why safety programs are evaluated fall under two broad categories:

1. to demonstrate accomplishment of proposed objectives;
2. to guide internal program decision-making.

The two categories of evaluation differ markedly. The first is usually called for by a source external to a program. The second is performed by a program manager to enable the best use of resources etc to accomplish the proposed objectives. The first is historical (How well did I do?), the second current (How am I doing?).

Impact evaluation is a third general type that seeks to determine the effects of the program.

No matter what the reason for being undertaken, the evaluation needs to consider a range of perspectives including the organisational and the worker perspective.

This research project was designed to provide a framework for the evaluation of the effectiveness, efficiency and appropriateness of safety programs and initiatives at all levels in the coal mining industry and to identify the key factors affecting the success of programs. This project was funded by the Australian Coal Association Research Program (ACARP) with additional co-operation and in-kind support from mines in New South Wales and Queensland and Simtars and MISHC.

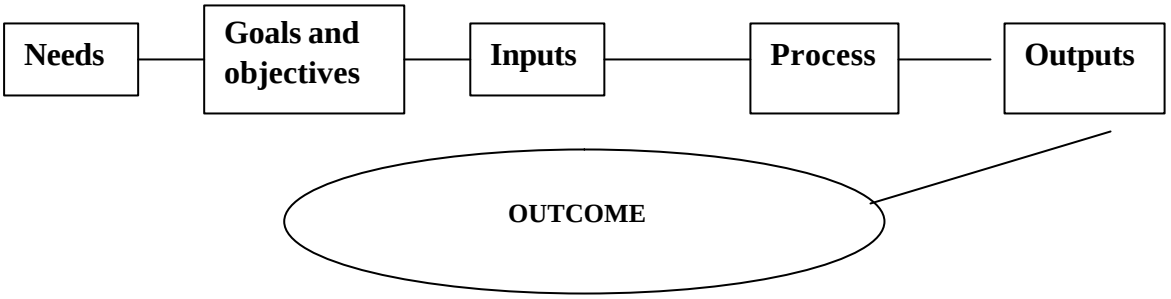
PROJECT WORK PROGRAM

The project was conducted in three stages. In part 1, the key strategies currently in use in the industry were investigated and defined by using a survey to identify the drivers, complexity, regulatory requirements, type of program, and use of incentives. Additional information was included from recent Queensland and New South Wales mining health and safety conferences. This information was used to set the safety programs investigated in part 2 in the industry context.

Part 2 of the project assessed selected safety programs and strategies at a site specific level. Assessments were undertaken at five sites and covered a range of programs. The

evaluations followed the model for evaluation proposed for the project (Figure 1) and covered both programs already in place and programs about to be implemented.

Figure 1 Model for evaluation of safety programs



The following programs were included in the project.

1. Fatigue management training program.

This was a training program designed to promote self awareness and management of factors that could lead to fatigue at a mine site. It involved face to face training sessions that ran for approximately 60 minutes. These were provided by well qualified external providers. Additional reference materials were supplied for participants to take home.

2. Perform: Manual tasks project

This project examined the effectiveness of an industry wide, rather than workplace specific, approach to the prevention of manual tasks injuries. The aim was to generate potential solutions to common high risk manual tasks in the open cut coal mining industry through the results of manual task risk assessments and control measures suggested by staff participating in Perform training sessions. These solutions were then implemented and their effectiveness assessed.

3. Safety Audit Observation Program

This program introduced safety act observations (SAO) as a method of identifying unsafe acts and conditions at the mine site. The purpose of the safety observations was to improve the safety and welfare of all people who work and visit a site.

4. Risk Assessment

The project was the completion of a risk assessment to evaluate the risks associated with fatigue on site and to identify control options. The risk assessment was part of a larger project to address fatigue on site.

5. Positive Action Safety System (PASS)

This program was a safety management system called Positive Attitude Safety System (PASS). PASS was introduced to improve safety communications between workers and management. This system was both a top down/bottom up approach that requires individuals to identify and control safety issues at site level. It was introduced using a training program for both management and workers.

In part 3, these results were used to identify the key components of safety programs that lead to success. The measures of the success of the safety strategies were considered in terms of

- Effectiveness of health and safety outcomes, eg
  reduction in injury, disability, stress or hazard exposure;
  increase in knowledge;
  change in behaviour or attitudes.

- Economic outcomes and return on investment,
  eg the effect of the program on productivity, employee turnover, equipment, or costs.

  The original intent of the project was to assess the economic outcomes in terms of the following formula.

  $\text{Cost}_{\text{problem}} \; 8 \; \text{Cost}_{\text{cost of solution}}$

  $\text{Cost}_{\text{cost of solution}} = \text{Cost}_{\text{safety program}} \times 100/\%$ effectiveness

  These formula suggest that the cost of a safety program must be less than the cost of the problem it is intended to address taking into account the program effectiveness. No program is 100% effective and it is generally recognised that different types of programs have different levels of effectiveness.

  This could allow an analysis of the allocation of resources and return on investment in terms of seriousness of the problem and effectiveness of solutions

RESULTS

Part 1 Strategies currently used

Given the limitations of the data available for assessment, the results of the questionnaire and the analysis of the conference proceedings provided some reasonable insight into the key strategies currently being used by the industry.

There was greater emphasis on individual and work environment programs than on organisational programs (Figure 2). These programs were generally driven from a management level (Figure 3). These management driven programs were more likely to have been the result of a needs assessment than worker driven programs ie a need was identified and management drove a program to address that need.

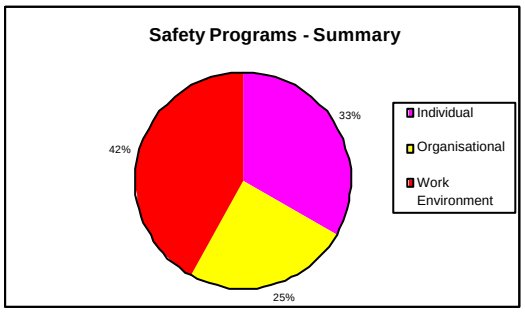


Figure 2

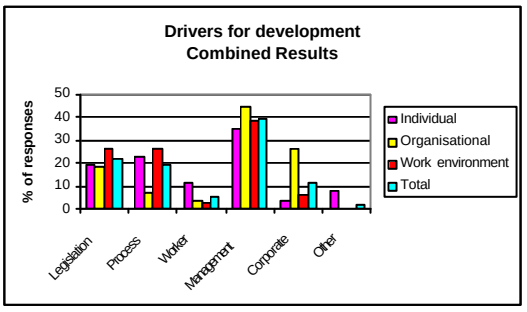


Figure 3

The literature reports on the need for management to make a commitment to the longevity of safety program. The programs reported indicated a relatively short time frame of less than 12 months for most projects. 24% of programs were reported as being implemented over greater than 12 months This may have been because most programs reported were only initiated less than 12 months prior to reporting and were still active programs for a longer period of time.

The most important resource issue reported was rostering with the associated difficulties of the availability of personnel. Physical resources were not reported to be an issue and that indicates a level of commitment by the management and organisation to the programs.

The combined questionnaire and proceedings results showed that approximately 80% of the programs had been assessed and also that approximately 90% of the programs had meet objectives (Figures 4 and 5).

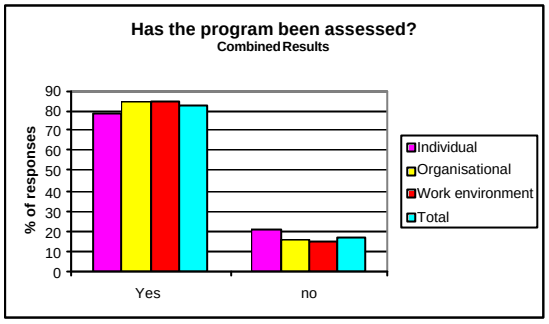


Figure 4

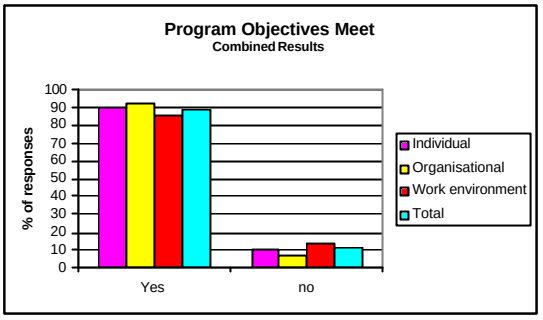


Figure 5

For the organisational programs reported as having met objectives, 92% had been assessed and for the successful work environment programs, 83% had been assessed.

Part 2 Mine Site Safety Programs

This part of the project involved the evaluation of five different safety programs at five sites. The five programs were:

i. Fatigue management training program
ii. Perform: Back care project
iii. Safety Audit Observation Program (SAO)
iv. Risk Assessment
v. Positive Action Safety System (PASS)

Evaluation Methodology

The evaluation methodology was based on the model shown in Figure 1. The terms used in the model are defined below and were based on Harrison (1999) and Robson et al (2001).

Needs:

Predisposing factors or the identification of risk of injury, groups or individuals exposed to some risk, or the deficiency of information and/or lack of intervention to address an injury risk. This is sometimes seen as absolute need eg legislative requirements, but more often as a relative need eg excessive risk. This determines what type of program is needed.

Goals/objectives:

A key link with strategic planning as a statement of intended outcome eg reduction in injury rate by 10%. This is the basis for identification and assessment of effectiveness.

Inputs:

The financial, physical and human resources that are allocated and consumed to enable a program to operate eg the funds allocated to purchase equipment or train users.

Processes:

The operations of the program being evaluated eg participation in training. This evaluation can be used to determine if the program was implemented as planned and assess the quality of the delivery of the program.

Outputs:

The products or immediate results created by the intervention or program.

Outcomes:

The consequences for the stakeholders of the process and/or its outputs. The outcomes may not necessarily be the impact of the outputs.

The evaluation process covered each of these areas and included:

- A series of questions completed by the site program co-ordinator;
- Observations by the project personnel of the programs in operation;
- Questionnaires and interviews with workers participating in the project;
- Analysis of data collected for the project (where available).

The evaluation consisted of the following criteria.

Effectiveness	as indicated by the extent that the outcomes achieve the objectives. It shows the relationship between the outcomes for the intended recipients and the objectives for the project. It is **"*doing the right thing*"**.
Efficiency	as indicated by the amount of outputs for the given inputs. This is an important type of indicator in terms of accountability for the resources used and productivity. It is **"*doing it for the right cost*"**.
Appropriateness	identifies the relevance of the objectives to participants needs eg a program requiring heavy personal protective gear may be efficient and effective but may be inappropriate due to the hot physical environment. It is **"*doing it right*"**.

Effectiveness and appropriateness

The programs evaluated have been assigned a percent effectiveness based on the information provided by the sites and the experience of the research personnel during the evaluation exercises.

The results are based on an estimate of how well the objectives were defined and whether the programs met the objectives. The simpler the objectives, the easier to estimate effectiveness eg the risk assessment had a straightforward objective; the SAO program was more complex in what it was trying to achieve. The results of questionnaires and interviews are the basis for the attributed effectiveness. This remains a somewhat subjective estimate and the results are open to discussion.

Efficiency based on economic estimates

In order to evaluate the economic efficiency of the safety programs studied, a number of estimates were made.

A single lost time injury was allocated a direct insured cost of $4000. This is an average cost based on the data supplied in the Queensland Mines and Quarries Safety Performance and Health Report, 2001 (Department of Natural Resources and Mines, 2001) and the costings estimated for Queensland and New South Wales by Culvenor et al (2000).

Work completed by Esson (1992), estimated the indirect or uninsured costs associated with an accident or injury for the open-cut coal mining industry to be 9 times the insured costs. This is considerably higher than estimates for other industries that vary between 1 and 4 times and takes in to account lost productivity. This means the total cost of a single lost time injury could vary between $4 000 and $40 000.

Musculoskeletal injuries (sprains and strains) represent more than half of all compensation claims in coal mining involving five or more lost days. NOHSC has determined that sprain/strains involving more than 5 days lost work for the Australian coal industry averaged 810 per year for the four years 1996/7 to 1998/9 (http://nohsc.info.au.com/). While national claims cost data is not available, Qstats has estimated the average cost of similar claims in Queensland in 99/00 was $22,486. This equates to a daily direct costs of $4000. This is consistent with the direct costs estimated for other injuries in this project.

Mabbott et al (1999) estimated the cost of a fatigue related injury to be $40 300. This took into account direct and indirect costs of injuries excluding equipment damage.

The Occupational Safety and Health Administration (OSHA) in the United States reports that the ratio of indirect to direct costs varies from a high of 20:1 to a low of 1:1. The lower the direct costs of an accident, the higher the ratio of indirect to direct costs. OSHA generally uses a ratio of 4.5 (OSHA, 2002).

Given the range of these estimates, the OSHA value is used in this project. Using this value, $22 000 was chosen as the total direct and indirect cost to be assigned to a lost time injury for the estimate of the economic value of the programs considered.

Table 5.1
Costs and effectiveness of safety programs

Program	% effectiveness	Cost of safety program		Cost of solution	
		Implementation	On-going per year	Implementation	On-going per year
PASS	70	18 500	26 000	26 428	37 142
SAO	70	10 350	5 400	14 857	7 714
Risk Assessment	80	22 500		28 125	
Fatigue training					
▪ Legislative obj	95	40 000	10 000	42 105	10 526
▪ Informed Workforce	<50	40 000	10 000	>80 000	>20 000

Given this averaged data, the costs of the solutions for the programs evaluated indicate that there is an economic return for the programs if they prevent more than one injury. This is consistent even for the fatigue training program that was of limited effectiveness.

Project Outcomes

The results of the analysis of the strategies and factors associated with safety programs at an industry level were consistent with the factors identified in the individual mine site programs evaluated. The model proposed for use in evaluating the programs was effective in identifying the strengths and weaknesses of the programs.

The factors affecting the success of safety programs are complex and inter-related. It is not possible to identify a single factor that guarantees success. A model was developed to

demonstrate the relationship between these factors. At the simplest level, the three major factors leading to success were identified as:

- The clear identification of the need and objectives for the program;
- Actual and perceived commitment by management;
- Allocation of adequate resources, including timeframe.

The impact of management commitment greatly influences the perceptions and impacts of the programs on individuals. These in turn affect the safety behaviours in the workplace. There are intrinsic and extrinsic motivators that must be consistent with the program to allow continued success. These motivators are also influenced by management commitment and a number of environmental, organisational and individual factors.

The results of this project allowed the development of "Steps to a successful safety programs". This guide identifies the basic steps that need to be considered for the development, implementation and success of safety programs for the coal mining industry.

The guide suggests that programs are considered under the following headings.

Steps to a successful safety program

Step 1 – Determine the Need

The identification of why a safety program is needed acts as the first step in the process. .

If more than one need is identified, it is important to consider if these needs can be met by a single program or if there are conflicts.

An estimate of the costs of the problem should also be established. Costs should include direct and indirect costs eg

- accident and injury costs;
- lost time costs;
- investigation costs;
- equipment damage and repair costs;
- productivity losses;
- possible costs to reputation.

This allows a program appropriately costed to meet the problem to be devised.

Step 2 – Identify the main driver

Program drivers assist in shaping a program's goals and objectives and are important in providing both intrinsic and extrinsic motivation for program success. These drivers may change throughout the life of the program depending on the nature of the program eg a management introduced program being "owned" by workers. If such changes to drivers are anticipated, they need to be clearly identified at the introduction of the program.

Step 3 – Goals and objectives

The goals and objectives of the safety program need to be defined and reflect the identified program needs before the program is developed. The outcomes of the program need to reflect the goals and objectives.

The strategies to achieve the objectives need clarification as to whether they are based on:

- Knowledge, attitude or behavioural change;

- Environmental change;
- Technical/equipment change.

These objectives need to be achievable and, where possible, measurable.

The stakeholders and target audience for the program also needs to be clearly defined at this stage.

Step 4 - Implementation of Program

(a) Timeframe

The timeframe of the project should be defined as part of the initial process. .

(b) Identification and Allocation of Resources

The allocation of resources needs careful consideration if the goals and objectives are to be met. Resources need to be appropriate and adequate.

Resources fall under the following categories

- Physical resources eg equipment, training materials;
- Human resources eg trainers, co-operation of supervisors and - management;
- Financial resources eg cost of time of program, effect on productivity.

(c) Costs estimates

Estimating the costs of the program allows a comparison of the cost of the problem with the cost of the solution and fills a need for objective evidence to support claims of program cost effectiveness.

The programs costs need to include:

- Development costs;
- Implementation costs;
- On-going costs.

Step 5 Evaluation

An evaluation of a safety program should consider the outputs and the outcomes of the program.

- The overall worth of the program in terms of effectiveness, efficiency and appropriateness.

A copy of the guide in included in the project report available from ACARP.

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