PRO-ACTIVE SAFETY MANAGEMENT: APPLICATION AND EVALUATION WITHIN A RAIL CONTEXT

Graham D. Edkins *, Clare M. Pollock

School of Psychology, Curtin University of Technology, Perth, Western Australia, Australia

Abstract—Pro-active safety management is becoming increasingly popular as a means of preventing workplace accidents and near accidents. This study applied the REVIEW method developed by Reason (1993) within an Australian public rail authority. REVIEW helps identify latent failures that pose a threat to system safety. The purpose of this study was firstly to; evaluate the value and practicality of REVIEW for use by safety professionals; and secondly, to more clearly identify the nature of management deficiencies and fallible decisions specified in Reason’s (1992) model. REVIEW was found to be useful, especially from a participative safety management perspective, and for targeting safety areas that need current attention. Factor analysis revealed three distinct factors; Policy and Decision Making, Workplace Culture and Operating Conditions. These factors imply that the most effective way to minimise workplace accidents is to direct remediation strategies at the most global features of the system. Copyright © 1996 Elsevier Science Ltd

1. Introduction

Interventions designed to reduce accidents in organisations have typically been reactive. Detailed analyses of past accidents have been undertaken as a means of determining all possible contributing factors, that may threaten safety. While this may tell the investigator much about the details surrounding particular accidents that have already occurred, the exact same accident is not likely to re-occur bearing in mind the complex processes that interacted to produce the final error.

There are additional problems with classifying past accidents. There is an over reliance on accident reports, which typically attribute blame, and are usually incomplete or inaccurate, even when conducted by experienced accident investigators. Also many accident classification methods tend to focus on active failures. That is, human performance failures such as errors or violations.

* Corresponding author. Now at the Bureau of Air Safety Investigation, P.O. Box 967, Canberra, ACT 2608, Australia. Tel: +61 6 274 6413; Fax: +61 6 247 1290.
However, investigation into tragic accidents such as the Clapham Junction rail disaster (Hidden, 1989) and the King’s Cross Underground fire (Fennell, 1988) have revealed that active failures may only account for a mere portion of accident contributory factors. In response to this, Reason (1992) uses the term *latent* failures to describe decisions or actions that have damaging consequences but lie dormant for a period of time. Latent failures may be the result of high level decision making, equipment design, installation, planning or maintenance.

What would be of greater benefit to safety professionals, is a pro-active method that makes latent failures more visible, so that remedies can be implemented to prevent accidents.

2. Review

Reason (1995) has developed a diagnostic method that pro-actively assesses organisational safety health. Shell International use this method in their tanker and exploration operations in the form of Tripod-DELTAX (Hudson et al., 1994). British Airways currently employ a similar method called MESH (Managing Engineering Safety Health), to identify safety occurrences in their engineering operation (Reason, 1994). Likewise Reason (1993) has produced an instrument called REVIEW, which is currently being used at British Rail. All three instruments measure latent failures that have been common denominators in major accidents. In addition, they assess processes generic to all technological organisations.

REVIEW has a number of elements:
- it exploits the positive rather than the negative aspects of safety;
- it measures the organisations intrinsic resistance to individual and organisational error;
- it targets areas that need immediate improvement;
- it assumes that the inherent concerns and working practices of staff are synonymous with safety problems.

The principles behind the REVIEW method are based on the model shown in Fig. 1.

The model suggests that accidents arise from fallible decisions and line management deficiencies (organisational policies and procedures). This is not to say that individual

![Fig. 1. A model of accident causation. Adapted from Reason (1992), Human Error, Cambridge: Cambridge University Press, p. 208.](image-url)
psychological factors have no part to play in accidents, but research and history have repeatedly shown, that front line operators are merely the inheritors of system defects created higher up within the operating system. Reason (1992) refers to deficiencies in the managerial and organisational sectors as *failure types* and those relating to individual conditions and unsafe acts, as *failure tokens*. Clearly failure types have the greatest influence over system error, since this is where latent failures develop. The model illustrates the value of addressing human error pro-actively in order to catch as many types (and therefore reduce token failures) as possible.

The purpose of the present study was to implement the REVIEW method within an Australian public rail authority. This was done for two reasons; firstly to determine the value and practicality of REVIEW as a safety tool; and secondly, to more clearly identify the nature of management deficiencies and fallible decisions specified in Reason’s (1992) model. It was hoped that by conducting exploratory factor analysis on the problem factors, this would help reveal underlying dimensions that are uncontaminated by both unique and error variance.

3. Method

The research process consisted of three stages:

3.1. Stage 1: train driver and management focus groups

Twenty five train drivers were randomly selected from a sample of 454. Selection accounted for homogeneity across age, location, length of experience and type of train service (freight or passenger). In addition, forty managerial staff were selected on the basis of operational experience.

Focus groups were conducted with both groups. The rationale for using focus groups was four fold. According to Morgan (1988) focus groups are particularly useful for:

- orienting the researcher to the topic at hand (as well as the organisation);
- generating hypotheses based on informant’s insights;
- developing survey methods;
- preliminary or exploratory analysis.

The purpose of the focus groups was to identify a number of salient Railway Problem Factors (RPF’s) that potentially have an adverse effect on train operating safety. RPF’s could be any organisational, behavioural, situational, social or technical contribution to unsafe working practices.

Each focus group consisted of 6–8 participants, guided by a facilitator. The same facilitator was used in all groups. The role of the facilitator, in terms of discussion content was minimal. A Nominal Group Technique (Van De Ven, 1974) was used to facilitate the focus group process. The discussion centred around the following question: “What are the human factors problems associated with the Design, Build, Operate and Maintain aspects of railway functioning”? Human factors problems meant any organisational process or workplace condition that influences the safe operation of trains. For example: (1) Design factors (how easy is equipment to use?). (2) Build factors (how good and accessible are materials needed to complete a task?). (3) Operation factors (are the safe working rules appropriate?). (4) Maintenance factors (are repairs attended once reported?). To avoid a blaming process, participants were told to identify problem areas generic to rail operations, not problem people.
The final outcome of each group process was a list of approximately 30 Railway Problem Factors. All focus groups were audio-taped, and the explanation and process used by the facilitator was standardised across groups to maintain validity.

3.2. Stage 2: compilation of Railway Problem Factors (RPF’s)

Two raters independently collapsed each focus group list into a master list, utilising the tape transcripts for further clarification. Full agreement was reached on the following 13 RPF’s.

- Training
- Communication
- Operating equipment
- Maintenance
- Staff attitude
- Supervision
- Working conditions
- Rules/procedures
- Staffing
- Management
- Housekeeping
- Equipment design
- Organisational policies

This list enabled the construction of a “Railway Safety Checklist” that asked participants to rate the extent to which each factor had been a problem in carrying out their job, in the past two months. The rating was done on a 5 point scale, with 1 being “no problem at all” and 5, being “a serious problem”. Each factor was clearly described, via appropriate representative examples. The checklist was piloted on 20 management staff, who all had previous train driving experience. As a result a number of wording changes were made to improve clarity.

3.3. Stage 3: checklist distribution

The checklist was sent to 454 appointed train drivers. The train drivers were all male. The checklist was accompanied by a complete set of instructions for completing the checklist and information about confidentiality.

No names were requested, but the checklist did require the respondent to indicate their work location, business division and years of experience as a driver. 190 checklists were returned, indicating a 42% response rate. Exploratory factor analysis was conducted on the checklist results to reveal any underlying structure across the 13 items. It was expected that factor analysis would group related items in to more distinct factors and therefore indicate the relative importance of each, in terms of latent influence.

4. Results

4.1. Organisational profile

Three problem factors; Staff Attitude, Maintenance and Operating Equipment, were identified by checklist distribution as the most serious. These results are shown in Fig. 2. Of
these three items, Staff Attitude was the most frequently cited problem, with 66% of respondents indicating that this was a serious problem in carrying out their job over the previous two months. Items in this category included low morale, over complacency/familiarity with the job, lack of pride, poor motivation, not caring about work and taking short cuts. 60% of respondents drew attention to the problem of low morale.

Operating Equipment was identified as a serious problem by 48% of respondents. This category includes items specifying the reliability, quality and useability of frequently operated equipment. Equipment such as in-cab radios, cab instruments, lighting, air conditioning, safety apparatus, signal placement and the quality of brakes. 44% indicated that the quality of brakes was a serious problem.

Maintenance consisted of items regarding the quality and consistency of repairs and equipment service. 47% of respondents identified this as a serious problem, with particular attention drawn to delays with repair work (40%).

4.2. Passenger division profile

Profiles were also conducted for specific business divisions (passenger or freight operations). For the Passenger division, the profile revealed Staff Attitude (78%), Operating Equipment (61%) and Maintenance (40%) as factors of concern. These results are shown in Fig. 3. Low morale (72%) and the quality of brakes (67%) were identified as problems on the public rail cars.

4.3. Freight division profile

The Freight division showed a similar pattern with Staff Attitude (58%), Maintenance (52%) and Operating Equipment (40%) indicated again as items of concern. Maintenance
appeared to be more of a serious problem compared to passenger operations with repair delays (39%) cited most frequently. These results are shown in Fig. 4.

4.4. Factor analysis

In order to determine the underlying constructs of the 13 Railway Problem items, Factor Analysis was conducted. This factor extraction technique was employed due to an interest in deriving underlying dimensions that are uncontaminated by both unique and error variance. Snook and Gorsuch (1989) have recently demonstrated that Factor Analysis as opposed to
Principal Components Analysis produces unbiased estimates of loadings and reduced standard errors.

Prior to analysis, the data was screened for the presence of outliers, absence of multi-collinearity and factorability of the correlation matrix. In relation to factorability of $R$, a Kaiser-Meyer-Olkin measure of sampling adequacy of 0.81159 was obtained. Tabachnick and Fiddell (1989) outline that any value greater than 0.6 is required for good factor analysis.

Three factors, with eigen values greater than 1, were extracted using an Oblique rotation. This rotation was necessary to increase interpretability as it was expected that factors would be correlated with one another. Factor 1 explained 26.9% of the variance with factor loadings ranging from 0.46 to 0.74. This factor was comprised of the following items; Management, Organisational Policies, Rules and Procedures, Equipment Design, Communication and Supervision.

Factor 2 explained 11.3% of the variance with factor loadings ranging from 0.32 to -0.60. The Housekeeping, Staff Attitude and Staffing items made up this factor.

The final factor constituted 5.3% of the variance and consisted of the Maintenance, Working Conditions, Training and Operating Equipment items. Factor loadings ranged from 0.46 to 0.73. Overall, the three extracted factors explained 43.5% of the total variance.

Factor loadings for each item can be found in Table 1. Factor loadings less than 0.3 have been blanked to aid in interpretation. Factor 1 and 3 appear internally consistent and well defined by the items.

5. Discussion

5.1. An evaluation of REVIEW

The 13 RPF's identified in the present study are virtually identical to the those revealed at British Rail (BR). This finding would appear to support Reason's (1995) notion that these
factors are generic. That is, the factors are representative of the processes and functions that an organisation typically performs within a dynamic environment (e.g. maintenance, communication etc.). Reason (January 1994, personal communication), argues that the number of RPF's identified is arbitrary. Whether an organisation has thirteen (the present study) or sixteen (British Rail) factors is unimportant. Having more does not mean that the work environment is unsafe. More factors are simply indicative of the complexity and dynamic nature of the functions that an organisation performs. BR's additional factors may simply be a reflection of the size and traffic volume in the United Kingdom, compared to the relatively small operational demand in Australia.

The rationale behind REVIEW is that people are very good at making global estimates of situations on simple rating scales. However to overcome the problem of individual bias it is important to access a large sample on a regular basis. Due to a number of organisational and time constraints placed upon the researcher it was only possible to conduct one measure. Therefore, the profile of this study represents a snapshot view. Reason (1995) suggests that identifying safety deficits is like “guerrilla warfare” and periodic reviews are required to battle the safety problem. In the present study a little under half (42%) of the sample responded. This poor response rate appears reflective of the finding that staff attitude is a serious problem within the organisation. Since the work environment is dynamic it would be advisable for the checklist to be redistributed every two months, over a six month trial basis to obtain a profile pattern that would reflect any fluctuations. Furthermore, the present sample, consisted of appointed train drivers only. It is recommended that further reviews sample all personnel involved in front line train operations, e.g. drivers assistants.

While only one measure was conducted in the present study, it is possible to evaluate the utility of the REVIEW method. In practice, REVIEW is a simple and user friendly method. None of the respondents indicated difficulty in completing the checklist. Furthermore, because it identifies problem areas not problem people, it avoids the blaming process so prevalent in accident analysis. One distinct advantage of REVIEW is its participative approach. Involving employees in safety monitoring encourages them to become more accountable for workplace safety.

REVIEW is useful for targeting areas that need current safety attention. This is helpful since organisations typically have limited time and resources to deal with more than a few areas at one time. REVIEW assumes that safety is a management problem. For example, it is common knowledge among accident investigators that most accidents involve a repeat factor, i.e. one that has been a cause factor in the past. The very fact that human error continually reveals itself in accident records is an example of this fact. If the cause factor shows itself again, this is an indication that the safety system has failed. If this factor continues then management become the true underlying cause of system accidents because they have failed to prevent recurrence. Human error is simply a symptom of the failure, not the cause itself. Because REVIEW is a monitoring tool it provides management with a systematic method for preventing recurrence.

While REVIEW adopts a systems perspective, such breadth may also be a weakness. REVIEW would have difficulty in identifying local conditions that trigger accidents unless detailed data is collected. Furthermore, REVIEW focuses on generic factors like communication. However, communication, good or bad, is present in all organisations. But it does not mean that poor communication will lead to an accident. In other words, organisational processes like communication, are not necessarily good predictive factors of accidents, because the link between them and safety is not always clear. Therefore, current attempts to
pro-actively monitor potential latent failures may be misplaced due to the unforeseeable nature of latent failures and the crucial role that defences play in preventing accidents. Research within the aviation industry (Edkins, 1996) is focusing on developing a model to pro-actively identify and evaluate the integrity of safety defences.

To be considered valid, REVIEW requires continual input from many employees in diverse areas. From a safety management perspective this can be a disadvantage, because REVIEW depends upon maintained employee enthusiasm. In addition, periodic application of REVIEW can mean the analysis of results becomes a full time task.

Consultation with senior rail management revealed mainly positive comments about the application of REVIEW, particularly in regards to participative management. Rail managers felt a distinct advantage of REVIEW was getting staff more actively involved in safety. However, management felt that the Railway Safety Checklist shows only negative indicators. The checklist does not give staff the opportunity to indicate where safety is being managed well within the organisation.

5.2. Further development of REVIEW

Factor analysis revealed three distinct factors; Policy and Decision Making, Workplace Culture and Operating Conditions. These factors explained 43.5% of the total variance and allows further specification of Reasons model. This is shown in Fig. 5.

Figure 5 illustrates the human contribution to system accidents, rather than equipment breakdown, because even what may appear at first glance to be a simple technical fault, can usually be traced to human influence. The essential elements of the model indicate a causal sequence from top level decision making through to the release of energy, characteristic of all accidents.

The first factor was labelled Policy and Decision Making and was comprised of the management, equipment design, organisational policies, rules and procedures, communication and supervision items. Functions in this category involve both the architects and the senior executives of the system. The latter not only set the production and safety goals for the system, but strategically direct the means by which these goals should be met. These items are mainly high level functions and are concerned with the allocation of finite resources. Due to
the association of these items with high level decision makers, this factor has a large influence on safety activities. Not surprisingly, this factor made up the largest proportion of the explained variance.

The second factor was labelled Workplace Culture and included the housekeeping, staff attitude and staffing items. These items are the responsibility of line management who implement the strategies of the decision makers. The actions of line managers can determine and reinforce cultural assumptions amongst staff, since line management are the more visible decision makers. While the scope of line management intervention is constrained by the size of their department, the competencies of line managers can cause good decisions to have bad effects or transform good decisions into even better ones.

The third factor was labelled Operating Conditions and includes the following items: maintenance, working conditions, training and operating conditions. These functions are also the responsibility of line management and represent the functional departments of a system. Each of these functions have a direct impact upon staff because of their very nature. For example, the quality and attention directed at staff training, the availability of staff amenities and the responsiveness of equipment repairs can set the standard for how staff perceive management to be conducive to their needs.

The next element in the model is psychological precursors which are mostly unforeseeable and are introduced by the limited human capacity to see, hear, communicate, anticipate and react. Individuals are subject to stress, may fail to perceive hazards or have low motivation. Each of these human limitations can be exaggerated by decisions or policies made at the top level of the system.

Unsafe acts occur for a variety of reasons but are basically mediated by the elements of a particular system (work environment) and forces arising from the outside world (environmental influences). An unsafe act can only be "unsafe" if an error or violation occurs in the presence of a particular hazard. Thus, failing to wear protective footwear in not unsafe unless heavy objects are dropped in the vicinity of your toes.

The last element between unsafe acts and accident occurrence are safety defences. Defences can be as simple as personal safety equipment (work boots, hard hats) or automatic safety devices, such as Automatic Train Protection. An important function for effective safety management is to periodically review the quality of safety defences in order to determine how system defences might be breached, ignored or circumvented.

The arrows in Fig. 5 indicate a link between each element of the accident causation sequence. For example the link between operating conditions and workplace culture with psychological precursors. The exact nature of this link will be a complex function between the task being performed, the presence of a hazard and environmental influences. Deficiencies in the maintenance department may manifest themselves as a variety of preconditions such as improper use of equipment, use of faulty equipment, failure to identify sub standard equipment and motivational difficulties. In reverse, a precondition (e.g., improper use of equipment) could be the result of line management deficiencies such as lack of supervision, poor communication or inadequate training.

While factor analysis has revealed three distinct factors, future research could be conducted to create a smaller number of variables by estimating factor score coefficients through the reduction procedures of factor analysis. These factor scores can be calculated for each case and would enable associations to be determined between variables and factors e.g. analysis of variance may be undertaken to determine the relationship between factors and work location. Subsequent analysis may investigate such relationships.
In addition, factor analysis explained a little under half of the variance. It is clear that further research is needed on a much larger sample to further specify other contributing types. In relation to the generic nature of the items, future research needs to determine whether a series of standardised problem factors (as distinct from local factors) can be used across different types of high risk organisations.

6. Conclusion

The analysis of the items in the Railway safety Checklist, allows safety managers to identify which factors are most likely to be involved in accidents. The results of this study imply that the most effective way to minimise accident occurrence, is to direct attention to the most global features of the system. As such, remediation strategies would have the most promising effect targeted on those indicators associated with top level decision making. The indictment of senior management in safety matters is not new. The Fennell (1988) and Hidden (1989) reports directed principal blame of these two railway accidents to the way management conducted themselves. The present analysis appears to support these conclusions. That is, reduced opportunity for employees error may only come about through managerial action.

References


