The role of management and safety climate in preventing risk-taking at work

Steven Yule* and Rhona Flin

Industrial Psychology Research Centre, School of Psychology,
University of Aberdeen, Aberdeen AB24 2UB, UK
Fax: +44 1224 273211 E-mail: s.j.yule@abdn.ac.uk
E-mail: r.flin@abdn.ac.uk
*Corresponding author

Andy Murdy

E.ON UK plc, Westwood Way,
Westwood Business Park, Coventry CV4 8LG, UK
E-mail: Andy.Murdy@eon-uk.com

Abstract: Safety climate is a leading performance indicator that can provide insight into safety performance before accidents have occurred. Managerial variables have emerged as a primary determinant of safety climate in empirical research. In order to investigate the mechanisms of that influence a theoretical model was developed to test the relationship between management commitment and worker risk-taking. Workforce perceptions of safety climate ($n=1026$) were collected using the Health and Safety Executive climate survey tool and analysed using Structural Equation Modelling (SEM). The tested model revealed that the relationship between management commitment and supervisor involvement with risk-taking behaviours was mediated by knowledge and training. Additionally, a positive attitude towards risk taking (i.e. not engaging in risk taking behaviours) was related to enhanced feelings of workers' responsibility for safety and more positive appraisals of senior management commitment. Managers may find the model useful when attempting to improve safety climate.

Keywords: continual improvement; risk; safety climate; senior management commitment; supervisor involvement.

Reference to this paper should be made as follows: Yule, S., Flin, R. and Murdy, A. (2007) 'The role of management and safety climate in preventing risk-taking at work', *Int. J. Risk Assessment and Management*, Vol. 7, No. 2, pp.137–151.

Biographical notes: Steven Yule (MA, MSc, PhD) is a Research Fellow in the School of Psychology at the University of Aberdeen. His research is on the impact that non-technical skills (i.e. situation awareness, decision making, teamwork, communication, leadership) can have on the safety performance of organisations that are exposed to major hazards. He also has a particular interest in safety climate, senior managers' leadership and patient safety. His current work is developing a behavioural marker system with the Royal College of Surgeons of Edinburgh and the NHS, which will be used to train and rate surgeons' non-technical skills in the operating theatre.

Rhona Flin (BSc, PhD Psychology) is Professor of Applied Psychology in the School of Psychology at the University of Aberdeen. She is a Chartered Psychologist, a Fellow of the British Psychological Society and a Fellow of the Royal Society of Edinburgh. She directs a team of psychologists working with high reliability industries on the management of safety and emergency response. The group has worked on projects relating to aviation safety, leadership and safety in the offshore industry, team skills and emergency management. She is currently studying anaesthetists' and surgeons' non-technical skills and the safety climate in hospitals.

Andy Murdy is Senior Health and Safety Advisor for E.ON UK. He has worked for E.ON UK and its predecessors since 1987, with a full-time health and safety role since 1996. Andy's career in health and safety has involved work in six countries, including a two year post in the USA looking at operations and construction health and safety issues. In his current role, his key responsibilities include performance management, audit and behavioural safety. Andy is a corporate member of IOSH.

1 Introduction

The safety performance of industrial organisations has traditionally been assessed against lagging criteria such as accident and injury rates. More recently, leading performance indicators have allowed organisations to assess their safety performance without the need for retrospective analysis of accidents. Examples of leading performance measures include safety audits, hazard analysis and safety climate. The concept of safety climate is of particular interest to managers, engineers and psychologists as it has a number of implications for the relationship between individual and group perceptions of safety management, and behaviours at work which can have an impact on safety performance. A number of studies have found workforce perceptions of safety climate to be directly and indirectly linked to safety outcomes (Donald and Canter, 1994; Hofmann and Stetzer, 1996; Lee, 1998; Mearns et al., 2001; Niskanen, 1994; Tomas et al., 1999; Zohar, 2000). Among these are studies that use Structural Equation Modelling (SEM), a method of multivariate analysis in which interrelations between concepts made along theoretical dimensions can be tested statistically (Byrne, 1994). Authors often interpret the results of SEM as evidence for causal paths between latent and observed variables.

2 Safety climate

It is generally accepted that safety climate is a 'snapshot' of workforce perceptions about safety (Mearns et al., 1997). However, researchers are in less agreement regarding which safety climate factors or dimensions are most important in influencing behaviours at work. The multiple definitions of safety climate in the literature (Flin et al., 2000; Guldenmund, 2000) have determined to a large extent what variables research teams have incorporated when developing measures of safety climate. The central debate among theorists appears to be whether the safety climate should be restricted to workforce perceptions about management and the manner in which management reconciles safety with productivity (Brown and Holmes, 1986; Dedobbeleer and Beland, 1991; Zohar, 1980, 2000), or whether the role of management is incorporated with other safety issues such as risk perception, worker involvement, personal accountability, perceptions of the physical environment and job communication (Cheyne et al., 1998; Cox and Cox, 1991; Cox and Flin, 1998; Lee, 1998; Mearns et al., 1998; Mearns et al., 2001; Williamson et al., 1997). This debate has not been resolved, and has led to a proliferation of instruments that, with one or two exceptions, are specific to an organisation, or at best, to the industrial sector for which they were developed. Two notable exceptions include the Offshore Safety Questionnaire (OSQ), developed by Flin et al. (1996) on the basis of earlier work by Marek et al. (1985), and Rundmo (1994). The OSQ has been used in several offshore environments, as well as in healthcare, mining and forestry settings around the world. The second exception is the HSE Health and Safety Climate survey tool (Health and Safety Executive, 1997), which was developed by the UK regulator to be used across all UK industrial sectors.

3 Management commitment to safety

Despite the disagreement outlined above, management clearly has a role to play in safety climate. A review and thematic analysis of safety climate factors by Flin et al. (2000) found that management was central to 72% of the studies. Management was also identified as one of only two factors (the other being workforce involvement) that were properly replicated across studies (Dedobbeleer and Beland, 1998). A third review of safety climate themes included a number of studies not covered in the two reviews above, and found that management was the most frequently measured dimension (Guldenmund, 2000).

Management commitment to safety had actually been studied before the term 'safety climate' was coined. Smith et al. (1978) found that workforce perceptions of a high level of management commitment to safety were associated with low accident rates in a cross-section of 42 US industrial plants. The seminal study on safety climate by Zohar (1980) identified two dimensions as being most influential in determining safety climate level. The second of these (after relevance of safety to job behaviour) was workforce perceptions of management attitudes to safety. Zohar argued that the management commitment was a prerequisite of successful initiatives aimed at improving the state of safety in industrial organisations. This argument has found considerable empirical support across industrial sectors (although mainly in the energy sector and manufacturing). From a study of workers in UK chemical plants, Donald and Canter (1994) found that a number of safety climate scales correlated with self-reported accident involvement, including management commitment.

Further evidence is provided by Diaz and Cabrera (1997), who reported that safety climate differentiated organisations with differing levels of safety in a sample of Spanish airport workers. Workforce perceptions of company safety policy (including management commitment) were deemed to be the most important factor, with perceptions of the organisational philosophy regarding the relative priorities of productivity versus safety. Rundmo (1994) also found that management commitment to safety was the most important determinant of workforce satisfaction with safety, and with safety-related contingency measures. Organisational support provided by management was the second most important determinant. Finally, Cheyne et al. (1999) found that management influenced workforce appraisals of commitment across three UK industries: manufacturing, dairy produce and transport. Management also consistently influenced training across all three samples but only influenced workforce personal actions and responsibility in the manufacturing and dairy produce samples.

The applied use of such associations is underlined by a study in Australian healthcare. Coyle et al. (1995) argue that modifying the attitudes of management and workforce toward health and safety should improve an organisation's safety climate and ultimately their safety record. These findings are not universal, however.

4 Supervisor involvement in safety

Empirical research also indicates that supervisors have an important role to play in safety climate. For example, a model that integrates the safety influences of managers and supervisors is offered by Thompson et al. (1998), who tested a model based around two central pathways

- from 'organisational politics' to 'manager support for safety' to 'safety conditions'
- from 'supervisor fairness' to 'supervisor support for safety' to 'safety compliance'.

Management support for safety was also found to positively influence supervisor support for safety. They concluded that management has an influence on safety conditions but workforce compliance with safety rules and regulations under those conditions is influenced by the perceived fairness of the supervisor. O'Dea (2002) also found that supervisor commitment to safety was predictive of worker propensity to take safety initiatives, and comply with rules.

Supervisors have been shown to have other important influences regarding safety climate. From three Spanish samples of 'high risk organisations', Tomas et al. (1999) found that supervisors played an important role in the accident prevention process by transferring the elements of safety climate to members of the workforce. Evidence for this came from support for a tested model in which the causal chain ran from 'safety climate' to 'supervisor response' to 'co-worker response' to 'worker attitude', and then to 'safety behaviour', 'risk' and finally 'accidents'. Brown et al. (2000) report the corollary that supervisors can have a negative impact on safety climate by applying too much pressure on workers, a conclusion based on a study in the US steel industry.

Zohar (2002) studied some of these concepts experimentally at an Israeli maintenance plant. He measured the number of safety-related interactions (episodes) between supervisors and workers, and gave weekly feedback to supervisors on their performance. As a result, the frequency of safety-related interactions increased rapidly from 9 to 58% of all interactions. In experimental groups there was an associated significant decrease in accidents, an increase in personal protective equipment (PPE) use (earplugs), and a significant improvement in safety climate perceptions compared with no change in control groups. This study showed that supervisors could dramatically improve safety performance and PPE use by merely emphasising safety in interactions that take place on the shop floor as a matter of course, and is an example of a micro-level change in culture.

5 The role of risk in safety climate

Early research on safety climate incorporated risk as a key factor. For example, Zohar (1980) measured risk in his seminal work, and Brown and Holmes (1986) found that a three factor model of safety climate comprising risk, management concern and management action, had an acceptable fit to workforce safety climate in a US production sample. A number of studies have used risk an outcome variable. For example, Dedobbeleer and Beland (1991) found that workforce attitudes towards safety practices (i.e. propensity to take risk) were predicted by perceptions of management concern, replicating the Brown and Holmes (1986) findings. Additionally, Tomas et al. (1999) found that perception of actual risk was the only factor to directly predict accidents in their model outlined earlier. Although there is little research linking worker attitudes to senior management and risk-taking, Kivimaki et al. (1995) found that workforce trust in senior managers was linked to workers' risk perception and goal acceptance. More recent research on the role of senior managers confirms the conclusion that the attitudes of senior managers influence workers' behavioural intentions, and are related to the achievement of safe working practices (Rundmo and Hale, in press). Yule (2003) also found that senior managers in the UK and US energy sectors who received higher performance appraisals from their employees were more likely to discuss and understand the risks that their workers were exposed to.

The aim of the present paper is to examine the role of managers and supervisors in influencing risk-taking behaviours. In order to achieve this goal, a theoretical model of safety climate was developed, based on the previous research findings outlined above, along with consideration of the underlying theory. For these reasons, and the fact that workers have been found to perceive risks in industrial contexts (Rundmo and Sjöberg, 1998) in a valid and reliable manner, perceptions of risk-taking behaviour will be used as an outcome measure in the model.

6 Developing the model

The present section outlines the rationale for developing a theoretical model of safety climate. The model is presented in Figure 1 below. Management has been shown to hold a significant influence on workforce safety climate (Flin et al., 2000; Kozlowski and Doherty, 1989). Andriessen (1978) also argues that workforce perception of the safety attitudes of senior management is an important factor in influencing motivation to behave safely and Clarke (1999) argues that different levels of management have distinct roles and are perceived differently by the workforce. This distinction is reflected in the current model as two layers of management – senior management and supervisors – are identified on the basis of exploratory factor analysis of the workforce safety climate data set. The relationship between these managerial factors and other factors will form the basis of the theoretical structural component.

It is plausible that relationships exist between attitudes towards different levels of management. Both Dedobbeleer and Beland (1991) and Thompson et al. (1998) provide tested models that show that attitudes toward first-line supervisors are predicted by attitudes toward senior management. Witt et al. (1994) take the opposite view and tested a model which displays a path running from 'supervisor fairness' to 'management support for safety'. On the basis of the research evidence, the hypothesised model in the present paper argues for a reciprocal relationship between senior managers (F1) and supervisors (F5). This reciprocal relationship is imposed because supervisors implement the majority of resources, incentives and procedures laid down by senior management for workforce health and safety.

In the model, senior managers are thought to have their primary influence on elements of the safety system (F7), i.e. by establishing and endorsing the Permit-To-Work (PTW) system[1], and by providing safety training (F3). Senior management sets the framework of the safety system and it is hypothesised that perceptions of their commitment to workforce safety predicts the perceived efficacy of the procedures in place and the PTW system. Further evidence for this link is provided by the International Nuclear Safety Advisory Group (INSAG). They published a three-level framework for the measurement of safety culture (INSAG, 1991). One of the levels, 'Managers' Commitment' is distinguished by (among others) 'definition of responsibilities'; definition and control of safety practices' and 'qualifications and training'.

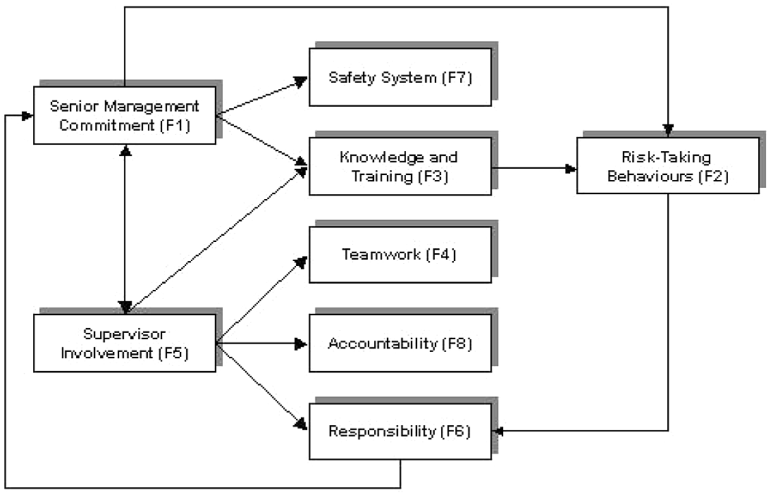
The role of knowledge and training in health and safety (F3) is pivotal in the model as it is hypothesised to be directly related to risk taking behaviours and thus to mediate the relationship between senior management commitment and risk taking behaviour. This is proposed to be an inverse relationship – as knowledge increases, the propensity to engage in risk-taking behaviours will decrease. A direct relationship between senior management commitment and risk taking behaviour was also specified in the model so that a comparison between that relationship and the mediated relationship could be made.

The model acknowledges previous research that has emphasised the importance of supervisor involvement in safety climate. For example, Fleming et al. (1996) suggest that offshore supervisors should adopt a participative style of leadership and be involved in workforce training. Training is one contribution to knowledge so a theoretical path from supervisor involvement (F5) to knowledge (F3) was imposed. Simard and Marchand (1994) argue that first-line supervisors who adopt a participative style are also most effective in occupational safety and effective at encouraging team members to participate in safety initiatives. Participating in safety initiatives is one way of boosting responsibility for safety. Cheyne et al. (1998) also show the influence of management attitudes on worker responsibility, through mediating factors of involvement, communication and hazards in the manufacturing sector. This is in line with the management literature where delegation is an important managerial practice (Yukl, 1998). By delegating, supervisors encourage workers to accept responsibility for safety in the workplace. This principle provides more evidence for a relationship between supervisor involvement and responsibility which is stipulated in the model. However, the path was imposed with the awareness that feelings of responsibility may arise also through other sources such as job characteristics (Hackman and Oldham, 1980).

Simard and Marchand (1995) place supervisory characteristics, such as their experience and approach to safety management, along with workgroup cohesiveness at the micro-level of their organisational model. This cooperation between workforce and supervisor should make it easier for the workforce to make suggestions and exert pressure for change; see also Fleming et al. (1996). Therefore, a structural path from supervisor involvement (F5) to teamwork (F4) was hypothesised.

Workforce involvement in a behaviour-based safety (BBS) programme engendered trust in co-workers and management according to DePasquale and Geller (1999). They also found that accountability was a predictor of involvement in a BBS programme. For these reasons, and the possibility that team leaders may make team members accountable by being 'law enforcers' (Fleming et al., 1996), a structural path from supervisor involvement (F5) to accountability (F8) was specified. It was also hypothesised that there would be a relationship between propensity to engage in risk-taking behaviour and feelings of responsibility, so this path was specified in the model. Finally, a feedback loop was inserted, from responsibility (F6) to senior management commitment (F1). This feedback loop completes a hypothesised cycle of improvement in safety climate. When considering the model as a whole, the main proposition tested is that senior managers can reduce risk-taking behaviours by investing in resources for knowledge and training. In turn, this will enhance feelings of responsibility for safety among workforce members and through a series of affective responses, will build perceptions of senior management commitment. As stated, this proposition is cyclical. The remainder of the present paper describes an empirical study which was designed to test this model.

Figure 1 Theoretical model of safety climate (model 1). For clarity, the individual items are not displayed



7 Method

7.1 Organisational context and participants

The research context for this study was a UK power-generating company. The participants were 1023 workforce members from six conventional UK power stations. A relatively flat management structure is in place on those stations, team members (i.e. the workforce) report to a team leader who reports to a functional manager. Above this layer of management lies the Station Manager. Safety climate questionnaires were administered to the workforce during working hours and completed on company premises between March and November 1999. The total response rate was 87%.

7.2 Measures

Workforce safety climate perceptions were collected using the HSE Climate Survey tool (Health and Safety Executive, 1997), which was developed by the UK regulator (Health and Safety Executive) as a standardised tool for measuring safety climate across all UK industry sectors. It has been used in over 400 companies since commercialisation. However, unlike other measures of safety climate only a superficial evaluation has been conducted of this tool (Health and Safety Executive, 2002). Although an analysis of the tool's psychometric properties has been conducted (Yule et al., under review), there are currently no published results or models emanating from data collected using the tool. The HSE Climate Survey tool consists of 71 statements to which responses are made on a five point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Some items are negatively worded to balance the questionnaire.

7.3 Analytic strategy

Structural Equation Modelling (SEM) is ideally suited to exploring theoretical paths of influence among safety climate dimensions and testing theoretical models. The technique has been used on a number of occasions in the safety sciences (Cheyne et al., 1999; Coyle et al., 1995; Griffin and Neal, 2000; Mearns et al., 2001; Tomas et al., 1999). SEM was achieved using EQS for windows version 5.5 (Bentler and Wu, 1995).

8 Results

8.1 Exploratory factor analysis

The factorial structure of the safety climate questionnaire was tested with raw responses (n=1023) to preserve statistical power. Responses to negatively worded statements were reversed so higher scores reflected stronger perceptions of safety climate. Exploratory principal components analysis (PCA) with varimax rotation was performed using SPSS 9. A criterion of 0.45 was set for individual questionnaire items to significantly load on factors. The factor analysis identified an eight-factor solution that incorporated 47 questionnaire items and accounted for 47% of the variance in safety climate scores. This was deemed to be a statistically acceptable foundation to test for structural linkages between factors using this data set. The eight factors reflect the underlying dimensions of safety climate as measured by the HSE tool in this study. In order to interpret and label these factors a group of human factors experts and safety practitioners were given the relevant questions grouped as factors and asked to provide a unifying label for each factor. A thematic analysis was then used to generate a set of generally accepted factor labels. The resulting factor labels are presented as Table 1, along with example questions and the proportion of total variance accounted for by each factor.

8.2 Confirmatory factor analysis

In accordance with Byrne (1994), a judicial selection of items from each factor was made to represent that factor in the modelling. These factors can be conceptualised as subscales of safety climate and are used as predictor variables in the modelling.

Table 1 Safety climate factors and example items

Factor	*Label*	*Example item*	*% total variance*	*Cronbach's alpha*
1	Senior management commitment	Productivity is usually seen as more important than health and safety	11.0%	0.91
2	Risk-taking behaviours	Some jobs here are difficult to do safely	9.1%	0.85
3	Knowledge and training	People here do not remember much of the health and safety training which applies to their job	5.9%	0.77
4	Teamwork	I trust my workmates with my health and safety	5.6%	0.84
5	Supervisor involvement	My immediate boss is receptive to ideas on how to improve health and safety	5.2%	0.78
6	Responsibility	I fully understanding the health and safety risks with the work for which I am responsible	4.2%	0.74
7	Safety system	The Permit to Work system is over the top given the real risks of some of the jobs it is used for	3.2%	0.69
8	Accountability	People who cause accidents here are not held sufficiently accountable for their actions	2.4%	0.60

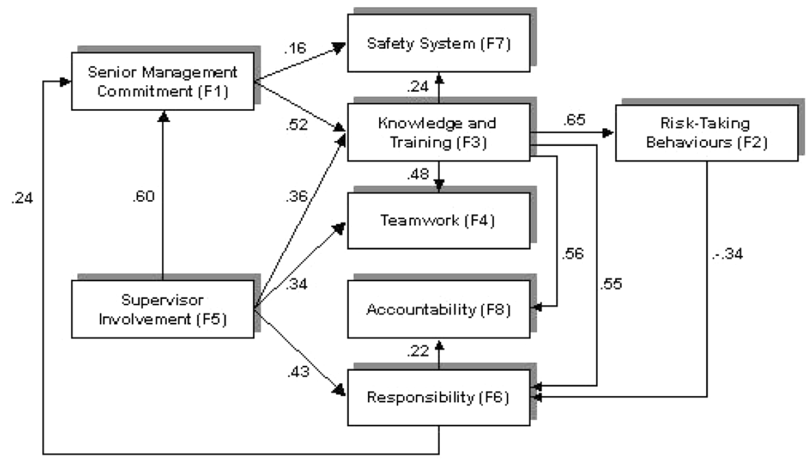
The structural paths detailed above were imposed according to theory. All disturbance and error variances were freely estimable as were all structural path coefficients between latent variables. The model was tested using EQS for Windows version 5.5 (Bentler and Wu, 1995). The solution converged in six iterations with a final function of 1.12507. The chi-square for this run was 888.8 based on 316 degrees of freedom and with an associated probability less than 0.001. The CFI and robust CFI were above the critical value of 0.9, the fit index of choice, CFI being 0.905. See Table 2 for complete information about fit indices. The hypothesised structural model of safety climate provides an acceptable fit to the data.

8.3 Respecified structural model

Model 2 uses the hypothesised model in Figure 1 as a basis for respecification. Results from the Wald test suggested the redundancy of three structural paths: from senior management to risk-taking behaviour (F1 $\rightarrow$ F2); supervisor involvement to senior management (F5 $\rightarrow$ F1), and supervisor involvement to accountability (F5 $\rightarrow$ F8). These paths were subsequently dropped from the analysis in the interests of parsimony as even though they were theoretically plausible, they did not add to the fit of the model. The multivariate LaGrange Multiplier test suggested several paths to be added of which six were chosen for inclusion on theoretical grounds. The majority of these paths were expected on the basis of the factor covariation matrix from the initial exploratory factor analysis and appeared intuitively plausible.

The model was revised nine times to include the suggested new paths and remove those that did not add to the fit of the model to the data. The solution converged in five iterations with a function of 0.71689. The chi-square for this final run was 566.3 based on 305 degrees of freedom and with an associated probability less than 0.001. All four fit indices for the model were above the acceptable level of 0.9, the fit index of choice, CFI, being 0.957. The respecified model is shown as Figure 2.

Figure 2 Respecified model of safety climate (model 2), CFI = 0.957. Standardised path coefficients are given. For clarity, the individual items and associated errors are not displayed



A table of fit indices for the two models discussed in this study is shown as Table 2. This table facilitates comparison of the goodness of fit of the two models tested. Fit indices are based on the chi-square value of the model under scrutiny. EQS provides several different fit indexes of which four are utilised in this study: CFI, NFI, NNFI and robust CFI. The comparative fit index (CFI) is considered the most reliable [51] and is the fit index of choice for this study. The proportion of total variance accounted for by endogenous variables was 53%.

Table 2 Indices of fit for the theoretical and respecified models of safety climate

Model	χ^2	*p*	*CFI*	*NFI*	*NNFI*	*Robust CFI*
1 (theoretical)	888.8_{316df}	< 0.001	0.905	0.860	0.894	0.905
2 (respecified)	566.3_{305df}	< 0.001	0.957	0.911	0.950	0.957

9 Discussion

Table 2 shows that the fit indices increased from models 1 (theoretical) to 2 (respecified). Model 2 provides a foundation for identifying and exploring the important relationships between safety climate variables such as the role of management, knowledge and accountability.

Only three of the *a priori* specified paths were deemed non-significant and dropped from the analysis. This means that the majority of the initial theoretical paths of influence were imposed correctly. As they were done so in line with literature and previous research this is reflective of the validity of the data set and final model. The majority of added paths were added on an intuitive basis as some of the links have not been documented in previous studies. With hindsight, several of the added paths could have been included in the initial theoretical model but were not in the interests of parsimony. The added paths were all in line with the results of the principle components extraction and reflect relationships between factors that show high individual correlations.

The respecified model shows knowledge of health and safety as a key mediator between perceptions of senior management commitment and responsibility for safety. The influence of knowledge and training on reducing risk-taking behaviours was one of the strongest in the model (0.65, the path coefficient is positive because the scale used was recoded so that positive perceptions of risk-taking behaviour equated to a lower frequency of risk-taking behaviours). Knowledge and training also had direct relationships with responsibility and accountability. The hypothesised direct relationship between senior management commitment and risk-taking behaviour was not supported which provides further evidence of that relationship between these variables being mediated. In two paths added in the respecification stage, knowledge was also found to have a significant impact on the use of the safety system and on the level of teamwork experienced. It is plausible that knowledge may improve team cohesiveness and performance, reduce the number of errors made by team members, and increase the capacity for the team to capture error.

Evidence for a reciprocal relationship between senior management and supervisors was not found. Instead, perceptions of supervisor involvement were found to influence perceptions of the commitment of senior management. This was a strong relationship in the model at 0.60 and supports the notion that supervisors must enact the safety policy and vision laid down by senior managers. The degree of senior management commitment to safety perceived by the workforce may vary as a function of how well supervisors achieve this. O'Dea (2002) found the same effect between perceptions of supervisors and Offshore Installation Managers (OIMs, i.e. the site manager) in a study conducted in the UK oil and gas sector. If the supervisor is perceived to do this poorly, or has a low level of involvement with the team, then the messages of strong commitment to safety from senior management may not be received by the workforce. In short, relaying the commitment to safety of senior management to the workforce is one of the key roles of supervisors. The respecified model also shows that supervisor involvement has an impact on knowledge and training, again emphasising the central role of knowledge in the model.

Accountability for safety is significantly influenced by knowledge and training (0.56) and to a lesser extent individual responsibility (0.22). These relationships seem logical, as accountability cannot be genuinely felt unless workers have both technical knowledge and knowledge of what is and is not acceptable working practice. It is also logical that workers who feel responsible for health and safety will also feel more accountable, partly because they will show a desire for job characteristics such as enrichment and enlargement that boost their responsibility and make them more accountable (Hackman and Oldham, 1980).

Perceptions of risk-taking behaviours were found to have an inverse influence on responsibility (−0.34). This relationship may seem counter-intuitive at first as it suggests that fewer risk-taking behaviours are associated with less responsibility. This is not likely to be the case because the occasions where risk-taking is seen as having high valence are the very occasions where the workforce feels that the procedures are laborious, over the top and time consuming. The workforce also knows that the procedures are driven by legislation and policy that is there to protect them and as a result they may be dissatisfied with the practicalities of some procedures but still follow them (i.e. do not take risks) through a higher source of motivation. The tested model also provides evidence for the hypothesised feedback loop as feelings of responsibility for safety have a positive relationship with perceptions of management commitment.

10 Conclusions

The present paper outlines the development of a model of safety climate that stipulated management commitment and involvement as input variables, and risk-taking behaviour as an outcome. The fit of this model to a safety climate database was tested using EQS and then respecified. The respecified model confirmed our *a priori* assumption that the relationship between senior management commitment and worker risk-taking behaviour was mediated by knowledge and training. In turn, reducing the level of risk-taking behaviour had a positive impact on workers' appraisals of senior management commitment to safety through the mediating variable of responsibility for health and safety. The involvement of supervisors was also found to predict perceptions of knowledge and training.

The model has applications for both practice and research. In practice, the model stipulates that senior managers can reduce risk-taking behaviours at work in two ways. Firstly, they can invest in the knowledge and training of their workforce so the workforce may understand the risks inherent in high hazard work. Workers are more likely to follow procedures when faced with the option of taking a risk if they understand why those procedures are in place and have a more complete picture of the risks that they will be exposed to if they do not follow procedures. Secondly, senior managers can encourage supervisors to be more involved in safety activities. Suggested behaviours for supervisors include being receptive about workforce ideas about ways to improve health and safety, implementing suggestions from the workforce, demonstrating a duty of care and providing assistance if workers ask for help. Transactional leadership behaviours (Bass, 1998) such as those have already been found to be effective for supervisors in reducing injury rates at work (Kivimaki et al., 1995). Managers should note that *not* investing in training will have a negative effect and may actually encourage risk-taking as workers will not feel that senior managers are committed or interested in the welfare of their employees.

For research purposes, the tested model provides a framework which can be used to guide more focused research on the processes of management commitment and supervisor involvement on safety. The model establishes 'risk-taking behaviours' as a viable outcome in safety research. One limitation of the current study is that the outcome measure is self-report. Self-report measures are not in themselves unreliable but there is a potential to underestimate engagement in undesirable behaviours such as risk-taking. Future research can build on the findings here by establishing independent measures of risk taking and incorporating them in the model. One way of achieving this would be to observe the actual numbers of risks taken in a set period of time and establish whether workers who perceived senior managers to be committed and supervisors to be involved in safety actually took fewer risks than workers who did not think that managers were committed and supervisors involved. Despite this caveat, there are strong real world applications of the research presented here for managers and supervisors who want to improve the state of safety in their organisations.

References

Andriessen, J.H.T.H. (1978) 'Safe behaviour and safety motivation', *Journal of Occupational Accidents*, Vol. 1, pp.363–376.

Bass, B.M. (1998) *Transformational Leadership: Industrial, Military, and Educational Impact*, Mahwah, NJ: Lawrence Erlbaum Associates.

Bentler, P.M. and Wu, E.J.C. (1995) *EQS for Windows User's Guide*, Encino, CA: Multivariate Software, Inc.

Brown, K.A., Willis, P.G. and Prussia, G.E. (2000) 'Predicting safe employee behaviour in the steel industry: development and test of a socio-technical model', *Journal of Operations Management*, Vol. 18, No. 4, pp.445–465.

Brown, R.L. and Holmes, H. (1986) 'The use of a factor analytic procedure for assessing the validity of an employee safety climate model', *Accident Analysis and Prevention*, Vol. 18, No. 6, pp.445–470.

Byrne, B.M. (1994) *Structural Equation Modelling with EQS and EQS/Windows: Basic Concepts, Applications and Programming*, Thousand Oaks, CA: Sage.

Cheyne, A., Cox, S., Oliver, A. and Tomas, J.M. (1998) 'Modelling safety climate in the prediction of levels of safety activity', *Work and Stress*, Vol. 12, No. 3, pp.255–271.

Cheyne, A., Tomas, J.M., Cox, S. and Oliver, A. (1999) 'Modelling employee attitudes to safety: a comparison across sectors', *European Psychologist*, Vol. 4, No. 1, pp.1–10.

Clarke, S. (1999) 'Perceptions of organisational safety: implications for the development of safety culture', *Journal of Organisational Behaviour*, Vol. 20, No. 2, pp.185–198.

Cox, S. and Cox, T. (1991) 'The structure of employee attitudes to safety: a European example', *Work and Stress*, Vol. 5, No. 1, pp.93–106.

Cox, S. and Flin, R. (1998) 'Safety culture: philosopher's stone or man of straw?', *Work and Stress*, Vol. 12, No. 3, pp.202–216.

Coyle, I., Sleeman, S. and Adams, D. (1995) 'Safety climate', *Journal of Safety Research*, Vol. 22, No. 4, pp.247–254.

Dedobbeleer, N. and Beland, F. (1991) 'A safety climate measure for construction sites', *Journal of Safety Research*, Vol. 22, No. 2, pp.97–103.

Dedobbeleer, N. and Beland, F. (1998) 'Is risk perception one of the dimensions of safety climate?' in A. Freyer and A. Williamson (Eds), *Occupational Injury: Risk Prevention and Intervention*, London: Taylor & Francis, pp.73–81.

DePasquale, J.P. and Geller, E.S. (1999) 'Critical success factors for behaviour-based safety: a study of twenty industry-wide applications', *Journal of Safety Research*, Vol. 30, No. 4, pp.237–249.

Diaz, R. and Cabrera, D. (1997) 'Safety climate and attitude as evaluation measures of organisational safety', *Accident Analysis and Prevention*, Vol. 29, No. 5, pp.643–650.

Donald, I. and Canter, D. (1994) 'Employee attitudes and safety in the chemical industry', *Journal of Loss Prevention in the Process Industries*, Vol. 7, No. 3, pp.203–208.

Fleming, M.T., Flin, R.H., Mearns, K. and Gordon, R.P.E. (1996) *The Offshore Supervisor's Role in Safety Management: Law Enforcer or Risk Manager*. Paper presented at the 3rd International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, New Orleans (SPE paper 35906).

Flin, R., Mearns, K., Fleming, M. and Gordon, R. (1996) *Risk Perception and Safety in the Offshore Oil and Gas Industry. (OTH 94454)*, Suffolk, HSE Books.

Flin, R., Mearns, K., O'Connor, P. and Bryden, R. (2000) 'Measuring safety climate: identifying the common features', *Safety Science*, Vol. 34, No. 1, pp.177–192.

Griffin, M.A. and Neal, A. (2000) 'Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge and motivation', *Journal of Occupational Health Psychology*, Vol. 5, No. 3, pp.347–358.

Guldenmund, F.W. (2000) 'The nature of safety culture: a review of theory and research', *Safety Science*, Vol. 34, No. 1, pp.215–257.

Hackman, J.R. and Oldham, G.R. (1980) *Work Redesign*, London: Addison Wesley.

Health and Safety Executive. (1997) The Health and Safety Climate Survey Tool: HSE.

Health and Safety Executive. (2002) *Evaluating the Effectiveness of the Health and Safety Executive's Health and Safety Climate Tool* (No. 042). Norwich: Health and Safety Executive.

Hofmann, D.A. and Stetzer, A. (1996) 'A cross-level investigation of factors influencing unsafe behaviours and accidents', *Personnel Psychology*, Vol. 49, No. 2, pp.307–339.

Kivimaki, K., Kalimo, R. and Salminen, S. (1995) 'Perceived nuclear risk, organisational commitment, and appraisals of management: a study of nuclear power plant personnel', *Risk Analysis*, Vol. 15, No. 3, pp.391–396.

Kozlowski, S.W.J. and Doherty, M.L. (1989) 'Integration of climate and leadership: examination of a neglected issue', *Journal of Applied Psychology*, Vol. 74, No. 4, pp.443–449.

Lee, T. (1998) 'Assessment of safety culture at a nuclear reprocessing plant', *Work and Stress*, Vol. 12, No. 3, pp.217–237.

Marek, J., Tangenes, B. and Hellesoy, O.H. (1985) 'Experience of risk and safety', in O.H. Hellesoy (Ed.), *Work Environment Statfjord. Work Environment, Health and Safety on a North Sea Platform*, Oslo: Universitetsforlaget.

Mearns, K., Flin, R., Fleming, M. and Gordon, R. (1997) *Human and organisational factors in offshore safety (OTH 543)*, Suffolk, Offshore Safety Division, HSE Books.

Mearns, K., Flin, R., Gordon, R. and Fleming, M. (1998) 'Measuring safety climate on offshore installations', *Work and Stress*, Vol. 12, No. 3, pp.238–254.

Mearns, K., Whitaker, S.M. and Flin, R. (2001) 'Benchmarking safety climate in hazardous environments: a longitudinal, interorganisational approach', *Risk Analysis*, Vol. 21, No. 4, pp.771–786.

Niskanen, T. (1994) 'Safety climate in the road administration', *Safety Science*, Vol. 17, No. 4, pp.237–255.

O'Dea, A. (2002) *Site Managers and Safety Leadership in the Offshore Oil and Gas Industry*, University of Aberdeen.

Rundmo, T. (1994) 'Associations between safety and contingency measures and occupational accidents on offshore petroleum platforms', *Scandinavian Journal of Work and Environmental Health*, Vol. 20, pp.128–131.

Rundmo, T. and Hale, A.R. (In press) 'Managers' attitudes towards safety and accident prevention', *Safety Science*.

Rundmo, T. and Sjöberg, L. (1998) 'Risk perception by offshore oil personnel during bad weather conditions', *Risk Analysis*, Vol. 18, No. 1, pp.111–118.

Safety culture. (No. No. 75-INSAG-4)(1991), Vienna: International Atomic Energy Agency.

Simard, M. and Marchand, A. (1994) 'The behaviour of first-line supervisors in accident prevention and effectiveness in occupational safety', *Safety Science*, Vol. 17, No. 3, pp.169–185.

Simard, M. and Marchand, A. (1995) 'A multilevel analysis of organisational factors related to the taking of safety initiatives by work groups', *Safety Science*, Vol. 21, No. 2, pp.113–129.

Smith, M., Cohen, H., Cohen, A. and Cleveland, R. (1978) 'Characteristics of successful safety programs', *Journal of Safety Research*, Vol. 10, No. 1, pp.5–15.

Thompson, R.C., Hilton, T.F. and Witt, L.A. (1998) 'Where the safety rubber meets the shop floor: a confirmatory model of management influence on workplace safety', *Journal of Safety Research*, Vol. 29, No. 1, pp.15–24.

Tomas, J.M., Melia, J.L. and Oliver, A.M. (1999) 'A cross validation of a structural equation model of accidents: organisational and psychological variables as predictors of work safety', *Work and Stress*, Vol. 13, No. 1, pp.49–58.

Williamson, A., Feyer, A., Cairns, D. and Biancotti, D. (1997) 'The development of a measure of safety climate: the role of safety perceptions and attitudes', *Safety Science*, Vol. 25, No. 1, pp.15–27.

Witt, L.A., Hellman, C. and Hilton, T.F. (1994). *Management Influences on Perceived Safety*, Paper presented at the American Psychological Society Annual Meeting, San Francisco, CA.

Yukl, G. (1998) *Leadership in Organizations*, (4th ed.), NJ, Prentice Hall Inc.

Yule, S. (2003) *Senior Management Influence on Safety in the UK and US Energy Sectors*, University of Aberdeen.

Yule, S.J., O'Connor, P. and Flin, R. (Under review) 'Testing the structure of a generic safety climate survey instrument: Implications for applied research and practice'.

Zohar, D. (1980) 'Safety climate in industrial organisations: theoretical and applied implications', *Journal of Applied Psychology*, Vol. 65, No. 1, pp.96–102.

Zohar, D. (2000) 'A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs', *Journal of Applied Psychology*, Vol. 85, No. 4, pp.587–596.

Zohar, D. (2002) 'Modifying supervisory practices to improve sub-unit safety: a leadership-based intervention model', *Journal of Applied Psychology*, Vol. 87, No. 1, pp.156–163.

Notes

[1] This manuscript is based on a paper previously presented at the annual SIOP Conference, San Diego, 2001.

[2] In the PTW system, an authorised person issues a printed 'permit' to workers once risk assessments for the job have been completed. Work can only commence once the permit has been issued.