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Chapter 3. Human Factors in Safety Management:

Safety Culture, Safety Leadership and Non-Technical Skills

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Abstract

Human factors science can be applied to many different facets of safety management. There are ergonomics issues of equipment design, usability and the layout of working environments; processes related to safety management systems (SMS); organisational issues (e.g. cultural aspects) and psychological factors pertaining to elements of human performance for individuals and work teams. In this chapter, we focus on three of these topics which are inter-related, namely safety culture, safety leadership and behaviours relating to non-technical skills. We present the fundamental aspects of each concept and then discuss applications, with specific reference to a) the oil and gas industry and b) healthcare.

KEY TERMS

Crew Resource Management (CRM) – *training which was developed in aviation, designed to encourage aircrews to use all available resources – equipment, people, and information – in order to enhance flight safety.*

Non-Technical Skills (NTS) - *the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance.*

Safety culture - *the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management.*

Safety leadership – *the behaviours of managers and supervisors that maintain, improve and promote the state of workplace safety.*

INTRODUCTION

Human factors/ ergonomics (HFE) aspects of safety management are wide-ranging and it is now recognised that these are essential for effective risk control, as well as performance efficiencies and worker well-being. Traditionally, safety management was mainly concerned with engineering barriers (e.g. blast walls, guard rails), personal protection (e.g. hard hats) and devising rules and regulations to govern workers' and managers' actions. As accident investigations became more sophisticated, it was clear that these techniques alone did not provide sufficient protection and that human and organizational factors had to be considered and managed (Reason, 1997; CSB, 2016). The scope of human factors science applied to safety encompasses ergonomic issues of equipment design, usability and the layout of working environments, processes related to safety management systems (SMS), organisational issues (such as cultural aspects) and psychological and physiological effects on human performance for individuals and work teams. As the subject is extensive, in this chapter, we have focused on just three of these safety topic areas which would be of particular interest to the Gulf region: i) safety culture, ii) managers' safety leadership and iii) worker behaviours relating to non-technical skills (see Figure 1 which indicates how these are related). We discuss these in the context of our research in two sectors: healthcare, and the oil and gas industry.

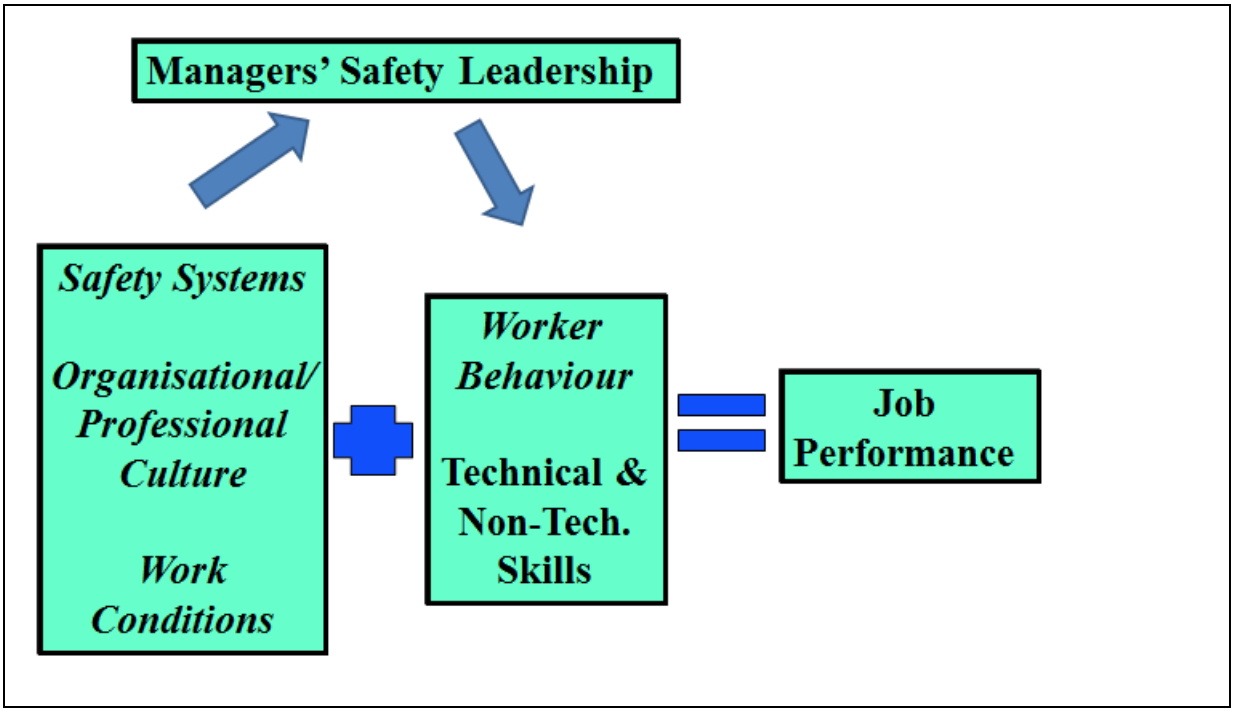


Figure 1. Three components of safe job performance discussed in this chapter.

FUNDAMENTALS

Safety Culture

Analysis of major industrial accidents in the 1980s began to shift regulatory and research focus from failures of equipment and of individual workers to an examination of the underlying culture of the organisation. This began with the Chernobyl nuclear power plant disaster in 1986 where the investigators concluded that aspects of the organisational culture had contributed to the accident (IAEA, 1986). Nowadays culture frequently features as a causal factor. For example, the review of the crash of an RAF Nimrod aircraft in 2006 with 14 deaths, is subtitled: *'A failure in leadership, culture and priorities.'* (Haddon-Cave, 2009). Similarly, a recent report from the American National Academy of Sciences (NAS, 2016) emphasised the importance of managing the organisational culture on offshore oil and gas installations in order to enhance safety.

The term safety culture is often used interchangeably with safety climate, but in the academic literature these are typically regarded as two distinct concepts (Cox & Flin, 1998). Safety culture is defined not only as encompassing safety-related attitudes, behaviours and perceptions but also covering deeply rooted values and assumptions that individuals hold about the organisation (Pettita, Probst, Barbaranelli, & Ghezzi, 2017). On the other hand, safety climate is proposed to be a surface manifestation (Schein, 1990), a 'snapshot' of the existing culture (Mearns, Flin, Gordon & Fleming 1998). The distinction between the concepts can be crucial: Recent research suggests that certain dimensions of safety culture (autocratic and bureaucratic) can undermine the effects of safety climate on safety outcomes (Petitta et al, 2017). Given the limited space in this chapter, we use the term safety culture to cover both concepts.

There are different approaches to studying organisational culture and safety outcomes. The most common is to talk of an over-arching safety culture which essentially reflects managerial and worker attitudes related to the control of risk and the prioritisation of safety. *'The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management.'* (ACSNI, 1993, p.23). The main dimensions of organisational safety culture typically include: management commitment to safety, work practices, relative prioritisation of safety, adherence to safety rules, risk management, reporting of errors and incidents.

A second approach emphasises subcomponents that are types of culture. For instance, Reason (1997, p195) suggested that a safety culture had elements which were: an 'informed' culture – knowing about all the factors that influence the safety of the system; a 'reporting' culture - that encourages

telling about incidents; a 'just' culture - where employees believe they are treated fairly and will not be inappropriately blamed for errors; a 'flexible' culture that favours a flatter structure; a 'learning' culture that is willing to draw appropriate conclusions and act on them. Dekker (2016) provides a detailed account of why a just culture, which he describes as a culture of trust, learning and accountability is particularly important for safety management. Thirdly, safety culture maturity models (based on Westrum, 1995) have been devised, which characterise a staged evolution from a pathological culture which does not pay attention to safety, through to a very safety-conscious 'generative' culture (Fleming 2000; Goncalves et al, 2010; Parker et al, 2006).

Whichever framework is adopted, the safety culture is of interest because it essentially influences what become the normal workplace behaviours in relation to safety, such as taking risks, following rules, speaking up about safety concerns, reporting accidents and errors. Essentially, organisations need to maintain a culture which makes it 'easy to do the right thing, and hard to do the wrong thing' for safety. The safety culture is normally measured by questionnaires which assesses workforce perceptions of the dimensions (e.g. supervisor support for safety) and their associated behaviours (e.g. willingness to report incidents).

Across industries, safety culture has been shown to be a robust predictor of both workers' safety behaviours and objective safety outcomes, such as injury and accident rates. Worksites with more positive cultures show lower accident rates, workers who perceive their supervisor/manager to be more committed to safety engage in more safety-related behaviour and fewer risk-taking behaviours (Clarke, 2010; Probst & Estrada, 2010; Zohar, 2014). In a meta-analyses based on different industrial settings, safety climate was shown to influence employees' safety behaviours through its effects on safety knowledge and motivation (Christian, et al., 2009). The motivational mechanism linking culture to behaviour is likely to be a function of expectations, that is, whether workers expect to be rewarded or reprimanded for particular actions related to safety and production (Zohar, 2014). Again this indicated the important role of managers and supervisors in creating expectations that will affect workers' behaviour choices. Later, the roles of safety climate acting as a source for employees' safety motivation and knowledge, as well as a predictor of employees' safety behaviours, were validated across cultures in both English and non-English speaking countries (Barbarabelli, Pettita, & Probst, 2015).

Following the Piper Alpha accident in 1988, studies of safety culture were conducted on offshore installations in the North Sea (Mearns et al, 1998; 2001; Rundmo, 1992). These portrayed the key cultural features showing that management and supervisor commitment to safety were particularly important for building safer norms of behaviour. A study comparing offshore installations across the

Norwegian and UK sectors showed that there were more differences among companies than between the two nationalities (Mearns et al, 2004).

In healthcare, interest in measuring safety culture emerged after the high rates of adverse events suffered by patients were revealed (Vincent, 2010) therefore the focus has usually been on features of the safety culture in hospitals that protects patients from errors and harm. Fan et al (2016) found an association between safety culture scores and surgical site infections. A study of intensive care units revealed an association between poorer safety culture scores and increased length of stay for patients, as well as a link between less favourable perceptions of management and higher mortality rates (Huang et al. 2010).

The relationships between safety culture and healthcare workers' wellbeing have also been assessed. In a study with nurses, negative associations were found between unit level safety culture scores and workers' back injuries, as well as with patient urinary tract infections and medication errors (Hofmann & Mark 2006). Similarly, Gimeno et al. (2005) found that safety culture was related to self- reported work-related injuries. Blood and body fluid exposure incidents for workers were lower when senior management support, safety feedback and training were perceived favourably (Gershon et al. 2000). Zohar et al. (2007) showed both group and hospital level culture as predictors of future safety behaviours.

As mentioned above, one of the most influential safety culture dimensions is leadership quality (Nahrgang, Morgeson & Hoffman, 2011), with managerial commitment to safety emerging as the most robust predictor of future incidents (Beus, et al., 2010). We consider managers' and supervisors' Safety Leadership in the next section.

Safety Leadership

For effective safety management, leadership is important at every level of management, from team leaders, to site managers, to top-level managers. Most research on managerial leadership concerns productivity (Yukl, 2013), but there is now an increasing interest in the relationship of leadership styles to safety outcomes (e.g. Agnew et al, 2014a; Hofmann & Morgeson, 2004). Particular styles of leadership are associated with better safety behaviours by workers (e.g. compliance to rules) and more favourable organisational safety performance, such as decreased accident rates.

The model most often applied to the study of managers' safety leadership is the transactional/ transformational model (Bass 1998). The transactional component involves the leader offering incentives and/ or punishments that are contingent on the subordinate's performance meeting agreed standards. Bass argued that this transactional relationship, at best, produces expected performance

levels, because it only appeals to individual goals and aspirations. While all leaders use the transactional component, he showed that leaders of the highest performing teams also display transformational behaviours. Transformational leaders are charismatic, inspiring, stimulating, and considerate. They provide followers with a sense of purpose; portray an image of success, self-confidence and self-belief; articulate shared goals and question traditional assumptions, while taking into account the needs of subordinates. Clarke (2013) conducted a meta-analysis on transactional/ transformational leadership and safety outcomes. The findings demonstrated the crucial role of both leadership styles to predict the safety behaviours of the workers. For example, active transactional leadership such as anticipating problems and taking proactive actions were strongly associated with workers' compliance with the organisation's safety rules and regulations. On the other hand, transformational style was a better predictor of safety participation behaviours of the workers. The related theory of authentic leadership (Avolio & Gardner, 2005) has also been applied in safety research (e.g. Nielsen et al, 2013) indicating that this style can also be effective.

Although leadership practices as a predictor of safety outcomes are well documented, Yukl (2013) pointed out that the level of management has to be taken into account. Top managers may have more of an influence on rule-related behaviours whereas supervisors may be better at encouraging voluntary activities that are related to safety (Clarke & Ward, 2006). Zohar and Luria (2005) identified supervisors as better than senior managers at influencing workers' safety behaviours.

Supervisory safety practices have been found to decrease the number of minor accidents and positively influence workers' safety climate perceptions. Transformational leadership behaviours of supervisors were related to fewer occupational injuries (Zohar, 2002). The literature on supervisors and safety emphasises the importance of good communication, the need to build trust and to care about the team members, as well as setting and reinforcing safety standards, especially when there are strong production or cost reduction goals (Hofmann & Morgenson, 2004). Therefore, relying solely on the written safety rules might not ensure an increase in voluntary safety activities of the workers. Rather, supporting and providing training for supervisors on specific leader behaviours to improve their leadership styles might yield more desirable safety-related outcomes.

Safety leadership behaviours of supervisors (Fleming, 1996) and managers (O'Dea & Flin, 1991) on offshore installations have been investigated showing the importance of both transactional and transformational behaviours. More recently, Nielsen et al (2016) in a time-lagged study of Norwegian offshore workers found that constructive leadership emerged as the only significant predictor of subsequent psychological safety climate.

An investigation into patient safety in a healthcare organisation in England (Healthcare Commission, 2009) revealed that failure of the senior management's leadership was one of the factors contributing to high mortality rates. In a study of surgery in the USA, the team leader's behaviours were shown to influence team members' willingness to speak up (Edmondson, 2003).

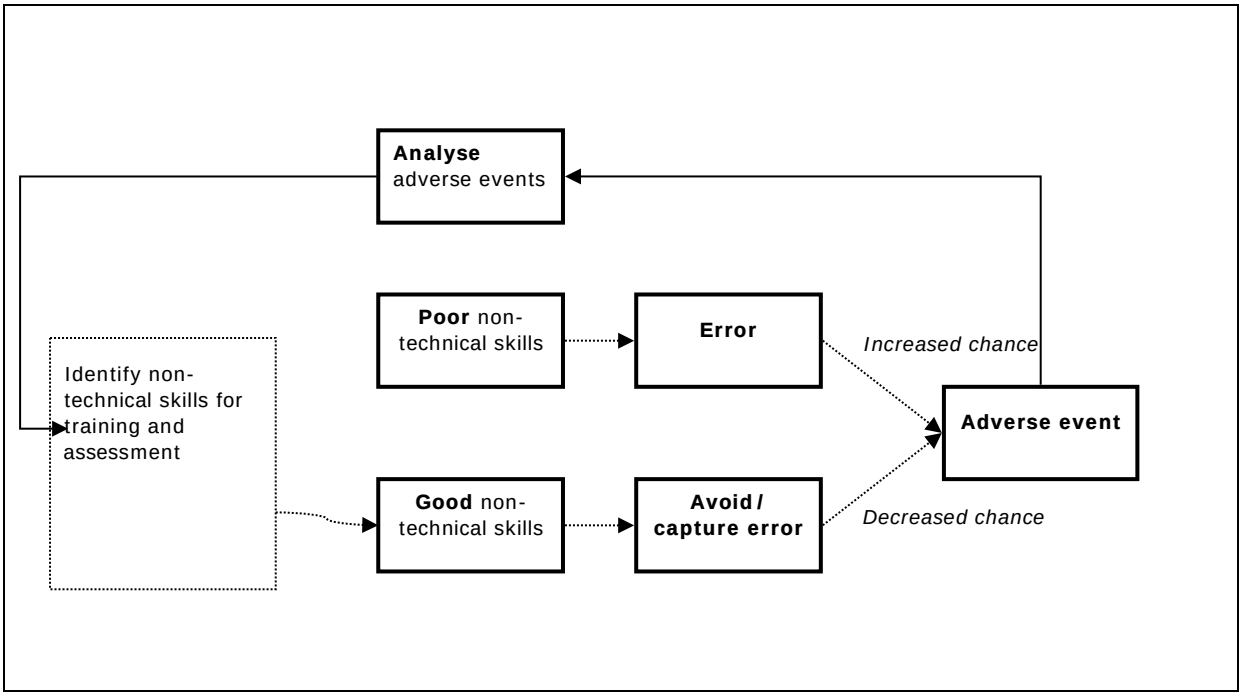
While both safety culture and safety leadership can create supportive conditions for safe working practices, it is also necessary to consider the skills of the workforce and how these can relate to job performance, errors and accidents (as shown in Figure 1).

Non-technical skills

The term 'non-technical skills' (NTS) was first used by the European civil aviation regulator in relation to airline pilots' behaviour on the flight deck. NTS can be defined as *"the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance"* (Flin et al, 2008, p. 1). It is not only in aviation where these skills contribute to workplace safety, studies of accidents in other industries reveal similar patterns. Today Crew Resource Management (CRM i.e. non-technical) skills training is used as part of safety management and skills development in the maritime industry, rail, nuclear power production, mining, and the emergency services.

In essence, the non-technical skills enhance workers' technical skills. As Figure 2 shows, poor NTS can increase the chance of error, which in turn can increase the chance of an adverse event. Good NTS (e.g., high vigilance, clear communication and team coordination) can reduce the likelihood of error and consequently of accidents.

Figure 2: Relationship between non-technical skills and adverse events
(Flin et al, 2008, Fig 1.2, Ashgate. Reprinted with permission of Taylor and Francis).



The aviation industry had realised by 1980, from a series of accidents with no primary technical failure, that maintaining high standards of safety was going to require attention to the pilots' behaviours that could diminish or enhance flight safety (Kanki et al, 2010). From interviews, experiments and accident analysis the behaviours that contributed to accidents or were effective in preventing them were extracted. A key source of information was the cockpit voice recorder which enabled analysis of the pilots' conversations prior to an accident. The identified behaviours were classified into categories of non-technical skills and a special training course for pilots was devised called Crew Resource Management (CRM). This was designed to increase the pilots' understanding of the importance of particular behaviours for safety and to provide opportunities to practise the non-technical skills in exercises and simulated flights (CAA 2016). The non-technical skills are assessed alongside technical skills as part of licensing requirements for pilots (Flin, 2019).

The main categories of non-technical skills are similar, although not identical, for operational jobs in higher risk work settings. Each category can be subdivided into constituent elements and for each element, examples of good and poor behaviours (behavioural markers) can be specified. A typical set of non-technical skills (described in Flin et al, 2008) is shown below in Table 1.

Table 1 Examples of categories and elements in a generic non-technical skills framework

Categories	Definitions	Typical Elements
Situation awareness	Developing a dynamic awareness of the situation during a task, based on assembling data from the environment, understanding what it means and anticipating future developments.	• Gathering information • Comprehending (forming a mental picture) • Anticipating (thinking ahead)
Decision making	Determining possible courses of action (options) to deal with the assessed situation; reaching a judgement in order to choose an appropriate course of action; implementing the chosen option and reviewing its effect.	• Generating one or more options • Evaluating options • Selecting and implementing option • Reviewing
Teamwork	Skills for working in a team context to ensure that the team has an acceptable shared picture of the situation and can complete tasks effectively.	• Co-ordinating actions • Resolving conflicts • Sharing information • Helping others
Leadership[1]	Leading the team and providing direction, demonstrating high standards of practice and care, and being considerate about the needs of individual team members.	• Setting and maintaining standards • Monitoring progress • Supporting others • Allocating tasks
Managing Personal Resources (e.g. stress and fatigue)	Skills for diagnosing one's state of mental and physical fitness for the task; taking action to maintain the necessary level of fitness or to find an alternative solution.	• Identifying causes of stress and fatigue • Recognising effects • Implementing coping strategies

Many higher-risk work domains (e.g. ships, mines, hospitals, railways) have adopted a non-technical skills approach and introduced Crew Resource Management training. In healthcare, studies are beginning to show that the non-technical skills of clinical staff are related to patient outcomes (Hull et al 2012). Analysis of the Deepwater Horizon drilling rig accident have indicated specific failures in non-technical skills (Reader & O'Connor, 2014; Roberts et al, 2015). A new report on the accident from the Chemical Safety Board in the USA (CSB, 2016) - recognises that there is a *'need for development and*

[1] Leadership within the discussion of non-technical skills refers to the behaviours of the leader who is co-located with his or her team during task execution. Safety Leadership in the previous section refers to the leadership style of managers and supervisors who are not directly engaged in the workers' task execution.

use of non-technical skills, including communication, teamwork, and decision making by the operator, drilling contractor and other well services providers.'(p24).

It should be noted that safety culture and safety leadership are important for the maintenance of non-technical skills at the worksite (see McCulloch et al, 2009).

METHODS

Many sources of information are available on human factors methods for safety management, for example books on the design of safe work environments (McLeod, 2015); accident analysis methods (Weigmann & Shappell, 2003; Gordon et al 2003); human error (Reason, 1997); data gathering techniques (Crandall et al, 2006: Stanton et al, 2013); risk management (Glendon & Clarke, 2015). Specialist journals publish reports of studies using human factors techniques to study safety issues (e.g. *Human Factors; Ergonomics; Safety Science; Journal of Safety Research; Accident Analysis and Prevention, Journal of Loss Prevention in the Process Industries; BMJ Quality and Safety).* Many organisations concerned with safety management have websites with human factors advice e.g.:

Civil Aviation Authority (CAA, UK) https://www.caa.co.uk/Safety-initiatives-and-resources/Working-with-industry/Human-factors/Human-factors/

Clinical Human Factors Group www.chfg.org

Energy Institute (UK) https://www.energyinst.org/technical/human-and-organisational-factors

Eurocontrol (Air Traffic Management) https://www.eurocontrol.int/tags/human-factors

Health and Safety Executive (HSE, UK) http://www.hse.gov.uk/humanfactors/index.htm

Methods of measuring safety culture

Assessing the state of the safety culture requires a baseline assessment of the current level of relevant cultural factors in the workplace, so that interventions can be targeted and any subsequent improvements can be assessed (Antonsen, 2009). The measurement is normally achieved with a questionnaire survey asking workers and managers about their attitudes to safety and perceptions of how safety is prioritised and managed in their work unit or across the organization. It may also ask respondents to report on their behaviours (e.g. reporting incidents) and to say how many injuries or accidents they have suffered or witnessed. There are many safety culture questionnaires available, generic instruments such as the HSE safety climate tool (website given above) or bespoke questionnaires designed for a specific sector e.g. healthcare (Jackson, Sarac [Agnew] & Flin 2010;

Waterson, 2015). To determine if safety culture has effect on safety behaviours and accidents, different types of outcome data can be collected, e.g. (i) near miss and accident incident records (ii) self-reports of incidents and injuries (iii) workers' safety behaviours (self-reported or observed).

The nuclear power industry has advocated the measurement and management of safety culture for 30 years following the Chernobyl accident, and it provides guidance on performing safety culture assessments (IAEA, 2016). The focus of this report is on using such assessments as a learning opportunity for organizational growth and development rather than as a fault-finding or 'find and fix' exercise. The guidance advises having engagement with all levels of the organization and using techniques such as document reviews, questionnaires, interviews, observations and focus groups. It emphasises the need to use multiple measurements and qualitative, as well as quantitative methods, of gathering data. Similarly, the level of safety culture maturity can be assessed by questionnaires or card sorting and discussion tasks (see the Energy Institute, Hearts and Minds toolkit). Nowadays many oil and gas companies conduct regular safety culture surveys as part of their safety management system (e.g. Tharaldsen et al, 2008).

Methods of measuring safety leadership

Safety leadership is also usually measured by questionnaires, either completed by the leader and/or by those directly reporting to that leader. For example, *Perceptions of supervisory behaviours for safety* by Zohar and Luria (2005) was designed to identify how supervisors prioritise safety over productivity using self-report items in a questionnaire. There are standard leadership questionnaires which can be purchased from psychometric test suppliers, such as the Multifactor Leadership Questionnaire (MLQ) designed to assess transactional and transformational leadership (available from www.mindgarden.com). One method of assessing managers' commitment to safety and safety behaviours, originally developed for the multinational company Shell, involves the leader completing a self-rating questionnaire and asking several of his or her team to complete an 'upward' rating (Bryden et al, 2006), which means that the staff rate their direct boss. These scores are fed back to each manager as a personal report and aggregated scores are presented for group discussion. (This is now part of the Energy Institute Hearts and Minds Toolkit).

Methods of identifying and measuring non-technical skills

While the main skill categories are similar across professions, the component elements and examples of good and poor behaviours need to be specified for a given profession and task set. Analysis of

incidents, interviews with experienced workers, as well as observation of behaviour during routine and non-routine work can reveal which workplace behaviours positively or negatively influence job performance and adverse events. These are all forms of task analysis (see Stanton et al, 2013) and where cognitive skills play a major part, e.g. control room operators, then cognitive task analysis can be used (Crandall et al, 2006). Having identified the skills and related behaviours, these need to be refined and organised into a concise, hierarchical structure or taxonomy. This is usually achieved using panels of subject matter experts. This skill set then forms the basis of NTS (CRM) training and related assessment methods (e.g. behaviour rating systems).

Pilots are regularly assessed on their non-technical skills, using behaviour rating systems such as NOTECHS (CAA, 2016; Flin et al, 2003, Flin, 2019). In healthcare, the Anaesthetists' Non-Technical Skills (ANTS) system was developed from data on anaesthetists' behaviour gathered from a literature review, observations, interviews, surveys and incident analysis (Flin et al, 2010). There are also similar rating tools for surgeons (NOTSS) and for scrub nurses (SPLINTS) and anaesthetic assistants (ANTS-AP) - see Flin et al (2015). For papers and copies of these rating tools, see www.abdn.ac.uk/iprcs.

APPLICATIONS

Safety culture

The main application of the safety culture concept has been in the use of diagnostic tools (described above) to measure the level of culture and identify strengths and weaknesses. For example, Agnew et al (2013) conducted a study of 1,866 healthcare staff to provide a baseline assessment of safety culture in Scottish hospitals. Their findings illustrated the links between safety perceptions and safety outcomes both for worker and patient injuries and focus groups with frontline staff were conducted to get a deeper understanding of the significant factors. More importantly, both the qualitative and the quantitative data were used as a tool to generate discussions with the management through an interactive workshop designed as a feedback mechanism (Agnew & Flin, 2014b). The main aim of the workshop was to discuss the project findings, present the available tools to assess safety culture and formulate recommendations for improving safety culture. This was based on an approach devised in air traffic management (Kirwan, 2008; Mearns et al, 2013).

Safety culture measurement can also be carried out across companies using a bench marking approach (Mearns et al 2001) so that organisations can learn from each other. Hudson (2007) discusses techniques that were used in a major operating company to enhance safety culture. The nuclear power industry (IAEA, 2016) recommends safety culture assessments as a learning opportunity for organizational development rather than as a fault-finding or 'find and fix' exercise.

Safety leadership training and non-technical skills training are both designed to shift the norms of behaviour, and thus drive the workplace culture in a safer direction.

Safety leadership

The main applications of safety leadership research are diagnostic tools to determine leadership style and training programmes for leaders. Part of the Hearts and Minds behavioural safety toolkit (mentioned above) is a training guide '*Improving Supervision'* designed to provide a step by step guide to identify the areas of concerns with the supervisors' leadership styles and the ways to improve people's safety behaviours and performance (https://heartsandminds.energyinst.org/). Similarly, IOGP (2013) produced guidance for shaping the safety culture through effective safety leadership. Recently, there have been improved efforts to train leaders to manage safety in healthcare organisations. The World Health Organisation developed the *Leadership Competencies Framework on Patient Safety and Quality of Care* identifying the key leader competencies to ensure safe and quality patient care (www.who.int). In the USA, the Institute for Healthcare Improvement offers a programme called *High Impact Leadership* in order to help leaders to build safer healthcare organisations (Swensen, McMullen & Kabcenell, 2013).

Non-technical skills

Crew Resource Management training programmes to enhance non-technical skills are very well established in the aviation industry (CAA, 2016). Other sectors are beginning to adopt this method. It was recommended for offshore oil and gas production operations following the Piper Alpha accident (Flin, 1995) but was not endorsed until the Deepwater Horizon rig blowout 22 years later. Now, courses on Well Operations CRM (WOCRM) have been developed for rig crews (IOGP, 2014). Other sectors of the energy industry, such as refineries and pipelines, have been advised to adopt a CRM approach (Energy Institute, 2014).

In healthcare, CRM is a recent innovation. Ab-initio courses in the medical and nursing schools are teaching students the importance of non-technical skills for patient safety. In some universities there are now psychologists employed to lecture on human factors and patient safety to healthcare students and these topics are being embedded throughout the curriculum. There are also courses on non-technical skills for qualified medical staff, such as surgeons (see Flin et al 2015).

For recent guidance on the training and assessment of non-technical skills, see Thomas, 2017.

Future Trends

Product Safety Culture

New applications of safety culture have been emerging, relating to the safety of consumers rather than of workers. The concept of product safety culture has appeared in the manufacturing sector following a series of product failures that injured consumers, e.g. faults in cars, children's toys, medical implants. Companies are now recognising that organisational culture may influence their design, manufacturing or service practices in ways that can ultimately affect the well-being of the product users. The empirical literature on this topic is, as yet limited, although there are studies of product safety culture in manufacturing (e.g. Zhu et al, 2016) and in the food industries, where the concept of food safety culture is now being discussed (e.g. Jesperson et al, 2016). At this stage it is unclear whether the components of the organisational safety culture that are protective for workers are the same as those that ensure the safety of consumers and product users (Suhanyiova et al, 2017).

Managers' Safety Leadership

Expressing some concerns about the limitations of a safety culture approach, Kirwan (2008), a senior psychologist at Eurocontrol, proposed that more attention needed to be paid to the knowledge and skills of senior managers in relation to organisational safety. He coined the term 'safety intelligence' and subsequently sponsored research to explore the concept (Fruhen et al, 2014a). A resulting White Paper (Eurocontrol, 2013) explains how senior managers can become more intelligent safety leaders.

A related approach has been to examine 'chronic unease' in senior managers. This concept first appeared in the high reliability literature and refers to managers retaining sufficient level of concern about the safety of their work sites and not being complacent about ever-present risks. Fruhen et al (2014b, 2016) identified five key attributes of chronic unease: Pessimism, propensity to worry, vigilance, requisite imagination and flexible thinking. Interviews with senior managers from oil and gas companies found that chronic unease was described as having positive effects on safety.

Non-Technical Skills and the Safety Management System

The aviation industry continues to review its CRM (NTS) training and evaluation and recent guidance from the European Aviation Safety Agency (EASA, 2015) emphasises that the CRM methods should be evidence-based and embedded within the organisation's safety management system, for example by using safety data to inform CRM training requirements. A new component that should be included in pilots' CRM training is the effects of a startle response which can occur after a sudden 'threat' in the environment and cause a loss of concentration. This was recommended following the findings of the investigation report into the Air France (AF447) fatal accident in 2009 when the pilots lost control of a large passenger aircraft flying between Rio and Paris (BEA, 2012).

Conclusion

Organisations striving to improve their safety performance need to adopt a wide ranging human factors/ergonomics approach. This chapter focused on psychological research on workplace safety culture and associated safety behaviours, describing human factors measurement tools and training techniques, applied in healthcare and the oil and gas industry. These are being used to measure safety culture and to address two key aspects of behaviour that influence the culture, namely managers' safety leadership and workers' non-technical skills.

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