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Ripples in a Pond: An Open System Model of the Evolution of Safety Culture

F.J. Joel Morley
Don Harris

School of Engineering, Cranfield University, Cranfield, United Kingdom

The development of an effective safety culture is essential to promote safe operations. Previous studies have either identified the characteristics of effective safety culture analytically, inferring them from signs and symbols derived from working practices, or have restricted the study of the development of safety culture to workers within an organisation. This paper describes a large-scale survey-based study in which the factors influencing the evolution of safety culture are identified empirically and, drawing upon open systems theory, are also extended beyond the bounds of the organisation. Three major determinants of safety culture are identified: safety concerns, influences *and* actions. *Sub-components within each of these categories are also identified and the relationship between them is hypothesised.*

safety culture open systems safety management in-depth interviews workplace surveys

1. INTRODUCTION

Few people would argue that company management is not central in promoting safe and efficient operations. It is somewhat of a moot point to determine if appropriate management standards and practices promote a good safety culture, or vice versa; however, it is probably unnecessary to resolve this debate as all would agree that both good management and an effective safety culture are essential and that the two are inextricably interlinked. The central tenet in this paper focuses on the notion that safety culture as a concept cannot be understood if inquiries are confined to the organisation. Rather, it is necessary to look at the entire system in which an organisation operates to understand how effective safety cultures develop.

There is a great deal of commonalty in the desirable organisational characteristics—the manifest symbols and processes—indicative of an effective safety culture [1, 2, 3]. Reason [3] describes a good safety culture as one which demonstrates commitment (the motivation and resources to pursue safety goals), competence (the ability to gather and disseminate safety information), and cognisance (an awareness of the risk factors). Palframan [2] similarly focuses on commitment to safety from senior management; the involvement of all personnel in promoting safety; and learning lessons from accidents and incidents, not apportioning blame. Pidgeon [1] described a healthy safety culture as having well-developed norms and rules to promote safety, an informed and healthy attitude toward risk, and possessing mechanisms to provide feedback concerning safety performance.

These authors by no means represent a comprehensive review of the dimensions of safety culture—they are just typical. For an authoritative review, the excellent paper by Guldenmund [4] contains an appraisal of the dimensions elicited by 15 (or more) authors working in the field. Although on first sight a vast variety of dimensions appear

Joel Morley is now at the Human Performance Division, Transportation Safety Board of Canada, 200 Promenade du Portage, Gatineau, Que., K1A 1K8, Canada.

Correspondence and requests for offprints should be sent to Don Harris, Human Factors Group, School of Engineering, Cranfield University, Cranfield, Bedfordshire MK43 0AL, United Kingdom. E-mail: <d.harris@cranfield.ac.uk>.

to have been elicited in these works, the core concepts described earlier are inherent in every paper reviewed. It is notable that in none of the cases, though, are the implicit determinants of safety culture assumed to be the product of an open system.

Perhaps the most comprehensive (and prescriptive) model is that of the International Nuclear Safety Advisory Group (INSAG) [5] which intertwines safety culture and safety management practices. INSAG provides a specific and comprehensive picture of what constitutes an effective safety culture at three levels: policy level, management level and at the level of the individual. All personnel are expected to exhibit a questioning attitude toward safety; show a rigorous and prudent approach, and communicate concerns in an appropriate and timely manner. The management should provide the motivation to encourage personnel to adopt safe working practices with clear lines of safety authority defined, a rigorous quality assurance process should be in place, and appropriate training should be provided. These processes should be audited on a regular basis. Unlike the previously cited conceptualisations of safety culture, though, the INSAG approach extends beyond the organisation at the highest (policy) level. In the nuclear power industry the policy required for developing an effective safety culture originates at the legislative level. Governments have a duty to protect the public and the environment and must also provide the regulators with the expertise, resources and authority to ensure safe operation. Within the organisation itself, the policy level should manifest itself in the provision of management structures and resources to promote safety, and a commitment to openness in safety matters. The policy level should also go beyond the minimum required by legislation.

It is essential to consider elements outside the organisation when examining safety culture but this is often not done. McDonald and Ryan [6] argue that the development of an effective safety culture is dependent upon the control that the management can exercise over the work process, which is a product of other factors, some of which are external to the organisation (e.g., geography, economics). Similarly, Simard and Marchand [7] found that external macro-level factors external to the organisation (e.g., socio-economic context and market conditions) indirectly predicted workers' compliance with safety rules.

The safety culture of an organisation is one of many cultures to which a worker will simultaneously belong. Authors such as Merritt and Helmreich [8] and Glendon and Stanton [9] propose safety culture is a sub-culture of organisational culture, which is a sub-culture of the industry culture, which in turn is a sub-culture of national culture (cf. Hofstede's conceptualisation of culture in general [10]). Furthermore, organisational culture is a multidimensional construct [10, 11] and safety culture is only one aspect. As a person simultaneously belongs to many cultures, at times the core values of each of these social edifices may be in conflict. Safety culture cannot be separated from these other aspects; hence any model of safety culture needs to extend beyond the boundaries of the organisation if it is to provide a comprehensive framework.

All industries are open systems (i.e., they must interact with their environment). As Schein [12] stated

> The environment places demands and constraints on the organization in many ways. The total functioning of an organization cannot be understood, therefore, without explicit consideration of these environmental demands and constraints (p. 101).

Open Systems Theory is derived from General Systems Theory [13] although Katz and Kahn [14] assert that this is not a theory but a framework within which the workings of a system may be understood. They also argue that organisations are only selectively open, in that they interact with their environment but also need boundaries in order to exist. However, placing a boundary around an organisation (as do many authors; see [4]) limits the development of a comprehensive theory of safety culture, as influences beyond that boundary do not receive sufficient attention. As Lintern [15] notes

> Most approaches to safety management attempt to lock the system down so that it

> does not generate new properties…. However, open systems are infinitely generative. Thus, we cannot construct a rule set that will incorporate all possibilities.

Elements outside an organisation have a profound effect on safety culture. As a result, the boundaries for the conceptualisation of safety culture must be extended beyond the organisation if a comprehensive model of the evolution of safety culture is to be developed. To develop such a framework, a two-stage approach was employed. First, a series of interviews with safety professionals in a range of industries was conducted. The data gained were analysed to develop meta-categories to conceptualise the drivers (and barriers) to develop an effective safety culture. Second, components within these meta-categories were elicited empirically using large samples of safety professionals and members of the general public to derive a tentative, open-system model.

2. MODEL DEVELOPMENT

2.1. Interviews

Six target industries were identified using Perrow's [16] two axes of coupling and complexity. The university sector represented a loosely coupled, complex system; the construction industry was representative of a loosely coupled, linear system; the rail industry was chosen as an example of a tightly coupled, linear system. As most safety critical industries are tightly coupled, complex systems, aircraft operations, offshore mining and the nuclear power industry were all sampled in this particular sector. To ensure a broad representation at all levels, interviewees came from middle management, board level, trade associations and from the regulator.

The interviews followed a semi-structured format, and lasted 1–1 1/2 hrs. The key areas addressed included asking the interviewee about the safety characteristics of their industry (e.g., what are the main hazards faced; what degree of risk is there to employees, customers and the public); the mechanisms for hazard reporting and the use of safety information (e.g., what use is made of formal risk assessments, are there methods in place to identify and report hazards, what organisational structures are in place to deal with safety information, how is information fed back to the workforce, how is performance monitored); employee empowerment (e.g., what power do employees at all levels of the company have to take safety-related decisions)? Emphasis was placed upon questions relating directly to safety culture (e.g., is there a long-term focus on safety in the organisation, how are conflicts between safety and production resolved, is safety included in the mission statement of the company) and barriers (e.g., what are the most significant barriers to effective safety management)?

A total of 16 interviews were undertaken. Interviews were conducted at the interviewee's place of work. The sessions were recorded and transcribed for later content analysis. All data gained during the interviews was confidential and was de-identified for the purposes of confidentiality during the transcription process.

2.2. Analysis

A grounded-theory based analysis of the interview data [17] was undertaken using methods based around the procedures and techniques outlined by Strauss and Corbin [18]. The emergent categories were then analysed in the context of the existing safety culture literature to develop a framework for further analysis.

This analytical process revealed three distinctive, quasi-independent, meta-categories evident in all the interviews which impacted the evolution of safety culture. These dimensions were labelled *concerns*, *influences* and *actions*.

- Concerns encompass threats to the needs of the individual and worries about meeting the requirements placed on them by others.
- Influences describe the factors that dictate the methods by which safety needs can be accomplished.
- Actions encompass behaviours that directly impact upon safety, in either a positive or negative manner.

These meta-categories were hypothesised to act at various levels across the system. Although these dimensions reflect different facets of safety culture, they do interact to some degree, as is explained in the following sub-sections. Six layers applicable to all industries were also identified (see Figure 1): line workers, middle management, senior management, the regulator, government (legislative/judiciary) and society as a whole.

The comments extracted from the interviews were organised within the dimensions to allow further analysis consistent with a grounded theory approach. Constant comparison [19] between the constructs elicited from the interviews and the literature was undertaken to further develop the model.

The core components of each of these dimensions are described in the following sub-sections.

2.2.1. Concerns

Concerns drive an individual to accept or reject safe working practices as a result of the prevailing culture. These concerns operate an emotive level and only drive actual behaviour to an extent, as a result of other influences.

At the line worker level, concerns centred on personal safety and health, job security, job satisfaction and well-being. Middle management was concerned with similar issues; however, their concerns were moderated by issues relating to meeting targets (including safety targets) set by senior management and controlling the financial bottom line. Senior management's additional concerns were associated with meeting organisational and shareholder goals, maintaining stability and assuring the financial health of the organisation. However, they were also concerned with the potential for criminal and civil liability in the event of an accident and maintaining the organisation's relationship with the regulator and the public.

From outside the organisation, the principal safety concern of the regulators was demonstrating that it could control the level of risk in its industry; its ability to respond to the economic and regulatory agenda set down by government; and its ability to balance the conflicting demands of the public while allowing industry the leeway to operate in a cost effective manner. The primary concern at governmental level was simply maintaining stability of the government and appearing responsive to the concerns of society while also helping promote economic growth.

2.2.2. Influences

Influences are those factors present within a system which determine the actions available. While concerns refer to an individual's need for safety, influences refer to those factors that determine industry's ability to actually act in the desired manner.

At the level of line workers, influences included attitudes toward safety, the skills and knowledge to deal with safety issues, the motivation to employ safe working practices, and the workforce's sense of ownership and empowerment. At the level of middle management, the influences behind promoting a sound safety culture included the supervisory style of management, management's technical knowledge and ability, its leadership and communication skills, access to senior management, and the level of autonomy and empowerment afforded to it. Senior management's influences included the same factors as middle management, plus implementing their operating philosophy (long- versus short-term requirements); responding to public pressures, social and economic imperatives and dealing with pressures from the regulator.

The regulator's prime influences were identified as the amount of power granted to it and the regulatory culture present in the industry (particularly the degree of self-regulation). These influences were perceived to be almost solely the product of government, whose major influences stemmed from the societal level, such as the influences of national culture, public perceptions of risk and economic imperatives.

2.2.3. Actions

Actions are defined as the behaviours that may have either a positive or negative impact upon safety. Descriptions of what constitutes good safety management fall into this category.

In addition to actually working in a safe manner, at line worker level, the safety actions described

included being vigilant for new operating hazards, participating in safety initiatives and communicating safety issues to others in the organisation. Middle management played a key role in promoting safety, being responsible for communicating information both up and down the organisation; monitoring (and encouraging) safe working practices in the workforce; and scheduling work to allow time for it to be undertaken safely. Senior management's actions encompassed many of the duties of middle management but also included setting organisational values and goals to promote safety and monitoring performance.

At the regulatory level, in addition to setting, monitoring and enforcing industry-wide safety standards, the role of the regulator was also to aid sharing safety information across operators and integrating initiatives across the industry. The role of the government included providing a clear mandate to the regulator (with the required legislative powers) and responding to society's safety concerns. Actions from the societal level involved making efforts to form realistic assessments of risk, communicating these concerns but also demonstrating a willingness to pay for safety.

2.3. Discussion

The results of the interviews suggest that safety culture has three major determinants: concerns, influence and actions. These are described diagrammatically in Figure 1. It can be seen that the emphasis in these dimensions differs with respect to the level of the employee within an organisation. Higher levels of management also need to take into account other factors beyond the boundary of the organisation (i.e., the organisation is an open system).

Although not subject to further analysis, failures, which are represented in the model in Figure 1, as incidents and accidents, have an impact on the safety culture of an organisation often resulting in additional scrutiny and added financial pressures.

To establish if the dimensions of safety culture elicited during the interviews were comprehensive and generalisable it was necessary to establish if these factors were recognisable in a wider population of safety professionals and the general public. This was accomplished through two large scale questionnaire studies.

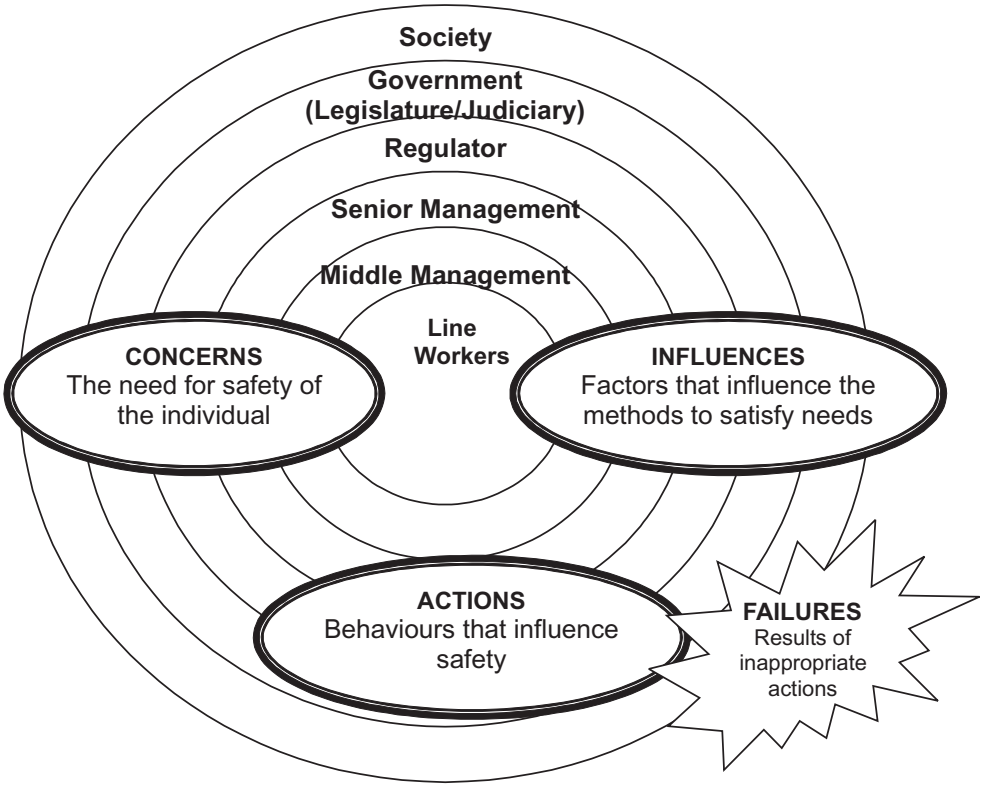


Figure 1. Layers of influence and categories comprising a model of safety culture.

3. QUESTIONNAIRE STUDIES

3.1. Overview of Questionnaire Studies

Using the interview data as a basis for item generation, two large-scale surveys were undertaken to elicit the underlying dimensions of safety culture within the meta-categories of safety concerns, influences and actions. As safety culture extends beyond organisational boundaries, the safety concerns questionnaire was administered to a large sample of the general population, so all members of society and representatives from many industrial sectors would be included. At the outer levels of the model described in Figure 1, safety concerns apply as much to those industries that people do not work in as the ones in which they do work. A second survey instrument eliciting the dimensions within the categories of actions and influences was completed by a large sample of safety professionals, as they were better placed to pass informed comment in these aspects.

3.2. Safety Concerns Questionnaire

3.2.1. Method

Sample. One hundred and sixty-eight completed survey instruments from people currently in employment were returned and were suitable for analysis.

The mean age of the sample was 41.0 and the mean time of employment in their current job was 13.6 years; 60.7% of the sample was male and 39.3% female. Line workers comprised 46.7% of the sample; 23.6% were middle management; 13.7% senior management; and 2.2% were safety professionals, a distribution of responses fairly typical of the UK working population. The remainder of the sample consisted mainly of autonomous professional workers (e.g., teachers and doctors). Using Perrow's [19] scheme for the categorisation of industries, 17.9% were from tightly-coupled, linear industries; 8.9% were employed in tightly-coupled, complex industries; 51.8% were from loosely-coupled linear industries and 21.4% were from loosely-coupled complex industries.

Instrument. In addition to basic demographic details and items about the nature of the respondent's work (industrial sector and job role), the survey instrument comprised of 29 seven-point Likert scale type items. Respondents were required to complete the questionnaire with regard to how often they considered each item when making choices in their working environment. The scale ran from 1 (*rarely*) to 7 (*always*). A *does not apply* option was also included.

Four main areas were addressed in the survey: concern for the individual, concern for the organisation, concern for the industry and concern for society. Example items can be found in the following Results section.

The questionnaires were distributed by post to named individuals selected at random from the UK electoral register. A FREEPOST return envelope was included with the survey instrument.

3.2.2. Results

The data were subject to a Principal Components Analysis (PCA) using a Varimax rotation, to establish the underlying dimensions of safety culture within the concerns meta-category. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for the data set was .87, suggesting that the data were highly suitable for this type of analysis. Using Kaiser's criterion, five principal components were extracted, accounting for 62% of the sample variance (see Table 1). All items loading significantly onto a component were included on a component [20]. As summated scales were constructed from each component its internal consistency was evaluated using Cronbach's alpha. The components extracted were entitled "Concern for organisational image and compliance" (alpha = .95, Eigenvalue = 5.32), "Concern for health and safety" (alpha = .88, Eigenvalue = 3.03), "Concern for organisational performance" (alpha = .85, Eigenvalue = 2.65), "Organisational citizenship" (alpha = .85, Eigenvalue = 2.37), and "Personal financial and career concerns" (alpha = .80, Eigenvalue = 1.73).

TABLE 1. Summary Principal Component Analysis Statistics (and Example Questionnaire Items) for Analysis of Safety Concerns Questionnaire

Component	Component Label (No. of Items) and Example Items	Eigenvalue	Cronbach's Alpha
1	Concern for organisational image and compliance (10) • Demonstrating to the public that the industry is in control of risk • Creating a good public image for the industry with respect to safety	5.32	.95
2	Concern for health and safety (5) • My own personal safety • The health of others	3.03	.88
3	Concern for organisational performance (5) • Ensuring that my actions are consistent with the values and mission of my organisation • Achieving the long-term goals of my organisation	2.65	.85
4	Organisational citizenship (4) • Allowing the organisation to make a positive contribution to the quality of life in the local area • Ensuring that the industry's activities are consistent with the goals and values of society	2.37	.85
5	Personal financial and career concerns (3) • Personal financial well-being • My own personal job security	1.73	.80

3.3. Safety Influences and Actions Questionnaire

3.3.1. Method

Sample. Two hundred and forty-eight completed questionnaires were returned in time for analysis. The mean length of time respondents had been involved in health and safety was 11.4 years (with a range from 1 to 44 years). Fifty percent of the sample described themselves as safety officers/representatives, 20.1% were middle management, 11.7% senior management, 3.2% were line workers and 0.6% were industry regulators. Using Perrow's [16] scheme for the categorisation of industries, 12.0% were from tightly-coupled, linear industries; 23.2% were employed in tightly-coupled, complex industries; 35.2% were from loosely-coupled linear industries and 29.6% were from loosely-coupled complex industries.

Instrument. The survey instrument asked respondents to complete one section concerned with gathering demographic data (e.g., respondent's job role, the industrial sector in which they were employed). There then followed two further sections: safety influences and safety actions.

The safety influences section comprised 42 seven-point Likert scale type items. Respondents indicated from their experiences in the industry in which they worked, on a scale running from 1 (*strongly disagree*) to 7 (*strongly agree*), their agreement with a series of statements concerned with factors that influenced safe working practises. Example questionnaire items are included in the following Results section.

The safety actions section comprised of 38 items. In this section respondents indicated on a scale from 1 (*does not describe at all*) to 7 (*very accurately describes*) their evaluation

of statements concerned with safety actions. Illustrative examples of these items can also be found in the following section.

Questionnaires were distributed to IOSH (Institute for Occupational Safety and Health*) members. Each questionnaire pack contained a covering letter explaining the nature of the study, a FREEPOST return envelope and the survey instrument itself.

3.3.2. Results

PCA—safety influences. As before, the data were subject to a PCA using a Varimax rotation, to establish the underlying dimensions of safety culture within the influences meta-category. The KMO measure of sampling adequacy for this data set was .89, indicating that it was again highly suitable for PCA. Six principal components were extracted which accounted for 59% of the sample variance (see Table 2). The internal consistency of each component also evaluated using Cronbach's alpha. The components extracted were entitled "Management competence" (alpha = .93, Eigenvalue = 5.33), "Line personnel competence and characteristics" (alpha = .90, Eigenvalue = 3.51), "Quality of working life" (alpha = .85, Eigenvalue =

TABLE 2. Summary Principal Component Analysis Statistics (and Example Questionnaire Items) for Analysis of Safety Influences Questionnaire Items

Component	Component Label (No. of Items) and Example Items	Eigenvalue	Cronbach's Alpha
1	Management competence (11) • Most senior managers are effective leaders • Generally, senior managers have the skills to communicate effectively	5.33	.93
2	Line personnel competence and characteristics (8) • Line workers' level of skill and knowledge (relating to safety programmes) is generally very good • Line workers develop an active interest in the design and operation of safety programmes	3.51	.90
3	Quality of working life (6) • Line workers experience a reasonable amount of job satisfaction • Line workers are highly motivated	2.37	.85
4	The regulatory environment (5) • The regulator has the ability to communicate effectively with the industry • The regulator is willing and able to prosecute companies and individuals for breaches of safety	2.33	.80
5	Economic stability (5) • The economy is sufficiently stable to ensure the long term viability of the industry • The government will be able to ensure the industry's long term viability	2.23	.76
6	Public involvement (2) • The general public take a keen interest in the activities of the industry • The general public have a good understanding of the industry	2.13	.62

* http://www.iosh.co.uk/

2.37), "The regulatory environment" (alpha = .80; Eigenvalue = 2.33), "Economic stability" (alpha = .76; Eigenvalue = 2.23) and "Public involvement" (alpha = .62; Eigenvalue = 2.23).

PCA—safety actions. The data were again subject to a PCA using a Varimax rotation. The KMO measure of sampling adequacy was .93. Six identifiable principal components were extracted accounting for 61% of the sample variance (described in Table 3) which also include values for Cronbach's alpha. The components extracted were entitled "Actions of middle and senior management" (alpha = .96, Eigenvalue = 8.03), "Actions of the regulator" (alpha = .90, Eigenvalue = 4.56), "Actions of the government" (alpha = .85, Eigenvalue = 3.43), "Line worker involvement in safety" (alpha = .80, Eigenvalue = 1.85), "Understanding and involvement of the general public" (alpha = .76, Eigenvalue = 1.81) and "Level of line worker empowerment" (alpha = .62; Eigenvalue = 1.31).

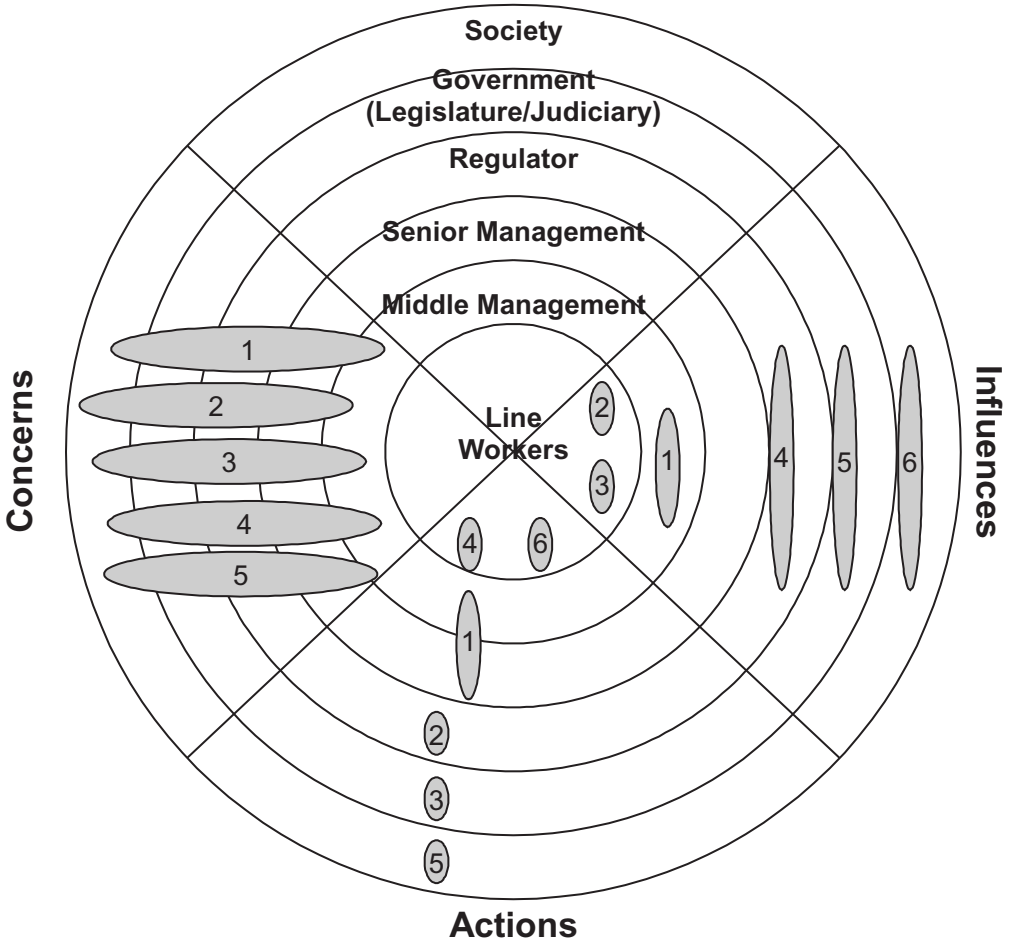
TABLE 3. Summary Principal Component Analysis statistics (and Example Questionnaire Items) for Analysis of Safety Actions Questionnaire Items

Component	Component Label (No. of Items) and Example Items	Eigenvalue	Cronbach's Alpha
1	Actions of middle and senior management (15) • Senior management clearly demonstrate, through communication and actions, the positive value of safety to the organisation • Senior mangers take visible actions in response to safety concerns	8.03	0.96
2	Actions of the regulator (8) • The regulator encourages and participates in sharing safety information and experiences between operators • The regulator effectively communicates clear minimum expectations for safety to all operators	4.56	0.90
3	Actions of the government (6) • The government responds to public concerns with appropriate legislative and judicial action • The government creates and enforces a reasonable degree of criminal and civil liability to support the regulator	3.43	0.85
4	Line worker involvement in safety (3) • Many employees tend to get involved with safety committees and other safety initiatives, not just union representatives • Most line personnel notice and report workplace hazards on a regular basis	1.85	0.80
5	Understanding and involvement of the general public (4) • The general public have a good understanding of the risks associated with the industry • The general public are willing to pay extra for increased safety in the industry	1.81	0.76
6	Level of line worker empowerment (2) • If line personnel stop production on safety grounds their judgement will not be questioned with the benefit of hindsight • All line personnel have the power to stop operations or production on safety grounds	1.31	0.60

4. DISCUSSION

In Figure 2 the principal components elicited within the three major safety culture meta-categories of concerns, influences and actions are plotted over the layers of the system described previously in Figure 1.

It can be seen that the underlying dimensions of safety culture elicited reflect different identifiable concerns common across all levels within an organisation and across society (in its broadest sense) outside the boundaries of an organisation (i.e., the regulator, government and society itself). However, the dimensions of safety culture



Concerns		Actions		Influences	
1	Organisational image and compliance	1	Actions of middle and senior management	1	Management competence
2	Health and safety	2	Actions of the regulator	2	Line personnel competence and characteristics
3	Organisational performance	3	Actions of the government	3	Line personnel—quality of working life
4	Organisational citizenship	4	Line worker involvement in safety	4	The regulatory environment
5	Personal financial and career concerns	5	Understanding and involvement of the general public	5	Economic stability
		6	Line worker empowerment	6	Level of public involvement

Figure 2. Median values from the principal components elicited within the three major safety culture categories of *concerns*, *influences* and *actions* are plotted over the organisational and societal layers of the safety system.

underlying influences and actions are more closely associated with a particular level of management or society. With respect to safety concerns the PCA results can be contrasted with the contrary views expressed at the interview stage. However, the empirical data support the position of other authors who suggest that many aspects of safety culture are common across an organisation (e.g., [1, 2, 3]). However, this is only true for the category of concerns.

Although participants in the interviews were asked to restrict themselves to the concept of safety culture, their concerns extended far beyond this topic. Not only was health and safety regarded as being important, it was also a concern to demonstrate that it was seen to be important and that companies were seen to be complying with the requirement. The same applied to other factors, such as career concerns and organisational performance. This again strongly suggests that safety culture cannot be studied in the absence of other factors.

It is of no surprise that the components in the two remaining categories of influences and actions reflect either the managerial level or the level of influence outside the organisation. Simard and Marchand [7] noted that factors external to an organisation, such as the socio-economic context or market conditions, affected workers' compliance with safety rules. The principal components derived from the data in this study also support this point of view. As organisations are selectively open systems [14], it follows that to understand safety culture within them, the boundaries for study must reflect this. The INSAG [5] model does this to some extent; however, as this is essentially an approach to safety management rather than a model of safety culture, it only extends to the regulatory (perhaps governmental) level and it only addresses safety actions not influences. Nevertheless, the data obtained in the present study support the multi-layered approach of INSAG and other authors (e.g., [7]). Many of the components derived in the categories of influences and actions are also recognisable in the work of previously cited authors (see also the exhaustive list of safety culture dimensions in the review by Guldenmund [4]). For example, "Management and line personnel competence" appear as an influence in the current study (cf. [3]); "Regulatory environment" also appears as an influence on safety culture (cf. [1]); and the actions of management appear as a component in the actions category (cf. [2]).

Organisational safety culture is a sub-culture of other cultures [8, 9, 10]. This is reflected in the structure of the principle components elicited in the influences and actions meta-categories but not the concerns category. Responses suggest that safety concerns are almost universal but the manner in which these concerns are responded to (actions) reflects position in the organisation (or society) and is influenced by other (higher) positions in the organisation (or society). Previous studies have inferred the dimensions of safety culture largely from policies and procedures (actions), as these are the symbols taken to mark the existence of a safety culture. However, these actions can only be interpreted in light of the less overt influences and concerns that drive them. These influences and concerns are driven by many factors external to the organisation, hence the requirements for an open systems based approach.

It should be noted that there is no suggestion whatsoever that the categories of concerns, influences and actions are orthogonal, indeed quite the reverse is likely to be true. An action from one level in the model (e.g., the regulator) may serve to act as an influence at another level (e.g., senior management). The model of safety culture described in Figures 1 and 2 can be likened to the pattern of ripples in a pond. Government responds to society's influence, concerns and even actions, however not directly but usually through the actions of the regulator. The regulator's requirements are translated into safety actions impinging on the workforce by several layers of management. At each level of management and society the actions and influences aspects of safety culture at play differ. In a similar manner, working from the inside of the model outward, the empowerment of line workers in safety issues can influence successive layers of management. However, it should also be noted that line workers can have a direct influence on government (as can managers) as they are all members of society.

The inter-relationship between concerns and influences needs some further exploration, specifically with their relationship to subsequent actions. A high level of concern for safety (across both the organisation and society) coupled with appropriate influences promoting safety (particularly at higher levels of management and governmental levels) should lead to appropriate and effective actions. However, a high level of concern for safety associated with a low level of influence may result in ineffective or inappropriate safety actions being taken. Similarly, a low level of concern for safety associated with high levels of influence may result in potentially effective safety initiatives being ignored or only partially complied with.

Further work needs to be undertaken to establish the reliability of the constructs elicited in the principal components analyses conducted. A structural equation modelling based study would also be desirable to establish the strength (and direction) of the relationships between the dimensions of safety culture established, the managerial/societal levels in the model identified and the implementation of safe working practices. Nevertheless, the model proposed begins to define the wider mechanisms at work, including those operating beyond the boundaries of the organisation, when attempting to develop an effective safety culture.

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