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Guided by principles or rules: A Delphi study on how safety professionals frame safety practices

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ABSTRACT

This study explores how safety professionals conceptualize and articulate safety practices, examining how their framing influences actions, facilitates learning from failures, and impacts overall safety outcomes. Twenty-nine safety professionals participated in a Delphi study, which included three online workshops and three rounds of surveys. Eighteen safety practices were developed, framed as both rules-based and principles-based practices. Survey results indicated that both rules-based and principles-based practices were considered essential for achieving safety, with their relative balance likely being context-dependent. While all practices were considered important for preventing accidents, those framed as principles were seen as more challenging to implement but ultimately more effective, especially in complex situations. Better understanding of the way in which safety practices are framed has significant implications for the development of safety standards, guidelines, and recommendations.

1. Introduction

Frames are mental models that help us make sense of the world around us (Goffman, 1974; Cornelissen and Werner, 2014) and can be defined as "principles of organisation which govern the subjective meanings we assign to social events" (Goffman, 1974, p. 11). So, the way an event, such as a safety incident (accident or fatality), is addressed can be significantly influenced by the framing used to understand how safety is managed and maintained in practice. In organizations with safety professionals, the response to an incident may be guided by their underlying beliefs about the nature of safety and its attainment. Carroll et al. (2022), in a recent study of 220 safety practitioners in the USA, identified 42 different factors that each lead to practices that contribute to creating and maintaining a high level of safety. Similarly, a large study of safety professionals in 12 countries conducted by Hale and Guldenmund (2006) identified 22 different practices suggesting considerable variation in the framing of safety management practices by safety practitioners. The way practices are framed can profoundly impact actions and shape organizational outcomes (Murphy et al., 2021). Frames also play a significant role in shaping the way professionals communicate messages and provide guidance, impacting what they emphasise and how they present information (Murphy, et al., 2021). However, individuals may be unaware of the frames they employ or the extent to which their framing of issues can shape and influence others (Grint, 2005).

Rules, often conveyed as procedures and regulations, are recognised as a mechanism for controlling organizational activities and ensuring safety (Reason et al., 1998; Weichbrodt, 2015). A common reaction to safety incidents is to introduce stricter or more detailed regulations (Hale and Borys, 2013), based on the belief that such incidents often stem from noncompliance with existing rules. Hale and Borys (2013) noted several studies documenting the failure to follow rules as a common occurrence, even in safety critical industries, such as chemical industries and railways. Others challenge this approach (Bourrier and Bieder, 2013; Dekker, 2014), arguing that while rules formalize work practices and provide control, the proceduralization of safety—particularly in complex, safety–critical industries—raises questions about whether alternatives to increasing description and prescription exist.

Provan et al. (2020) identify two alternative modes of safety management that require safety professionals to adopt different practices. One approach implements practices that direct, coordinate and monitor activities to create and maintain safety. The alternative supports adaptation by encouraging anticipation, responsiveness to local situations and proactive learning. They conclude their paper by provocatively

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asking, "are [safety professionals] the 'controller', or are they the 'guide'?", or more particularly do safety professionals frame safety practices in the form of rules to control behaviour or principles to guide action? A rules-based framing of a practice provides explicit directives, minimising ambiguity and establishing compliance (Arjoon, 2006). Rules-based framing centres on procedural knowledge, emphasizing the "how" of execution, leaving little room for flexibility and prioritising task-oriented expertise (Burgemeestre et al., 2009). In contrast, principles-based framing of a practice emphasises declarative knowledge, focusing on the "know what" of overarching intent and objectives, providing flexibility in decision-making and permitting local adaptation (Arjoon, 2006).

The earlier safety literature on rules is largely discursive or conceptual (e.g. Hale and Swuste, 1998; Hopkins, 2011; Hale and Borys, 2013), often lacking direct empirical evidence. Furthermore, the literature provides limited insight into how safety professionals—those commonly seen as responsible for organizational safety—frame safety management practices, or how they perceive the importance and practicality of implementing these practices to achieve safety (Provan et al., 2017; Guennoc et al., 2019). This paper seeks to fill this gap by exploring the question – how do safety professionals frame safety practices in their efforts to prevent and mitigate accidents? Specifically, do they present these practices as rigid rules to follow, or as adaptable principles that allow flexibility? Additionally, it examines a related question: how do safety professionals perceive both the importance and the ease of implementing these practices to achieve safety?

This study addresses these questions using a Delphi method. The Delphi method is an "established method of harnessing the opinions of an often diverse group of experts on practice-related problems" (Powell, 2003, p.376) that has been deployed in many sectors, including transport systems (Melander, 2018), and healthcare (Keeney et al., 2006). Moreover, it is an approach that has been used previously in safety science to evaluate the process of adaptation in managing safety related risks in complex sociotechnical systems (Foster et al., 2020), the role of weak signals in accidents and incidents (Nicolaidou et al., 2022) and to evaluate safety performance indicators in the construction industry (Oguz Erkal, et al. 2023). Using this method and drawing on the experience of safety professionals we investigate how experienced safety professionals frame practices for managing safety. The paper is organized as follows. It reviews the literature on safety professionals, frames and rules that underpin this work. The Delphi method adopted in this study is then explained. Findings related to the frames used by safety professionals and their importance and ease of implementation are reported. A discussion of these findings then follows, which includes implications for a contingency-based approach to managing safety, writing recommendations and regulation.

2. Safety professionals, frames, and rules

2.1. The role of safety professionals

Safety professionals are integral to ensuring workplace safety, particularly in safety–critical and high-risk industries such as aviation, oil and gas, and healthcare (Guennoc et al., 2019). Their responsibilities extend beyond addressing technical safety concerns to fostering organizational safety cultures and promoting compliance with external regulations. A significant part of safety professional's work involves interpersonal interactions, as safety professionals must influence a wide range of stakeholders, including frontline workers, managers, and external regulators. Success in this domain often depends on their credibility, which is shaped by technical knowledge, communication skills, and the ability to build trust (Guennoc et al., 2019; Provan et al., 2019). For example, in industrial settings, safety professionals might introduce new protocols and rely on persuasive communication to secure buy-in from sceptical employees. Despite the importance of their role, there remains a lack of empirical research into their specific practices and contributions, leaving gaps in our understanding of how they influence safety outcomes (Provan et al., 2017).

Safety professionals' roles are multifaceted: they must balance technical expertise with organizational, social, and political demands. For instance, in many cases, their activities are designed not only to enhance safety but also to demonstrate adherence to legal or regulatory expectations, reducing liability and reputational risks. Operating within institutional frameworks, safety professionals are often expected to prioritize compliance with rules and standards. These frameworks provide a baseline for safety performance but can also constrain innovation and adaptability, particularly in dynamic or emergent scenarios (Provan et al., 2019). In addition to institutional pressures, safety professionals' individual beliefs, values, and experiences significantly influence their approach to safety management (Swuste et al., 2014). These beliefs vary widely, reflecting differences in professional backgrounds and educational pathways, as Carroll et al. (2022) have recently shown. For example, they may have different perspectives on how to manage and learn from errors (Klamar, et al., 2024). Some safety professionals may focus on strict prevention and compliance, while others advocate for error management and continuous learning. This diversity underscores the importance of examining the frames safety professionals employ to interpret and address safety challenges.

2.2. Frames and their role in safety

Frames and framing are used in a variety of ways to study different phenomena ranging from individual cognitions to institutionalized meaning structures at a field level (Cornelissen and Werner, 2014). Frames, according to Goffman (1974), are 'schemata of interpretation' that "help to render events or occurrences meaningful and thereby function to organize experience and guide action" (Benford and Snow, 2000, p.614). In other words, they serve both diagnostic and prognostic purposes. Not only do they diagnose a situation by suggesting what has happened and provide meaning to others, but also, they suggest solutions or ways in which the problem can be addressed. While the former has been extensively investigated, Kaplan (2008) indicates that prognostic frames have received more limited empirical examination.

Frames are not randomly created in the moment, rather they are constructed by individuals through their past experiences of education and career history, for example. Inevitable differences in these individual histories will result in each individual having a unique repertoire of frames (Goffman, 1974). These may allow them to suggest alternative diagnoses or solutions to others in any particular circumstance. While common backgrounds or shared experiences might allow the development of a standardized repertoire of frames, some variation in frames is inevitable, especially if individual backgrounds and circumstances differ significantly. These differences create tensions (Lewis and Smith, 2014) and may result in 'framing contests' (Kaplan, 2008) where the salience of an effective frame for a particular situation is disputed either between individuals or groups. Often this results in the creation of dominant and subordinate frames, where, contingent upon the setting, one frame is perceived to be more acceptable than another (Lewis and Smith, 2014). In the context of this paper, even though safety professionals hold different repertoires of frames, it is likely that some are dominant and so more prevalent than others.

Framing contests are customarily investigated as differences between individuals or groups. Much less common are considerations of intra-individual framing contests, where an individual is making their own selection between alternative frames. Nevertheless, Cowley et al. (2021) showed that individual front-line employees in the oil and gas industry had an institutionalized predisposition towards an error prevention frame rather than an error management frame that shaped their actions, notably what they reported and documented. Individuals followed the traditional 'rule-following' and 'command and control' paradigm dominant in high hazard industries, even when they also held the alternative frame. Maslen and Ransan-Cooper (2017) indicated that

pipeline engineers held two frames for safety compliance, either as a matter of expert judgement or as a matter of process, which they used selectively depending on context. However, they also noted that a hybrid frame was created through the dynamic interactions between these engineers and others.

2.3. A rules-based framing of safety management

The rules-based frame in safety management prioritizes standardization, control, and compliance, interpreting safety challenges as deviations from established norms. Stricter rules are framed as solutions to mitigate these deviations, aligning with diagnostic and prognostic framing—identifying issues and prescribing corrective actions (Hale and Borys, 2013; Dekker, 2014). Rules play a critical role in defining and maintaining operational boundaries. In sociotechnical systems, accidents and near misses often occur when these boundaries—representing the transition from safe to unsafe operations—are crossed (Rasmussen, 1997). Rules act as beacons for these boundaries, providing clear markers of acceptable behaviour and establishing control mechanisms to guide organizational activities (Hale and Borys, 2013). Rules standardize work processes, offering workers clarity on what to do and how to do it, while also facilitating compliance assessments—a cornerstone of safety assurance. For example, pre-flight checklists in aviation ensure consistency, reduce variability, and minimize human error. Similarly, strict compliance with surgical protocols in healthcare reduces risks and improves patient outcomes. By providing structured guidance, rules enable safety professionals to approach safety as a measurable, enforceable process.

Hale and Swuste (1998) identify three types of safety rules, each reflecting varying levels of prescriptiveness. Performance goals define desired outcomes without prescribing methods, offering flexibility. For instance, workers may determine their approach to handling materials safely. Process rules provide structured guidance for decision-making and assign roles, retaining some adaptability. For example, maintenance procedures in manufacturing might allow adjustments based on real-time conditions. Action rules detail exact behaviours or procedures, leaving little room for interpretation, such as step-by-step protocols for operating hazardous machinery. These rules represent a spectrum of control. While action rules ensure consistency, they can be restrictive. Conversely, performance goals allow flexibility but may lack specificity in high-risk contexts. Effective application of rules requires careful consideration of context to balance consistency and adaptability within the rules-based frame.

2.4. The limitations of a rules-based frame

While the rules-based frame offers structure and predictability, it struggles to address the complexities of dynamic environments. Reiman et al. (2015) critique this approach for oversimplifying real-world operations, where rigid adherence to rules can hinder adaptive responses. Hollnagel (2014) emphasizes the gap between "work as imagined" (prescribed processes) and "work as done" (actual practices), highlighting the inability of rules to capture the emergent nuances of sociotechnical systems. Similarly, Snook (2000) highlights practical drift, involving the slow and steady uncoupling of practices from written procedures and rules. As organizations grow more complex, rules tend to proliferate, often shifting the focus from genuine safety improvements to procedural compliance. Dekker (2014) describes this as the "bureaucratization" of safety, where rules serve more as legal defenses than effective risk mitigation strategies. Excessive proceduralization, as noted by Amalberti (2001) and Weichbrodt (2015), can overwhelm workers, leading to noncompliance or rule-breaking.

The rules-based frame's emphasis on control and predictability often conflicts with the fluidity of modern operations. Mascini's (2005) study of coke factory workers revealed how conflicting rules forced employees to prioritize one directive over another, undermining both compliance and safety outcomes. Similarly, safety rules can clash with broader organizational goals, such as performance targets, further complicating adherence (Neri et al., 2022; Hashemian and Triantis, 2023). Poor communication or inadequate training exacerbates these challenges, leaving workers unable to comply effectively.

In dynamic contexts, rigid rules often fail to support the flexibility required to address novel challenges. Grote (2015) advocates for "flexible rules" that allow workers to adjust actions based on situational demands. For example, in emergencies, strict protocols may delay critical responses, whereas adaptable rules empower immediate, context-appropriate actions. This aligns with the Safety 2 perspective, which prioritizes underspecified, evolving rules over the static, top-down approach of Safety 1 (Dekker, 2005; Hollnagel, 2014). Safety 2 emphasizes adaptability, with rules designed to be interpreted and modified in response to specific contexts (Hale and Borys, 2013). Midtlyng (2022) demonstrates this in her study of prison officers who adapted safety protocols to meet situational needs, showcasing the value of flexibility in achieving safety outcomes.

2.5. A principles-based framing of safety management

A principles-based frame offers a dynamic alternative to the rigidity of rules, emphasizing flexibility and adaptability, particularly in complex systems. With a principles-based approach, safety is framed not as a static state but as an ongoing accomplishment (Weick, 1995), achieved through continuous adjustments and mindful organizing (Weick et al., 1999). Informal, often unnoticed actions are central to this process and become evident only when their absence leads to failure (Hollnagel et al., 2006). Provan et al. (2020) describe this approach as "guided adaptability," positioning safety professionals as facilitators of dynamic responses to challenges. Weick et al. (1999) identify five principles central to high-reliability organizations (HROs): preoccupation with failure, reluctance to simplify, sensitivity to operations, commitment to resilience, and deference to expertise. These principles frame safety as collaborative and proactive, particularly in high-risk environments. For example, in aviation, sensitivity to operations allows pilots to make real-time decisions based on dynamic conditions, while healthcare principles such as patient-centered care prioritize tailored, effective responses.

Unlike the rigidity of rules-based practices, principles emphasize iterative problem-solving and decentralized decision-making, supporting local adaptation while maintaining alignment with broader goals (Folke et al., 2005; Sharma-Wallace et al., 2018). Safety emerges locally from these continuous adjustments (Hollnagel, 2014). Associated principles-based practices foster capabilities like anticipation, coping, and adaptation, enabling organizations to navigate complexity and mitigate risks (Duchek, 2020; Denyer, 2017). Principles embody organizational values, translating abstract ideals into practical behaviours (Selznick, 1957). By embedding these values into operations, organizations enhance resilience and adaptability, encouraging creative thinking and critical adaptation (Folke et al., 2005). This flexibility helps organizations align their actions with desired outcomes, such as improved safety and long-term stability. This frame also fosters cooperative relationships between regulators and organizations, emphasizing intent over procedural compliance and reducing the risk of creative compliance strategies (Black et al., 2007). Open dialogue ensures clarity, trust, and alignment with safety goals, particularly for entities navigating complex regulatory landscapes.

2.6. Research problem

This succinct review of the literature highlights that safety professionals, shaped by their diverse backgrounds, likely hold varied frames for managing safety. In responding to safety incidents, certain frames—both diagnostic and prognostic—become dominant. These dominant frames are often rules-based, reflecting the institutionalized nature of safety in organizations, though principles-based frames are

gaining advocacy. Despite growing theoretical interest in framing, there are few empirical studies examining how safety professionals conceptualize and operationalize safety practices. It remains unclear whether safety professionals predominantly adhere to institutionalized, rules-driven methods or integrate principles to encourage adaptability and learning. Furthermore, how these professionals interpret, prioritize, and balance competing frames in practice are underexplored. By addressing these gaps, the research aims to provide deeper insights into how safety management practices are conceptualized by safety professionals and operationalized in diverse and evolving contexts.

3. Methods

3.1. Research design

A Delphi study provides a way to capture the opinions of experts, often on complex problems for which there is no single definitive answer (Day and Bobova, 2005; Hirschhorn, 2019). These opinions, like frames, shape interpretations and guide actions. Safety professionals, as noted above, have a wide range of beliefs about safety and the most appropriate practices for managing it (Carroll, et al. 2022). To elicit these practices and their description we invited participants to identify practices that could be used to mitigate the causes of accidents and untoward incidents with which they were very familiar, e.g. because they had been involved in the investigation. By a process of abduction, we were able to interpret these empirical findings using the existing literature on safety rules. This allowed us to infer two abstract frames that underpin safety professionals' preferred solutions to safety incidents.

The Delphi method may take many forms, but reviews (e.g., Drumm et al., 2022; Schmidt, 1997; Okoli and Pawlowski, 2004; Paré et al., 2013) consistently suggest the following three steps (brainstorming or discovery of issues, narrowing down or determining the most important issues, and ranking). Two distinct phases were deployed in this study. Fig. 1 shows a timeline of the phases, and the activities contained within each phase. A 'brainstorming' phase in which reasons for failure, i.e., occurrence of incidents, were elicited in the first workshop. These provided the basis for compiling practices that had been observed to mitigate these failures in a second workshop. This was followed by a survey phase to narrow down and revise issues. In the first round of the survey phase the importance and ease of implementation of each of the practises elicited in the second workshop were evaluated. Respondents also selected their top 25 % of practices for both importance and ease of implementation. A second survey further refined this selection providing an implicit ranking of practices in terms of importance and ease of implementation. In a final workshop participants identified explanations (or reasons) for the observed rankings of importance and ease of implementation. Following best practice, a subsequent survey tested the stability and degree of consensus of the earlier survey results (Von der Gracht, 2012), which may have changed following discussion with others in the final workshop (Belton et al., 2019). This design was approved by the university ethics committee (CURES/18072/2023).

3.2. Research participants

Three of the approaches outlined by Mauksch et al. (2020), namely informal approaches, external cues, and personal involvement, were used to identify potential experts. Individuals known to have extensive experience in relevant roles in organizations operating in high-risk environments from the researchers' collective personal networks were invited informally to participate in a series of three on-line workshops spread over a 50-day period. Commitment to attend all three workshops was a requirement for participation and consequently a number of interested volunteers withdrew. In order to compare different perspectives two groups of experts were identified and defined *a priori* from within this convenience sample of those who could participate. The first group included those with direct experience of accident investigation and implementation of recommendations. A second group included those who had a professional interest in the topic (i.e., without direct experience), for example safety advisors, senior members of professional safety bodies, academic researchers, and legal representatives.

In this study there were 15 volunteers in the first group with on average 31(±9) years' experience and 14 in the second group with on average 18(±6) years' experience. All participants had > 10 years' experience in the field. Some had more than 40 years' experience, giving a combined experience for all participants across both groups in excess of 800 years. Of the 29 volunteers, seven identified themselves as female. Participants were deliberately selected from the UK and asked to consider incidents that had occurred in the UK, to reduce the possible influence of national cultural variation or differences due to legislative regimes and regulatory environments. To mitigate potential normative sector influences participants were selected from a wide variety of different sectors, including aviation, construction, oil and gas, energy,

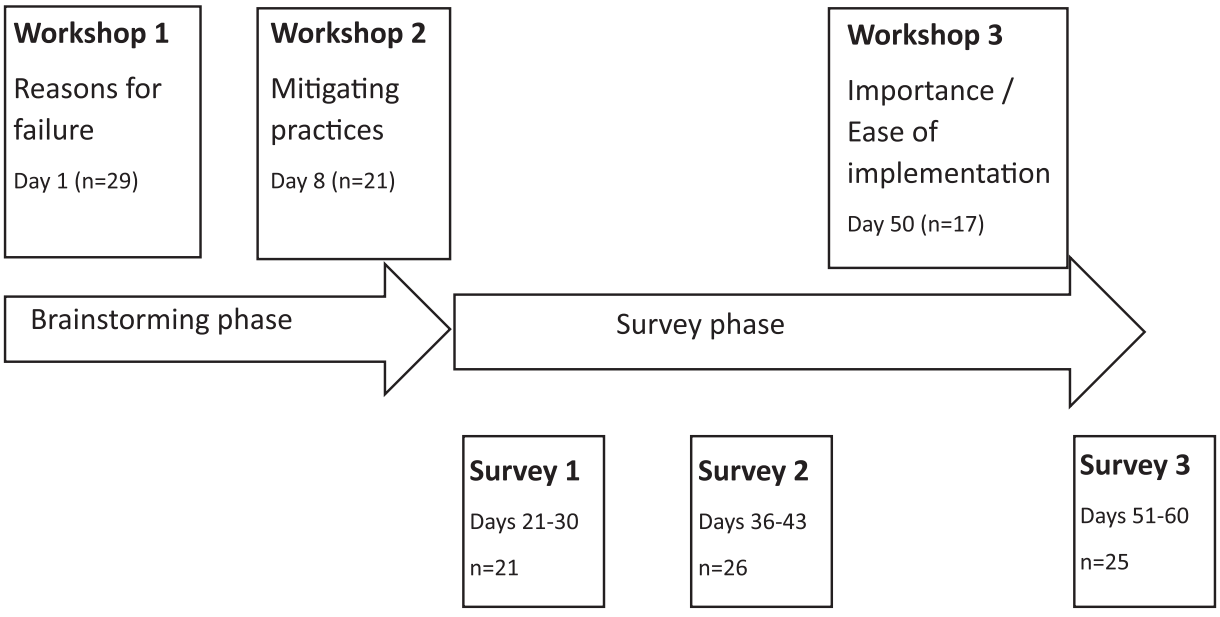

Fig. 1. Research design and timeline for Delphi study on learning from failures. N = number of respondents in each activity.

healthcare, automotive, rail, and manufacturing. These include high-risk sectors and those acknowledged as operating in complex environments.

3.3. Participation and attrition

A frequently observed challenge with Delphi studies is the loss of participants between rounds (Hirschhorn, 2019; Rowe and Wright, 2011). Number of participants from each of these groups in the different workshops and rounds of surveys are shown in Table 1. Twenty-nine individuals joined the first workshop and more than 20 of these supported each of the subsequent phases of the study. The attrition rate in this study is less than that reported by Nowack et al. (2011) in a review of 24 Delphi studies.

There are several factors that might explain this sustained engagement. First, the topic is an important one, and of significant interest to the participants. The opportunity to explore solutions with peers from different sectors was attractive. Second, the study was conducted at a high tempo. The initial workshop on day 1 was followed by another workshop a week later, two subsequent rounds of surveys followed, with the final workshop on day 50. Focus could be sustained over this relatively short period. Third, the activities were all completed on-line. The need for travel to a specific location was avoided. Time commitment was reduced to a minimum. Moreover, attendance was possible from any location with a good internet connection. Participants made use of this flexibility. Finally, participants were provided with necessary information in advance of each activity, with regular updates and reminders throughout the study. Others (see review by Paré et al., 2013) have advocated this level of communication to sustain participation.

3.4. Data collection and analysis

The three 90-minute on-line workshops were run separately for either group but on the same day; one in the morning and one in the afternoon. They made use of an on-line white board to capture written responses to each of the workshop activities. This approach was trialled on two separate occasions with four colleagues from our university in advance, and subsequently refined. In the first workshop (day 1) the use of the on-line whiteboard was explained and demonstrated. Participants had been briefed via an email prior to this workshop to identify three incidents with which they were familiar either through direct experience or from professional interest. They were invited to briefly describe (<20 words) the incident in general terms and identify the sector in which the incident occurred. Taking each of their identified incidents in turn and working in groups of 2 or 3 they were asked to identify reasons for the occurrence of their incident, and through the challenge of others in the small group to identify reasons beyond the superficial. These reasons were captured on the white board. In the first workshop the first group of 15 safety professionals provided 271 separate reasons for the occurrence of 44 different incidents (an average of 6 ± 2 reasons per incident), while the second group of 14 safety professionals identified 268 separate reasons for the occurrence of 33 different incidents (an average of 8 ± 4 reasons per incident). Each of these reasons were not necessarily different from any other, as similar reasons for the occurrence of an incident are common. Data from each workshop were exported into a separate spreadsheet. Statements were then clustered by the second author (DD) into categories of similar meaning, producing respectively 15 and 16 (including 'bad luck') different categories of reasons for failure from the morning and afternoon workshops. These data are not included in this manuscript.

In the second workshop (day 8) participants attending either workshop were again divided into small groups and invited to identify practices that they had used, or observed, that were effective in preventing each of the causes of incidents identified by that particular group in the previous workshop. These reasons for failure (excluding 'bad luck') had been clustered into five triplets by the research team in advance to facilitate the smooth running of the workshop. Each group spent approximately 15 min responding to a set of triplets, before moving on to the next set. This was repeated until each small group had observed and responded to each set of three. The two workshops for the two different groups of safety professionals generated respectively 342 and 329 statements of practices that had been used to prevent the occurrence of the different causes of failure.

The combined dataset of 671 statements was coded inductively by the second author (DD), resulting 18 different practices. After a thorough examination of statements within each category of practice by the authors, it became apparent that participants framed each of the 18 practices in two distinct ways. The analysis revealed a dichotomy: one frame leaned towards a rules-based approach, exemplified by practices like 'establishing clear roles and responsibilities with RACI charts (Responsible-Accountable-Consulted-Informed),' while the other leaned towards a principles-based approach, characterised by practices such as 'cultivating a culture of shared responsibility for safety' (Table 2). We believe that the differentiation between a rules-based frame and a principles-based frame is both significant and important. Moreover, the participants in the workshop frequently used both a rules-based framing and a principles-based framing of the same practice. They appeared to be unconsciously switching between the two frames in their conversations to create different emphasis. For the remaining data collection both descriptors were used for all 18 practices (i.e. 36 descriptors) that could be used to prevent the occurrence of incidents. The wording of each of these descriptions were discussed and agreed by the research team. These formed the basis for the survey phase (see below).

The 36 statements of practices to mitigate the chance of failure identified in the second workshop were incorporated into an on-line survey developed in Qualtrics. This was piloted with two members of each group to test functionality and check clarity of wording of practice statements. As a result, refinements to the wording and adjustments to the design of survey were made.

All 29 participants were then sent a link to the online survey on day 21 with a request to complete it by day 30. Three email reminders were sent at regular intervals during the intervening period to encourage participation. After providing details of the work, informed consent was requested to continue to participate in the survey. There were several blocks of questions, including demographic details (including sector and years of experience). Participants were asked to rate each of the 36 practices using a 5-point Likert scale for importance (1 = not important, 2 = fairly important, 3 = important, 4 = very important, 5 = extremely important) and ease of implementation (1 = very easy, 2 = easy, 3 = neutral, 4 = hard, 5 = very hard). They were then asked to identify their 'top 9′ items from the list of 36 practices (*i.e.*, 25 %) for both importance and also for difficulty of implementation.

Table 1
Number of participants from either group of experts in each round of the Delphi study.

	Workshop 1 (Day 1)	Workshop 2 (Day 8)	Survey round 1 (Day 21–30)	Survey round 2 (Day 36–43)	Workshop 3 (Day 50)	Survey round 3 (Day 51–60)
Group 1 (AM)	15	11	9	13	11	11
Group 2 (PM)	14	10	12	13	6	14
Total	29	21	21*	26	17	25*

* an additional participant declined to respond to the survey.

Table 2
Descriptors of 18 practices for preventing the occurrence of safety failures in complex systems identified in a Delphi study.

Practice Dimension		Descriptors	
		Rules-Based	**Principles-Based**
1	Maintenance and equipment	Evaluate data, including breakdown occurrences and resource availability, to optimize maintenance schedules.	Deepen the understanding of maintenance quality's impact on process safety and adapt practices accordingly for ongoing improvement and effectiveness.
2	Design and Construction	Create clear design specifications, risk registers and standards for equipment or system design.	Develop shared understanding and enable the effective management of changes in equipment or system design.
3	Communication and Engagement	Employ a variety of communication mediums tailored to specific contexts and audiences for effective communication.	Foster an inclusive environment that values and shares diverse perspectives and enables collaboration and information sharing.
4	Leadership	Provide leadership skills training encompassing communication, decision-making, and safety.	Foster visible leadership at all levels, prioritizing safety and promoting leaders' understanding of the impacts of their decisions.
5	Quality Management and Assurance	Utilize standard terminology and accessible, transparent quality management systems to ensure consistent and auditable practices.	Continuously adapt and refine terminology and management systems to meet evolving needs and foster agile practices.
6	Responsibility and Accountability	Establish clear roles and responsibilities with RACI charts (Responsible-Accountable-Consulted-Informed)	Fostering a culture of shared responsibility for safety.
7	Risk Management	Implement a structured review process to ensure competent evaluation and scrutiny of risk assessments for improved quality and effectiveness.	Embrace, modify and constantly evolve risk evaluation approaches to incorporate promising practices.
8	Competence and Training	Design and implement a system that assesses, monitors and assures the competence of employees, aligning their skills and knowledge with their roles.	Customize development to the unique needs of individual and organization, enabling the development of both technical and soft skills, and evolving as those needs change.
9	Compliance and Regulation	Establish internal governance processes to ensure compliance with the relevant laws and regulations that apply to the organization's operations.	Enable the judicious, transparent and effective application of the principles of governance, policy and regulation.
10	Human Factors and Organisational Behaviour	Recognize that human errors can occur due to factors such as fatigue, stress, workload and poor organisation of work, and put in place strategies to mitigate associated risks.	Foster an inclusive culture that supports open dialogue and learning.
11	Organizational Learning and Continuous Improvement	Implement processes for feedback collection, conducting reviews, and evaluating performance to identify areas of improvement.	Enable individuals and groups to adapt and innovate to improve practices.
12	Risk-Based Decision Making	Integrate risk evaluation and management principles into decision-making processes, assuring that risks are appropriately considered and addressed.	Foster an environment that encourages informed risk-taking, empowering individuals to make risk-based decisions.
13	Employee Wellbeing and Work-life Balance	Provide resources that support for work-life balance, mental health, and overall wellbeing.	Recognise, value and celebrate employee contributions, fostering a positive environment that boosts morale and enhances engagement.
14	Streamlined Processes and Documentation	Simplify procedures and streamline processes to make work practices easily accessible and user-friendly.	Develop documentation, including procedures and instructions, that encourages informed decision making and thoughtful application.
15	Resource Planning and Management	Implement robust resource planning processes that consider workload, capacity, and availability to effectively allocate resources.	Develop staff with the skills and capabilities to cope with and meet dynamic operational requirements.
16	Change Management and Communication	Establish and utilize a structured process to effectively manage change, ensuring safe implementation and minimizing potential risks.	Embrace a participative approach to change, conveying the purpose of the change and involving all levels of the organization.
17	Incident Response and Learning	Establish well-defined procedures that dictate the response protocols during emergencies, ensuring swift and effective actions in a crisis.	Develop the capability of individuals and teams to deal with emergency situations and quickly respond to emergent, unexpected issues and problems.
18	Learning from Incidents and Accidents	Establish a process for investigating incidents and making recommendations for change.	Promote a culture where failures, incidents, and accidents are seen as opportunities for growth, learning and improvement.

Complete data sets were obtained from 19 respondents. A further respondent provided only 'top 5′ rather than 9 items, but otherwise the data were complete. Another respondent failed to answer the question rating the ease of implementation of each practice. Otherwise, the data were complete. These two responses have been included in the analysis. Finally, another respondent declined to participate, giving an overall response rate of 79 %.

Means and standard deviations were calculated for ratings of importance and ease of implementation for each practice separately. For each practice (with two descriptions – see above) the pair of means were compared using independent sample t-tests adjusted with a Bonferroni-correction, meaning that only results where $p < 0.001$ were deemed significant. Cohen's D effect sizes were calculated to show the strength of the difference between the two means. Counts of the number of respondents who had included the practice in their 'top 9′ for both importance and difficulty of implementation were calculated. If one-third or more of the participants (i.e., at least 7) had included the practice in their selection of the 'top 9′ for importance or difficulty of implementation, then these factors were taken forward into the second

survey. There were 14 descriptions of practices out of a possible 36 that were identified, as important, or difficult to implement, or both, by at least 7 respondents.

These 14 items were then incorporated into a second Qualtrics survey. All 29 participants were sent a link to this second survey on day 36 with a request to complete it by day 43. Three reminders were sent at regular intervals during this period. As part of the 'narrowing down' process, participants were invited to select the 'top 5′ items from the list of 14 practices for either importance or difficulty of implementation.

A third Qualtrics survey which exactly replicated the second was sent to all participants immediately following the third workshop (day 51) to check the stability of their earlier responses following discussion at the third workshop. They were requested to complete the survey by day 60. They were sent three reminders at regular intervals throughout the period.

Distributions of counts across the 14 practices from each round of survey were compared using Chi-square tests.

In the third workshop (day 50) participants were provided with the combined results from the first survey where they had individually selected their top 9 practices from the 36 (i.e., 25 %) that they deemed important and/or difficult to implement. In small groups they were asked to provide reasons why each of the 10 particular practices they had collectively identified were either important or difficult to implement. Combined across both workshops, this resulted in a total of 83 short statements indicating reasons for importance, and 92 short statements of reasons why these practices were difficult to implement. For each group these were summarised by the first author (CP) for each stated practice and then the summary statements from either group were combined into an overall reason why each practice was either important or difficult to implement. These summary statements and overall reasons were discussed and agreed by the research team.

4. Findings

4.1. Importance and ease of implementation of individual practices

Individually each of the 36 identified practices were considered on average to be important or very important (Table 3), although all possible ratings on the Likert scale were used by survey participants. Mean values ranged from 3.4 (±1.27) to 4.76 (±0.44). Practices framed as principles typically had slightly greater mean values than those framed as rules, but these were not significant, and Cohen's D values were generally modest (<0.5) or weak (<0.2). Exceptions to this pattern of principles having a greater mean value were quality management and assurance, risk management, risk-based decision making, employee wellbeing and work-life balance, and streamlined processes and documentation. Considering all 18 practices together, there was no significant difference between the two groups of participants in their assessment of importance.

On average the 36 practices ranged from easy to hard to implement (Table 3), and in aggregate none was considered very easy or very hard. Although some individuals used these ratings for specific practices, mean values ranged from 1.95 (±0.89) to 3.9 (±0.72). Practices framed as rules, with two exceptions (Employee wellbeing and work-life balance and streamlined processes and documentation) were easier to implement than practices framed as principles, in four cases significantly so (Table 3). The effects sizes for these significant differences were large (Cohen's D = 1.21–1.86).

For each of the 36 identified practices, Fig. 2 plots the mean rating of importance against the mean rating of difficulty of implementation. Notably, practices framed as principles are considered to be more difficult to implement (scores typically above 3), while practices framed as rules are considered to be relatively easy to implement (scores typically below 3). Approximately twice as many practices framed as principles had mean ratings of importance above 4 (= very important) compared to those practices framed as rules.

4.2. Safety professionals' perceptions of practices in combination

In Round 1 of the survey at least one-third of participants (≥7) included 14 of the 36 practices in their 'top 9′ in terms of either importance or difficulty to implement (Table 4). Six of these 14 items were considered both important and difficult to implement by at least 7 people. There were 10 practices that were considered important by at least seven participants and 10 practices that were considered difficult to implement (Table 4). Four of the 10 practices considered important were written as rules, the others were written as principles. Only one of the 10 practices considered hard to implement was written as a rule, the others were all framed as principles.

The two most commonly included practices in terms of importance

Table 3
Overall means and standard deviations of ratings according to their importance and difficulty of implementation of practices considered by experts to minimize safety failures in complex systems framed either as rules or principles.

Practice (see Table 2)	**Importance**[a]						**Difficulty of implementation**[b]					
	Rules-Based		**Principles-Based**				**Rules-Based**		**Principles-Based**			
	Mean	**SD**	**Mean**	**SD**	**t-test**[c]	**Cohen's D**	**Mean**	**SD**	**Mean**	**SD**	**t-test**[c]	**Cohen's D**
1	3.86	0.79	4.19	1.08	1.12	0.35	2.65	0.93	2.75	1.12	0.31	0.10
2	4.00	1.18	4.33	1.02	1.03	0.31	2.60	1.10	3.50	0.95	2.82	0.89
3	3.71	1.15	4.62	0.67	3.08	0.99	2.60	0.88	3.60	1.14	3.14	0.97
4	4.43	0.75	4.57	0.68	0.55	0.20	2.75	0.91	3.15	1.18	1.24	0.37
5	3.67	1.15	3.40	1.27	−0.78	0.22	2.65	1.09	3.15	0.99	1.55	0.48
6	3.57	1.12	4.33	1.02	2.39	0.72	2.20	0.83	3.45	1.00	***4.13****	1.35
7	4.00	1.00	3.90	0.94	−0.31	0.10	2.50	0.89	3.60	0.75	***3.84****	1.35
8	3.76	1.18	4.05	1.02	0.88	0.26	2.70	1.03	3.65	0.99	2.99	0.94
9	3.62	1.07	3.62	1.07	0.00	0	2.30	0.98	2.90	1.02	1.90	0.60
10	4.38	0.86	4.76	0.44	1.53	0.58	2.75	1.07	3.65	1.04	2.77	0.85
11	3.71	1.15	4.10	0.83	1.24	0.39	2.30	0.73	3.25	1.02	3.21	1.05
12	4.19	1.12	3.67	1.20	−1.58	0.45	2.95	0.89	3.90	0.72	3.35	1.19
13	4.19	0.98	4.14	0.96	−0.16	0.05	3.30	1.13	2.60	0.99	−2.15	0.66
14	4.00	1.10	3.81	1.21	−0.57	0.16	2.95	1.10	2.65	0.81	−0.97	0.32
15	4.14	1.11	4.29	0.72	0.48	0.16	3.00	1.12	3.40	0.88	1.26	0.40
16	4.05	1.07	4.19	1.03	0.45	0.14	3.15	1.14	3.40	0.99	0.77	0.24
17	3.90	1.09	4.52	0.68	2.13	0.70	2.25	0.72	3.35	1.04	***3.71****	1.21
18	4.38	0.80	4.71	0.46	1.36	0.52	1.95	0.89	3.65	0.93	***5.63****	1.86

[a] 1 = not important, 2 = fairly important, 3 = important, 4 = very important, 5 = extremely important. [b] 1 = very easy, 2 = easy, 3 = neutral, 4 = hard, 5 = very hard.
[c] Adjusted with Bonferroni correction *p < 0.001.

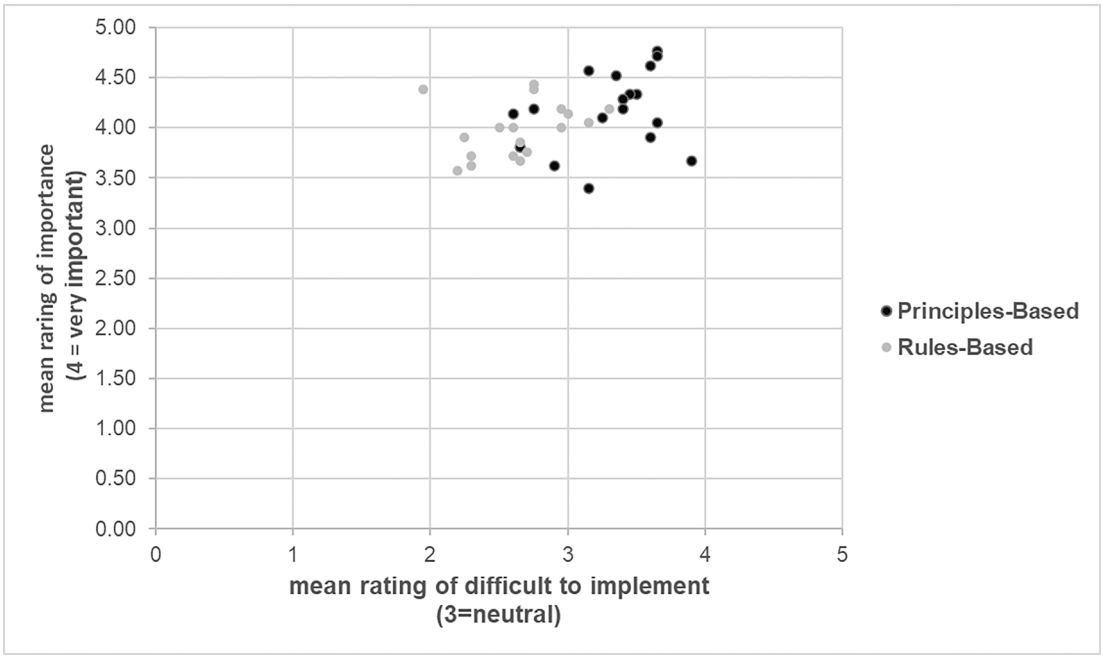

Fig. 2. Mean rating of 36 practices for ease of implementation and importance.

(cited by 13 participants) were 'promote a culture where failures, incidents and accidents are seen as opportunities for growth, learning and improvement', and 'recognize that human errors can occur due to factors such as fatigue, stress, workload and poor organisation of work, and put in place strategies to mitigate associated risks', while 'employing a variety of communication mediums tailored to specific contexts and audiences' was not included in the 'top 9′ by anyone (Table 4).

The most commonly identified practice that was difficult to implement was 'foster an environment that encourages informed risk-taking, empowering individuals to make risk-based decisions', cited by 16 participants (Table 4). Four practices were never included in any participant's selection of the 'top 9′ most difficult practices to implement. These were 'establish a process for investigating incidents and making recommendations for change', 'implement a structured review process to ensure competent evaluation and scrutiny of risk assessments for improved quality and effectiveness', 'establish clear roles and responsibilities with RACI charts' and 'implement processes for feedback collection, conducting reviews and evaluating performance to identify areas of improvement'.

Five practices (4 principles-based and 1 rules-based) were considered both important and difficult to implement by more than a third of participants (Table 4). Conversely, 22 practices were considered important and difficult to implement by six or fewer participants in round 1 of the survey (Table 4) and consequently discarded from consideration in subsequent rounds of the survey.

In the second round of survey (Table 4) the two practices most commonly indicated (cited by 17 participants) as being important were 'promote a culture where failures, incidents, and accidents are seen as opportunities for growth, learning and improvement', and 'foster visible leadership at all levels, prioritizing safety and promoting leaders' understanding of the impacts of their decisions', while 'continuously adapting and refining terminology and management systems to meet evolving needs and foster agile practices' was recognised by only one of 26 respondents as important. 'Foster an environment that encourages informed risk-taking, empowering individuals to make risk-based decisions' was the practice most indicated to be difficult to implement (cited by 19 participants). Nobody indicated that 'establish a process for investigating incidents and making recommendations for change' was difficult to implement.

Responses from round three of the survey were consistent with those in round two. In the third round of survey (Table 4) most participants (cited by 18) still considered 'promote a culture where failures, incidents and accidents are seen as opportunities for growth, learning and improvement' as being important, but emphasized equally 'integrate risk evaluation and management principles into decision-making processes, assuring that risks are appropriately considered and addressed' and 'foster visible leadership at all levels'. 'Enable individuals and groups to adapt and innovate to improve practices' was seen as important by only 2 participants. Two practices were often considered difficult to implement. They were 'promote a culture where failures, incidents, and accidents are seen as opportunities for growth, learning and improvement' (cited by 16), and 'foster an inclusive environment that values and shares diverse perspectives and enables collaboration and information sharing' (cited by 15). Once more, nobody indicated that 'establish a process for investigating incidents and making recommendations for change' was difficult to implement.

Of the 14 practices that at least one third of respondents to the round 1 survey included in their selection of 9 practices that were important or difficult to implement, some were always rated as important or difficult to implement by more survey respondents than others (see Table 4). Comparing combined responses from participants for the selection of particular practices for either ease of implementation or importance showed no significant difference between the three rounds for either importance ($X^2 = 14.8$; df = 26) or for difficulty of implementation ($X^2 = 10.65$; df = 26).

4.3. *Reasons for importance and ease of implementation of safety practices*

Participants generated a total of 83 statements providing reasons for why the 10 identified practices, indicated by at least a third of respondents as being in their top 25 % of practices in the first round of the survey, were considered to be important. Often individual reasons for a particular practice were duplicated by others, and so summaries of these reasons for each of the 10 practices are provided in Table 5. These have been abstracted into a single statement for each practice. Integrating all of these reasons suggests that practices are considered to be important if they encourage a system-wide view that includes a consideration of

Table 4
Number of survey participants including each of the identified practices in their selection for importance and difficulty of implementation in the three rounds of surveys.

Statement of practice	Survey round 1[a] (n = 21)		Survey round 2[b] (n = 26)		Survey round 3[b] (n = 25)	
	Importance	Difficult to implement	Importance	Difficult to implement	Importance	Difficult to implement
Promote a culture where failures, incidents, and accidents are seen as opportunities for growth, learning and improvement.	***13***	***15***	17	16	18	16
Foster an inclusive environment that values and shares diverse perspectives and enables collaboration and information sharing.	***12***	***13***	13	16	12	15
Foster an inclusive culture that supports open dialogue and learning.	***12***	***13***	14	10	13	10
Foster visible leadership at all levels, prioritizing safety and promoting leaders' understanding of the impacts of their decisions.	***11***	***11***	17	10	14	12
Recognize that human errors can occur due to factors such as fatigue, stress, workload and poor organisation of work, and put in place strategies to mitigate associated risks.	***13***	***8***	10	6	11	11
Foster a culture of shared responsibility for safety	***7***	***7***	4	8	3	7
Simplify procedures and streamline processes to make work practices easily accessible and user-friendly	***10***	4	9	5	8	3
Integrate risk evaluation and management principles into decision-making processes, assuring that risks are appropriately considered and addressed.	***9***	2	14	5	14	8
Establish a process for investigating incidents and making recommendations for change.	***8***	0	3	0	4	0
Develop staff with the skills and capabilities to cope with and meet dynamic operational requirements.	***7***	5	7	8	7	10
Foster an environment that encourages informed risk-taking, empowering individuals to make risk-based decisions.	3	***16***	7	19	5	12
Embrace a participative approach to change, conveying the purpose of the change and involving all levels of the organization.	6	***13***	11	12	11	9
Continuously adapt and refine terminology and management systems to meet evolving needs and foster agile practices.	2	***8***	1	6	3	5
Enable individuals and groups to adapt and innovate to improve practices.	5	***7***	3	9	2	7
Embrace, modify and constantly evolve risk evaluation approaches to incorporate promising practices.	2	6				
Provide resources that support work-life balance, mental health, and overall wellbeing.	3	6				
Customize development to the unique needs of individual and organization, enabling the development of both technical and soft skills, and evolving as those needs change.	2	6				
Develop documentation, including procedures and instructions, that encourages informed decision making and thoughtful application.	4	4				
Develop the capability of individuals and teams to deal with emergency situations and quickly respond to emergent, unexpected issues and problems.	6	4				
Deepen the understanding of maintenance quality's impact on process safety and adapt practices accordingly for ongoing improvement and effectiveness.	2	4				
Enable the judicious, transparent and effective application of the principles of governance, policy and regulation.	1	4				
Develop shared understanding and enable the effective management of changes in equipment or system design.	2	3				
Implement robust resource planning processes that consider workload, capacity, and availability to effectively allocate resources.	3	3				
Create clear design specifications, risk registers and standards for equipment or system design.	3	3				
Design and implement a system that assesses, monitors and assures the competence of employees, aligning their skills and knowledge with their roles.	6	3				
Establish well-defined procedures that dictate the response protocols during emergencies, ensuring swift and effective actions in a crisis.	2	3				
Provide leadership skills training encompassing communication, decision-making, and safety.	3	3				
Establish internal governance processes to ensure compliance with the relevant laws and regulations that apply to the organization's operations.	4	2				
Recognise, value and celebrate employee contributions, fostering a positive environment that boosts morale and enhances engagement.	4	2				
Employ a variety of communication mediums tailored to specific contexts and audiences for effective communication.	0	2				
Utilize standard terminology and accessible, transparent quality management systems to ensure consistent and auditable practices.	2	2				
Establish and utilize a structured process to effectively manage change, ensuring safe implementation and minimizing potential risks.	5	2				
Evaluate data, including breakdown occurrences and resource availability, to optimize maintenance schedules.	5	1				
Implement a structured review process to ensure competent evaluation and scrutiny of risk assessments for improved quality and effectiveness.	4	0				

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Table 4 (*continued*)

Statement of practice	Survey round 1[a] (n = 21)		Survey round 2[b] (n = 26)		Survey round 3[b] (n = 25)	
	Importance	Difficult to implement	Importance	Difficult to implement	Importance	Difficult to implement
Establish clear roles and responsibilities with RACI charts (Responsible-Accountable-Consulted-Informed)	1	0				
Implement processes for feedback collection, conducting reviews, and evaluating performance to identify areas of improvement.	3	0				

[a] Items in bold italics were selected by 7 or more participants in their 'top 9' for importance or difficulty of implementation and carried forward into survey round 2.
[b]Number of participants including item in 'top 5' from 14 items carried forward from survey round 1.

people, and if they enable more effective working in a dynamic environment and permit learning.

Similarly, participants generated 92 statements, in total, providing reasons why each of the 10 identified practices were difficult to implement. For each practice summaries of the reasons are provided in Table 6. Aggregating these statements across the 10 practices suggests that practices are difficult to implement if they require well developed relationships that enable clear and open communication, and an understanding of the interactive nature of the system and the implicit tensions, and also if they remove the sense of control implicit in current practices.

5. Discussion

This investigation sought to answer two questions: how do safety professionals frame safety practices? and how do safety professionals perceive both the importance and ease of implementation of these practices in achieving safety? Current knowledge of safety professionals and their role and the literature on frames and framing suggests strongly that safety professionals are likely to have a repertoire of frames that help them identify preventive safety measures to mitigate incidents and accidents. Through a Delphi method, this study reveals that experienced safety professionals framed safety practices as both rules and principles, adding to the surprisingly limited empirical data on the work of safety professionals (Provan et al., 2017; Guennoc et al., 2019), and providing much needed empirical validation for the earlier studies conceptualizing safety rules (Hale and Swuste, 1998; Hale and Borys, 2013; Grote, 2015; Weichbrodt, 2015). The implications of these novel findings are considered below. While safety professionals recognised the importance of rule-based practices for safety they considered principles-based practices to be even more necessary, especially in dynamic environments. They also acknowledged that principles-based practices were harder to implement. The 18 practices identified here closely resemble the 15 higher-order categories of safety causation that reflect the beliefs of experienced safety professionals about practices to mitigate failure and ensure safety identified by Carroll et al. (2022) in a survey of safety practitioners in the US. Significantly in that study practices were not differentiated into those framed as rules or as principles.

Classical methods of managing risk and assuring safety emphasize control often through the standardization of practices (Provan et al., 2020). This is most easily achieved by establishing rules that define and shape how activities are performed and by whom, and which offer certainty and predictability in a stable environment (Grote, 2015). However, emergence is an inherent property of complex systems, and therefore as organizational systems become more complex, so they become less stable, more unpredictable and more uncertain. Consequently, greater flexibility is required than would be permitted by 'formalized rules' (Dekker, 2014). In such situations Grote (2015) argued for 'flexible rules' that support adaptive action and empowerment thereby securing locally appropriate responses. These 'flexible rules' resemble the notion of principles-based practices identified in the findings of this Delphi study, while the rules-based practices correspond to Dekker's 'formalized rules'. Hale and Swuste (1998) had earlier identified different types of rules, notably goal and action rules, which respectively define the 'what' and the 'how' of a particular activity, but without providing empirical evidence to support this. These correspond respectively to the principles-based and rules-based safety practices identified in this empirical study.

As systems become more complex, the efficacy of rules-based practices to safety is likely to decrease and therefore some might advocate for a wholly principles-based approach, contrary to the 'centralized control' approach suggested by Provan et al. (2020) as being adopted routinely by safety professionals. This dualism, however, does not resonate with the views of the safety professionals in this Delphi study, who offered both as important means of mitigating adverse events, and discussed them interchangeably in the workshops suggesting that they were able to operate as both controllers and guides (Provan et al., 2020).

Holding the two frames simultaneously these safety professionals seemed neither to engage in 'framing contests' (Kaplan, 2008) nor experience cognitive dissonance which commonly occurs when individuals hold contradictory beliefs. There may be several related explanations for this. First, the frames considered in this study are prognostic, seeking to provide mitigating solutions to prevent the occurrence of an incident, rather than diagnostic, seeking to explain what has happened. Hindsight bias and the heuristics of availability and representativeness (Tversky and Kahneman, 1973) encourage the swift adoption of single (often simple) explanations for an incident but these may not constrain the identification of possible solutions for a potential incident. So, based on their wide experience, there may be several different frames offering potential solutions to mitigate possible accidents, as seems to be the case here. Second, the study focused participant attention on generic solutions to mitigate accidents, rather than on identifying solutions to a particular situation, which allowed participants to engage in a more general consideration of the topic. Furthermore, they were aware that the final outcome would not be scrutinized subsequently by others, who might hold a contrary view, and would challenge the legitimacy of their proffered solutions. In this way the participants may have had greater freedom to consider a wider array of options rather than being constrained by an institutionalized view of risk and how to respond to it. In their analysis of how workers at the 'sharp end' of a multinational Oil & Gas and Petrochemicals company integrated error prevention and error management practices to mitigate adverse consequences, Cowley et al. (2021) report a similar occurrence. They observed that while actors held a broad array of constructs that embraced both of these approaches as indicated by the use of a repertory grid technique, in their discussion of incidents during interviews actors focused mainly on error prevention. This suggests a mismatch between the error constructs that people think are important and the practices they are willing to discuss and document, which perhaps need to reflect a more 'acceptable' discourse of prevention. Third, the consideration and acceptance of more than one frame might also be a function of the extensive experience of the participants, and a growing maturity in the global discussion around safety that recognises the limits of prescription (Bieder and Bourrier, 2013) in increasingly complex interactive systems.

The coexistence of these apparently contradictory elements creates a paradoxical situation (Smith and Lewis, 2011; Lewis and Smith, 2014).

Table 5
Reasons given for the importance of specific practices identified by experts in a Delphi study.

Statement of practice (rules-based practices in italics)	Summary statements. **It is important because…**	Overall: **This is important because …**
Promote a culture where failures, incidents, and accidents are seen as opportunities for growth, learning and improvement.	It permits continuous improvement; discourages blame; the past can provide lessons for the future	It encourages learning (including reflection / recollection)
Recognize that human errors can occur due to factors such as fatigue, stress, workload and poor organisation of work, and put in place strategies to mitigate associated risks.	It brings people into the system; human factors matter; external circumstances influence how people act and behave.	People are part of the system, and how they are affected by the system is often overlooked
Foster an inclusive environment that values and shares diverse perspectives and enables collaboration and information sharing.	Breadth of experience identifies more safety issues; it promotes effective team working and higher performance	It provides a more complete / comprehensive view of the system
Foster an inclusive culture that supports open dialogue and learning.	It allows expression / acceptance of diverse perspectives; encourages transparency and information sharing; safety involves everyone, and all should be heard	It captures a wider perspective of the whole system and encourages sharing and transparency
Foster visible leadership at all levels, prioritizing safety and promoting leaders' understanding of the impacts of their decisions.	It role models desirable behaviours; it builds trust; embeds safety in the core of organizational activity	It role models desirable behaviours building trust. It ensures causes and effects of safety are integrated into the system
Simplify procedures and streamline processes to make work practices easily accessible and user-friendly	It ensures processes more likely to be followed and reduces short-cuts; allows easier integration; easier to explain and train; more efficient	Processes are more likely to be followed, improving efficiency. It positively effects other activities (like training and monitoring).
Integrate risk evaluation and management principles into decision-making processes, assuring that risks are appropriately considered and addressed.	It reduces future risks and so likelihood of incidents; allows effective prioritisation of resources; keeps risk considerations 'visible' allowing learning; it broadens perspectives and encourages a systems view	It integrates safety considerations into all decisions, and reduces future risks (and incidents) through better resourcing
Establish a process for investigating incidents and making recommendations for change.	It enables learning and permits change; It reduces repeat work; It builds resilience	It allows learning and reduces repetition of work, saving resources
Develop staff with the skills and capabilities to cope with and meet dynamic operational requirements.	Hazards and risks are dynamic and so the response must be also; environment is dynamic and complex; adaptability is required	Context (and therefore hazards and risks) is dynamic
Foster a culture of shared responsibility for safety	Safety is a collective responsibility / activity; safety is integral to work; encourages collective engagement; allows more effective monitoring	Safety is a collective responsibility

Table 6
Reasons given for the difficulty of implementation of specific practices identified by experts in a Delphi study.

Statement of practice (rules-based practices in italics)	Summary statements. **It is difficult to implement because…**	Overall: **It is difficult to implement because …**
Promote a culture where failures, incidents, and accidents are seen as opportunities for growth, learning and improvement.	Lessons are rarely shared extensively or applied appropriately; blame is easier; of fear of speaking up	Appropriate lessons are not easily identified and implemented following an incident, and blame is easier
Foster an inclusive environment that values and shares diverse perspectives and enables collaboration and information sharing.	Consensus is difficult to achieve; it requires a long-term view; it is time consuming; of suspicion / distrust between stakeholders	It requires trusting relationships, and these take time to develop
Foster an inclusive culture that supports open dialogue and learning.	The number of stakeholders is often extensive; people are undervalued; it requires a variety of communication strategies for different stakeholder groups; it needs commitment from everyone	Appropriate communications with a wide variety of different stakeholders are challenging. Individuals need to take ownership and develop a sense of belonging
Foster visible leadership at all levels, prioritizing safety and promoting leaders' understanding of the impacts of their decisions.	Of counteracting pressures (often with more immediate tangible personal consequences); every decision has a safety component that is not clearly understood	There are conflicting pressures in the organization (and safety may not be the most pressing)
Recognize that human errors can occur due to factors such as fatigue, stress, workload and poor organisation of work, and put in place strategies to mitigate associated risks.	Of failure to understand interaction of people with system; effect of organizational context on individual performance is not well understood and poorly managed	Interaction between people and wider system (including technology and other people) is poorly understood and not managed well.
Foster an environment that encourages informed risk-taking, empowering individuals to make risk-based decisions.	The concept of risk is generally poorly understood, and it would need buy-in to a shared understanding of risk; fear of loss of control, or blame if something goes wrong	Risk is not well understood, and a common view is not shared. Fear of loss of control
Embrace a participative approach to change, conveying the purpose of the change and involving all levels of the organization.	Requires engagement from a wider range of stakeholders who may have conflicting perspectives; benefits to all stakeholder groups often unclear and so difficult to communicate; time / cost implications	Engaging effectively with a wide range of diverse stakeholders is demanding
Continuously adapt and refine terminology and management systems to meet evolving needs and foster agile practices.	It runs counter to standardisation; there is security in stable documentation; it implies continuous change which is challenging / uncomfortable	It runs counter to standardisation. It requires an understanding of 'work as done' not 'work as imagined'.
Enable individuals and groups to adapt and innovate to improve practices.	Preference is for familiar ways of working; skill sets are unavailable and investment in teams is lacking; of possible loss of control and introduction of risk	It risks apparent loss of control in departing from familiar ways of working. Investment in necessary skills is lacking
Foster a culture of shared responsibility for safety	It takes time and involves everyone; risks loss of	It requires engagement with everyone to build

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Table 6 (*continued*)

Statement of practice (rules-based practices in italics)	Summary statements. **It is difficult to implement because…**	Overall: **It is difficult to implement because …**
	control; lack of trust; not everyone understands that all are involved	trust to mitigate perceived / actual loss of control.

To resolve this, we suggest that both rules-based and principles-based approaches act as a duality, to create an integrated whole, rather than as a dualism, where they are in opposition to each other. Both approaches are necessary to manage safety in complex organizational systems that are faced with contradictory demands (Smith and Lewis, 2011). Rules need principles to prevent the exploitation of gaps (Black, 2008). Not every circumstance is covered by a rule, and opportunism arises where there are no rules. Principles remove the ambiguity about what is required. Conversely, principles need rules to make them tractable (Black, 2008). Rules remove the ambiguity about how something should be done. Dekker (2014, p.355) comments that "a balance between controlled safety and managed safety, between deference to protocol and procedure, and practical expertise on the other, is likely the broadest and most useful prescription". Whilst rules-based and principles-based practices are dichotomised in this paper for the purpose of explanation, Beauchamp and Childress (2001) appreciate the 'loose distinction' between the two and suggest that there is a spectrum that ranges from high-level principles to detailed rules, and practices can be tailored along this spectrum according to the organisational objectives.

This balanced approach has implications for the governance and regulation of organizational systems. In particular it is characteristic of adaptive governance occurring in systems that are dynamic, complex and uncertain (Chaffin and Gunderson, 2016). In these situations, adaptive governance is seen as a robust solution for organizing structures and processes to achieve locally effective and resilient solutions (Rijke et al., 2012). The more important practices from the 36 considered by participants in workshop 3 were those that took a systemic view and enabled effective operations in a dynamic environment. Adaptive governance contrasts with traditional approaches to governance (Brunner, 2010), including safety management, which rely on centralized decision-making, the creation of plans and targets, the deployment of generalizable practices and the assumption of linear and predictable outcomes. These fail, however, where outcomes are contingent upon interactions between many different factors, as is often the case in safety incidents and moreover in organizational systems as they become more complex. Such situations require flexibility and responsiveness to local conditions, because as Rochlin (1999, p.1558) notes "'operational safety' is not capturable by a set of rules or procedures". However, it should be acknowledged that principles-based approaches are more difficult to implement than rules-based approaches (Black et al., 2007). Nine of the 10 top practices identified through the survey in this study as difficult to implement were principles-based. Participants explained that this was because they required not only an understanding of the interactive nature of the system, but also positive working relationships between all of the various stakeholders in the system that affords open communication and empowerment of others (Gibbons et al., 2023).

5.1. Practical application

Through the Delphi process safety professionals generated findings with important practical applications. First, the identification of both rules-based and principles-based framing of the practices to mitigate failure permits a contingency based approach for the management of safety in organizational systems. Depending on the context, one or other of these approaches will be more appropriate. In highly centralized organizations or those demanding efficient and effective completion of tasks, then rules-based approaches may be more appropriate, although as Jeffcott et al. (2006) warn this may lead to a compliance culture. In contrast, in organizations that are decentralized and encourage adaptability a principles-based approach may be preferred. Similarly, principles-based approaches may be more appropriate in collectivist cultures, which are "more receptive to concern-driven or precautionary-principle approaches, necessitating communication with a wide audience of stakeholders" (Luther et al., 2023, p.7), and where there are strong social controls, than in the individualistic cultures characteristic of developed countries in the west (Arjoon, 2006). Recognising the context specific application of either rules- or principles-based approaches also suggests that OSH professionals (and others) need to develop competence in distinguishing when either is appropriate. Taking the wrong approach in a particular context will inevitably lead to failure. Clearly, this requires professional judgement and a wider acceptance that sometimes mistakes will be made, and failures occur (Power, 2004).

Second, differentiating between rules-based and principles-based framing of safety practices has implications for written policies and procedures and how these shape the practice of safety management in organizations. Adopting a principles-based approach may reverse the proliferation of rules accompanying the 'bureaucratization' of safety (Dekker, 2014). A principles-based approach may be more effective as a means of ensuring safety as organizational complexity increases (Bieder and Bourrier, 2013). Similarly, this differentiation also has implications for the language used in accident and inquiry reports. Recommendations written as rules are easier to check than those written as principles making compliance post incident easier to monitor. They may however fail to encourage the tackling of systemic issues underlying the incident. Principles-based recommendations would permit the adaptive responses that may be required in the aftermath of an incident.

Third, extending beyond the organizational level, the distinction between rules-based and principles-based practices has implications for the design of the regulatory regime and regulatory practices (May 2007). Rules characterize prescriptive regulatory systems providing certainty, clear standards of behaviour and standardized practices, but lead to rigidity and inflexibility and necessitate constant readjustments to new situations making these systems increasingly complex (Black, et al., 2007). Principles, on the other hand, are consistent with performance-based regulation that has a results or outcomes focus. These offer flexibility and encourage responsiveness and mitigate 'tick-box' compliance. But lacking certainty they encourage the proliferation of guidance notes both internally and externally, and this risks becoming a required practice (Black, et al., 2007).

5.2. Limitations of the study and future work

The limitations of the work are immediately apparent, and these provide opportunities for further study. First, the study was UK-centric. The safety professionals recruited to the Delphi process were all based in the UK and consequently may share common beliefs about safety based on the experience of a common legislative and regulatory context. There is naturally an opportunity for comparison of these findings with those from professionals elsewhere. Second, the study selected experts. An inevitable consequence is that some voices, which may have alternative views, were excluded. Replicating the process with a more diverse population may give different results, although their level of experience would likely be less perhaps limiting the level of insight. Third, the incidents used as exemplars in workshop 1 of the study were not restricted to a specific sector. While this supports the generalizability of the findings, it does assume that accidents and incidents are caused in similar ways irrespective of sector and that practices to prevent or mitigate them are also similar. Repeating the process on a sector basis may provide unique practices, although identifying sufficient safety professional to support a Delphi study may be a practical challenge in some sectors. A fourth limitation is the small sample from which the data were collected, although their extensive combined experience in excess

of 800 years may mitigate this. Furthermore, this small sample was eroded further as the study progressed. However, this is characteristics of Delphi studies, and the attrition rate here was less than that observed in many other studies, as discussed above.

In addition to the opportunities for further work highlighted by these limitations, another avenue worthy of further exploration presents itself. Developing further the framing perspective (Chong and Druckman, 2007; Cornelissen and Werner, 2014) adopted here may provide insights into different understandings of the nature and basis of safety and the practices that achieve it in different settings. By using quantitative comparative analysis (QCA) (Ragin, 1987) it would be possible to identify common configurations of safety practices for particular situations.

6. Conclusion

Safety professionals engage in a wide variety of practices to generate and maintain safety in organizational systems. Using a Delphi method, safety professionals in the study identified a common set of 18 practices that could be deployed to mitigate the occurrence of safety incidents in organizational systems. This study is the first empirical investigation to show the differentiation of these practices into rules-based and principles-based practices that others have conceptually highlighted previously. These two frames of practice form a duality. Both frames were present in the repertoire of frames held by safety professionals, and both were deemed important and necessary for effective safety management and the prevention of incidents in complex organizational systems. Nevertheless, practices framed as principles were generally perceived to be more difficult to implement than those framed as rules, perhaps explaining the reported tendency for OSH professionals to prefer ‘centralized control’ over ‘guided adaptability’.

CRediT authorship contribution statement

Colin Pilbeam: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **David Denyer:** Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Mike Sutliff:** Methodology, Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Amalberti, R., 2001. The paradoxes of almost totally safe transportation systems. Saf. Sci. 37, 109–126.
Arjoon, S., 2006. Striking a balance between rules and principles-based approaches for effective governance: a risks-based approach. J. Bus. Ethics 68, 53–82.
Beauchamp, T.L., Childress, J.F., 2001. Principles of biomedical ethics, 5th Edition. Oxford, Oxford University Press.
Belton, I., MacDonald, A., Wright, G., Hamlin, I., 2019. Improving the practical application of the Delphi method in group-based judgement: a six-step prescription for a well-founded and defensible process. Technol. Forecast. Soc. Chang. 147, 72–82.
Benford, R.D., Snow, D.A., 2000. Framing processes and social movements: an overview and assessment. Annu. Rev. Sociol. 26, 611–639.
Bieder, C., Bourrier, M., 2013. Concluding remarks. In: Bieder, C., Bourrier, M. (Eds.), Trapping Safety into Rules. CRC Press, Boca Raton, pp. 273–278.
Black, J., 2008. Forms and paradoxes of principles-based regulation. Capital Markets Law J. 3 (4), 425–457.
Black, J., Hopper, M., Band, C., 2007. Making a success of principles-based regulation. Law Financ. Mark. Rev. 1 (3), 191–206.
Bourrier, M., Bieder, C., 2013. Trapping safety into rules: an introduction. In: Bieder, C., Bourrier, M. (Eds.), Trapping Safety into Rules. CRC Press, Boca Raton, pp. 1–9.
Brunner, R.D., 2010. Adaptive governance as a reform strategy. Policy Science 43, 301–341.
Burgemeestre, B., Hulstijn, J., Tan, Y.-H., 2009. Rule-based versus principle-based regulatory compliance. In: Governatori, G. (Ed.), Frontiers in Artificial Intelligence and Applications (JURIX 2009). IOS Press, Amsterdam, pp. 37–46.
Carroll, J.S., Pfeiffer, Y., Nowak, H., Friis, S., 2022. The variety of beliefs about the causes of safety among safety practitioners. Saf. Sci. 148, 105641.
Chaffin, B.C., Gunderson, L.H., 2016. Emergence, institutionalization and renewal: Rhythms of adaptive governance in complex social-ecological systems. J. Environ. Manage. 165, 81–87.
Chong, D., Druckman, J.N., 2007. Framing theory. Annu. Rev. Polit. Sci. 10, 103–126.
Cornelissen, J.P., Werner, M.D., 2014. Putting framing in perspective: a review of framing and frame analysis across the management and organizational literature. Annals Acad. Manage. 8, 181–235.
Cowley, C., Denyer, D., Kutsch, E., Turnbull James, K., 2021. Constructing safety: reconciling error prevention and error management in Oil & Gas and Petrochemicals operations. Acad. Manage. Discoveries 7 (4), 554–580.
Day, J., Bobova, M., 2005. A generic toolkit for the successful management of Delphi studies. Electron. J. Business Res. Methodol. 3 (2), 103–116.
Dekker, S.W.A., 2005. Ten questions about human error: a new view of human factors and system safety. Lawrence Erlbaum, New Jersey.
Dekker, S.W.A., 2014. The bureaucratization of safety. Saf. Sci. 70, 348–357.
Denyer, D., 2017. Organisational Resilience: a summary of academic evidence, business insights and new thinking. BSI and Cranfield School of Management, UK.
Drumm, S., Bradley, C., Moriarty, F., 2022. ‘More of an art than a science’? The development, design and mechanics of the Delphi technique. Res. Soc. Adm. Pharm. 18, 2230–2236.
Duchek, S., 2020. Organisational resilience: a capability-based conceptualization. Bus. Res. 13, 215–246.
Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annu. Rev. Env. Resour. 30, 441–473.
Foster, C.J., Plant, K.L., Stanton, N.A., 2020. A Delphi study of human factors methods for evaluation of adaptation in safety-related organisations. Saf. Sci. 131, 104933.
Gibbons, R., Grieder, M., Herz, H., Zehnder, C., 2023. Building an equilibrium: rules vs. principles in relational contracts. Organ. Sci. 34 (6), 1997–2525.
Goffman, E., 1974. Frame Analysis. Harper Row, New York.
Grint, K., 2005. Problems, problems, problems: The social construction of leadership. Hum. Relat. 58 (11), 1467–1494.
Grote, G., 2015. Promoting safety by increasing uncertainty – implications for risk management. Saf. Sci. 71, 71–79.
Guennoc, F., Chauvin, C., Le Coze, J.-C., 2019. The activities of occupational health and safety specialists in a high-risk industry. Saf. Sci. 112, 71–80.
Hale, A., Borys, D., 2013. Working to rule, or working safely? Part 1: a state of the art review. Saf. Sci. 55, 207–221.
Hale, A.R., Guldenmund, F.G., 2006. Role and tasks of safety professionals: Some results from an international survey. Safety in Action: Melbourne.
Hale, A.R., Swuste, P., 1998. Safety rules: procedural freedom or action constraint? Saf. Sci. 29, 163–177.
Hashemian, S.M., Triantis, K., 2023. Production pressure and its relationship to safety: a systematic review and future directions. Saf. Sci. 159, 106045.
Hirschhorn, F., 2019. Reflections on the application of the Delphi method: lessons from a case in public transport research. Int. J. Soc. Res. Methodol. 22 (3), 309–322.
Hollnagel, E., 2014. Safety-I and Safety-II: The past and future of safety management. Ashgate Publishing Limited, Surrey, UK.
Hollnagel, E., Woods, D.D., Leveson, N., 2006. Resilience engineering: concepts and precepts. Ashgate Publishing Limited.
Hopkins, A., 2011. Risk-management and rule-compliance: Decision-making in hazardous industries. Saf. Sci. 49, 110–120.
Jeffcott, S., Pidgeon, N., Weyman, A., Walls, J., 2006. Risk, trust and safety culture in UK train operating companies. Risk Anal. 26 (5), 1105–1121.
Kaplan, S., 2008. Framing contests: strategy making under uncertainty. Organ. Sci. 19 (5), 729–752.
Keeney, S., Hasson, F., McKenna, H., 2006. Consulting the oracle: ten lessons from using the Delphi technique in nursing research. J. Adv. Nurs. 53 (2), 205–212.
Klamar, A., Horvath, D., Frese, M., Keith, N., 2024. Different approaches to learning from errors: Comparing the effectiveness of high reliability and error management approaches. Saf. Sci. 177, 106578.
Lewis, M.W., Smith, W.K., 2014. Paradox as a metatheoretical perspective: sharpening the focus and widening the scope. J. Appl. Behavioral Sci. 50 (2), 127–149.
Luther, B., Gunawan, I., Nguyen, N., 2023. Identifying effective risk management frameworks for complex socio-technical systems. Saf. Sci. 158, 105989.
Mascini, P., 2005. The blameworthiness of health and safety rule violation. Law Policy 27 (3), 472–490.
Maslen, S., Ransan-Cooper, H., 2017. Safety framing and compliance in relation to standards: Experience of the Australian gas pipeline industry. Saf. Sci. 94, 52–60.
May, P.J., 2007. Regulatory regimes and accountability. Regulat. Governance 1, 8–26.

Melander, L., 2018. Scenario development in transport studies: Methodological considerations and reflection on Delphi studies. Futures 96, 68–78.
Midtlyng, G., 2022. Safety rules in a Norwegian high-security prison: the impact of social interaction between prisoners and officers. Saf. Sci. 149, 105690.
Murphy, J., Denyer, D., Pettigrew, A., 2021. The role of framing mechanisms in explaining system-wide change: The case of the Northern Ireland conflict and peace process. Br. J. Manag. 31 (3), 407–427.
Neri, A., Cagno, E., Paredi, S., 2022. The mutual interdependencies between safety and operations: a systematic literature review. Saf. Sci. 153, 105812.
Nicolaidou, O., Dimopoulos, C., Varianou-Mikellidou, C., Mikellides, N., Boustras, G., 2022. Weak signals management in occupational safety and health: a Delphi study. Saf. Sci. 146, 105558.
Nowack, M., Endrikat, J., Guenther, E., 2011. Review of Delph-based scenario studies: quality and design considerations. Technol. Forecast. Soc. Chang. 78, 1603–1615.
Oguz Erkal, E.D., Hallowell, M.R., Bhandari, S., 2023. Formal evaluation of construction safety performance metrics and a case for a balanced approach. J. Saf. Res. 85, 380–390.
Okoli, C., Pawlowski, S.D., 2004. The Delphi method as a research tool: an example, design considerations and applications. Inf. Manag. 42, 15–29.
Paré, G., Cameron, A.-F., Poba-Nzaou, P., Templier, M., 2013. A systematic assessment of rigor in information systems ranking-type Delphi studies. Inf. Manag. 50, 207–217.
Powell, C., 2003. The Delphi technique: myths and realities. J. Adv. Nurs. 41 (4), 376–382.
Power, M., 2004. The risk management of everything. J. Risk Financ. 5 (3), 58–65.
Provan, D.J., Dekker, S.W.A., Rae, A.J., 2017. Bureaucracy, influence and beliefs: a literature review of the factors shaping the role of a safety professional. Saf. Sci. 98, 98–112.
Provan, D.J., Rae, A.J., Dekker, S.W.A., 2019. An ethnography of the safety professional's dilemma: Safety work or the safety of work? Saf. Sci. 117, 276–289.
Provan, D.J., Woods, D.D., Dekker, S.W.A., Rae, A.J., 2020. Safety II professionals: How resilience engineering can transform safety practice. Reliab. Eng. Syst. Saf. 195, 106740.
Ragin, C.C., 1987. The comparative method: moving beyond qualitative and quantitative strategies. University of California press, Berkeley.
Rasmussen, J., 1997. Risk management in a dynamic society: a modelling problem. Saf. Sci. 27 (2/3), 183–213.
Reason, J., Parker, D., Lawton, R., 1998. Organizational controls and safety: the varieties of rule-related behaviour. J. Occup. Organ. Psychol. 71, 289–304.
Reiman, T., Rollenhagen, C., Pietikäinen, E., Heikkilä, J., 2015. Principles of adaptive management in complex safety-critical organizations. Saf. Sci. 71, 80–92.
Rijke, J., Brown, R., Zevenbergen, C., Ashley, R., Farrelly, M., Morison, P., van Herk, S., 2012. Fit-for-purpose governance: a framework to make adaptive governance operational. Environ Sci Policy 22, 73–84.
Rochlin, G.I., 1999. Safe operation as a social construct. Ergonomics 42 (11), 1549–1560.
Rowe, G., Wright, G., 2011. The Delphi technique: past, present, and future prospects – Introduction to the special issue. Technol. Forecast. Soc. Chang. 78, 1487–1490.
Schmidt, R.C., 1997. Managing Delphi Surveys using nonparametric statistical techniques. Decis. Sci. 28 (3), 763–774.
Selznick, P., 1957. Leadership in administration. Harper & Rowe, New York.
Sharma-Wallace, L., Velarde, S.J., Wreford, A., 2018. Adaptive governance good practice: Show me the evidence! J. Environ. Manage. 222, 174–184.
Smith, W.K., Lewis, M.W., 2011. Toward a theory of paradox: a dynamic equilibrium model of organizing. Acad. Manag. Rev. 36, 381–403.
Snook, S.A., 2000. Friendly Fire: The accidental shootdown of US Black Hawks over Northern Iraq. Princeton University Press.
Swuste, P., van Gulijk, C., Zwaard, W., Oosendorp, Y., 2014. Occupational safety theories, models and metaphors in the three decades since World War II, in the United States, Britain, and the Netherlands: a literature review. Saf. Sci. 62, 16–27.
Tversky, A., Kahneman, D., 1973. Availability: a heuristic for judging frequency and probability. Cogn. Psychol. 5 (2), 207–232.
Von der Gracht, H.A., 2012. Consensus measurement in Delphi studies. Review and implications for future quality assurance. Technol. Forecast. Soc. Chang. 79, 1525–1536.
Mauksch, S., von der Gracht, H.A., Gordon, T.J., 2020. Who is an expert for foresight? A review of identification methods. Technol. Forecast. Soc. Chang. 154, 119982.
Weichbrodt, J., 2015. Safety rules as instruments for organizational control, coordination and knowledge: implications for rules management. Saf. Sci. 80, 221–232.
Weick, K.E., 1995. Sensemaking in organisations. Sage Publications, Thousand Oaks, CA.
Weick, K.E., Sutcliffe, K.M. and Obstfeld, D. (1999). Organizing for high reliability: processes of collective mindfulness. Research in Organizational Behavior 1:81-123. R.S. Sutton and B.M Staw. Stanford: JAI Press.

Guided by principles or rules: a Delphi study on how safety professionals frame safety practices

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