rPOT
Revista Psicologia: Organizações & Trabalho
SBPOT

Safety Culture and Safety Performance in High-Reliability Organizations: A Synthesis of IDOCAL'S Contributions to the Literature

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Abstract

Improving safety culture and safety performance is a constant concern for companies operating in high-risk environments. For almost two decades, IDOCAL (the Research Institute of Personnel Psychology, Organizational Development and Quality of Working Life) has been contributing to advancing our understanding of these important concepts through theoretical development and empirical research. The objective of this article is to synthesize these contributions. Some of the most prominent are (1) the development of a framework for the evaluation of safety culture and its correlates based on the AMIGO model, (2) the establishment of the empowering leadership model as a valuable concept in safety leadership, and (3) the establishment of a three-dimensional safety performance model. In addition, the researchers within IDOCAL have made great progress in understanding the main predictors of safety performance, including empowering leadership and safety culture. Within this paper, IDOCAL's plans to advance this line of research in the coming years, by extending it from the nuclear power sector to other high-risk industries, are also outlined.

Keywords: safety culture, safety performance, high-reliability organizations.

Cultura de Segurança e Desempenho de Segurança em Organizações de Alta Confiabilidade: Uma Síntese das Contribuições do IDOCAL para a Literatura

Resumo

Melhorar a cultura de segurança e o desempenho de segurança é uma preocupação constante para empresas que operam em ambientes de alto risco. Há quase duas décadas, o IDOCAL (Instituto de Pesquisa em Psicologia do Pessoal, Desenvolvimento Organizacional e Qualidade de Vida no Trabalho) tem contribuído para o avanço da compreensão desses importantes conceitos por meio do desenvolvimento teórico e da pesquisa empírica. O objetivo deste artigo é sintetizar essas contribuições. Alguns dos mais proeminentes são (1) o desenvolvimento de uma estrutura para a avaliação da cultura de segurança e seus correlatos com base no modelo AMIGO, (2) o estabelecimento do modelo de liderança capacitadora como um conceito valioso em liderança de segurança, e (3) o estabelecimento de um modelo tridimensional de desempenho de segurança. Além disso, os pesquisadores do IDOCAL fizeram um grande progresso no entendimento dos principais preditores de desempenho de segurança, incluindo capacitação de liderança e cultura de segurança. Neste documento, os planos do IDOCAL para avançar esta linha de pesquisa nos próximos anos, estendendo-a do setor de energia nuclear a outras indústrias de alto risco, também são descritos.

Palavras-chave: cultura de segurança, desempenho de segurança, organizações de alta confiabilidade.

Cultura de Seguridad y Desempeño de Seguridad en Organizaciones de Alta Fiabilidad: Una Síntesis de las Contribuciones de IDOCAL a la Literatura

Resumen

Mejorar la cultura de la seguridad y el desempeño de seguridad es una preocupación constante para las empresas que operan en entornos de alto riesgo. Durante casi dos décadas, IDOCAL (el Instituto de Investigación en Psicología de los Recursos Humanos, Desarrollo Organizacional y Calidad de Vida Laboral) ha contribuido a mejorar nuestra comprensión de estos importantes conceptos a través del desarrollo teórico y la investigación empírica. El objetivo de este artículo es sintetizar estos aportes. Algunos de los más destacados son (1) el desarrollo de un marco para la evaluación de la cultura de la seguridad y sus correlatos basado en el modelo AMIGO, (2) el establecimiento del modelo de liderazgo empoderador como un concepto valioso en el liderazgo en seguridad, y (3) el establecimiento de un modelo tridimensional de desempeño de seguridad. Además, los investigadores de IDOCAL han logrado grandes avances en la comprensión de los principales predictores del desempeño en seguridad, incluido el liderazgo de empoderamiento y la cultura de seguridad. En este trabajo también se describen los planes de IDOCAL para avanzar en esta línea de investigación en los próximos años, extendiéndola desde el sector de la energía nuclear a otras industrias de alto riesgo.

Palabras clave: cultura de seguridad, desempeño de seguridad, organizaciones de alta fiabilidad.

Safety is defined as the absence of unexpected results, such as accidents or incidents. Achieving safe operations is of paramount importance in most organizations. However, ensuring safe operations is not always easy as it needs to be compatible with acceptable levels of productivity and profitability. Safety is especially relevant in high-risk industries, such as nuclear power generation, commercial aviation, or air traffic control. In these industries, a small mistake can have catastrophic consequences. An accident or incident in these environments has the potential to end the lives of thousands of people in an instant, cause irreparable damage to the environment, and harm millions of people for many years to come. A prime example of one of these catastrophes is the Chernobyl nuclear accident in 1986. This disaster highlighted the importance of "safety culture" in achieving safe operations under fluctuating conditions. Since then, understanding what safety culture is, how to diagnose it and how to develop and strengthen it over time, has become a subject of interest for both practitioners and researchers.

The Research Institute of Personnel Psychology, Organizational Development and Quality of Working Life (IDOCAL) (previously known as the Research Unit in Psychology of Organizations and Labour (UIPOT)) has been studying safety culture and safety performance in high-risk organizations and industries where safety is critical for almost two decades. The objective of this article is to summarize the main contributions made to the literature by IDOCAL throughout these years. Among these contributions, we will highlight the model for the evaluation of safety culture and its correlates based on the AMIGO model, as well as all the empirical evidence developed from this model.

Conceptual and Theoretical Frameworks

To better understand the contributions that have been made to the literature from this line of research, we must first clarify a series of basic concepts.

Safety. The most widespread definition of safety is "the absence of undesired results, such as accidents or incidents" (Hollnagel, 2014, p. 1). A more complex and detailed definition of the concept of safety is "the property or quality of the system that is necessary and sufficient to ensure that the number of events that could cause harm to workers, the public, or the environment is acceptably low" (Hollnagel, 2014, pp. 1-2).

Personal safety and process safety. When studying safety, it is valuable to differentiate between personal safety and process safety. Personal safety (or occupational safety) refers to any potential harm to workers in the context of performing their job. This harm could arise from either the performance of basic tasks (e.g., a construction worker falling from scaffolding), the work environment (e.g., employees having to work in an excessively noisy environment) or even activities not directly related to the task (e.g., an employee slipping while moving through the corridors of the company). Process safety, on the other hand, refers to risks that need to be managed that are directly linked to the main purpose of the organization (e.g., generating electrical power in a nuclear power plant, transporting people in commercial aviation, healing patients in a hospital). It should be noted that in this case, the damage incurred from process risks, does not necessarily always impact the workers involved (e.g., death of a patient due to a medication error).

In our line of research, our main focus is on process safety in high-risk industries in which the consequences of failure can be catastrophic, such as the explosion of a nuclear reactor, an airplane crashing in the middle of the ocean, the derailment of a train, or the spread of an epidemic among the population.

High-risk systems and the theory of normal accidents. Yale University sociologist Charles Perrow published the book "Normal Accidents" in 1984. His main thesis is that certain accidents are normal, in the sense that these accidents are inevitable, given the structural characteristics of certain systems. According to Perrow, technological development has led to the emergence of high-risk systems. There are two characteristics of high-risk systems: interactive complexity and tight coupling. When combining both characteristics, the result is that any failure, no matter how small, cannot be fully isolated, and will have repercussions that are impossible to anticipate on other elements of the system. In these systems, accidents will eventually happen. Perrow refers to these types of accidents as systemic or normal accidents. Normal accidents have nothing to do to the frequency of these accidents. They are normal accidents in the sense that it is the logical result of the properties inherent in such systems. Accidents can be expected because the combination of organizational complexity and the close interconnectedness of the different components in the organization makes it easy for a small failure or deviation in one component to interact with others. These interactions quickly trigger a catastrophe before we can understand what is happening. Systemic accidents are infrequent, but that is not reassuring when they can lead to catastrophes. Most of these high-risk systems have catastrophic potential, that is, an accident can end the lives of hundreds of people with a single blow and have dire effects on thousands of people in the future.

In contrast to Normal Accidents Theory, and Perrow's deterministic predictions (e.g., accidents are inevitable), is the theory of highly reliable organizations. This theory points out that among high-risk systems we find some organizations that manage to function exceptionally reliably over time, despite having "a million accidents waiting to happen" (Weick & Sutcliffe, 2015, p. 2). Therefore, the authors of this theory argue that it is important to look at what these organizations do to achieve these results in order to extrapolate lessons about how other organizational systems could improve their reliability. In the next section, we discuss high reliability organization theory in more detail.

High-reliability organizations. The concept of highly reliable organizations (hereinafter, HROs) was introduced in the late 1980s by a group of researchers at the University of Berkeley (LaPorte & Consolini, 1991; Roberts, 1990; Roberts & Rousseau, 1989; Rochlin et al., 1987). In her early writings, Karlene Roberts stated that one way to identify these types of organizations was by answering the following question: "How many times could this organization have failed resulting in catastrophic consequences and it did not? If the answer is of the order of tens of thousands of times, the organization can be considered an HRO" (Roberts, 1990, p. 160). We can define HROs as organizations that have been successful in preventing catastrophes in an environment where one might expect accidents to occur with some "normality" given their structural characteristics.

In contrast with this perspective, Rochlin (1993) argued that an HRO can be understood more meaningfully by looking at the processes it uses to successfully manage the risks involved within the complexity of its system, beyond merely looking at the statistics of accidents. Since then, numerous experts have studied what these organizations do to achieve such safe and reliable performance over time, despite being in environments of high risk and complexity. These investigations into how HROs operate aim to extrapolate potential models that other organizations can imitate to better manage risk. Within this research, probably the best-known model has been developed by Weick and his collaborators (Weick et al., 1999; Weick & Sutcliffe, 2007; Weick

& Sutcliffe, 2015). These authors identified five fundamental characteristics or principles of highly reliable organizations: a preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise. Weick and Sutcliffe (2007) argue that preoccupation with failure/error, reluctance to simplify interpretations and sensitivity to operations allow groups in HROs to collectively anticipate unexpected problems and events (anticipation). On the other hand, the principles of commitment to resilience and deference to expertise have to do with the collective capacity to contain a problem or problems once triggered (containment). Weick and his colleagues named these five processes *collective mindfulness* or *mindful organizing*. Weick et al. (1999) define mindful organizing as the collective ability (typically of a team or work unit) to perceive slight indications of emerging problems and to act quickly and forcefully in response to these indications to prevent them from becoming more serious problems. Ultimately, it is a collective capacity to manage uncertainty and includes both the collective capacity of a team to anticipate unexpected events and to contain the problem or recover from it as soon as possible once it has been triggered. *Mindful organizing* and the five processes (mentioned above) have frequently been proposed as responsible for the safe and highly reliable performance of HROs.

Since its inception, the literature on HROs has set an example for the nuclear power industry (Roberts, 1990; Rochlin et al., 1987), and the nuclear power sector is still the most important benchmark when it comes to highly reliable organizations. In fact, the concept of safety culture originally comes from the nuclear industry.

Safety culture. Safety culture is a relatively new concept. Its origin dates to the events after the Chernobyl catastrophe that took place in 1986. The concept appears for the first time in the report prepared by the group of experts of the International Atomic Energy Agency (IAEA) in charge of determining the causes of the catastrophic accident. This group of experts concluded that what had happened could not be explained by the classical theories of accidents (International Atomic Energy Agency [IAEA], 1986). It could not be attributed to technological failure, human error, or even to the interaction between the technological and social system. The experts concluded that what had failed was a broader set of organizational factors, which they called "safety culture".

Since then, the importance of safety culture, as well as its evaluation in plants around the world, has grown rapidly, reaching the point of being considered the cornerstone of all human safety behavior in nuclear power plants. According to theorists and professionals of the applied world, for nuclear power plant employees to behave safely, it is necessary to establish a safety culture that instils certain values and beliefs in workers (for example, the value that safety has absolute priority above any other aspect).

From the nuclear sector, the interest in a safety culture quickly spread to the rest of high-risk industries (aviation, transport, oil, chemical, health, etc.). Many of these industries have since used measures of safety culture to guide them in their efforts to promote safety in their facilities and operations (Wilpert & Schöbel, 2007).

Within the context of safety culture in the nuclear power sector, IDOCAL has done much work collaborating with nuclear power plants (hereinafter NPPs) to develop measurement tools to better diagnose safety culture and implement actions for its improvement. These collaborations have spanned almost two decades, and from them, we have made significant contributions to advancing scientific knowledge about organizational behavior and process safety. We have also provided practical recommendations for professionals in the nuclear sector and

other high-risk industries, and all those interested in improving safety in their organizations. In the remainder of this article, we will detail these contributions. The seminal and main contribution was the development of a theoretical model and a methodology for the assessment of safety culture in nuclear power plants, and by extension, in other high-risk industries and HROs. This model was inspired and based on the Multifaceted Analysis Model for Management in Organizational Intervention (Peiró, 1999; Peiró & Martínez-Tur, 2008), hereinafter the AMIGO model.

Model for the Assessment of Safety Culture and its Correlates Based on the AMIGO Model

An important milestone in this line of research was the project "Assessment of the safety culture and the organizational system in NPPs and their safety implications. Development based on the AMIGO model". This project was set up in 2005 within the National Plan for Scientific Research, Development and Technological Innovation 2004-2007 (Ref. Project: ENE2005-08619). In this project, we developed a methodology for evaluating safety culture that positions it within a broader model that considers its relationship with other important organizational variables. In developing this model, we used the AMIGO model (Peiró, 1999; Peiró & Martínez-Tur, 2008) (Figure 1).

Through the conceptual development of our safety culture model, we identified existing scales or developed new ones for the measurement of each of the variables contemplated in the model. This model is described in detail in Peiró et al. (2015). Understanding and measuring the interaction of safety culture with other organizational variables is essential for three reasons. Firstly, because it will allow us to determine if this safety culture is reflected in other facets of the organization, such as the practices, behaviors, rules and procedures within the organization. Secondly, because it allows us to assess the impact that safety culture has on safety performance and other results of great value to the organization. Thirdly, it will allow us to identify the main predictors of safety culture or levers to change it when inadequate levels are detected.

Our model for evaluating safety culture and its correlates include the following variables.

Hard facets. Economical resources and infrastructure. The extent to which respondents consider that the company and its different units (e.g., departments) have sufficient material as well as adequate financial and personal resources to be able to do their job.

Formalization of procedures. The extent to which respondents estimate that the company has formalized procedures to follow to fulfil working obligations and the quality of these procedures (clarity of writing, detail, up to date). The scale used for its evaluation is original and can be found in Martínez-Córcoles et al. (2014).

Role ambiguity. The extent to which the definition of the role workers must play within the company is clear or not. It is measured through four items taken from the Rizzo et al.'s (1970) scale. The scale can be found in Martínez-Córcoles et al. (2014).

Role overload. The frequency with which employees perceive that they have difficulty completing their work within the time allotted to them. The scale can be found in Gracia and Martínez-Córcoles (2018).

Soft facets. Encouragement of employee participation. The extent to which the company encourages workers to participate in the everyday functioning of the organization by offering their opinions, suggestions, and ideas. The scale is an original scale and can be found in Renecle et al. (in press).
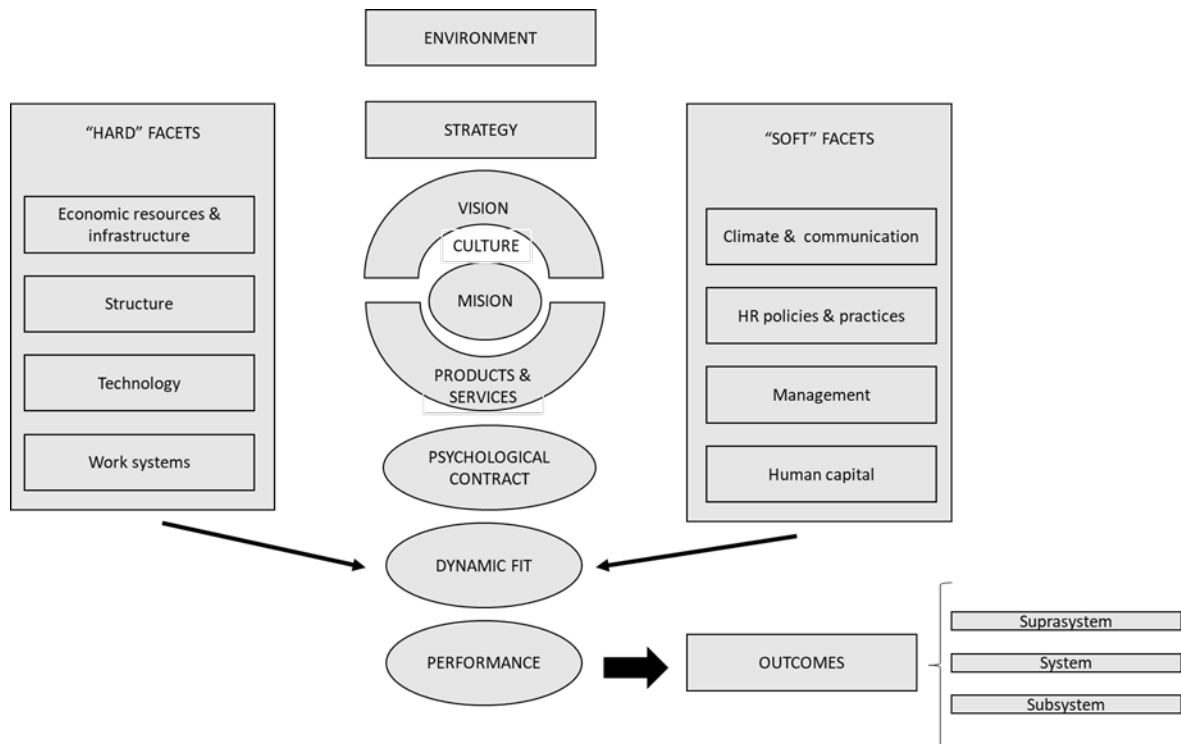
Figure 1. The AMIGO model [adapted from Peiró et al. (2015)]

Critical upward communication or upward voice. The extent to which employees feel safe to express challenging views to their direct managers. The scale was developed by our team and can be found in Silla et al. (2020).

Human resource practices. The extent to which employees believe that the company carries out a series of high-quality human resource practices.

Empowering leadership. The extent to which leader behavior toward their subordinates contributes to their development and self-management. Later we will describe this model and the instrument used for its assessment in detail.

Trust. The extent to which employees trust various stakeholders in the company (colleagues from their work unit, colleagues from other units, their immediate boss, and the management team). The scale was developed by our team and can be found in Ayenew et al. (2015).

Safety culture and climate.

Safety culture. This is the central variable in the evaluation model. We understand safety culture as the value or importance that the organization (and all its members) attaches to safety. If safety is important for an organization, it will be reflected in all its actions (decision-making, resource allocation, formal and informal reward systems, etc.). Later we will discuss the different instruments used for its evaluation.

Organizational safety climate. Shared perceptions among the members of the organization about how safety is managed. The questionnaire used in our research is an adaptation of the Zohar and Luria scale (2005) to Spanish and the nuclear sector. The measure can be found in Martínez-Córcoles et al. (2011).

Team safety climate. Shared perceptions among members of the work unit about safety management in their team. The questionnaire used in our research is an adaptation of the Group-level Safety Climate scale of Zohar and Luria (2005) to Spanish and the nuclear sector. The measure was validated by Latorre et al. (2013).

Dynamic fit variables.

Team learning. The degree to which a team learns over time, adjusting to both internal and external demands. The model and the instrument developed for its evaluation are detailed in the next section.

Mindful organizing. A team's collective capacity to anticipate unexpected problems or events and the ability to act resiliently once problems or errors arise, quickly restoring the stability of the system. The scale used to measure mindful organizing is by Vogus & Sutcliffe (2007) and was adapted into Spanish and validated by Renecle et al. (2020). In another recent study by our team, we did a review of the literature on mindfulness at work (Goilean et al., 2020).

Safety performance and safety satisfaction.

Safety performance. The safety behaviors carried out by the members of an organization. It includes three dimensions: compliance, participation and risky behaviors. To evaluate safety compliance and safety participation, the Neal and Griffin (2006) scale is used. To evaluate risky behaviors 10 items taken from the Mearns et al. Scale (2000) are used. The 10-items scale can be found in Martínez-Córcoles et al. (2011). In a later article, we described the three-dimensional model of safety performance in detail (Martínez-Córcoles et al., 2013).

Safety satisfaction. The extent to which members of the organization are satisfied with safety within the company and how it is managed. The scale was developed by our team and can be found in Gracia and Martínez-Córcoles (2018).

Results directly or indirectly related to safety.

Job satisfaction. The extent to which members of the organization are satisfied with the company, the work unit, and the work that they do. This scale was developed by our team can be found in Gracia and Martínez-Córcoles (2018).

Intention to quit the team. A one-item measure that assesses the likelihood that employees would leave their current work-unit if they could.

Intention to quit the organization. A one-item measure that assesses the likelihood that an employee would leave their current company if they could. This scale was used in previous work by our team (Renecle et al., in press).

This methodology for evaluating safety culture and its correlates has been successfully transferred to the nuclear sector and has since been used systematically and regularly by certain Spanish NPPs for the assessment of safety culture. This has allowed us to obtain data every three years since 2008 from approximately 500 workers and about 50 teams in Spanish NPPs.

These samples are the basis of the research results that we will summarize in the next sections.

Main Contributions

Our research in this field has generated two doctoral theses so far, as well as numerous articles in scientific journals. The main criterion we have used to structure these contributions has been their relevance. The main contributions of our research team have been in three areas:

1) The conceptualization of safety culture and the development of methodologies to evaluate safety culture. The development and validation of quantitative and qualitative tools to measure safety culture was borne out of the following research: (a) the three studies within Lopez de Castro (2017)'s doctoral thesis, (b) the study that examined work meetings as a tool for evaluating safety culture (Gracia & Peiró, 2010) as well as (c) the general model for safety culture explained in section 2 (also see Peiró et al., 2015).

2) The proposal of an empowering leadership model as a highly relevant antecedent for developing and strengthening safety culture and safety performance in high-risk environments. The studies conducted in the second doctoral thesis (Martínez-Córcoles et al., 2012) contributed to this line of work and this contribution was reflected in four publications in top-level international scientific journals in the field of safety (Martínez-Córcoles et al., 2011, 2012, 2013, 2014).

3) The theoretical development and empirical validation of a three-dimensional model of safety performance, and the study of its main predictors. This line of research is ultimately intended to improve safety performance. For this reason, much of the research carried out has been aimed at determining the main predictors of safety performance, that is, safety compliance, safety participation, and risky behaviors. The three-dimensional model of safety performance was proposed and validated for the first time in Martínez-Córcoles et al. (2012), and nine subsequent scientific articles have contributed to shed some light on its main predictors.

Other more recent contributions described in the following sections are the conceptual development of team learning and the creation and validation of an instrument for its evaluation, and some empirical studies on the role of employees' participation and upward voice in HROs. We detail our empirical work on team learning before safety performance as it is one of the predictors of safety performance. We detail each of these contributions below.

Development and Validation of Questionnaires and Other Methods for Evaluating Safety Culture

Safety culture assessments can be measured with both quantitative and qualitative methodologies. It is often recommended to resort to triangulation methods to get a more comprehensive view of an organization's safety culture (IAEA, 2016; Schöbel et al., 2017).

Our team developed a methodology for evaluating safety culture using the qualitative technique of observing natural work meetings (Gracia & Peiró, 2011). This technique was useful for evaluating safety culture for two reasons. Firstly, because it is a less disruptive technique than others are since it consists of observing activities that take place in the company naturally. Secondly, because it is an indirect evaluation technique, it is less vulnerable to social desirability bias than other techniques. Observing natural work meetings also allows us to assess the enacted culture

compared to the espoused culture. The espoused culture is usually what comes up when people answer questions in an interview or a questionnaire. We will return to this idea later.

However, our main contribution to the field of safety culture evaluation has been the development and validation of questionnaires for its assessment. There are well-known advantages of this method (e.g., it requires less time, can be disseminated to a larger number of people, requires a smaller budget, and provides data that can be easily coded, analysed and compared). In addition to these advantages, the questionnaire as an assessment method is especially relevant in the nuclear sector because it allows the safety culture of NPPs to be evaluated more frequently and systematically. Frequent monitoring at NPPs is vital for the early detection of declining and weakening safety cultures and taking corrective action before safety levels fall below the acceptable level (IAEA, 2006, López de Castro et al., 2017). In addition, the use of questionnaires is more widely accepted by professionals in this sector over other techniques that are perceived as more subjective.

A questionnaire based on the IAEA model. In one of our studies (López de Castro et al., 2013), we developed a questionnaire based on the IAEA (2006) safety culture model. The IAEA is an organization belonging to the United Nations which was involved in the development of the concept of safety culture. This model, consisting of 5 dimensions and 37 attributes of a safety culture, is widely used and accepted in most nuclear power operators and numerous regulatory bodies within the nuclear industry (e.g., the Spanish Nuclear Safety Council). However, its validity had never been empirically tested. That was precisely the objective of our work.

Therefore, our team developed a questionnaire made up of 37 items that corresponded to the attributes of the IAEA model. Subsequently, to validate this questionnaire and the theoretical model it was based on, we carried out three independent empirical studies. In the first study, we tested the face validity of the model based on the opinions of a sample of 290 university students. In the second study, a sample of 48 experts in organizational behavior was used to assess the validity of the content of the model. In the third study, we analysed the responses to the questionnaire from a sample of 468 workers at a Spanish NPP to ascertain the extent to which the data replicated the five-dimensional theoretical model.

The results obtained suggested that most of the attributes of the model were not related to their corresponding dimensions. It appeared as if the IAEA model could be one-dimensional instead of consisting of the five dimensions that the IAEA proposed. In addition, our results revealed that there was no evidence to support the content and face validity of the model. The results obtained opened the door to the improvement of a model that was widely used, which could have great potential to contribute to the improvement of safety. This discovery encouraged the community of professionals in the nuclear power sector to contribute to improving the model, to maximize its utility in the nuclear industry and ultimately the positive impact it could have on the safety of operations.

Safety Culture Enactment Questionnaire. In a second study, we developed and validated the Safety Culture Enactment Questionnaire (López de Castro et al., 2017). The motivation that led us to develop our own questionnaire was twofold. After an exhaustive review of the literature, we found that the safety culture and climate questionnaires that existed at that time evaluated only the most superficial level of the safety culture, that is, artefacts and products (Schein, 1985). On the other hand, most of these questionnaires were not based on a sound theoretical model. With the development of the Safety Culture Enactment Questionnaire (SCEQ), we tried to overcome both shortcomings in the available

safety culture scales. The objective was to create a questionnaire that would allow us to assess the level of safety value in action, and that it would be based on a sound safety culture model.

The safety culture model that the SCEQ is based on purports that an organization has a safety culture when safety is the most important value within the company (overriding priority; IAEA,1991). Consequently, safety culture permeates "everything" that an organization does. In our model, "everything" an organization does is covered by three fundamental components: 1) important strategic and operational decisions guarantee that safety is prioritized at all times, 2) human resources policies and practices as well as formal reward systems promote safety within the organization and, 3) safety is reflected in day-to-day routines, actions and operational behaviors.

Based on this model, we developed the SCEQ, a questionnaire designed to assess the degree to which safety is a "value in action" in the daily operation of NPPs and, by extension, any highly reliable organization. There is an important convention of distinguishing between declared values and values in action (espoused theories vs. theories in use -Argyris & Schon, 1974-; espoused rules vs. real rules -Shapiro, 1995-; or espoused values vs. enacted values -Simons, 2002). It refers to the coherence between the values that the organization openly declares and the values that are reflected in the actions taken by the organization (i.e., "walking the talk").

We developed our questionnaire to assess the degree to which safety is a "value in action" by following two strategies. First, we made sure that the statement of the questions led respondents to answer about the importance of safety in day-to-day operations. This allowed us to assess the real importance of safety rather than assessing the theoretical importance of safety. Second, since we were asking about values, we had to follow the criteria established more than 40 years ago by Guttman and Levy (1976) to consider that an item belongs to the universe of values. These criteria, widely accepted in the scientific community are: 1) that its content should ask about the importance of a goal (e.g., safety) in a given context (e.g., work), and 2) that the response scale should go from very unimportant to very important. As far as we know, our questionnaire is the only safety culture questionnaire that meets these criteria, and therefore allows us to capture the extent to which safety is a value in action.

For its validation, two studies were carried out (López de Castro et al., 2017). The first study with a sample of 533 workers from two Spanish NPPs included the creation of the items and the examination of the factorial structure and reliability of the SCEQ. Exploratory Factor Analysis (EFA) carried out revealed a three-factor solution corresponding to the three components of the theoretical model: strategic decisions ensuring safety, human resources practices driving safety, and daily activities and behaviors supporting safety. Reliability analyses showed strong internal consistency for the three scales of the SCEQ, and each of the 21 items on the questionnaire contributed to the homogeneity of the theoretically developed scale. A second study was carried out a few years later with a sample of 598 workers from two Spanish NPPs. A Confirmatory Factor Analysis (CFA) supported the internal structure of the SCEQ. Internal consistency of the scales was also supported. Furthermore, the three scales of the SCEQ showed the expected correlation patterns with four safety outcomes (safety climate, safety satisfaction, job satisfaction, and risky behaviors). Finally, results provided evidence of discriminant validity between the SCEQ and safety climate. In summary, empirical evidence was obtained that shows the validity of the SCEQ and supports the dimensionality derived from the theory.

This article (López de Castro et al., 2017) brings a new approach to understanding and evaluating safety culture. The SCEQ has the advantages of questionnaire methods, and at the same time, provides more accurate and relevant information than existing conventional questionnaires. This is because it focuses on the degree to which safety is an enacted value and not just a theoretical aspiration. In this vein, the SCEQ may serve as a better predictor of safety performance than existing safety questionnaires that merely assess the endorsement of safety values. On the other hand, the safety culture model formulated helps scholars and practitioners to understand the main organizational components where the value of safety is expressed, and where the safety culture is constructed and carried out. Thus, the SCEQ may be particularly useful for the assessment of safety culture in NPPs, fulfilling diagnostic functions and providing guidance for interventions to improve safety culture. The model depicted and the assessment tool developed also provides a guiding framework for practitioners to develop interventions to improve safety culture in NPPs.

Comparison between SCEQ and OCI. In a third study (López de Castro, 2017) we compared the SCEQ with another questionnaire widely used in the nuclear sector for the evaluation of safety culture, the Organizational Culture Inventory (OCI) (Cooke & Lafferty, 1987). Both the questionnaire based on the IAEA model and the SCEQ address the study of safety culture directly and immediately. However, an alternative approach, the distal approach, understands that the safety culture is part of a broader organizational culture and that by studying the latter, we can also obtain information about the organization's safety culture. However, there is little empirical evidence in the literature about which of these two approaches would be recommended.

The most widely used model and questionnaire for evaluating safety culture from a distal perspective is the OCI. It was developed by Human Synergistics International (Cooke & Lafferty, 1987), and has since been used by thousands of organizations from different sectors, completed by over two million respondents, and translated into numerous languages. The questionnaire evaluates three different cultural styles: constructive, passive/defensive and aggressive/defensive. The theoretical framework underlying the OCI postulates that constructive styles are indicative of positive and supportive environments that facilitate problem-solving, decision making, teamwork, productivity, long-term effectiveness, etc. On the other hand, passive/defensive and aggressive/defensive are negatively related to desirable outcomes and positively related to undesirable outcomes, impairing effective organizational performance. Detection of defensive styles is useful, insofar as they will allow us to identify potentially dysfunctional environments.

In a study conducted in the nuclear sector, it was concluded that in an optimal culture for NPPs, constructive standards should take precedence over defensive standards. They also noted that a certain degree of defensive standards is needed, especially an opposition standard, that encourages the kind of questioning attitude and rigor required to perform at the highest levels of excellence in an NPP (Utility Service Alliance and Human Synergistics, 2004).

In our study (López de Castro, 2017), SCEQ and OCI were analysed and compared through two studies. In the first (cross-sectional) study, the sample consisted of 566 workers from two Spanish NPPs who responded in 2008 to the OCI, the SCEQ, and four other questionnaires measuring safety culture outcomes. In the second study (longitudinal), 163 respondents who participated in the first study completed three questionnaires in 2011 measuring safety performance (safety compliance, safety participation, and risky behaviors). The results obtained supported the factorial structures of the OCI and the SCEQ proposed by

their corresponding theoretical models. However, the reliability analyses of the scales show more evidence of the reliability of the SCEQ scores than of the OCI. On the other hand, the expected relationships between the OCI, the SCEQ and the results of the safety culture investigated (organizational safety climate, group safety climate, safety satisfaction, and job satisfaction) were confirmed. Evidence of validity was obtained based on the power of the OCI and SCEQ to predict, jointly or separately, three safety performance indicators. Specifically, the results suggested that the OCI might be more useful for predicting risky behaviors, the SCEQ for measuring safety engagement, and both questionnaires similarly predicted safety compliance. Finally, the results improved when both questionnaires were used together to predict safety performance. Although the two questionnaires proved adequate for the evaluation of the safety culture, the fact that the SCEQ is considerably shorter (21 items compared to 120), makes it less time-consuming, and, therefore, organizations may be less reluctant to administer it often to monitor safety culture.

Empowering Leadership

The leadership model we opted for in this line of research was that of empowering leadership introduced by Arnold et al. (2000). For these authors, the basic function of the leader is to increase the capacity of the teams they lead to self-manage. To do this, they implement a series of behaviors that can be grouped into five dimensions: (1) *Leading by example* means that the leader is a role model for his/her followers; (2) *Participatory decision making*, implies that the leader stimulates the participation of his/her team members and takes their ideas and suggestions into account for decision making; (3) *Coaching*, refers to the leader's behaviors through which he/she helps his/her team members to be more autonomous, helping them to detect areas for improvement and training them to solve problems on their own; (4) *Explaining* means that the leader takes time to provide information to his followers that helps them to understand their role within the company, and the reasons for the different decisions that affect the team, and (5) *Showing concern for the well-being of the team*, means that the leader shows interest in the well-being and success of his/her followers and is available to listen to them and talk about their concerns, interests, needs, values and goals.

We developed a measure from the Empowering Leadership Questionnaire (Arnold et al., 2000) selecting 17 items from the original 38. This scale was used for the first time in Martínez-Córcoles et al. (2011), obtaining positive evidence of both reliability and validity, and since then we have used it in numerous studies. The content of the items can be found in Martínez-Córcoles et al. (2011).

Our studies were the first to propose empowering leadership as a relevant leadership model to contribute to improving safety. This is recognized in the chapter on safety leadership that can be found in The Wiley Blackwell Handbook of the Psychology of Occupational Safety and Workplace Health (Wong et al., 2015). This chapter only mentions three leadership models: the transformational model, the transactional model, and the empowerment model. In the section dedicated to empowering leadership, it is stated that the general nature of transformational leadership may not make it ideal for certain industries, where safety is critical, and then summarizes several of our studies on empowering leadership and safety (Martínez-Córcoles et al., 2011, 2012, 2013). From this review, the authors conclude that empowerment leadership is a promising model as it shows great potential to predict a wide range of safety performance outcomes.

Team Learning: Development of a Theoretical Model and an Assessment Instrument

We also developed a theoretical team-learning model and an instrument for its evaluation (Bresó et al., 2008). In this article, we define team learning as the "set of behaviors and activities carried out by a team on a regular basis that enhances the acquisition and development of competencies (e.g., knowledge, skills, attitudes…) for better functioning over time" (p. 148).

In our model, the set of behaviors and activities carried out by the learning teams is grouped into four dimensions: (1) *Search for continuous improvement:* the degree to which the team has a strong will to learn from past experiences (e.g., mistakes) and a great interest in taking actions that allow them to continuously improve. (2) *Promotion of dialogue and open communication:* the degree to which open and honest communication is encouraged and takes place within the team. This communication between team members, and between teams and their leaders, is highly relevant for reporting problems, difficulties or obstacles, reporting deficiencies in their own performance, not hiding mistakes, asking questions, promoting the exchange of ideas and opinions, expressing opinion freely during team meetings, and avoiding group thinking (Janis, 1972). (3) *Collaborative learning:* the degree to which team members are seen and used as sources of knowledge by the rest of the team. It is considered that much can be learned from other team members, so they try to create conditions for such learning to take place, such as stimulating teamwork or sharing the unique knowledge of each team member in the decision-making processes. (4) *Strategic and proactive leadership that promotes team development:* the degree to which the team leader takes an active role in the search for opportunities that allow the development and growth of the members of his team. These leaders think about the development of their team members anticipating competencies that they will have to acquire to face future challenges. For the acquisition of these competencies, they resort to numerous practices, over and above training. Among these practices are the assignment of new tasks, enhancing teamwork, providing feedback on performance, coaching, mentoring, behavior modelling through benchmarking, giving greater autonomy, or job rotation, etc.

Based on this model we developed the Team Learning Questionnaire, a multidimensional scale of 17 items that measure the four dimensions. The CFAs showed that the four-factor model fit the data better than the one-factor model. Furthermore, the internal consistency of the scale and each of the dimensions was also satisfactory. This scale has been used in subsequent work by our team.

The Three-Dimensional Model of Safety Performance

The most widely used safety performance model in the literature is the one proposed by Griffin and Neal (2000), which is based on the classic work performance model of Borman and Motowidlo (1993). This traditional work performance model differentiates between "task performance" and "contextual performance" (Borman & Motowidlo, 1993; Motowidlo & Van Scotter, 1994), and in turn has its origin in the distinction between in-role and extra-role behavior (Katz & Kahn, 1966). The model of Griffin and Neal (2000) considers two safety performance indicators: safety compliance and safety participation. *Safety compliance* would be "task performance" or "intra-role behaviors" related to safety and is defined as those core safety activities that must be carried out by individuals to keep the workplace and workers safe (e.g., follow safety procedures and standards, use personal protective equipment). *Safety participation* would be

"contextual performance" or "extra-role behaviors" related to safety and is defined as those behaviors that do not directly contribute to safety in the workplace, but that help develop an environment where safety comes to be a priority (e.g., participate in safety-related activities voluntarily or attend non-mandatory meetings that address safety-related issues).

Considering that work performance should take into account not only those positive behaviors (compliance and participation in safety) but also those that may be negative or counterproductive for the organization (Rotundo & Sackett, 2002), our team proposed a new three-dimensional model of safety performance (Martínez-Córcoles, et al., 2013) that included "risky behaviors". That is, those behaviors that increase the probability of an accident taking place (Martínez-Córcoles & Stephanou, 2017). In our study, we compared the two-dimensional model and the three-dimensional model of safety performance using various CFAs in a sample of 479 employees from two NPPs, obtaining empirical support for the three-dimensional model of safety performance (Martínez-Córcoles, et al., 2013). Subsequently, the three-dimensional model of safety performance has obtained additional support within a sample of 161 paratroopers from the Greek army (Martínez-Córcoles & Stephanou, 2017). More recently, our team released a study which explains three dimensions of safety performance in detail (Martínez-Córcoles et al., 2018).

Along with this theoretical contribution, we have carried out several studies throughout the last few years that have allowed us to obtain empirical evidence on some of the most important predictors of safety performance. These studies are summarized below.

Safety Performance Predictors

Two of our articles have explored all three safety performance indicators at the same time (López de Castro, 2017; Martínez-Córcoles et al., 2013). These studies provide empirical evidence of the association between safety culture and empowering leadership with safety performance. Specifically, López de Castro (2017) proposed a longitudinal study with two points of data collection three years apart. Regression analyses performed on a sample of 163 workers from two Spanish NPPs revealed that safety culture at time one (T1) positively predicted safety compliance and safety participation, and negatively predicted risky behaviors at time two (T2). On the other hand, organizational culture at time one (T1) was able to positively predict safety compliance but not safety participation and negatively predicted risky behaviors at time two (T2). Furthermore, the percentage of variance explained for safety compliance, safety participation and risky behaviors increased significantly when both variables were included as predictors.

In a separate study, Martínez-Córcoles et al. (2013) carried out a multilevel analysis, with a sample of 479 workers from 54 teams from two Spanish NPPs, in which empowering leadership was added at the team level and the safety performance variables were considered at the individual level. As expected, safety compliance and safety participation were positively predicted by team-level empowering leadership, whereas risky behaviors were negatively predicted by team-level empowering leadership.

The association with the two classic safety performance indicators, safety compliance and safety participation, were explored in three additional studies by our team (Ayenew et al., 2015; Gracia et al., 2020; Renecle et al., 2020).

Ayenew et al. (2015), with a sample of 496 employees from two Spanish NPPs, found that team learning partially mediated the effect of trust on safety compliance and safety participation. The results showed that employees who trusted other colleagues

(managers, co-workers, leader, and team members) tended to acquire and develop more knowledge, skills, and attitudes in teams, and were able to perform safety issues more effectively and efficiently.

In a study by Renecle et al. (2020), with a sample of 47 teams and 573 workers from a Spanish NPP, found that safety compliance and safety participation were positively related to mindful organizing, safety culture, team safety climate and team learning. Furthermore, evidence of incremental validity for mindful organizing in the prediction of safety compliance and safety participation was obtained. The results indicated that the percentage of explained variance that mindful organizing added to safety compliance and safety participation was statistically significant when controlling for safety culture, team safety climate, and team learning at the individual level, although not at the group level.

Gracia et al. (2020), in a longitudinal and cross-level design with a sample of 49 teams and 200 employees from a Spanish NPP, obtained general support for a model where empowering leadership was proposed as a predictor of mindful organizing that in turn was related to positive changes in safety compliance and safety participation. Empowering leadership and mindful organizing were aggregated to the group-level. The results of the proposed fully mediated model supported the mediated effect of empowering leadership on the change in safety compliance through mindful organizing, but not on the change in safety participation.

Below, we summarize other empirical studies carried out by our team that studied only one of the safety performance indicators.

Regarding safety compliance, Martínez-Corcoles et al. (2014) designed a study based on organizational role theory (Katz & Kahn, 1966) to test the association of two influential sources of expectations (i.e., procedures formalization and leadership) on safety compliance. It was expected that both variables would contribute to employees' role clarity, and in turn, would contribute to safety compliance. With a sample composed of 495 workers from two Spanish NPPs, they found empirical support for a model where empowering leadership along with formalization procedures contributed to employee's role clarity, and in turn, was positively associated with safety compliance. Moreover, procedure formalization had a direct association with safety compliance that was not observed in empowering leadership. These findings allowed the authors to conclude that staff will comply with safety if they clearly understand what is expected from them in their jobs. Additionally, both procedure formalization and empowering leadership are relevant to increase role clarity.

Considering safety participation, Martínez-Córcoles et al. (2012) studied the mediating role of team learning in the relationship between empowering leadership and safety participation within a sample of 495 employees from two Spanish NPPs. It was expected that empowering leadership enhances collaborative learning directly and through the promotion of open dialogue and honest communication among team members and with leadership. In turn, it was expected that collaborative learning would induce safety participation. The authors found support for their hypotheses. These findings suggest that empowering leadership induces a collaborative learning environment, which makes employees behave in a proactive and participative way with regards to safety. Moreover, the promotion of open and honest communication was found to foster collaborative learning.

Finally, two studies by our team provide some empirical evidence on predictors of risky behaviors (Gracia & Martínez-Córcoles, 2018; Martínez-Córcoles et al., 2011). Gracia and

Martínez-Córcoles (2018) studied the relationships between role stressors (role ambiguity and role overload), dissatisfaction (safety and job dissatisfaction) and risky behaviors, within a sample of 566 employees from two Spanish NPPs. They found that both role stressors were positively associated with risky behaviors. Interestingly, role overload was directly associated with risky behaviors, whereas role ambiguity created an attitudinal and emotional state (namely dissatisfaction with job and safety) that led workers to riskier behaviors.

The second study looked at how leadership, safety culture and safety climate relate to risky behaviors; making the study highly relevant given the importance of these variables in the current scientific literature. Martínez-Córcoles et al. (2011), with a sample of 566 workers from a Spanish NPP, found that empowering leaders create a safety climate that reduces the likelihood of risky behaviors occurring. Nevertheless, the most interesting result is that the safety culture moderated the relationship between empowering leadership and the safety climate so that it was stronger when the safety culture was low and weakened when the safety culture was high. That is, the empowering leader contributes to the safety climate, especially when the safety culture is failing. In other words, if the safety culture is high, the role of the empowering leader in creating a safety climate is less relevant but becomes essential when safety culture is low. It is noteworthy, however, that the highest safety climate occurred when a strong safety culture and high entrepreneurial leadership were combined.

Taken together, our studies provide ample evidence of the relationship between empowering leadership and safety performance. Specifically, empowering leadership contributes to increasing safety compliance by clarifying the role played by the members of their team and enhancing mindful organizing within it (Gracia et al., 2020; Martínez-Córcoles et al., 2013; Martínez-Córcoles et al., 2014). It also contributes to increasing safety participation by stimulating open and honest communication within the team that, in turn, enhances collaborative learning (Martínez-Córcoles et al., 2012; Martínez-Córcoles et al., 2013). Finally, empowering leadership reduces risky behaviors by contributing to creating and reinforcing a climate of safety (Martínez-Córcoles et al., 2011; Martínez-Córcoles et al., 2013). Furthermore, safety culture is another variable that has been shown to predict the three safety performance indicators. Higher safety culture was associated with higher safety compliance, higher safety participation, and lower risky behaviors (López de Castro, 2017). Additionally, some studies suggest a series of promising predictors of safety behaviours that merit further investigation in future research, such as the role of formalizing procedures (Martínez-Córcoles et al., 2014), trust and team learning (Ayenew et al., 2015), role stressors and dissatisfaction (Gracia & Martínez-Córcoles, 2018), and mindful organizing (Renecle et al., 2020).

Employees' Participation and Upward Voice

A critical aspect for safety in complex systems, such as exceptionally reliable organizations, is upward voice. It is defined as a discretionary and informal form of upward communication that assess the extent to which employees "voluntarily communicate suggestions, concerns, information about problems, or work-related opinions, to someone in a higher organizational position" (Morrison, 2014, p. 173).

In HROs, the concept of "voice" is especially relevant because: (1) it allows key stakeholders in decision-making to be aware of where their organization is concerning safety limits; (2) it allows any signs of safety degradation to be detected as soon as possible, and (3) provides important feedback on standards and work processes that are applied during daily activities.

Our team has produced two articles, in which theoretical models are proposed and empirical evidence is obtained, on various predictors and results on the behavior of "Voice" (Renecle et al., in press; Silla et al., 2020).

Silla et al. (2020) developed a theoretical model that attempts to show how a work environment that supports the behavior of "voice" can be favoured in highly reliable organizations, such as NPPs. Specifically, with a sample of 495 workers from two NPPs from the same organization, Silla et al. (2020) found that participatory decision-making stimulated by an empowering leader increases confidence in management and, in turn, favours the behavior of "voice". Furthermore, the safety climate moderates this relationship. Both the direct effect of participatory decision-making on the behavior of "voice", and its indirect effect, decrease as the safety climate increases. The safety climate could be acting as a frame of reference that establishes the behavior of "Voice" as a desirable behavior that would not depend solely on the relationship established between leaders and subordinates. In those environments where the safety climate is favoured, the influence of participatory decision-making on the behavior of "Voice" is mitigated. In contrast, the leader's role in promoting "Voice" becomes relevant when the safety climate is low. This result is in line with Martínez-Córcoles et al. (2011), where a similar modulating effect of the safety culture was found.

In another study, Renecle et al. (in press) studied the role of "voice" along with stimulating employee participation (a participation climate) as a prerequisite for mindful organizing. The authors argued that by stimulating employee participation the organization creates the context for mindful organizing to take place. However, that may not be enough. If stimulating employee participation is not accompanied by the perception that one can express critical views of the organization's operations, procedures, and processes to their supervisor without fear of being "punished", mindful organizing may not develop. This is because employees that feel encouraged to share their opinions and be involved in the organization, but do not feel safe to express challenging views to their supervisors, will participate only in "affiliative" ways and will not challenge the status quo. For mindful organizing to develop, "challenging" forms of participation need to take place (e.g., reporting errors, openly exposing failures that may occur).

To test their hypothesis, Renecle et al. (in press) collected data from 47 teams in an NPP at two different time points. In Time 1, they collected data on participation and communication practices (participation climate and upward dissent/voice), and in Time 2 they collected data on mindful organizing. The results supported the researchers' hypothesis. Critical upward communication or upward dissent (i.e. voice) moderated the relationship between a climate of participation and mindful organizing, such that the relationship between both variables was high when upward dissent was high. However, it was not significant when upward dissent was low. From these results, it was concluded that a participation climate is not enough to foster mindful organizing amongst teams. For mindful organizing to develop over time, it is necessary to have organizational practices that stimulate participation, and supervisors who receive critical or "challenging" feedback well.

Futures Lines of Research

In the next few years, we intend to extend our research to other risky industries where safety is critical. Specifically, we have started collaborating with air traffic control centres, hospitals, chemical companies, railways, and forest fire brigades. This extension to other sectors will provide us with the opportunity to

test whether it is possible to generalize our results from the nuclear sector to other industries, other high-reliability organizations and other companies looking for high reliability (Vogus & Welbourne, 2003). At the same time, it will allow organizations from these sectors to benefit from our research and thus lead to improved safety at their facilities.

The starting hypothesis for these new projects is that the improvement of safety should be approached from the integrated application of the principles of Safety-II in safety management (Hollnagel, 2014), and the characteristic principles of high-reliability organizations (Weick et al., 2007, 2015). For Hollnagel (2014), the human factor is essential to understanding safety, not necessarily because it is the main cause of accidents, but because humans adjusting their behavior in changing circumstances make operations work in most incidences. This is despite being in complex, dynamic, and highly uncertain environments. The classical approach to safety management (Safety-I) has focused on observing, detecting, and analysing the occurrence of adverse outcomes, and on finding ways to ensure that the number of adverse events is reduced, ideally to zero. In contrast, Safety-II focuses on observing daily work practices to understand why operations usually go well despite being in overly complex and highly changing environments. When we understand why operations go well, we can increase the probability that acceptable results will be produced in the future. Consequently, we decrease the probability of obtaining unacceptable results, but not because certain types of behaviors are prevented from taking place (e.g. deviations or violations), but because organizations learn to improve their daily functioning. Consequently, this may lead to an increase in successful outcomes (Hollnagel et al., 2019).

This proposal is consistent with the theory of highly reliable organizations that have inspired our research for almost two decades. If we want to understand why certain operations work well, it is advisable to analyse HROs as these organizations manage to achieve reliable and safe performance consistently despite operating in high-risk environments. Within the HROs, the five principles proposed by Weick et al. (Weick et al., 1999; Weick & Sutcliffe, 2007, 2015) seem especially relevant. Together, these principles make up mindful organizing. Given that mindful organizing has frequently been proposed as the reason for the safe and highly reliable performance of HROs (Sutcliffe et al., 2016; Vogus & Sutcliffe, 2012; Weick et al. 1999; Weick & Sutcliffe, 2007, 2015), it necessitates further investigation to gain a better and deeper understanding. Later this year, one of the authors of this paper will defend a doctoral thesis about mindful organizing (Renecle, forthcoming).

We believe that professionals who are dedicated to occupational risk prevention, and/or personal or process safety management, can find inspiration from the Safety-II principles and *mindful organizing* in their attempts to improve safety management in their teams and organizations. Despite the relevance of both approaches in the management and improvement of safety, these two theoretical frameworks have been developing in parallel without considering the complementarity of both approaches. As such, there is a gap in the research investigating the integration of both frameworks with the potential to impose a greater impact on safety management. Looking to the future, we intend to reconcile and integrate both perspectives and propose a theoretical framework that will allow us to successfully tackle the challenge of improving safety.

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