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Research article

Safety in high-reliability organizations: The role of upward voice, team learning, and safety climate

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ABSTRACT

Introduction: Maintaining and sustaining safety is extremely critical in high-reliability organizations. Upward voice contributes to a proactive approach to safety and allows the early identification of potential problems before they cascade into tragic consequences. Despite its relevance, research tends to focus on the antecedents of upward voice rather than its consequences or the mechanisms and boundary conditions that explain its potential benefits for safety. *Method:* This study responds to this research gap by examining the relationship between upward voice and safety performance, and the mediating role of team learning in this relationship. The current study also explores the moderating effect of safety climate on the direct effect of upward voice on team learning. Additionally, it examines how this moderation influences the indirect effect of upward voice on safety performance through team learning. The sample was composed of 617 workers from two nuclear power plants of the same organization. *Results:* Results revealed a moderated mediation effect: the indirect effect of upward voice on safety performance through team learning was conditional upon the level of safety climate. As safety climate increases, the indirect positive effect becomes stronger.

1. Introduction

High-reliability organizations (HROs), such as nuclear power plants, petrochemical plants, or aviation are complex systems in which safety is a critical component when it comes to achieving success and preventing catastrophic accidents. In such complex sociotechnical systems, upward voice becomes crucial and can be defined as the degree to which employees feel free to communicate any concern or challenging information to their superiors. In this way, when a supportive environment is cultivated, upward voice can help maintain safety in the long term (Bashshur & Oc, 2015).

This study examines the influence of upward voice on safety performance, the underlying mechanism explaining this relationship, and how the context in which voice may occur influences this process. In this way, we contribute to previous research based on a systemic proactive approach to safety. In HROs, characterized by complexity and high interdependence (Perrow, 1984), catastrophic failures *"are often preceded by smaller failures that were not identified as being worthy of examination and learning"* (Cannon and Edmondson, 2005). Thus, HROs must constantly work on anticipating these potential problems through proactive and timely detection of errors and failures (Dekker & Pruchniki, 2013; Oliver et al., 2017). Upward voice can enable such early identification of potential problems and areas for improvement that will stimulate team learning and, in turn, safety performance (Teperi et al., 2017). Moreover, safety climate can play a relevant role in this process (DeJoy, 1996), acknowledging the relevance of contextual factors and the need to adopt a systemic approach to safety.

In addition, this study recognizes employees' positive contributions to safety. First, it focuses on upward voice, which assumes employees can play a valuable and active role in their workplace. Second, it attempts to predict safety performance operationalized as safety behaviors rather than individual errors. This approach is also congruent with a proactive approach aimed at safety behaviors rather than accidents.

Previous research on upward voice has mainly focused on its antecedents (e.g., leadership; Curcuruto & Griffin, 2023; Liu et al., 2023; Nazir et al., 2021; Silla et al., 2020a) rather than its outcomes (e.g., Mohammad et al., 2023). There are only two studies that we are aware of (Chen & Chen, 2014; Newnam et al., 2021), which have focused on different forms of voice and safety. However, the relationship between upward voice and safety performance remains unexplored, as well as the

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mechanisms and boundary conditions underlying these relationships. This study addresses this research gap.

The current study explores the relationship between upward voice and safety performance, and the mediating role of team learning in this relationship (Fig. 1). It also considers the moderating effect of safety climate on the relationship between voice and learning. Safety climate is expected to moderate the indirect effect of upward voice on safety performance.

2. Theoretical background

2.1. Safety performance

In this study, safety performance is defined as a set of individual behaviors that contribute to safety achievement in organizations (Martínez-Córcoles et al., 2018). It follows the safety performance model developed by Griffin and Neal (2000), which distinguishes between safety compliance and safety participation. This approach responds to the need to move from a reactive to a proactive approach to safety (Haage, 2021), which recognizes employees' active role and their contribution to safety (Hollnagel, 2018; Teperi, 2021; Teperi et al., 2023). Lessons learned in the field of safety in nuclear power plants (e.g., accidents such as Three Mile Island 1979, Chernobyl 1986, and Fukushima 2011) support this approach (Haage, 2021).

By reframing our understanding of safety to focus on behaviors that promote it, we can implement a forward-looking approach. Safety behaviors act as safety leading indicators. They have predictive value (Zwetsloot et al., 2020) and are actionable in that they can help reduce risk (Sinelnikov et al., 2015). Monitoring safety behaviors enables the organization to be proactive and to improve its safety before potential degradation cascades into an accident. By contrast, safety outcomes (e.g., number of accidents or injuries), which are lagging indicators, do not provide guidelines for improvement (Zwetsloot et al., 2020) and lack predictive value. Thus, considering that accidents in HROs can be life-threatening (Sutcliffe, 2011), measuring safety performance through leading indicators such as safety behaviors is worthwhile.

Previous literature makes a distinction between safety compliance and safety participation. Safety compliance reflects activities that are key to safety and must be carried out by employees to guarantee the safety levels required by the organization and the different regulatory bodies (Martínez-Córcoles et al., 2018). Safety compliance is the basis and foundation for achieving good safety outcomes (INSAG-15, 2002). Safety participation refers to voluntary engagement in safety-related activities (e.g., participation in safety meetings, safety discussions with colleagues, helping others; Martínez-Córcoles et al., 2018), which may not directly contribute to safety but that create a supportive context for safety accomplishment (Griffin & Neal, 2000). It recognizes individuals' valuable contributions rather than focusing on errors or deviations from desired behaviors. Despite safety participation and compliance contributing to safety in different ways, both refer to

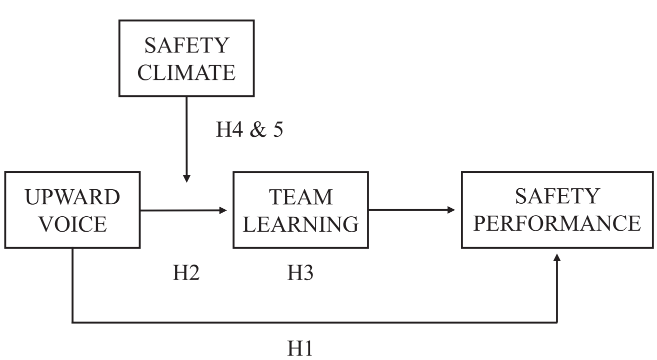

Fig. 1. Conceptual Model.

behaviors of expected value for the organization, which is a critical element that defines performance (Motowidlo et al., 1997).

This study focuses on overall safety performance. This approach is meaningful in HROs, where safety is an overriding priority and excellence is continuously pursued. In this context, many behaviors related to contextual performance, such as those voluntary behaviors considered as safety participation, are expected behaviors for which individuals receive training (Burke et al., 2002). Indeed, international organisms (e.g., IAEA, 2020–International Atomic Energy Agency) strongly encourage the active role of their employees (e.g., safety ownership, collaboration, anticipation capacity) rather than passive responses to work demands. Thus, some behaviors that typically lie under the category of safety participation could be considered as somewhat role prescribed.

2.2. Upward voice and safety performance

Consistent with a proactive approach to safety, this study examines the relationship between upward voice and safety performance. Some authors define upward voice as a discretionary behavior (Noort et al., 2019), or the informal and voluntary communication of work-related issues to someone in a higher organizational position who may enact change (Morrison, 2014). However, others refer to voice as the likelihood or willingness to communicate issues that should be addressed to create a better workplace (e.g., Aydon et al., 2016; Curcuruto & Griffin, 2023). Along these lines, this study conceptualizes upward voice as the degree to which employees feel free to raise their concerns or any challenging information to their superiors, aiming to provide relevant insights (e.g., Silla et al., 2020b).

We have focused on upward voice targeted to supervisors because it is likely to yield valuable insights. In fact, Detert et al. (2013) suggests that when employees feel free to voice their concerns to supervisors, they tend to self-censor low value ideas, refine others, or discuss them with peers before speaking up. In other words, employees are generally cautious about raising inadequate ideas to higher-power others (Detert & Edmondson, 2011). In addition, upward voice is targeted to supervisors who have the authority to act on potential issues, making it more likely to drive change in the workplace.

This study focuses on voice rather than safety voice because, in practice, distinguishing between safety and non-safety related concerns in HROs can be challenging. For instance, several authors (Perin, 2005; Weick & Sutcliffe, 2007) acknowledge that minor discrepancies, which may not appear significant for safety at first, can be critical in preventing failures in their early stages (e.g., the Davis-Besse event of 2002). This approach reinforces our proactive perspective on safety.

Altogether, the focus on upward voice and safety performance operationalized as safety behaviors can help prevent the incubation of a disaster (Pidgeon, 1997). In complex tightly coupled systems such as nuclear power plants, enabling upward voice helps employees to spot problems before they become bigger, make sense of emergent and unanticipated hazards, inform a timely response, improve task processes, or prevent progressive system safety degradation (Detert et al., 2013; Engemann & Scott, 2020; Haage, 2021).

Despite these arguments suggesting that upward voice might promote safety performance in HROs, empirical evidence on this relationship is scarce. Morrison's (2014) narrative review concludes that, overall, upward voice leads to desirable outcomes at the individual (e.g., Imran et al., 2023), group (e.g., Detert et al., 2013), and organizational levels. However, research on the influence of upward voice on safety performance is limited (e.g., Chen & Chen, 2014). Indeed, several literature reviews (Bashshur & Oc, 2015; Morrison, 2014) on voice neglect its influence on safety performance in their synthesis and integration of previous research.

Newnam et al. (2021) addressed the influence of safety voice on organizational safety outcomes in a sample of employees working on high-speed roads. However, they do not address voice targeted to supervisors and consider safety outcomes rather than behaviors. They found that safety voice was negatively associated with self-reported near misses and secondary incidents on the high-speed roads employees attend. However, Detert et al. (2013) claim the need to consider the target of voice to better understand its effects rather than to examine the correlates of an undifferentiated amount of voice.

Moreover, Chen and Chen (2014) have addressed the relationship between upward safety voice and safety performance. Findings showed upward safety communication was positively related to safety compliance and participation using a sample of cabin crew members working for international airlines in Taiwan. Thus, research on the relationship between upward voice and safety performance is scarce, apart from Chen and Chen (2014). However, these authors have focused on upward voice related to safety issues. This study extends previous research by examining the relationship between upward voice and safety performance in a different organizational context, nuclear power plants. Our focus on upward voice rather than upward safety voice is consistent with our proactive approach to safety, which recognizes the need to point out small discrepancies to be able to address failures in the early stages (Weick & Sutcliffe, 2007). In complex tightly coupled systems, it is difficult to distinguish between safety and non-safety related issues (Silla et al., 2017).

To sum up, theoretical arguments and empirical evidence suggest that upward voice may positively influence safety performance. However, to our knowledge, this relationship has not been previously examined. Hypothesis 1 reads as follows:

Hypothesis 1. Upward voice will positively influence safety performance.

2.3. The mediating role of team learning

Continuous improvement and learning are important elements in HROs, such as nuclear power plants (Koistinen, 2021). Organizational learning refers to the ability of an organization to improve the attainment and development of competencies through a set of behaviors and activities that enable better functioning over time (Breso et al., 2008).

This study addresses team learning. According to Huber (1991), teams hold a certain set of behaviors and activities that facilitate the process of learning and can be grouped into four dimensions (Bresó et al., 2008). First, *Continuous Improvement Seeking*, which highlights a team's willingness to learn from past experiences and execute actions to improve. Second, *Dialogue Promotion and Open Communication*, which emphasizes the open and honest communication between the team regardless of the roles each of the members play. Third, *Collaborative Learning*, which denotes the value placed on each team member as a source of knowledge and resources for the whole team. Finally, *Strategic and Proactive Leadership Promoting Team Development*, which anchors on the importance of the role the leader plays in promoting these behaviors and the proactive development of members.

High levels of upward voice are expected to facilitate team learning for several reasons. First, an increased flow of information and awareness about employees' concerns when it comes to organizational functioning will stimulate continuous team learning. Upward voice sets the foundation for open communication and collaboration within the team. On the contrary, low levels of upward voice might undermine learning. For instance, employees might be hiding information that confronts organizational policies and objectives to prevent interpersonal risks (e.g., creating unfavorable impressions, being judged as incompetent, or feeling embarrassed; Argyris, 1977). This would undermine team learning.

Second, upward voice is critical to truly learn from incidents and disturbances. In HROs, where incidents are caused by different factors that might interact in different ways, upward voice will nurture a deeper understanding of those contributing factors and their interrelationship (Haunschild & Sullivan, 2002). Moreover, upward voice might encourage employees to adopt learning behaviors such as discussing problems, asking for help, or admitting errors (Edmondson, 1999).

Third, overall, upward voice prevents organizational inertia, which diminishes team learning. Sometimes it is necessary to question taken-for granted assumptions and routines (Carroll, 1998; Pentland et al., 2022; Schöbel & Wahlström, 2023). When upward voice is high, employees have the chance to express their views and approach a problem from different perspectives and sources of knowledge. Upward voice will help to learn new adaptative behaviors and unlearn inefficient ones by exposing individuals to new paradigms and viewpoints (Van der Vegt & Bunderson, 2005). Seemingly, upward voice is a prerequisite to prevent *"groupthink,"* that is, the uniformity that emerges when members involved in a cohesive ingroup reinforce one another's tendency to perceive problems in similar ways (Janis, 1972). The need for consensus would undermine critical thinking and the appraisal of alternative courses of action (Jones, 2013).

Finally, upward voice can also make supervisors aware of any migration of the system toward safety boundaries (Rassmusen, 1997), which is critical in HROs. Inputs and contributions from different levels and sources within the organization provide critical information (Basten & Haamann, 2018) about the situation in which the organization operates. Thus, it can help supervisors to spot problems earlier and take appropriate actions to facilitate team learning and problem solving (Detert et al., 2013).

Despite several theoretical arguments suggesting that upward voice would benefit team learning, this relationship remains unexplored. However, some studies have shown the benefits of upward voice in very specific contexts. For instance, Edmondson (2003) found that upward voice contributed to the successful implementation of new technology for cardiac surgery in interdisciplinary teams. Upward voice proved to be useful for learning new tasks that present technical and interpersonal challenges. Therefore, the following hypothesis was formulated:

Hypothesis 2. Upward voice will positively influence team learning.

Team learning is critical for safety performance. Indeed, in HROs, safety performance is grounded in continuous learning and improvement processes that allow adopting the necessary proactive approach for early identification of hazards and implementation of solutions (Salas et al., 2020). Several studies in the field of railway, aviation, and mining (Baum & Dahlin, 2007; Haunschild & Sullivan, 2002; Madsen, 2009) have shown that organizational learning decreases accident rates. Along these lines, international organizations such as World Association of Nuclear Operators (WANO) or the Institute of Nuclear Power Operations (INPO) acknowledge the relevance of learning in nuclear power plants (Koistinen, 2021).

This study focuses on the influence of team learning on safety performance. Safety emerges from applying knowledge gained at different levels—individual, group, and organization—across the whole organization's operations (Basten & Haamann, 2018). In HROs, where safety rests on interdependent systems, the opportunity for team learning is high and significant. Moreover, teams are better prepared than individuals to adapt, be flexible, and respond to safety challenges (Jones, 2013; Salas et al., 2020). Teams could be portrayed as catalysts of safety emergence in HROs.

Several arguments support the positive influence of team learning on safety performance. First, team learning facilitates the development of competencies (e.g., knowledge, skills, and attitude) relevant to safety. These competencies provide employees with direction on how to implement safety rules and contribute proactively to the overall safety of the organization. Along these lines, a *meta*-analysis has shown that safety knowledge is positively associated with safety performance (Christian et al., 2009). Second, team learning facilitates system wide understanding that is needed to engage in the continuous improvement of system safety. Complex systems are continuously adapting to design flaws and responding to practical drifts of safety (Schöbel & Wahlström, 2023), which requires employees to hold a system wide perspective and engage in alternative ways to accomplish work safely.

Empirical evidence supports the positive relationship between team learning and safety compliance (Ayenew et al., 2015) and participation

(Martínez-Córcoles et al., 2012) in nuclear power plants. To sum up, despite previous research on the relationship between team learning and safety performance being scarce, theoretical and empirical evidence suggest that team learning will enhance safety performance.

This study builds upon previous research by examining the mediating role of team learning in the relationship between upward voice and safety performance. Upward voice is expected to facilitate team learning by providing informational resources and new insights, stimulating dialectical inquiry, or setting the basis for collaboration within the team. It is also expected to prevent organizational inertia and *groupthink*, and raise awareness among supervisors. In turn, team learning is expected to increase safety performance. Upward voice, through team learning, will therefore cultivate a system-wide perspective and establish directions for enhancing safety performance. It will make employees capable of performing safely in different circumstances and engage in safety activities. Employees will be able to manage complexities in the environment and adapt safely to organizational disturbances (e.g., Bashshur & Oc, 2015).

Despite previous research suggesting the potential mediating role of team learning in the relationship between upward voice and safety performance, we are not aware of any study addressing this link. Thus, this study builds upon previous research by testing the following hypothesis:

Hypothesis 3. Team learning will mediate the relationship between upward voice and safety performance.

2.4. The psychological safety climate

This study also examines whether the psychological safety climate affects the influence of upward voice on team learning. Psychological safety climate refers to individuals' perceptions of safety related policies, practices, and procedures (James & James, 1989). When these perceptions are shared among group members, we refer to them as group-level safety climate. Both psychological safety climate and group-level climate promote safety performance (Christian et al., 2009). However, this study focuses on psychological safety climate, that is, individuals' perceptions. From now on we will refer to it as safety climate.

Safety climate relates to the policies, procedures, and practices related to safety (Zohar, 2008), which is one of the overriding priorities in HROs. The safety climate will then serve as a framework for the interpretation of valued and adaptative behaviors (Neal & Griffin, 2004; Zohar, 2010). Thus, the processes that upward voice triggers are conditional upon the frame of reference that safety climate provides.

Therefore, in HROs, when exploring the context in which voice occurs, safety climate will be critical. Several authors (Bashshur & Oc, 2015; Lockett et al., 2015; Nacioglu, 2016) have claimed the need to explore the context in which voice takes place. In their exhaustive review of the literature on voice, Bashshur and Oc (2015) suggest that considering organizational climate is important to better understand the effects of upward voice. This study responds to this research gap by exploring the role of safety climate.

The study advocates that safety climate will cultivate a supportive upward voice environment. Several arguments support this postulate. First, when the safety climate is high, coworkers are more likely to feel free to communicate any concerns, and supervisors are expected to respond favorably to them. Subsequently, upward voice is more likely to elicit team learning under these favorable conditions. This might trigger a virtuous cycle on voice, as claimed by some authors (Bashshur & Oc, 2015). Second, safety climate serves as an interpretative framework guiding behaviors that will encourage the adoption of learning behaviors when employees raise their concerns. The search for excellence and continuous improvement that features high safety climate environments will strengthen the positive relationship between upward voice and team learning.

Despite the scarcity of empirical evidence delving into the context in which upward voice occurs, some studies suggest that safety climate may affect the outcomes of upward voice. Chen and Hou (2016) have shown that climate shapes how voice behavior translates into increased individuals' creativity, which is a critical element for learning. These authors found that the positive relationship between voice behavior and creativity was stronger when the climate for innovation was high. Thus, climate is a relevant boundary condition that modulates the effects of voice behavior. In addition, we posit that in HROs, where safety is critical, safety climate will become a relevant situational factor that can mitigate or intensify the effects of upward voice. Moreover, empirical evidence has proven that safety climate moderates the effects of individual factors such as employee engagement. Mark et al. (2007) found that when the safety climate is high, highly engaged nurses are less likely to suffer work injuries.

This study contributes to extending previous literature by shedding light on the context that shapes the influence of upward voice on team learning and the boundary conditions that influence the relationship between upward voice and team learning in HROs. Therefore, the following hypothesis was formulated:

Hypothesis 4. Safety climate will moderate the relationship between upward voice and team learning such that this linkage will be stronger when the safety climate is high.

To sum up, safety climate plays a relevant role in shedding light on the relationship between upward voice and team learning. Moreover, if safety climate is expected to moderate the relationship between upward voice and team learning, then it follows that the indirect effect of upward voice on safety performance via team learning will be contingent on safety climate. This study theorizes that the indirect positive effect of upward voice on safety performance through team learning will be stronger when the safety climate is high.

Hypothesis 5. Upward voice will influence safety performance through its indirect effect via team learning, and the indirect effect will be stronger when the safety climate is high.

3. Method

3.1. Sample and design

The sample consisted of 617 workers from two nuclear power plants from the same organization in Spain. All responsibility levels and functional areas in the nuclear facility were surveyed and the response rate was 76.55%. Most participants (73.2%) were older than 45 years, 21.3% were between 30 and 45 years of age, and 5.5% were less than 30 years old. Nearly half of the participants (54.3%) were university graduates. The study employed a cross-sectional research design with variables measured quantitatively using questionnaires.

3.2. Procedure

The University's Committee on Ethical Research involving Humans reviewed and approved the research project underpinning this study. The committee evaluated the project's aims, methodological design, sample characteristics, data collection procedures, and the nature of the information collected.

Questionnaires were distributed in small group sessions held in a quiet and convenient room during the employees' working time. At the beginning of each session, researchers explained the study's purpose, benefits, practical implications, funding, estimated response time and completion instructions. Participation was voluntary and employees were encouraged to answer honestly, taking as much time as they needed. The questionnaire contained no sensitive information and participants were informed they could leave questions blank. Anonymity and confidentiality were guaranteed, with only the research team having access to the data. Researchers assured participants that only aggregated data would be reported to the company to inform future workplace interventions. Participants were encouraged to ask questions, with researchers available to address concerns during the sessions. Additionally, contact information was provided for any future inquiries. All this information was also included in the questionnaire's introduction.

3.3. Measures

Upward voice was measured with three items developed by the research team based on previous literature. They assess to what extent employees feel free to communicate their concerns or any challenging information to their superiors as an attempt to provide relevant insights (e.g., Silla et al., 2020b). The items read as follows: "*I can tell my supervisor when things are not going well,*" "*I can freely express any disagreements I have with my boss,*" and "*I feel free to talk to my boss about any problems and difficulties I have in my job without any fear at all.*" The response scale ranged from 1 (*Completely disagree*) to 5 (*Completely agree*).

Team learning was assessed using the 20-item Team Learning Questionnaire by Breso et al. (2008). This scale has been validated and used in previous studies (Renecle et al., 2020; Martínez-Córcoles et al., 2012). It is based on a multidimensional model that measures four dimensions: Continued Improvement Seeking, Dialogue Promotion and Open Communication, Collaborative Learning, and Strategic and Proactive Leadership that Promote Learning. Some sample items are: "*The lessons learned are made available to all the members,*" "*Mistakes are openly discussed in order to learn from them,*" and "*Even when an error is stopped in time, it is reported so that it does not happen again.*" Response scale ranges from 1 (*Never or almost never*) to 5 (*Always or almost always*).

Safety climate was measured using 15 items adapted (Latorre et al., 2013) from the Group Nuclear Safety Climate questionnaire (Zohar & Luria, 2005). This questionnaire has been previously validated and used in other studies (de Castro, et al., 2017; Mezentseva et al., 2023; Renecle, et al., 2020). The questionnaire includes the following heading "*Below we present a series of statements about NUCLEAR SAFETY. Please indicate to what extent you agree with each of them with regard to your WORK UNIT.*" Some sample items are "*There is a frequent check on whether the safety norms and procedures are being followed,*" "*We make sure we have everything we need to do the job in a safe way,*" "*The safety parameters are emphasized when we are working under pressure,*" and "*The inherent risks in our work are often referred to.*" A 5–point Likert scale ranging from 1 "*Strongly disagree*" to 5 "*Completely agree*" was used.

Safety performance was measured using the scale developed by Neal and Griffin (2006). This scale comprises two dimensions: safety compliance and safety participation. It consists of six items, with responses measured on a five-point Likert scale ranging from 1 (*Completely disagree*) to 5 (*Completely agree*). The safety compliance dimension includes three items: "*I use all the necessary safety equipment to do my job,*" "*I use the correct safety procedures for performing my job,*" and "*I ensure the highest levels of safety when I do my job.*" The safety participation dimension also comprises three items: "*I promote the safety program within the organization,*" "*I make extra effort to improve safety in the workplace,*" and "*I voluntarily carry out tasks or activities that help to improve workplace safety.*".

Despite safety performance often being assessed along two dimensions, a unidimensional model of safety performance has also been employed (Clarke, 2010; Newaz et al., 2019; Quansah et al., 2023; Sha et al., 2024; Xu et al., 2022; Wang et al., 2023; Yu et al., 2021; Yu et al., 2022). Clarke (2010) argued that a unidimensional model could be considered because of the strong *meta*-analytic association Clarke (2006) found between safety compliance and safety participation. Along these lines, Christian et al. (2009) included a higher order safety performance composite measure in their *meta*-analyses following Burke et al. (2002). Consistently, in this study, a second-order factor of safety performance comprising two first-order factors, safety compliance and participation, was examined.

3.4. Analysis

Descriptive and correlation analyses were carried out. Cronbach Alpha coefficients were computed for all the scales using IBM SPSS Statistics (Version 26.0). Scale validity was examined through Confirmatory Factor Analysis (CFA) using M*plus* (Version 6.12).

Hypotheses were tested using several regression analyses. To test Hypothesis 1 and 2, a simple regression analysis was used. To test Hypothesis 3, a mediation regression analysis was conducted, specifically Model 4 (Hayes, 2013). Finally, to test Hypothesis 4 and 5, a first stage moderated mediation analysis was computed using Model 7 (Hayes, 2013). PROCESS macro (Version 4.2) developed by Hayes (2012–2022) for SPSS was used to conduct these analyses.

4. Results

4.1. Descriptive statistics and correlations

Descriptive statistics, reliability, and correlations are provided in Table 1. Reliability coefficients, as reported on the diagonal inside the parenthesis, reveal strong internal consistency across all measures used in the study. The patterns of correlations were also consistent with the theoretical and empirical arguments provided earlier. Upward voice was positively related to team learning and safety performance. Furthermore, team learning was positively related to safety performance. Reliability of all the variables were satisfactory, showing values above 0.80.

4.2. Confirmatory factor analysis (CFA)

The measurement model was examined through confirmatory factor analysis (CFA) using MPlus software. Robust maximum likelihood (MLR) estimation was employed. The measurement model consisted of upward voice, safety climate, a second-order factor of team learning comprising four first-order factors, and a second-order factor of safety performance including safety compliance and participation as first-order factors.

Acceptable fit indices were defined as Standardized Root Mean Square Residual (SRMR) values below 0.08 (Hu & Bentler, 1999); Root Mean Square Error of Approximation (RMSEA) lower than 0.08 (Browne & Cudeck, 1993; MacCallum et al., 1996); and a Comparative Fit Index (CFI) of 0.90 or higher (Iacobucci, 2010; Kyndt & Onghena, 2014). The proposed model showed an acceptable fit to the data (SRMR = 0.05; RMSEA [90% CI] = 0.057[.055, 0.06]; CFI = 0.91).

4.3. Hypothesis testing

Before testing our hypothesis, the normality of data distribution and the assumptions of no multicollinearity and independent errors were assessed. The normality of data distribution was assessed using the Kolmogorov-Smirnov (K-S) test and skewness and kurtosis values (See Table 2). The K-S test showed statistically significant results ($p < 0.05$) for all the variables, suggesting deviations from normality. However, caution is warranted due to the K-S test sensitivity to sample size. Large sample sizes (e.g., >200), may lead to rejection of normality

Table 1
Means, standard deviations, reliability, and correlations among study variables.

Variable	Range	M	SD	1	2	3	4
1. Upward Voice	1–5	3.93	1.01	(0.94)			
2. Team Learning	1–5	3.68	0.74	0.70**	(0.96)		
3. Saf. Climate	1–5	4.04	0.76	0.60**	0.78**	(0.96)	
4. Saf. Performance	1–5	4.44	0.58	0.38**	0.52**	0.62**	(0.89)

Note. ** $p < 0.01$. Reliability (coefficient alpha) is given in parentheses.

Table 2
Skewness, Kurtosis, and Normality Tests.

Variable	K-S *D*	*df*	*p*	Skewness Value	*SE*	Kurtosis Value	*SE*
Upward voice	0.15	611	0<.001	−0.91	0.10	0.17	0.20
Safety climate	0.10	611	0<.001	−0.88	0.10	0.41	0.20
Team learning	0.06	611	0<.001	−0.42	0.10	−0.25	0.20
Safety performance	0.17	614	0<.001	−1.26	0.10	2.25	0.20

Note. K-S: Kolmogorov-Smirnov test with Lilliefors correction.

assumptions even in the case of small deviations, although these minor deviations will not affect the results of a parametric test (Field, 2009; Hair et al., 2010). Thus, the K-S test should always be supplemented with skewness and kurtosis values (Field, 2009; Hair et al., 2010). Across most variables, skewness and kurtosis values fall within the acceptable range of ± 1.0, which is considered excellent (Geroge & Mallery, 2020). However, while skewness values for safety performance are within the acceptable range of ± 2.0 (Bandalos & Finney, 2010; Geroge & Mallery, 2020; Muthén & Kaplan, 1985, 1992), kurtosis values do not meet this criterion suggesting that distribution was leptokurtic for safety performance (more peaked than the normal distribution). Despite this, overall, the assessment of normality of the data distribution was satisfactory.

Moreover, the assumptions of no multicollinearity and independent errors were evaluated. Collinearity diagnostic tests, as presented in Table 3, revealed no evidence of collinearity among the variables. The variance inflation (VIF) values consistently remained below the threshold of 10, as stipulated by several authors (Bowerman & O'Connell, 1990; Myers, 1990). The tolerance statistics consistently exceeded the recommended threshold of 0.2 (Menard, 1995). Additionally, the Durbin-Watson statistics was close to 2, falling within the optimal range of 1 to 3, indicative of the independence of residuals (Hair et al., 2010).

Unexpectedly, the relationship between upward voice and safety performance was not statistically significant ($B = 0.02$, $p = 0.51$) when team learning was controlled for (Hypothesis 1). As hypothesized (Hypothesis 2), upward voice was positively associated with team learning ($B = 0.51$, $p = 0.001$). Team learning was also found to be positively related to safety performance when controlling for upward voice ($B = 0.39$, $p < 0.001$) (See Table 4). All these relationships were revealed to be statistically significant. In addition, bootstrapping procedures revealed a significant indirect effect of upward voice on safety performance through team learning (unstandardized indirect effect = 0.20; 95% CI [.16, 0.24]; standardized indirect effect = 0.35; 95% CI [.28, 0.42]). The number of bootstrapped samples was 5000. Thus, the results supported Hypothesis 3, which postulated that team learning would mediate the relationship between team learning and safety performance. Given that Hypothesis 1 was not supported, but the mediation effect was confirmed through Hypothesis 2 and 3, the findings reveal a full mediating relationship between upward voice and safety performance via team learning.

To test the moderation effect of safety climate (SC) on the pathway of upward voice and team learning (Hypothesis 4), a moderation regression analysis was computed. As hypothesized, safety climate moderated the relationship between upward voice and team learning ($B = 0.04$, $t = 2.20$, $p < 0.05$) (See Table 5). The interaction factor of upward voice and safety climate positively influenced team learning. Furthermore, the increase in explained variance when the interaction term was introduced in the model was statistically significant (R–square–change = 0.003, $F(1,609) = 4.838$, $p < 0.05$).

The mean, along one standard deviation above and below the mean, were used to define low and high levels of the moderating variable. Following the recommendations of Hayes (2018), the variables defining the interaction term were mean centered to avoid multicollinearity, so that their mean is 0. The conditional effect of upward voice on team learning was positive and statistically significant at low levels (−1SD: −0.75) (conditional effect = 0.24, 95% CI [.19, 0.28]) and high levels (+1SD: 0.75) (conditional effect = 0.31, 95% CI [.25, 0.36]) of safety climate. The conditional effect was found to be greater at high, rather than low, levels of safety climate. As such, all the confidence intervals were above zero and there were no statistical significance transition points within the observed range of the moderator found using the Johnson–Neyman method.

The graphical plot of the interaction effects (see Fig. 2) revealed that the relationship between upward voice and team learning was stronger when the safety climate was high rather than low, although both are statistically significant. Moreover, those who reported a high upward voice and high safety climate showed the highest levels of team learning. Thus, the findings supported Hypothesis 4.

Finally, Hypothesis 5, which postulated first-stage moderated mediation wherein the indirect effect of upward voice on safety performance through team learning is conditional on safety climate, was tested. Results indicated that the conditional indirect effect of upward voice on safety performance was consistently positive and became stronger as the safety climate increased. Table 6 shows confidence intervals (CIs) for bootstrap tests at three safety climate values: (1) −1SD, (2) Mean, and (3) + 1SD. The CIs were considered statistically significant if the range between the low and high CIs did not include zero (Hayes, 2013). The data revealed that this indirect effect is significant at all levels of safety climate as the range between low and high CIs did not include zero. Moreover, the index of moderated mediation, which tested the difference between conditional indirect effects, was significantly different from zero with an estimate of 0.017 (boot SE = 0.01; 95% confidence interval = 0.0004 to 0.0358). Overall, this result indicates that the conditional indirect effects projected at multiple levels of safety climate were significantly different from each other. Thus, Hypothesis 5 was supported, such that the indirect and positive effect of upward voice on safety performance through team learning was observed when levels of safety climate were low to high. It can also be noted that the conditional indirect effect became stronger as the safety climate increased.

Table 3
Collinearity Diagnostics and Durbin-Watson Test.

DV	Predictor	Tolerance	VIF	Durbin-Watson
Team learning	Upward voice (UV)	0.62	1.61	1.83
	Safety climate (SC)	0.61	1.65	
	UV x SC	0.80	1.25	
Safety performance	Upward voice	0.52	1.93	1.84
	Team learning	0.52	1.93	

5. Discussion

This study adopts a systemic proactive approach to safety in predicting safety performance in HROs. With this purpose, upward voice was considered a relevant antecedent (Engemann & Scott, 2020; IAEA, 2006) of safety performance, which was operationalized as safety behaviors (Griffin & Neal, 2000). This study attempts to respond to why upward voice may influence safety performance and under which conditions. Safety climate was considered a relevant contextual factor. As

Table 4
Regression results for the mediation model.

Predictor	Team Learning β	B	SE	p	Safety Performance β	B	SE	p
Constant	—	1.69	0.09	<0.001		2.92	0.10	<0.001
Upward Voice	0.69	0.51	0.02	<0.001	0.03	0.02	0.03	0.51
Team Learning		—	—	—	0.50	0.39	0.04	<0.001
	$R^2 = 0.483$ F (1,612) = 570.558, $p < 0.001$				$R^2 = 0.273$ F (2,611) = 114.842, $p < 0.001$			

Note. Standardized (β) and unstandardized (*B*) regression coefficients are reported.

Table 5
Results for Estimated Coefficients of the Moderated Mediation Model.

Predictor	Team Learning B	SE	p	Safety Performance B	SE	p
Constant	3.66	0.02	<0.001	2.99	0.14	<0.001
Upward Voice (UV)	0.27	0.02	<0.001	0.02	0.03	0.507
Team Learning	—	—	—	0.39	0.04	<0.001
Safety Climate (SC)	0.57	0.03	<0.001			
UV x SC → Team Learning	0.04	0.02	0.028			
	$R^2 = 0.6913$ F (3, 609) = 454.552, $p < 0.001$			$R^2 = 0.274$ F (2, 610) = 115.156, p < 0.001		

Note. Unstandardized regression coefficients are reported.

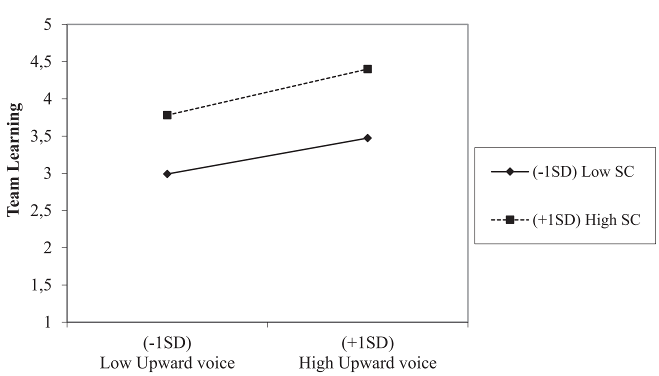

Fig. 2. Plot of interaction between upward voice and safety climate (SC) in predicting team learning.

Table 6
Bootstrap results for the conditional indirect effect at range of values of Safety Climate.

Moderator: Safety Climate	Bootstrapping indirect effect	SE	95% CI (LL, UL)
−1SD (−0.75)	0.09	0.013	0.07, 0.12
M (0)	0.11	0.014	0.08, 0.14
+1SD (0.75)	0.12	0.018	0.09, 0.16

Note. CI = Confidence interval; LL = lower limit; UL = upper limit.

expected, results showed that upward voice facilitates team learning, which in turn increases safety performance (Hypothesis 3). Findings support a full mediation given that the relationship between upward voice and safety performance was non-significant when team learning was controlled for (Hypothesis 1). As hypothesized, the indirect effect of upward voice on safety performance through team learning was conditional on the level of safety climate (Hypothesis 5): upward voice stimulates safety performance through team learning to a greater extent when safety climate is high.

As expected, upward voice influenced team learning (Hypothesis 2) and safety climate intensified this positive relationship (Hypothesis 4). Employees who reported high upward voice and high safety climate displayed the highest levels of team learning. Our findings were consistent with previous research that supports the benefits of upward voice for the team's successful implementation of new technologies and team learning (Edmondson, 2003). It is also consistent with previous studies showing a positive relationship between team learning and safety performance (Ayenew et al., 2015; Martínez-Córcoles et al., 2012) when controlling for upward voice.

Unexpectedly, the direct effect of upward voice on safety performance turned out to be non-significant when team learning was controlled for. Thus, our study suggests that a more holistic model of the effects of upward voice on safety performance is necessary. For instance, team learning and safety climate play a relevant role in better understanding the benefits of upward voice. Previous research on upward safety communication (Chen & Chen, 2014) might also benefit from a more comprehensive approach.

5.1. Theoretical implications

The current study evidences the benefits of upward voice and the mechanisms and boundary conditions that explain them. Despite academics (Engemann & Scott, 2020) and professionals (IAEA, 2020 −Safety Culture Model) in the field of safety having acknowledged the relevance of upward voice in HROs, we are not aware of any study that addresses its influence on safety performance, and the underlying mechanisms explaining this relationship. IAEA's Safety Culture Model (2020) emphasizes freedom to raise concerns, which resembles upward voice, as an important quality of healthy nuclear organizations. This guideline is grounded on the experience of experts from the nuclear industry but does not provide empirical evidence that supports its postulates. Therefore, the present study establishes the foundation for developing sound theoretical models on upward voice and safety and enables evidenced-based management.

Furthermore, this study supports the point made by some authors (Bashshur & Oc, 2015; Detert et al., 2013; Morrison, 2011) that the relationship between upward voice and its postulated outcomes cannot be oversimplified. This study delves into the conditions under which voice is cultivated and how it influences its effects on safety performance. Previous research has recognized the importance of safety climate (Casey et al., 2017) and team learning (Salas et al., 2020) for safety performance. However, it does not address how safety climate contributes to building a supportive environment and intensifies the positive effect of upward voice on team learning and the indirect effect of upward voice on safety performance through team learning.

The current study builds on previous research, showing the mediating role of team learning in the upward voice–safety performance connection. Subsequently, it contributes to upward voice theory development by providing insight into the mechanisms that explain the benefits of upward voice in HROs (Bashush & Oc, 2015). Additionally, our findings support the important role of team learning in HROs as suggested by previous researchers (Koistinen, 2021; Salas et al., 2020).

The present study also contributes to the development of safety climate theory by demonstrating that safety climate is a relevant contextual factor that helps understand the relationship between upward voice and safety performance. Moreover, findings from the current study are consistent with previous research that shows that safety climate is a relevant situational factor to be considered when predicting safety (Mark et al., 2007). Results are also congruent with previous studies that have shown that other facets of climate (e.g., innovation climate) influence the effects of voice on relevant organizational outcomes (Chen & Hou, 2016).

Moreover, the present study provides theoretical arguments that may explain the role of safety climate in the postulated model. The symbolic social interactionism postulates help to understand the influence of safety climate in the process triggered by upward voice. Safety climate may serve as a framework for the interpretation of valued and adaptative behaviors (Neal & Griffin, 2004; Zohar, 2010). A safety climate may encourage employees and supervisors to respond positively to upward voice for the sake of safety. Moreover, when the safety climate is high, the search for continuous improvement to assure safety may encourage employees to adopt learning behaviors when upward voice takes place. Future studies should explore whether safety climate acts as a frame of interpretation that mitigates or aggravates the influence of other relevant predictors of safety performance.

In addition, the proposed model contributes to the advancement of research in the field of safety in HROs. The model is based on a proactive approach that predicts leading indicators of safety (e.g., safety behaviors). Thus, it extends previous research focused on lagging indicators (Luo, 2020) that attempt to predict safety outcomes (e.g., accident or injury rates) based on past experience (Baum & Dahlin, 2007; Madsen, 2009).

Finally, this model will be insightful for system safety approach developments (Weick & Sutcliffe, 2007), which acknowledge that front–line employees' suggestions, ideas, worries, and concerns are crucial to prevent safety degradation in HROs. This study encourages system safety approach academics to incorporate upward voice literature into their theoretical developments. Upward voice may help to avoid safety degradation in the early stages. This approach is necessary to prevent systemic weaknesses that have caused tragic accidents in the past (e.g., Three Mile Island in 1970, the Chernobyl accident in 1986, and the Fukushima Daiichi nuclear power plant incident in 2011; Haage, 2021). Additionally, the proposed conceptual model incorporates contextual factors that can contribute to maintaining safety in the long run (e.g., safety climate).

5.2. Practical implications

This study has relevant practical implications on how to promote sustained safety performance, suggesting that organizations should promote organizational policies and practices that support safety climate and team learning. Results suggest that HROs should cultivate a strong safety climate that allows upward voice to translate into favorable safety outcomes. Promoting a safety climate will intensify the indirect positive effect of upward voice on safety performance. Without considering the safety climate, efforts to foster voice and learning to improve safety performance may be less effective. Future studies could also explore whether other safety related initiatives would also accomplish their goals more effectively when the safety climate is high.

Moreover, programs and initiatives centered on promoting upward voice should monitor organizational members' reactions to upward voice and make sure that they stimulate team learning. This study suggests that upward voice increases safety performance by stimulating team learning. Given that this study adopts a pragmatic approach to team learning that focuses on behaviors, several recommendations can be made to inform organizational programs and initiatives that pursue encouraging upward voice. Those initiatives should provide means, resources, and working conditions that enable upward voice to foster continuous improvement, open and honest communication within the team, and collaborative learning. Additionally, upward voice should inform leaders' actions to promote learning and team development.

Finally, the current study suggests that policies encouraging upward voice may stimulate team learning under favorable conditions. These findings may have practical implications for organizations in complex, fast-paced environments where team learning is essential for their survival (Oliver et al., 2017b). In these unpredictable environments, team learning capability provides a competitive advantage.

5.3. Limitations and future research

The current study presents some limitations. It is a cross-sectional study so causal relationships cannot be assumed. Despite several theoretical arguments supporting the positive influence of upward voice on team learning, this relationship could turn out to be reciprocal. Longitudinal studies that consider voice as a process may provide further insight into this relationship. A key assumption in the literature that supports the influence of upward voice on team learning is that the motive for voice is generally intended to help the organization perform better (Morrison, 2011), especially when it comes to upward voice (Detert et al., 2013). However, one may argue that this relationship could be reciprocal. When team learning is well-established, the perceived efficacy of voice may encourage employees' tendency to speak up, given that individuals will consider that their inputs and contributions will be considered.

Moreover, this study uses self-report measures, which may lead to common method bias. However, following Podsakoff et al. (2012), several procedural strategies were used to mitigate common method bias. Participants were assured of anonymity, which helped to avoid social desirability, and different anchor labels were used to measure the different variables included in the study. Despite this, safety performance showed a positively skewed distribution indicating that employees' responses tend towards the higher or more positive scores. Therefore, future research should combine the use of self-reported measures of safety with objective leading indicators of safety.

Despite its limitations, the current study is worthwhile and insightful for future research. It sheds light on the conditions under which upward voice improves safety performance and encourages others to follow the same line of research. This study has focused on upward voice targeted to supervisors, but when voice is targeted to other organizational members (e.g., leaders outside their change of command, coworkers), distinct outcomes and prerequisite conditions will feature the different sender-target combination of voice (Detert et al., 2013). Future research should address this issue as well as the role of context.

This study has been conducted in a particular context, the nuclear industry, where safety climate is salient for organizational members. Future studies conducted in different types of high-reliability organizations (e.g., petrochemical plants, aviation), that also place safety as a core element in its daily operations, would inform about the generalizability of our findings. Safety climate would also be salient in organizations that seek reliability (Weick & Sutcliffe, 2007). Future studies may go further by testing the role of different facets of climate in the upward voice performance link. One might argue that in other organizational settings with different priorities, the climate facet needed to better understand the effects of upward voice might be different. Studies following this research path would enrich theoretical developments that emphasize the importance of context for a better understanding of voice correlates (Bashshur & Oc, 2015).

Moreover, using a multilevel approach would be valuable to understand how to create a supportive environment conducive to individuals' safety performance. Regarding safety climate, future research may benefit from conceptualizing it as a multilevel construct (Zohar, 2000; Zohar, 2008; Zohar & Luria, 2005) and exploring the impact of safety climate alignment throughout the organizational hierarchy on creating a supportive environment. It can be expected that when safety climate policies and practices are highly enacted throughout the organizational hierarchy, the work environment will be perceived as supportive for safety and, subsequently, safety performance will be encouraged. A multilevel perspective on safety climate would also shed light onto research in the field of voice. This perspective addresses the claim that voice should be considered an ecological phenomenon (Noort et al., 2019) and, as such, its expected correlates are contingent upon contextual factors.

Additionally, future studies should integrate literature on voice and safety voice, providing empirical evidence on their similarities and distinct nuances. While some authors (e.g., Curcuruto & Griffin, 2023) regard safety voice as a specific form of voice, a systematic review by Noort et al. (2019) acknowledges some differences between the two constructs. Noort et al. (2019) argue that the ethical imperative associated with safety voice, its legal implications, and its closer proximity to safety outcomes distinguish it from voice. Future research should elucidate this debate and explore whether safety voice and voice exhibit unique antecedents and correlates. To address this inquiry, a more nuanced conceptualization of both safety voice (Curcuruto & Griffin, 2023) and voice (Morrison, 2014) should be considered. For instance, Curcuruto and Griffin (2023) provide a general framework that distinguishes between safety voice oriented toward improving workplace safety (promotive safety voice), related to potential risks or hazards (preventive safety voice), and reporting inappropriate conduct (proscriptive safety voice).

Finally, future studies should consider upward voice as a process rather than a *"one-shot exchange"* (Bashshur & Oc, 2015). Longitudinal studies would provide information about voice as a process that considers colleagues' and supervisors' reactions (e.g., whether voice is ignored or acknowledged), how voice dynamics change as a function of those reactions, and whether voice stimulates organizational change through learning in the short and long term (Bashshur & Oc, 2015; Engemann & Scott, 2020; Silla et al., 2020). This approach to voice would enrich theoretical developments by incorporating a feedback loop from outcomes to voice (Engemann & Scott, 2020).

6. Conclusion

This study encourages future research to move towards a proactive approach to safety, acknowledging the value of employees' contribution through upward voice. It extends previous research by showing the mechanisms and boundary conditions that explain the relationship between upward voice and safety performance. Results revealed that upward voice enhances safety performance through team learning to a greater extent when the safety climate is high.

CRediT authorship contribution statement

Inmaculada Silla: Writing – review & editing, Writing –, original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Julie-Anne Gajudo:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Francisco J. Gracia:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization.

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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