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SAFETY CULTURE AND RESILIENCE ENGINEERING IN HOSPITAL EMERGENCIES: A SCOPING REVIEW OF THE LITERATURE WITH A FOCUS ON OCCUPATIONAL SAFETY

CULTURA DE SEGURANÇA E ENGENHARIA DE RESILIÊNCIA EM EMERGÊNCIAS HOSPITALARES: UMA REVISÃO DE ESCOPO DA LITERATURA COM FOCO NA SEGURANÇA OCUPACIONAL

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Abstract: Safety culture and resilience engineering represent fundamental concepts in ensuring safety within hospital environments. Safety culture reflects behavioral patterns that signify an organization's commitment to its workers' safety, health, and well-being. Resilience engineering focuses on designing systems and processes capable of adapting to, learning from, and responding to complex conditions and unexpected events. Therefore, this scoping review of the literature explored mechanisms for evaluating both processes in hospital emergency settings, specifically concerning occupational safety. Publications on the subject were searched in the PubMed, Scopus, Web of Science, and Google Scholar databases. The screening process included 36 studies, divided into mechanisms for evaluating Safety Culture (n=27) and mechanisms for assessing Resilience Engineering (n=9). The results demonstrated that the safety attitudes questionnaire was the most frequently utilized tool for assessing safety culture and the resilience assessment grid for resilience engineering. These approaches were found to contribute to assessing occupational safety, although few methods are used to operationalize and measure it. Additionally, there is inconsistency in defining the dimensions of safety culture among professionals and researchers in occupational health and safety, leading to safety culture frequently being confused with safety climate.

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Keywords: Occupational health and safety. Safety culture. Resilience engineering.

Resumo: A Cultura de Segurança (CS) e a Engenharia de Resiliência (ER) representam conceitos fundamentais para garantia da segurança em ambientes hospitalares. A CS reflete os padrões de comportamento que determinam o compromisso organizacional com a segurança, saúde e bem-estar dos trabalhadores, enquanto a ER contribui para projetar sistemas e processos que funcionem em condições reais, adaptando-se, aprendendo e respondendo a condições complexas, incertezas, eventos inesperados ou distúrbios. O objetivo da presente pesquisa foi explorar os mecanismos para avaliação da CS e ER em ambientes de emergência hospitalar, focados na segurança ocupacional, por meio de uma revisão de escopo realizada nas bases de dados PubMed, Scopus, Web of Science e Google Scholar. O processo de triagem incluiu 36 estudos, divididos em mecanismos para a avaliação da CS (n=27) e mecanismos para a avaliação da ER (n=9). O *Safety Attitudes Questionnaire* - SAQ foi o instrumento de avaliação de CS com maior recorrência. Enquanto, a *Resilient Assessment Grid* - RAG se mostrou uma ferramenta consolidada para avaliar a resiliência em ambientes hospitalares. Os resultados indicaram que as abordagens podem contribuir para a avaliação da segurança ocupacional, entretanto, há uma limitação de métodos para operacionalizá-las e mensurá-las. Além disso, os estudos demonstraram que há uma inconsistência na definição das dimensões da cultura de segurança entre profissionais e pesquisadores de saúde e segurança do trabalho, fazendo com que a construção da cultura de segurança seja frequentemente confundida com o clima de segurança.

Palavras-chave: Saúde e Segurança Ocupacional. Cultura de Segurança. Engenharia de Resiliência.

Introduction

The dynamic nature of hospitals and the increasing demands challenge health professionals with changes in psychosocial working conditions. These conditions, characterized by a shortage or imbalance of skills, increased workload, and the complexity of tasks, can lead to occupational stress, burnout syndrome, and other mental health problems, negatively impacting the quality of care and patient safety [1,2].

As psychosocial risks have been recognized among healthcare professionals, the concept of safety climate assessment has emerged as an important tool for diagnosing the existing safety culture within an organization or work unit [3,4]. Safety climate, a crucial component of safety culture, reflects professionals' perceptions of safety priorities and practices in their work environment [5].

Consequently, healthcare organizations regard safety climate as essential for institutional efficiency and success. This has sparked significant interest in methods for

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measuring healthcare professionals' attitudes and perceptions regarding the safety climate [6]. Research evidence suggests that safety climate measures can vary between and within healthcare organizations. Furthermore, understanding the factors that influence and explain such sources of variation remains limited [7]. This variability underscores the need to explore the contextual factors shaping safety climate, such as organizational structure, leadership, and the specific characteristics of the work environment.

Studies focused on assessing and improving the patient occupational climate must consider the perceptions and attitudes of healthcare professionals, who are integral to building the patient and work safety culture in hospitals [8]. This underscores the need for specific tools to measure safety culture in healthcare organizations, identify weaknesses, and support the planning of personalized interventions [9]. Assessing safety culture enables identifying gaps between professionals' perceptions and ideal safety practices, targeting interventions that promote a more robust safety culture. These tools can contribute to developing recommendations to change sociotechnical systems by anticipating or detecting work or organizational characteristics that impact the health and safety of professionals and patients [10].

Safety culture, defined in 1986, encompasses the set of organizational and individual characteristics and attitudes that underscore safety issues [11,12]. It is determined by the interplay between organizational structures and processes, workers' attitudes, perceptions, skills, and individual and group behaviors related to safety [13; 9]. Safety culture reflects how organizations operationalize safety and guides workers and managers in carrying out their safety tasks [14], representing the shared values and norms that influence individuals' behavior regarding safety.

Unlike safety culture, safety climate stems from the organizational climate and reflects professionals' perceptions about the value of safety in the occupational environment relating to safety attitudes [15,16]. Safety attitudes or behaviors illustrate how professionals implement safety at work [17,18]. Safety climate can reflect safety culture since professionals' perceptions are influenced by the organization's safety values and norms.

Organizations with a positive safety culture provide higher quality healthcare services, maintain a better public image, and rely on engaged, trained, and committed professionals to foster a safe culture [19]. The active collaboration between hospital management and healthcare professionals is paramount in improving safety culture [20]. The participation of

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professionals in safety management is fundamental to establishing a participatory safety culture where everyone feels responsible for safety. This participation can be promoted through ergonomic or human factors approaches that involve and analyze the interactions between professionals and organizational systems dynamically and systemically [21].

Hospital management's commitment to safety is associated with safety performance, a crucial factor for enhancing safety awareness in hospital environments and strengthening the safety culture [22]. Safety performance reflects the level of safety within an institution, resulting from the actions and omissions of its members, systems, and structures [23,24,25]. Leadership committed to safety serves as a catalyst for cultural change, promoting the implementation of safe practices and creating a work environment that prioritizes safety.

Safety in the workplace is frequently assessed based on accidents, fatalities, and injuries [26, 22]. However, hospital managers must increase their commitment to safety by allocating more resources, conducting periodic risk assessments, performing constant inspections, holding safety meetings [22], and implementing awareness-raising measures to fortify the culture and commitment to safety. Measuring occupational safety should extend beyond accident counts to include proactive indicators that evaluate the safety culture, climate, and risk management. In emergency departments, which are complex, dynamic, open healthcare systems operating under high risk, uncertainty, and economic pressure, a resilient safety performance capability is critical [27]. In these settings, managers require effective tools to aid decision-making [28]. The complexity and dynamism of emergency departments necessitate innovative approaches to safety management that account for the interplay among human, technological, and organizational factors.

Resilience engineering has emerged as an alternative for safety management, although gauging and analyzing resilience potential in emergency departments remains a significant challenge [29]. According to the concept of resilience, safety is attributed to the ability of an organization, groups, and individuals to anticipate risks before damage occurs [30]. Resilience engineering aims to comprehend how complex socio-technical systems (e.g., emergency departments) manage to operate safely under challenging conditions by adapting and learning from adversity.

Thus, systems that maintain safety demonstrate resilience, which is the ability to succeed under both expected and unexpected conditions and maximize the number of intended and acceptable outcomes [31]. Hence, resilience engineering represents a novel

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approach to managing human error and enhancing safety systems, highlighting how people, systems, and organizations adapt and learn to ensure safety amid hazards, conflicting objectives, and adverse conditions [32]. This approach enables the work system to be characterized by its capabilities for response, monitoring, anticipation, and learning [33,34]. In high-risk environments such as emergency departments, resilience depends on professionals' ability to anticipate, monitor, respond to, and learn from events, ensuring continuity of care and patient safety.

Safety management in dynamic and complex environments is a vital tool for organizational management and should be integrated into its life and activities, including strategies, decisions, projects, processes, operations, services, and assets [35]. Tools that characterize safety culture and organizational resilience can aid in promoting occupational safety in complex socio-technical environments, such as hospitals. These tools capture interactions between people and the occupational system, the organization's capacity for adaptation and learning, and reflect the organizational structure in terms of recurring safety patterns and behaviors that can impact work safety, professional satisfaction, and motivation, consequently affecting patient safety.

Nevertheless, most studies on this topic in hospital settings primarily focus on patient safety [36-42]. Organizational learning in healthcare systems represents a growing demand for developing information systems that support safety management [43]. This focus, while essential, may overlook the occupational risks faced by healthcare workers, especially in high-demand environments (i.e., emergency departments).

Considering the need to deepen our understanding of occupational safety in hospital environments, this scoping review aimed to answer the following research question: What assessment mechanisms and tools have been reported in the literature to evaluate safety culture and resilience engineering in emergency departments, with emphasis on occupational safety?

This study assumes that existing instruments can be grouped into two major categories: Safety Culture (SC) tools, focused on perceptions and safety climate, and Resilience Engineering (RE) tools, aimed at assessing the adaptive capacities of work systems. Therefore, the review systematically mapped and categorized these tools according to their conceptual approach and application context.

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Methodology

This literature review was conducted as a scoping review [44]. To assure transparency and methodological rigor, the review was registered on the Open Science Framework platform (doi: 10.17605/OSF.IO/6UBWM). The review process utilized the Parsifal online tool and the Zotero software for the references. The research question formulation adhered to the PICo (Population, Interest, and Context) framework (Table 1).

Table 1 – The PICo strategy for assessing safety culture and resilience engineering criteria in hospital emergency settings.

Objective/problem	**Does the hospital emergency department have a defined safety culture and resilience engineering criteria for occupational health and safety management?**		
	P	**I**	**Co**
Extraction	Hospital emergency	Safety culture resilience engineering	Occupational health and safety management
Conversion	Hospital emergency	Safety culture resilience engineering	Occupational health and safety management
Combination	Emergency ward Emergency service hospital University hospital	Safety climate organizational	Safety management Occupational safety Safety engineering
Construction	(“Hospital emergency” OR “Emergency ward” OR “Emergency service hospital” OR “University hospital”)	(“Safety culture” OR “Safety climate” OR “Resilience engineering” OR “Organizational resilience”)	(“Occupational health and safety management” OR “Safety management” OR “Occupational health” OR “Safety engineering”)
Use	(“Hospital emergency” OR “Emergency ward” OR “Emergency service hospital” OR “University hospital”) AND (“Safety culture” OR “safety climate” OR “Resilience engineering” OR “Organizational resilience”) AND (“Occupational health and safety management” OR “Safety management” OR “Safety engineering” OR “Occupational safety”)		

Source: Prepared by the authors (2025).

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Studies were selected in April 2024 from the PubMed, Scopus, and Web of Science databases. To broaden the scope of the review, Google Scholar was utilized as a supplementary source, restricted to the first 100 results, and sorted by relevance. Duplicates and studies that did not align with the research objective (as determined by reviewing the titles and abstracts) were excluded. The inclusion and exclusion criteria are listed in Table 2.

Table 2 – The inclusion and exclusion criteria used in this systematic literature review.

Inclusion criteria	Exclusion criteria
Primary studies that address the contribution of safety culture and/or resilience engineering to occupational health and safety management.	Studies that do not address data collection mechanisms, diagnosis, or classification of safety culture and/or resilience engineering in hospital emergency environments.
Data collection mechanisms that characterize safety culture and/or resilience engineering in hospital emergency environments.	Clinical and epidemiological studies on patient health/safety.
	Studies on safety culture and/or resilience engineering focused exclusively on patient safety.
Mechanisms for diagnosing or classifying safety culture and/or organizational resilience in hospital emergency environments.	Literature reviews, books, opinion articles, editorials, commentaries, technical reports, abstracts, conference proceedings, or undergraduate course conclusion papers.
	Studies without access to the full text.

Source: Prepared by the authors (2025).

After reviewing the titles and abstracts, 156 studies remained for comprehensive analysis. Of these, 139 were accessible for full review, and 36 were incorporated into the systematic review after a thorough examination (Figure 1).

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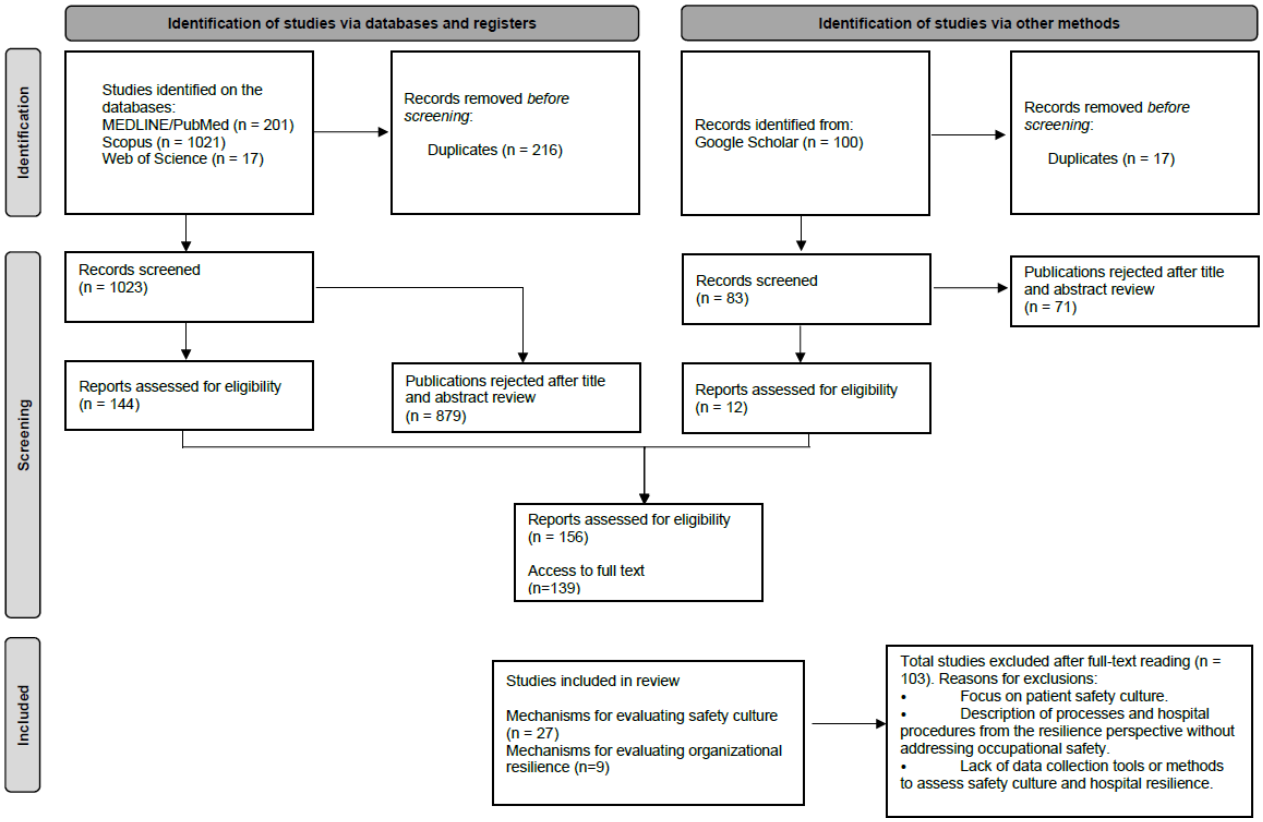
Figure 1 – Screening process.



Source: Prepared by the authors (2025).

The 36 studies included in the review were categorized into two analytical domains: Safety Culture/Safety Climate (SC), encompassing tools designed to assess healthcare professionals' perceptions, organizational climate, and safety attitudes; and Resilience Engineering (RE), comprising instruments focused on evaluating adaptive system capacities, such as anticipation, monitoring, response, and learning.

For data synthesis, results were organized into two summary tables, one for each domain, presenting, for every identified instrument: the corresponding publication, the assessment objectives, and the principal findings reported in the studies. This structured synthesis provided a descriptive summary of the identified instruments and their reported applications to occupational safety assessment in hospital emergency settings.

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It should be emphasized that this research involved only the analysis of secondary data from publicly available sources and did not include human participants. Thus, according to applicable ethical standards, approval by a research ethics committee was not necessary.

Results and Discussion

The 36 studies included in this scoping review of the literature facilitated the exploration of safety culture and organizational resilience from the perspective of occupational health and safety. They presented mechanisms capable of collecting data and assessing these domains within hospital emergency environments. The results of the review are presented below, divided into two topics: an analysis of safety culture in hospital environments and an analysis of organizational resilience in these settings.

Analysis of safety culture in hospital environments

In the health sector, a culture of safety encompasses organizational aspects related to occupational activities and patient care. Promoting patient and worker safety is contingent upon psychosocial working conditions, the management by leadership and supervisors, patient perception, and the safety climate, presenting an emerging challenge for hospitals [8].

Inconsistencies in defining the dimensions of safety culture among occupational health and safety professionals and researchers have led to confusion between the constructs of safety culture and safety climate [45,46]. Although the terms safety culture and safety climate are frequently used interchangeably, they represent distinct concepts [20,47-48].

Safety culture pertains to an organization's standards, norms, and values, whereas safety climate reflects workers' attitudes and perceptions regarding the priority given to safety [49]. Safety climate is considered a subset of safety culture, serving as a tangible manifestation of the latter [50,51] and refers to the measurable component of safety culture at a specific point in time [52,53,54]. Despite these distinctions, researchers often assess the safety climate to gauge the organizational safety culture [46,55].

Safety climate is conceptualized as a psychological construct that reflects professionals' attitudes toward safety, characterized by its relative instability and susceptibility

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to changes in environmental conditions and components [56]. Conversely, safety culture examines the organization's shared values and addresses formal elements of organizational safety [57].

Instruments for measuring safety culture and climate are prevalent. Among these, the safety attitude questionnaire, developed by Sexton et al. [6] and initially adapted from the aviation industry, stands out as one of the most successful and commonly employed within hospital settings [9,37,58-60]. The hospital survey on patient safety culture questionnaire is another tool used internationally and validated in multiple languages, designed to evaluate patient safety culture with domains that also explore occupational safety culture and climate [61,62,36,40].

Furthermore, the Manchester Patient Safety Framework (MaPSaF) is recognized internationally as a tool to assist healthcare organizations in reflecting on their progress and cultivating a mature safety culture [20]. The tools identified in 27 studies for assessing safety culture are presented in Table 3.

Table 3 − Mechanisms for assessing safety culture in hospital environments.

Instrument	Studies	Objective	Main results
Safety attitudes questionnaire [6]	[63]	Examining the relationship between the safety climate, teamwork, and the intention to stay at work, as perceived by hospital nurses.	The results indicated the positive effect of safety climate and teamwork on the level of intention to stay. Designing and implementing strategies that create a safety climate and teamwork culture is essential to increase the retention of professionals in healthcare organizations.
	[62]	Translating the safety climate survey into German and French.	The results indicated that the translated instrument provides useful measurements of the safety climate in Swiss hospital units. The items analyzed by the instrument make it possible to differentiate safety climate factors into positive and critical aspects.

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(9)	Verifying the psychometric properties of the Italian version of the safety attitudes questionnaire and to evaluate the safety culture in neonatal intensive care units.	Hospitals' organizational and structural characteristics can significantly influence awareness of safety culture issues. More research is needed to identify specific determinants and guide hospital administrations in identifying the positive and negative organizational aspects that affect safety issues and climate.
(64)	Assessing the safety culture among nurses at a tertiary university hospital in Saudi Arabia.	The nurses positively perceived four dimensions of safety culture: job satisfaction, working conditions, safety climate, and teamwork climate. Negative perceptions were identified in the perception of management and recognition of stress.
(65)	Determining the psychometric properties of the Slovenian version of the safety attitudes questionnaire in primary health care settings.	The results suggest that the Slovenian-language version of the six-factor safety attitudes questionnaire can be a valid tool for measuring safety culture in primary healthcare professionals with a leadership role.
(66)	Exploring the relationship between safety climate and teamwork climate with adverse events that resulted in patient harm.	The logistic regression results showed no significant predictors (type of unit, safety climate, teamwork climate) in predicting the likelihood of an adverse event. The likely reason was the similar safety attitudes questionnaire scores between the units, limiting variation and the ability to detect statistically significant differences. Respondents may have reported a positive safety climate and teamwork for reasons of social desirability.
(67)	Evaluating health professionals'	The total safety attitudes

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	perceptions of the safety culture in a highly complex public hospital, part of the Brazilian Unified Health System.	questionnaire score was below the recommended 75, suggesting that the institution should implement actions focused on developing a positive safety culture.
(68)	Measuring perceptions of the safety climate in an Australian metropolitan emergency department and examining the relationships between perceptions of the safety climate and staff characteristics, the safety attitudes questionnaire and the safety climate survey were used (Victorian Managed Insurance Authority, 2015).	Doctors and nurses have recognized that fatigue, increased workload, and the recognition of stress negatively impact the patient's safety.
(54)	Describing the safety culture of a teaching hospital in Ireland and identify areas where patient safety could be improved.	The hospital scored above the international benchmark in five domains, indicating a positive safety culture, but scored below the international benchmark in the "working conditions" domain.
(69)	Describing the perception of safety among nurses working in Indonesian hospitals and examining the association between demographic, professional, and organizational factors.	The lowest level of teamwork and safety climate was perceived by nurses working in the emergency sector. In addition, workers in private hospitals reported lower safety climate levels than nurses in public health centers.
(70)	Verifying the associations between presenteeism and safety culture among healthcare workers.	The associations were observed in the domains of teamwork climate, safety climate, recognition of stress, and working conditions.
(12)	Describing and comparing the differences in perceptions of teamwork climate and safety climate between clinical leaders	The teamwork climate was reported as positive by 67% of clinical leaders and 43% of frontline doctors. The safety climate was perceived as positive

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		and frontline doctors.	by 54% of clinical leaders and 32% of frontline doctors.
	(71)	Evaluating the perceptions of the employees of the University Perinatal Center about the safety culture.	The interviewees felt that managers did not value their efforts enough, that the units were understaffed, and that the workload was high. Improvements in these factors could improve patient safety and reduce the number of adverse events.
Safety performance scale [5]	(72)	Exploring the effect of the perceived risk of work-related musculoskeletal disorders on contextual and task performance in nurses, using risk perception (Fischhoff, 1978; Benthin et al., 1993) and safety performance scale instruments.	Risk perception positively affected safety behavior, while safety behavior positively predicted task and context performance.
	(73)	Developing a model to predict nurses' safety performance based on the psychosocial safety climate using equation modeling structural. Using the psychosocial safety climate scale (Hall et al., 2010) and safety performance scale.	Psychosocial safety climate correlated significantly with all the variables in the survey (work resources, work demands, emotional exhaustion, job satisfaction), and all the variables in the survey, except control, had significant correlations with safety performance.
	(22)	Examining the relationship between perceived management commitment to safety, psychological empowerment, and safety performance among emergency nurses in Jordan. Using the scales of perceived management commitment to safety (Vinodkumar & Bhasi, 2010) and safety performance.	The results showed a positive correlation between safety performance and management's perceived commitment to safety and psychological empowerment. Indicating that implementing continuous interventions focused on the psychological empowerment of emergency nurses positively impacts safety performance.

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Manchester patient safety framework [74]	(75)	Investigating the relationship between safety culture and safety-related behaviors of health professionals using the instrument safety climate in health care (Flin et al., 2006; Gershon et al., 2000) in conjunction with the Hospital Survey on Patient Safety Culture (Sorra et al., 2004) and the MaPSaF.	Nurses were more committed to complying with safety standards and precautions than doctors. The analysis showed a positive relationship between training in safety standards and safety culture.
	(20)	Conducting an integrated assessment of the safety climate and culture using the safety attitudes questionnaire and MaPSaF.	The results indicated the presence of subcultures with a positive impact on the performance of subgroups and the difficulties in translating the organization's needs into effective improvement strategies.
Hospital survey on patient safety culture of the agency for healthcare research and quality [61]	(4)	Investigating nurses' perceptions of the safety climate in Croatia, Czech Republic, Poland, and Slovakia and determining the relationship between the safety climate and nursing care.	The areas with the potential to initiate improvement strategies identified were: "personnel," "non-punitive response to error," and "teamwork between hospital units."
	(8)	Investigating hospital staff perceptions about psychosocial working conditions, leadership, patient safety climate, and occupational safety climate.	The results indicated a need for improvement in working conditions, patient safety climate, and occupational safety climate for healthcare professionals in German university hospitals, especially nurses.
Safety behaviors [16]	(76)	Understanding how safety climate can affect outcomes related to safety behavior, using adaptations of the instruments: safety climate (Neal et al., 2000); safety attitudes (Guldenmund, 2007), safety stressors (Spector et al., 1988; Rizzo et al., 1970), and safety behaviors.	The results indicated the partial mediating role of safety attitudes in the relationship between climate and safety behavior. Suggesting that safety attitudes can regulate the impact of perceptions of management values concerning safety, policies, and procedures.

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Hospital Safety Climate Scale [77]	[78]	Examining the dimensions, reliability, and main loading factors associated with a Japanese scale of safety climate and psychosocial risk factors.	The results suggest that the safety climate comprises three dimensions: workplace issues, protective devices or mechanisms, and management issues.
Safety organizing scale [79]	[80]	Exploring the psychometric properties of the safety organizing scale's German, French and Italian translations.	The safety organization scale portrays nurses' involvement in safety behaviors at the hospital unit level.
Airline safety culture index [81]	[46]	Evaluating the psychometric properties of the adapted airline safety culture among mental health professionals in Ghana.	The scale adapted from 25 to 11 items (modified safety culture index) showed good reliability estimates. It is a brief scale that measures resilient safety culture, has a stable unidimensional structure, and has adequate fit quality statistics.
Command safety assessment survey and Patient safety cultures in healthcare organizations developed by the Navy Graduate School and veterans from Palo Alto (USA)	[82]	Comparing the safety climate survey in the health sector with that in naval aviation.	The data indicated that hospital leaders recognize that commitment to safety is not sufficiently translated into a climate of safety and that organizational processes aimed at safety are not uniformly valued.
Safety climate questionnaire [83]	[7]	Exploring potential sources of variation and understanding the significance of safety climate for nursing practice in emergency hospital settings in the UK.	The results indicated that safety is a complex interaction between safety systems and clinical practice's social and interpersonal aspects.

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Safety climate questionnaire [84]	Examining the predictive role of safety climate on professional behavior among nurses. [85]	Nursing education, communication with other nurses, and reporting errors have a direct and significant positive relationship with professional behavior. The results showed that the domain of nursing education directly predicts professional behavior.

Source: Prepared by the authors (2025).

Recent developments indicate that analyzing dynamic and complex environments, observed notably in healthcare organizations, has transitioned from basic safety culture measurements to more in-depth evaluations and maintenance of resilient safety culture [46]. This shift emphasizes an ongoing commitment to assessing, managing, and improving organizational safety to bolster a secure work environment [86,87]. Consequently, the continual assessment of safety culture has emerged as a critical element for the success and sustainability of organizations.

Resilience analysis in hospital environments

Resilient health care is recognized as a burgeoning field of theory and research grounded in complexity and systems theory, aimed at elucidating how health organizations navigate dynamic, variable, and challenging environments [88]. Resilience has gained prominence as a pivotal concept in safety research. In this context, 'resilience engineering' has captivated safety science researchers for presenting a novel perspective on work processes within complex adaptive socio-technical systems [89, 90, 91].

Wiig et al. [34] noted that resilience engineering has extensive applications in healthcare, focusing on a system's capacity to revert to equilibrium post-disruption and bolster individuals' adaptive capacity. For Plunkett and Plunkett [92], resilience engineering and safety II strategies represent innovative safety paradigms that characterize work holistically, adopting a systems perspective rather than isolating incidents of failure. They delineate that, unlike safety I, which focuses solely on preventing failures and accidents, safety II aims to comprehend how systems

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operate and adapt safely. Resilience engineering, in contrast, seeks to understand system responses to threats and opportunities, facilitating resilient performance is achieved.

Resilience engineering posits that a system must possess four resilient potentials to operate effectively without relying on traditional safety management metrics, such as mortality, injury, and illness rates [29]. These potentials include (i) response, enabling timely and effective system reactions; (ii) monitoring, the capability to detect changes and maintain effective indicators; (iii) learning, or how the organization cultivates knowledge management; and (iv) anticipation, predicting and preparing for future scenarios [33].

The assessment of resilient performance can be conducted using the resilient assessment grid proposed by Hollnagel [93], which employs four sets of generic questions to construct a resilience profile across the four potentials [94]. The resilient assessment grid is adaptable to the specific needs of the organization and system under study, serving as a valuable tool for measuring resilience and identifying areas for enhancement [29].

While resilient performance is inherent to socio-technical systems, it can be enhanced through design for resilient performance, which involves redesigning systems by leveraging knowledge from existing operations, enhanced by human factors and ergonomics to create frameworks that support people at work [95,96]. Resilience engineering is further explored via the concepts for applying the resilience engineering model by Anderson et al. [97], which clarifies adjustments and adaptations necessary for aligning Work as Imagined with Work as Done. These constructs identify the discrepancies between standard procedures and the realities of work execution, shedding light on the natural variability due to system complexity [98]. Understanding this variance is crucial to the safety II approach [92].

The functional resonance analysis method proposed by Hollnagel [93] further aids in deciphering work processes by mapping complex systems through insights obtained from its workforce. It elucidates the interactions, relationships, variances, and areas of strength and weakness identified by team members [92]. Stemming from resilience engineering, it assumes that unsafe conditions and accidents often result from concurrent adverse circumstances rather than individual or component failures [99]. The seven mechanisms characterizing resilience in hospital emergency contexts identified in nine studies are listed in Table 4.

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Table 4 – Mechanisms for assessing resilience in hospital environments.

Instrument	Studies	Objective	Main results
Resilient assessment grid (93)	(29)	Redesigning the Hollnagel resilience assessment grid to support resilience management in Emergency Departments.	Definition of a set of reliable questions to describe the existing system in emergency departments and resolutions that address the current disadvantages of the (resilient assessment grid, such as the lack of standardization when defining each resilience potential's characteristics.
	(99)	Determining to what extent the safety II approach is being implemented and what measures can support its integration into daily clinical practice.	The resilient assessment grid was used to analyze interviews on the four resilience potentials and determine the potentials for reaction, learning, monitoring, and anticipation. During team meetings, positive experiences are often shared. In addition, the safety II approach is attributed to the corporate culture that needs to be integrated into daily work.
Functional resonance analysis method (94)	(100)	Developing and testing a framework to support the design of a patient flow system from an emergency department to an intensive care unit, combining knowledge of lean production and resilience engineering.	Eight design proposals were developed to support the framework: (1) waste; (2) value and customer; (3) quantitative parameters to describe the system; (4) kaizen principles; (5) awareness of the unintended consequences of improvements; (6) mechanisms for survival of complex systems based on dynamic interactions and adaptation; (7) description of the work carried out using theories and tools; (8) shared

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			understanding of the concepts of lean production and resilience engineering. The propositions contribute to the design of socio-technical systems that are both safe and efficient.
	(92)	Discussing the new safety paradigms in healthcare environments.	The functional resonance analysis method represents an approach to understanding work as it is done, work as done, in complex systems. It is designed to facilitate understanding complex systems, such as health systems.
Concepts for applying resilience engineering (101)	(102)	Identifying and selecting core operational concepts of resilience and proposing a working definition of resilience in the resilience in healthcare research program.	The study defined resilience as “the ability to adapt to challenges and changes at different levels of the system in order to maintain high-quality care.” In addition, four central questions were suggested to guide empirical approaches to resilience research: (i) Resilience to what; (ii) Resilience to what; (iii) Resilience of what; (iv) Resilience through what?
Knowledge framework for evaluating the design for resilient performance	(95)	Proposing an evaluation framework for using the practices and principles of the design for resilient performance. It was developed by collecting data from interviews, observations, and documents.	The results contributed to the design of resilient performance theory by designing a new approach to assessing resilience. The framework can be combined with existing tools to analyze and improve resilient performance. The framework for assessing DfRP principles and practices consists of five stages: (i) characterization of the socio-technical system and resilience rationale; (ii)

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			Identification and description of design for resilient performance practices; (iii) assessment of the use of the principles; (iv) analysis of the relationships between the principles; and (v) opportunities for improvement.
Integrated resilience engineering	(28)	Analyzing resilience engineering factors, job satisfaction, and patient satisfaction in a Tehran emergency department to determine strengths, weaknesses, and opportunities to improve safety, performance, staff, and patient satisfaction.	the integrated resilience engineering contains questions that reflect the six Resilience Engineering principles proposed by Hollnagel et al. (2006): top management commitment, flexibility, learning, awareness, anticipation, and reporting culture. Azadeh et al. (2014) proposed two additional principles: teamwork and redundancy. The results of the study indicated that salary, remuneration, admission, and patient discharge are the factors that strongly influence job and patient satisfaction.
Generic procedure for assessing the resilience of emergency departments based on simulation	(103)	Defining and characterizing an emergency service's resilience and proposingse a generic procedure for assessing the resilience of emergency services.	The resilience of an emergency service has been defined as its ability to provide the best patient care, maintaining its performance at an acceptable level in the face of planned or unplanned disruptions, adapting before, during and after disruptions occur. The steps of the proposed evaluation procedure include: identifying disruption and potential disruption; simulating behavior; estimating damage caused to the department; estimating performance and

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			evaluating resilience in emergency departments. The proposed approach makes it possible to i) simulate the behavior of the emergency departments as a function of the disturbance; ii) evaluate the effect (damage) of the disturbance on the behavior of the emergency departments, and the effectiveness of the proposed corrective actions; iii) evaluate the resilience of the emergency departments based on deformation indicators and the associated corrective actions.
Questionnaire to assess crisis management based on the resilience engineering approach.	(104)	Designing a questionnaire to assess crisis management based on the resilience engineering approach.	Four principles of resilience engineering (senior management commitment, flexibility, learning, and awareness) were evaluated using a questionnaire developed by the authors. The results suggest that evaluating crisis management using a questionnaire based on the approach contributes to evaluating hospital crisis management.

Source: Prepared by the authors (2025).

Discussion: Safety Culture and Resilience Engineering

According to the results of this review, Safety Culture (SC) and Resilience Engineering (RE), although conceptually complementary, continue to be addressed in a fragmented manner in hospital emergency research. Most identified studies prioritize safety climate assessment based on self-reported perception instruments, whereas significantly fewer investigations apply system-based methods aimed at evaluating adaptive capacities. This imbalance reinforces previous evidence indicating that safety management strategies in

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hospital settings often focus on awareness, training and climate monitoring, while structural and adaptive dimensions tend to be less systematically assessed [105].

From a methodological perspective, the predominance of cross-sectional questionnaire-based approaches reflects an emphasis on psychometric diagnosis of safety climate. Although these instruments are effective for identifying attitudes and perceptions, they do not fully capture how safety is dynamically constructed in complex sociotechnical systems such as emergency departments. Studies that apply ergonomic and qualitative approaches have demonstrated that organizational practices commonly remain reactive, with limited integration between formal safety management mechanisms and the real conditions faced by healthcare teams [106].

Furthermore, evidence from applied field research highlights the need to integrate SC assessments with resilience engineering principles, showing that the development of resilient capacities depends not only on shared safety values but also on the organization's ability to monitor, anticipate, respond and learn from operational variability [107]. The absence of integrated assessment models combining perceptual measures of safety culture with functional analyses of adaptive system performance remains a significant gap identified in both the present review and existing empirical investigations. This disconnect may restrict the effectiveness of occupational safety interventions, as improvements based solely on climate survey results may fail to address workflow design, coordination mechanisms, learning processes and leadership practices that underpin resilience. Therefore, strengthening occupational safety management in hospital emergency departments requires methodological convergence between SC and RE approaches, supporting the development of hybrid assessment frameworks capable of capturing both psychosocial perceptions and adaptive system capabilities.

Concluding Remarks

This research sought to explore the mechanisms for assessing safety culture and resilience engineering in hospital emergency environments, focusing on occupational safety through a scoping review of the literature. The results revealed inconsistencies in the definition of safety culture dimensions among professionals and researchers, leading to frequent confusion between safety culture and safety climate. Although safety climate is a component

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of safety culture, representing its practical manifestation, culture encompasses a broader set of values, beliefs, and norms that shape individual and collective behavior.

Analysis of the evaluation mechanisms identified showed that research exploring safety culture and resilience engineering is lacking. The safety attitudes questionnaire has been widely used in the hospital context to assess safety culture, while the resilient assessment grid has established itself as a tool to assess resilience in these environments. This dissociation between assessment tools can complicate understanding the interaction between safety culture and resilience in complex environments such as hospitals.

The studies reviewed demonstrated a strong relationship between safety culture and patient safety culture. However, it is crucial to recognize that building a robust safety culture fundamentally depends on the professionals working within the system. Quality of life at work directly impacts workers' health and is reflected in indicators such as turnover, absenteeism, presenteeism, accidents, and occupational illnesses. In this sense, building a positive and resilient work safety culture that benefits both workers and patients is imperative.

This research highlights the need for new paradigms in understanding occupational safety, adopting a holistic and systemic view that transcends organizational factors and individual performance. The principles of resilience engineering can contribute to this change in perspective, exploring safety culture from a comprehensive description of the work system and enhancing the ability to respond, monitor, learn, and anticipate events. This research contributes to the field of occupational safety in hospital environments by identifying gaps in the analysis of safety culture, present approaches, presenting frequently used approaches to evaluate safety culture and resilience engineering, emphasizing the intrinsic relationship between safety culture and patient safety culture, and reinforcing the need to reorientate security management practices, incorporating a holistic and systemic perspective.

The focus of this research on the PubMed, Scopus, Web of Science, and Google Scholar databases may be considered a limiting factor for the results, even though the first three are among the largest and most comprehensive scientific databases. Future research could benefit from incorporating additional data sources to enhance and broaden the scope of the review's findings. Additionally, we suggest investigating ways of integrating safety culture and resilience engineering to create a unified model for assessing safety in hospital emergency environments. Furthermore, it would be relevant to examine the impacts of resilience engineering-based interventions, such as the introduction of monitoring and continuous

learning practices, which provide data on safety culture over time and its influence on clinical and occupational outcomes.

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