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Seismic risk perception of non-structural elements in Italian hospitals: pilot studies

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ABSTRACT In this paper, we present initial findings from the analysis of seismic risk perception, focusing specifically on the vulnerability of non-structural elements. This analysis was conducted, as part of the PRIN 2020 ENRICH (ENhancing the Resilience of Italian HealthCare and Hospital Facilities) project, through focus group sessions with healthcare facility staff at two pilot sites in southern Italy: the healthcare unit of Lecce and that of Caserta. The study relies on qualitative content analysis within a grounded theory framework to explore discussions on seismic risk. In Lecce, discussions centred on regulatory/legal and scientific aspects underscore the importance of seismic prevention supported by legislative measures. Initial underestimation of non-structural risks evolved during the sessions, highlighting gaps in awareness. In contrast, the discussions in Caserta, driven by healthcare perspectives, emphasised the roles of medical staff during earthquakes, patient safety concerns, and the need for clearer protocols. Both groups identified common priorities such as proactive prevention measures, training needs for stakeholders, and the enhancement of awareness of non-structural vulnerabilities. These insights are critical for developing targeted interventions to strengthen community resilience to seismic events, aligning with the broader framework of disaster risk management and enhancing coping capacities within affected communities.

Key words: seismic risk prevention, non-structural elements, seismic risk communication, seismic risk perception, seismic risk prevention in hospitals.

1. Introduction

The risk perception plays an essential role in disaster risk management (DRM) because it significantly affects actions and strategies both before and after a disaster (Albulescu *et al.*, 2021). Studies suggest that low-risk perception is often associated with poor disaster outcomes (Otoufi *et al.*, 2019). Conversely, a proper risk perception can increase awareness, encourage safe behaviours, and predict, for example, disaster responses such as evacuation (Peacock *et al.*, 2005).

Importantly, risk perception is connected to coping capacity through risk communication, which serves as a bridge between scientific knowledge and practical actions. Coping capacity refers to the strengths, attributes, and resources within an organisation, community, or society that enable it to manage and reduce disaster risks, thus enhancing resilience (UNDRR, 2015). This capacity includes physical infrastructures, institutional frameworks, human knowledge, and collective attributes such as social relationships and leadership. By improving risk perception through effective communication, coping capacity can be strengthened, enabling better disaster preparedness and response (Keogh *et al.*, 2011). Risk communication plays a key role in this process by translating scientific knowledge into preventive measures that shape people's attitudes and behaviours towards risk (Musacchio and Solarino, 2019). It not only enhances risk perception but also promotes decision-making and preparedness actions, thereby improving coping capacity. This approach is rooted in social and decision-making psychology (Árvai and Campbell-Árvai, 2013) and aligns with the pragmatics of human communication theory, which sees communication equated with behaviour (Watzlawick *et al.*, 1978). As such, disseminating hazard information serves as 'a means to an end' to encourage action (Rickard, 2021). On the flip side, understanding risk perception is essential for designing effective communication campaigns, taking into account communities' awareness of their specific risk and influencing factors and acknowledging their role in addressing the complexity of the risk (Slovic, 1987; Lundgren and McMakin, 2018).

In DRM, hospitals play a strategic role during disasters, such as earthquakes, by providing immediate essential medical care and coordination of public health services. Hospitals prepared with disaster plans are more capable of responding swiftly and effectively, and this strengthens community resilience (Nasiripour *et al.*, 2013). Given the critical role of healthcare staff in hospital performance during a disaster, understanding their risk perception is crucial for increasing hospital preparedness (Heydari *et al.*, 2022). However, research on disaster risk perception - specifically that related to earthquakes - of hospital staff and their roles in disaster response (see Hammad *et al.*, 2011; Shapira *et al.*, 2016; Mirzaei *et al.*, 2019; Heydari *et al.*, 2022) is limited, with none focusing on perceived seismic risk within Italian hospitals.

A particularly critical issue for hospital disaster response involves the seismic vulnerability of non-structural elements. These include architectural parts, mechanical, electrical, electronic, and hydraulic facilities and components, furniture/contents, and other equipment (Zito *et al.*, 2022). Although non-structural elements can be crucial for the functioning of hospitals (Miniati and Iasio, 2012), these elements generally present two main weaknesses that influence their resilience: a) high vulnerability to extreme actions such as earthquakes and b) low flexibility and functional adaptability.

This paper presents preliminary results on healthcare facility perception of seismic risk, particularly concerning the vulnerability of non-structural elements. The study, using the focus group methodology, involved healthcare staff from two pilot sites: the public healthcare facilities in Lecce and Caserta, both located in southern Italy.

The research is part of the ENRICH (ENhancing the Resilience of Italian HealthCare and Hospital Facilities) project, which addresses seismic resilience by optimising seismic performance, ensuring functional adaptability, and assessing risk perception associated with these elements. The project follows a holistic framework based on the principle that the way communities cope with and recover from a natural hazard is multi-dimensional (Lazarus, 2011). One of the key objectives is to leverage risk perception data in order to design more effective seismic risk communication campaigns for healthcare facility staff in Italian hospitals.

The seismic risk perception assessment proposed in this study contributes to the estimation of the healthcare facility staffs' coping capacity in the Italian pilot sites considered, a crucial element in the decision-making process for the enhancement of community seismic risk resilience.

2. Background framework

In this chapter, we examine the framework of seismic risk perception in Italy, by addressing the challenges of communicating seismic risk effectively. We also explore the seismic resilience of hospitals, by discussing observed damages to healthcare facilities in Italy and Europe following earthquakes, as well as the engineering innovations developed to improve their resilience.

2.1. The seismic perception framework

Studies on the perception of seismic risk among the Italian population reveal a significant gap between perceived and actual risk (Crescimbene *et al.*, 2014) mostly related to a discrepancy between how people perceive hazard and vulnerability and the real values (Crescimbene *et al.*, 2016). This gap underscores the need for improved risk communication to better align public perception with actual risks, which is essential for enhancing societal resilience to disasters.

The Sendai Framework for Disaster Risk Reduction 2015-2030 highlights risk communication as a priority, emphasising the need for tailored communication strategies that consider the specific needs and capacities of different communities and stakeholders (UNISDR, 2015). However, communicating seismic risk effectively presents several challenges. A first challenge is that, unlike other communication fields, that concerning risk depends strictly on the disaster life cycle phases, i.e. mitigation, preparedness, response, and recovery (Flanagan *et al.*, 2011). Risk messages must be tailored to the different stages of precaution adoption, as their impact varies across these phases (Gerrard *et al.*, 1999).

Then, cognitive barriers also pose significant challenges to risk communication (Fiske and Dupree, 2014; Maier *et al.*, 2016; van der Bles *et al.*, 2020). Common biases such as the 'invulnerability illusion', where individuals perceive a lower probability of encountering adversity compared to others (Weinstein, 1984), and defensive strategies to diminish or distort risk information (Gerrard *et al.*, 1999) further complicate effective communication. Additionally, the use of numbers, probabilities, and percentages in risk messages often fails to translate into accurate perception of risk, particularly for low probability events like natural hazards (Slovic *et al.*, 2004; Savadori *et al.*, 2022).

The field of risk communication has evolved significantly over the years (McComas, 2006; Lundgren and McMakin, 2018; Musacchio *et al.*, 2023), with a growing emphasis on two-way communication approaches. These models recognise that people are active participants in the communication process, "bringing their own expectations and interpretive practices to the table of exchange" (Bush, 2003). Research suggests that merely disseminating information is not enough to foster protective behaviours (Kollmuss and Agyeman, 2002; Brenkert-Smith, 2010). Instead, community engagement and constructive collective action are necessary (Burnside-Lawry *et al.*, 2013). Seismic risk communication, however, entered academic literature later than other risks (Musacchio *et al.*, 2023), with increased interest driven partly by international disaster risk reduction frameworks. In Italy, such interest followed two dramatic earthquakes with a high emotional impact: the San Giuliano di Puglia earthquake in 2002 and the L'Aquila earthquake in 2009 (Dolce, 2009; Herovic *et al.*, 2017; Musacchio *et al.*, 2023).

Research has recently begun to explore the vulnerability of non-structural elements in seismic risk communication (Falsaperla *et al.*, 2021; Ferreira *et al.*, 2021; Lopes *et al.*, 2021; Solarino *et al.*, 2021). However, the perception of seismic risk regarding non-structural elements among healthcare facility staff remains largely unexplored.

2.2. The seismic resilience framework

In the context of various disasters and emergencies, hospitals typically exhibit scarce resilience (Kruk *et al.*, 2015). Post-seismic event surveys revealed that the functioning of hospitals can be significantly compromised in the aftermath (Price *et al.*, 2012; Mahmoud *et al.*, 2023). The seismic resilience of hospital facilities is strictly correlated with the seismic response and performance of non-structural elements, which are the primary contributors to operational disruptions and damage, particularly during low-to-moderate-magnitude seismic events (Di Sarno *et al.*, 2019).

In Italy, public buildings, including hospitals, have performed poorly during past earthquakes.

The 1976 Friuli and 1980 Campania-Basilicata events caused severe and widespread damage to the healthcare system. Despite these tragic events, in Italy little attention was paid to evaluate and mitigate the seismic risk of hospitals, schools, and public buildings until the 2002 Molise earthquake. During this earthquake, a primary school building collapsed causing the loss of the lives of 27 children and their teacher, and dramatically emphasising, once again, the high vulnerability of the existing public structures.

The 2009 L'Aquila earthquake severely impacted the San Salvatore regional hospital, a reinforced concrete facility inaugurated in 2000, which had to be closed in the aftermath of the event. Notably, while the hospital structural performance was generally adequate, significant non-structural damage occurred, particularly affecting inter-building/unit joints, external infill panels, and other architectural elements (Fig. 1a). Minor damage was observed in internal architectural elements, with limited impact on medical equipment and electric/electronic/ hydraulic facilities (Price *et al.*, 2012).

The 2016-2017 central Italy seismic sequence further highlighted the seismic vulnerability of Italian healthcare facilities. Significant structural and non-structural damage was exhibited by several hospital buildings, both masonry and reinforced concrete structures, including the facilities in Amatrice, Amandola, and Tolentino, which had to be closed in the aftermath of the event. In many cases non-structural elements posed a high potential life treat due to their seismic response (Santarsiero *et al.*, 2019) (Fig. 1b).

Similar seismic responses and damage conditions were observed in hospitals across other European countries following moderate to high-magnitude earthquakes. For instance, during the 2023 seismic sequences in Turkey, most hospitals experienced ground-shaking larger than their design basis. The reported damage varied based on the structural characteristics of the buildings. Base-isolated facilities generally performed satisfactorily in terms of operational functionality and non-structural element damage. Hospitals with fixed-based reinforced concrete structures built after 2001 also performed well in preventing collapse, with a few remaining operational despite the extremely high ground-shaking. In contrast, hospitals built prior to 2001 exhibited critical structural (and non-structural) response and major seismic damage (Qu *et al.*, 2023). In general, while modern structures, particularly base-isolated buildings, have demonstrated promising performance, the vulnerability of older hospitals remains a pressing issue. With regard to the abovementioned 2023 seismic sequences, it was found that current and emerging technologies, including satellite data, drone imaginary, and, more importantly, video cameras could significantly enhance the sustainability and resilience associated with the response to seismic events (Oliveira *et al.*, 2024).

These findings underscore the importance of continuous assessment, retrofitting efforts, and the implementation of more stringent design standards to mitigate risks, ensure operational continuity, and protect lives during future earthquakes.

Current literature on assessing the seismic resilience of hospitals often involves simulations,

Fig. 1 - Non-structural seismic damage observed in hospitals: a) full collapse of masonry infill panels above the entrance portico, San Salvatore Hospital following the 2009 L'Aquila earthquake (Price *et al.*, 2012); b) severe cracks in internal masonry partitions, the hospital in Amandola following the 2016-2017 central Italy seismic sequence (Santarsiero *et al.*, 2019); and c) critical damage to various non-structural elements including architectural systems and building contents, Nurdaği State Hospital following the 2023 Turkey earthquake sequence (Qu *et al.*, 2023).

numerical analyses, and risk-based measures, which sometimes account for non-structural elements. Bruneau *et al.* (2003) pioneered a framework for quantitatively assessing seismic resilience of communities, based on estimation and evaluation of quantitative resilience metrics. More recently, innovative methodologies implemented multiple approaches and methods, including seismic fragility curves (Shang *et al.*, 2020), novel seismic resilience indexes (Niazi *et al.*, 2021), and Bayesian networks (Liu *et al.*, 2022). These methodologies demonstrated their potential on both real and hypothetical case studies. Additionally, Olgun and Ozcelik (2024) implemented an optimisation framework to assess the resilience of hospital networks by processing the seismic vulnerabilities of building stocks.

The above-mentioned studies used advanced assessment methodologies that are typically challenging for practitioners and difficult to apply on a large territorial scale. While recent studies have developed frameworks for quickly estimating the seismic vulnerability and risk of hospitals, rapid resilience assessment remains complex. However, rapid vulnerability and risk assessment might serve as a first step towards the development of rapid resilience assessment methodologies typically implemented through rapid visual screening (RVS) and processing facility survey data. Perrone *et al.* (2015) developed an innovative RVS method for seismic risk assessments of hospitals, incorporating structural and non-structural elements, and organisational aspects. The method was validated through two case study applications with regard to the contribution of the structural members. Clemente *et al.* (2020) assessed the seismic vulnerability of all hospitals in Manila by using the RVS method defined in FEMA (2015) and found it potentially effective for quick assessments. More recently, Purushothama *et al.* (2023) evaluated an RVS method by considering results of nonlinear numerical analyses as a reference; this method was found to be in good agreement with the accurate data.

Attention to healthcare facility performance of post-earthquake is crucial to ensure they can serve patients and potential victims during and after seismic events. Bruneau and Reinhorn (2006) defined seismic resilience as "the ability of the system to reduce the probability of a shock, to absorb a shock if it occurs (abrupt reduction in performance) and to recover rapidly after one shock (restore normal performance)". The decrease in resilience equates to the reduction in system functionality during the recovery period.

3. Description of the pilot sites

We conducted three focus groups at two selected Italian public healthcare facilities, established as pilot sites for the project, in the towns of Lecce and Caserta both in southern Italy. These sites were chosen due to their distinct seismic hazard (Fig. 2). Lecce is located on the Apulian platform, an area with relatively low seismic activity. Caserta is in the Apennines, a region that experiences higher seismicity. This contrast allows us to address resilience in different seismic hazard contexts. By comparing these two locations, we aim to understand how varying levels of seismic hazard might influence perceptions and preparedness. This approach provides valuable insights into how different seismic hazards can affect the resilience strategies and attitudes within healthcare facilities.

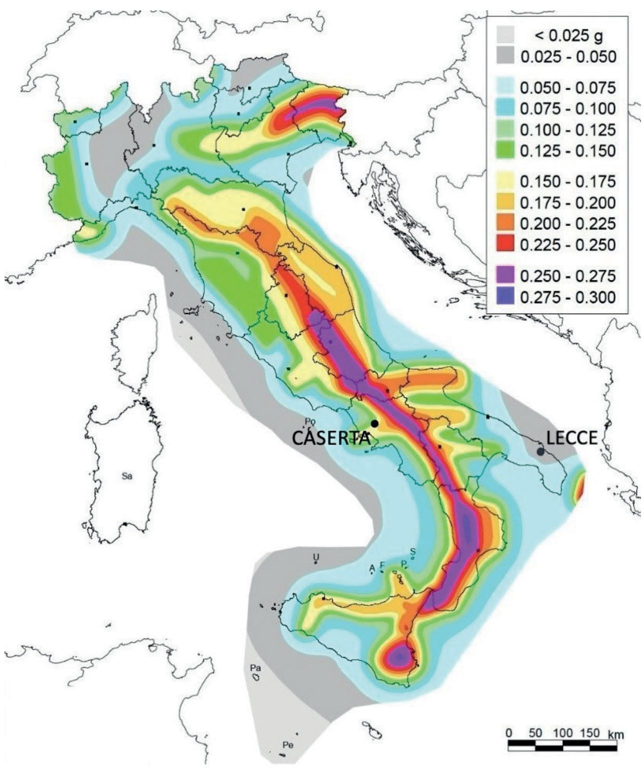

Fig. 2 - Seismic hazard model of Italy (MPS04), which serves as the basis for the Italian building code. The map plots colour coded peak ground acceleration with a 10% probability to be exceeded in 50 years (Stucchi *et al.*, 2004).

Both seismic engineering and psychometric data were collected from public key healthcare units in these areas. The level of hazard, the expected perception based only on the memory of past events, and the relevance of these selected facilities are summarised in the subsequent paragraphs.

3.1. Lecce: the public healthcare facility pilot site

The Lecce public healthcare facility, in the Salento region, is located in an area with low seismicity. Most events occur to the west and in the Strait of Otranto, where a *Mw* = 5.0 earthquake was recorded in October 1974 (De Lucia *et al.*, 2013; Rovida *et al.*, 2020, 2022). Despite this, historical seismic records [CPTI15: Rovida *et al.* (2020, 2022)] include significant past events, such as the lower Ionian earthquake in 1743, with *Mw* = 6.68. This strong earthquake was felt in Lecce with an intensity of *I* = VII (Galli and Naso, 2008), although it is likely no longer remembered by local communities, as historical memory of disasters tends to fade after about 100 years. Macroseismic data for the Lecce site over the past century (Fig. 3) reveal that the highest intensity reached is *I* = IV, the level at which damage to non-structural elements can occur. However, such low intensities are likely to result in a low perception of seismic risk among the local population.

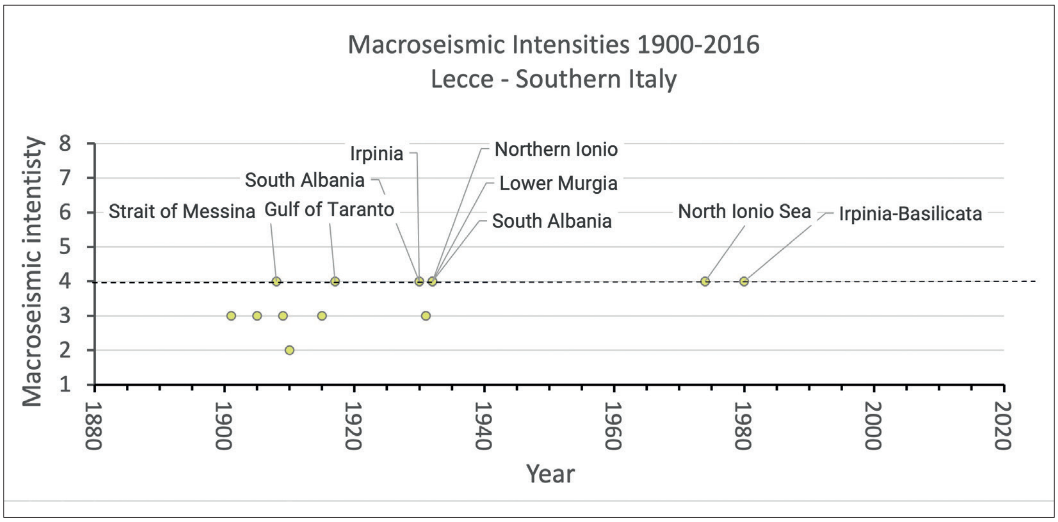

Fig. 3 - Last 100 years of seismic history of Lecce listed in CPTI15 (Rovida *et al.*, 2020, 2022) and CFTI5Med (Guidoboni *et al.*, 2018). The threshold for damage to non-structural elements is shown (dashed line).

The Vito Fazzi Hospital is located in Lecce (Fig. 4) and was built between 1969 and 1979. It is supposedly compliant with Italian codes of that time. The facility consists of 15 blocks and has a capacity of about 600 beds spread across 41 available medical departments. According to Italian Law Decree no. 70 of 2015 (Ministero della Salute, 2015), this hospital is classified as a hospital of national importance provided with an emergency and admission department, intended as a strategic facility.

Fig. 4 - The pilot site: the Vito Fazzi Hospital.

3.2. Caserta: the public hospital pilot site

The second healthcare facility pilot site of the ENRICH project is the Sant'Anna and San Sebastiano Hospital located in the province of Caserta, in southern Italy. Several earthquakes were felt at the Caserta site in the last 100 years, some of which were severe damaging events that remain in the country's collective memory. Among these, the *Mw* 6.9 Irpinia earthquake in 1980 stands out as one of the strongest and most recent in Italy over the last century. It affected a vast area of southern Italy, including the Campania and Basilicata regions, causing severe damage in over 800 locations. A total of 75,000 homes were destroyed and 275,000 were seriously damaged, resulting in approximately 3,000 fatalities and 10,000 injured (Porfido *et al.*, 2020).

Besides these heavy damaging events, the several I_{max} > 4 listed in the macroseismic intensities databases (Locati *et al.*, 2022) indicates that earthquakes matching the non-structural element damage threshold are likely to have been felt more than once in a person's lifetime (Fig. 5).

The Sant'Anna and San Sebastiano Hospital in Caserta (Figs. 6a and 6b) is a highly specialised public entity (AORN). The first blocks were built in the 1960s, but several blocks were built in the following decades, and the hospital facility is still undergoing expansion and modification. The area on which the hospital stands is structured like a campus with buildings, streets, squares, and green spaces, and is provided with several public street access points. The hospital facility includes 12 building blocks, most of which are interconnected. The facility currently counts

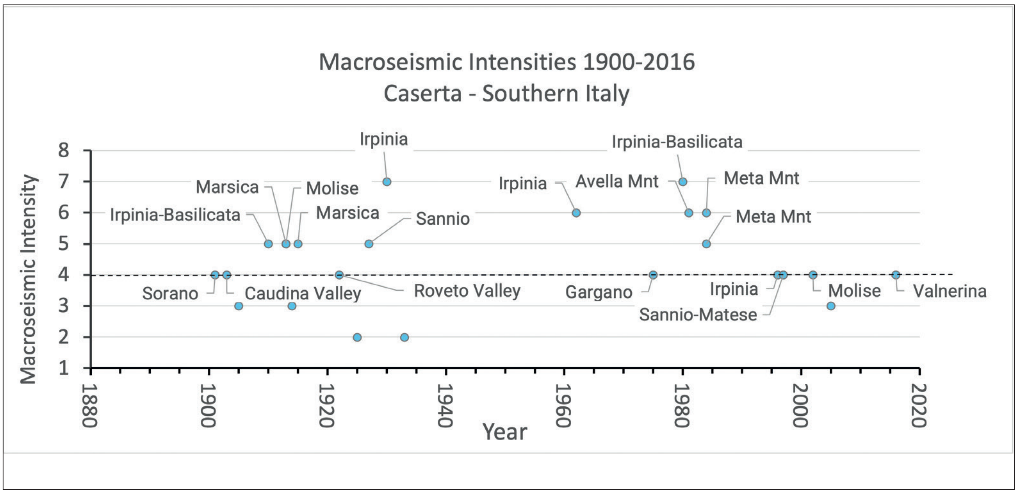

Fig. 5 - Last 100 years of seismic history of Caserta listed in CPTI15 (Rovida *et al.*, 2020, 2022) and CFTI5Med (Guidoboni *et al.*, 2018). The threshold for damage to non-structural elements is shown (dashed line).

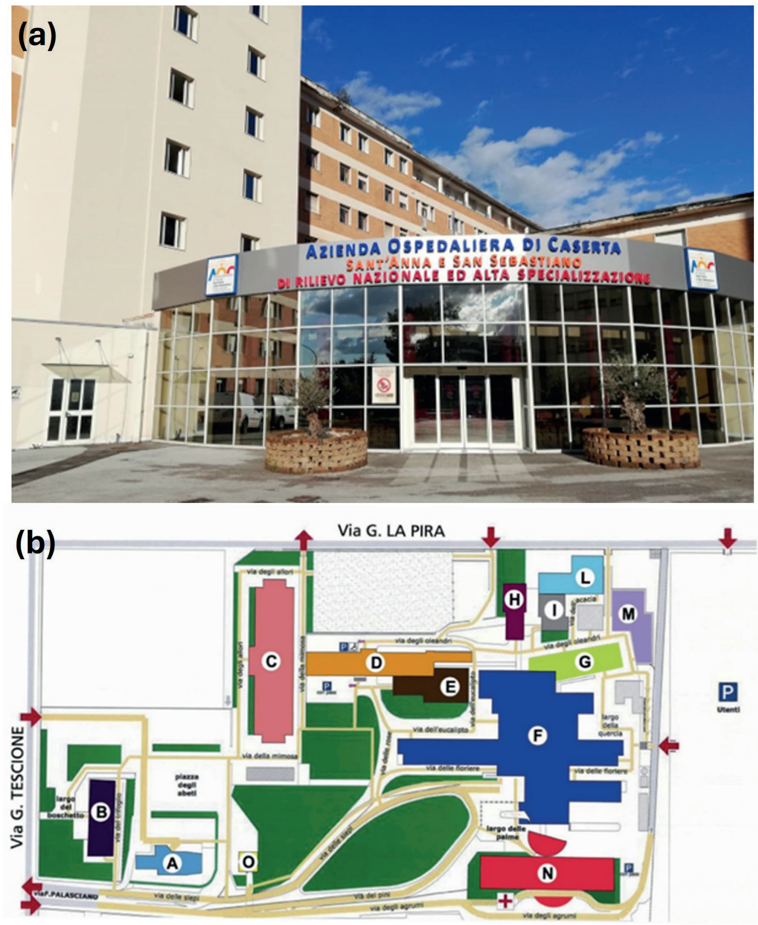

Fig. 6 - The pilot site: the AORN Sant’Anna and San Sebastiano Hospital of Caserta: a) entrance and b) planimetric view of the hospital campus.

almost 500 active hospital beds and can potentially activate more than 600 beds. Most buildings were only designed for gravity loads, whereas the most recent buildings and the ones under construction were designed considering seismic actions.

4. Methodology for data collection and analyses

To fully understand risk perception and its influencing factors, whether rational or intuitive, researchers rely on both quantitative (surveys, questionnaires, experimental studies, and content analyses) and qualitative (interviews and focus groups) methodologies (Lawrence Neuman, 2014; Hennink *et al.*, 2020). Focus groups, in particular, provide deeper insight into the living experiences of individuals and perspectives in specific settings using group dynamics to explore unplanned topics and observe collective sense-making (Murphy *et al.*, 1998; Wilkinson, 1998; Freeman, 2006). The methodology involves group discussions, moderated with predefined but flexible questions, requires a small homogeneous group, and a set time limit for the discussion. The moderator plays an active role during the discussion and must adapt the questions as needed to suit the psycho-social and relational dimensions of the group. Typically, the subsequent analysis will follow the grounded theory framework, an inductive approach that develops general interpretative categories after coding the text (Sargent *et al.*, 2016).

Our study used focus groups to gain deeper insights into how healthcare staff perceives the seismic risk posed by non-structural elements. This approach effectively established a comfortable setting where participants felt confident sharing their personal experiences and reasoning with each other and the moderators. Its ability to explore unplanned content made it particularly suited to our goal. We aimed to focus on the needs of hospital staff through a bottom-up strategy, gathering suggestions for implementing an effective seismic risk communication plan in Italian hospitals.

At the Lecce healthcare pilot site, one focus group, with 27 administrative and technical staff members, including engineers, architects, and safety managers, was held.

At the Caserta hospital pilot site, two focus groups involved 30 healthcare professionals from various departments including gastroenterology, neonatal intensive care, cardiology, operating room, anaesthesia, urology, gynaecology, obstetrics, emergency medicine, vascular surgery, and neurosurgery. Similarly to the Lecce site, the participants came from different professional backgrounds, including physicians, nurses, prevention and protection service specialists, and family doctors.

These diverse professional backgrounds at both sites provided a comprehensive view of seismic risk perception in healthcare settings. Four moderators (two geologists and two psychologists) facilitated these discussions (Fig. 7).

The objectives set for each focus group are as follows:

- understanding the level of seismic risk perceived by the staff members both in household settings and in the workplace;
- understanding the level of seismic risk posed to the staff members by non-structural elements;
- understanding the main factors that, according to the participants, influence risk.

To address the above objectives, we designed a set of seven questions that explore the topic of seismic risk, starting from a general level of discussion and progressively focusing on key-issues:

1. Has anybody ever felt an earthquake?

Fig. 7 - Discussion during the focus group in Lecce (left) and Caserta (right).

2. What does risk mean to you?
3. Have you ever heard about seismic risk?
4. According to you, which is the seismic risk in your territory?
5. Do you know what "non-structural vulnerability" is?
6. Would you know what to do in case of an earthquake?
7. In your opinion, how should a seismic awareness campaign be designed?

The first question aimed to engage participants on a personal and colloquial level, helping them feel comfortable and countering any evaluative dimension that could affect the quality of the research.

The second question required participants to provide a general definition of risk. This was designed to encompass as many meaning categories of risks associated by the staff members with their workplaces and personal experiences as possible.

The subsequent questions progressively focused on the specific topic of non-structural vulnerability. They ultimately explored the participants' level of preparedness for a seismic event and gathered their personal suggestions for an effective seismic awareness campaign.

Each focus group session lasted about an hour and a half. To foster open discussion, the chairs were arranged in a circle. The discussions were transcribed to ensure that all material was available for the analysis. At the end of each session, there was a short debriefing moment where researchers, who had moderated the focus group, provided information about the seismic level of the specific territory. They also answered any scientific curiosities from the participants, ensuring comprehensive understanding of the local seismic risks.

The typewritten texts from the discussions underwent qualitative content analysis using the grounded theory framework (Sargent *et al.*, 2016), an inductive approach. This method involves creating interpretative categories after coding the text. Each typewritten text, representing the answers given by the participants to the moderators' questions, was manually divided into meaningful sequences, termed communicative units. Subsequently, each unit was described and manually classified based on categories established *ex post*, after reading the entire text. Sampling phases were conducted to saturate these categories, which included:

- categorisation based on subjects addressed by each communication unit:
  - healthcare: aspects related to health and healthcare, including system organisation, services, people involved, etc.;
  - economics: costs, resources, etc.;
  - regulatory/legal: laws, regulations, legal responsibility;
  - scientific: aspects relevant to seismology, engineering, psychology;
  - personal experience: personal experiences of participants or of their acquaintances;

- moral: ethical considerations regarding the topic;
- social: societal customs related to the topic;
- behavioural: behavioural implications, including models, protocols, actions;
- politics: political considerations concerning the topic;
- psychology: emotional and cognitive aspects of the topic;

• identification of key issues that emerged and their recurrence.

Word clouds were generated from each typewritten corpus, to visually represent word frequencies, facilitating the ordering of words by their visual impact (translation in English required some adaptations in order to maintain the original recurrence of words, for example by unifying compound words or standardising elements that in Italian require a single form, for example “us” and “we”).

The preliminary qualitative analysis carried out on identified subject categories, word frequency, and key issues from the two pilot sites are presented below.

5. Results and discussion

5.1. Findings from the Lecce focus group

In the Lecce group, the analysis of the communication unit subjects (Fig. 8) reveals a prevalence of regulatory/legal (21%) and scientific (21%) subjects. Also, participants reported many personal experiences with earthquakes (19%). Politics, behavioural, and economics were also significantly present in the discussion (14%, 12%, and 10%, respectively), reflecting the technical and administrative expertise within the group, while psychological aspects were poorly addressed (4%), and healthcare, moral and social aspects were not addressed at all.

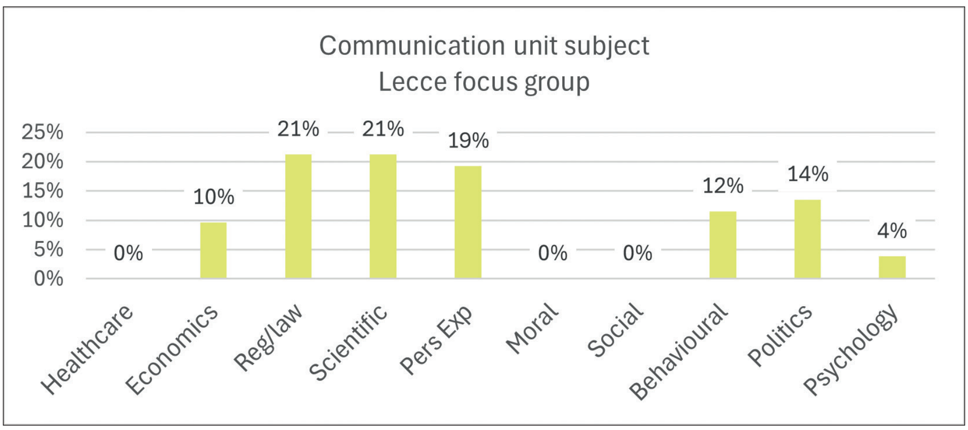

Fig. 8 - Percentage of communication unit subjects recurrence in the Lecce focus group.

The focus on regulatory/law, economics, and politics is also evident in the word cloud (Fig. 9a) where words such as “economic”, “pay”, “legislation”, “evaluation”, “damages”, “PNRR” (National Resilience and Recovery Plan), were prominently represented, highlighting their significance in the discourse.

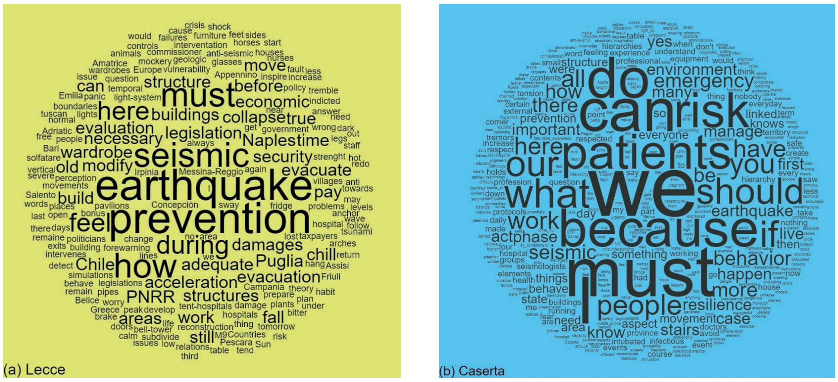

Fig. 9 - Word clouds derived from the discussions in Lecce (a) and Caserta (b).

Prevention emerged as a unanimous priority (with an occurrence of total 10 times: 5 "need for prevention" and 5 "economic implications in prevention") among the key issues (Table 1) approached through regulatory actions, economic obstacles, lack of financial resources, and political disinvestment. Several participants expressed hope in the PNRR. Discussion on earthquake consequences centred on reconstruction costs, political disinvestment, and economic impacts. Participants emphasised the urgency of addressing the structural vulnerability of buildings before considering non-structural elements. They noted that ensuring safety through interventions on non-structural elements is unfeasible if the buildings themselves are not structurally secure. This concern was frequently highlighted in discussions, with comments such as, "It's difficult to think about non-structural safety if the buildings aren't safe."

Table 1 - Key issues that emerged from the Lecce unit focus group with the number of times each issue was mentioned (occurrence), sorted in descending order.

Occurrence table	
Key issue	**N**
Need for prevention	5
Economic implications in prevention	5
Underestimation of seismic risk	4
Priority of structural prevention	4
Training request	4
Economic consequences of earthquakes	3
Reconstruction after an earthquake	3
Distrust in politics	3
Importance of legislations	**3**
Non-structural elements to be secured	3
Need for evacuation simulations	2
Issues mentioned just once: "need of experts' opinion"; "inspiring to other countries in Europe"; "animals perceive earthquakes"; "earthquakes in Salento come from Greece"; "physical sensations experienced during an earthquake"; "tsunami in Apulia"; "earthquakes repeat over time"; " importance of risk perception"; "need for seismic evaluations"; "hospitals' old buildings", "PNRR"; "seismic bonus"; "change starts with us"; "medical staff is overloaded"; "new geologic fault in the Adriatic Sea"; "heat of the Earth nucleus"; "geologic evolution of the Earth"; "peak acceleration"	1

Key observations and recommendations are discussed below.

Lack of awareness. While initial awareness of non-structural vulnerability was generally low among participants (with most having never heard about it), interest in the topic grew significantly once discussed, particularly with an emphasis on practical training to improve preparedness. This heightened interest is reflected in the frequent use of the adverb "how" in the word cloud (Fig. 8a).

Regarding seismic risk perception, the Lecce group showed a general awareness that Salento is a moderate hazard zone but often perceived the region as non-seismic. These findings underscore the need for effective risk communication interventions.

Non-structural vulnerability. The discussion highlighted the necessity to enhance awareness and promote an adequate perception of seismic risk associated with non-structural elements, which are often underestimated (Ferreira *et al.*, 2021). In moderate seismic zones, like Salento, non-structural damage can surpass structural damage, particularly in facilities such as hospitals, where the exposure value of non-structural elements may be higher than that of the structure (Rahman *et al.*, 2021). Implementing tools to inform and educate communities about the vulnerability of non-structural elements is crucial for enhancing resilience.

A more holistic approach to prevention. Another significant suggestion from the discussion is the promotion of a more holistic approach to prevention. Reducing structural vulnerability and enacting related laws are crucial, but global trends advocate for a more comprehensive risk reduction strategy. The Italian National Seismic Prevention Plan (art. 11, Law no. 77 2009) exemplifies this approach by linking seismic vulnerability reduction programs with non-structural measures, such as enhancing community knowledge on seismic hazard and emergency planning (Dolce *et al.*, 2021). This underscores the message that technological and legislative advancements alone may falter without sufficient public knowledge, awareness, and perception.

5.2. Findings from the Caserta focus group

In the Caserta group, the analysis of the communication unit subjects (Fig. 10) reveals a prevalence of regulatory/legal (21%) and scientific (20%) subjects, similarly to the Lecce group. However, in the Caserta group, the healthcare subject was predominant as well (19%), reflecting the participants' professional background. The behavioural aspects were also present in the discussion (14%). Personal experiences were shared with a percentage of 11%, and cognitive and emotional aspects were shared with an 8% percentage, higher than in the Lecce group.

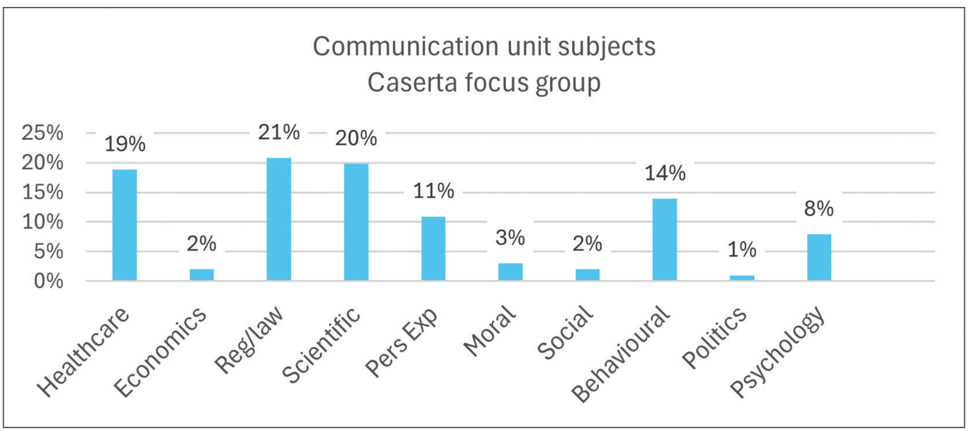

Fig. 10 - Percentage of the communication unit subjects recurrence in the Caserta focus group.

The word cloud representation supports this observation, featuring many words related to the semantic area of healthcare, such as “patients”, “doctors”, “equipment”, “infectious”, “health”, and “hospital” (Fig. 9b).

The key issues related to mitigating seismic risk and the consequences of an earthquake were strictly tied to healthcare concerns, particularly safety of patients (Table 2). Staff expressed serious concerns about the ability to safely move and secure bedridden patients or those with severe mobility issues or drainage systems. The general definition of “risk” was mostly discussed in healthcare terms, focusing on risk associated with infections, viruses, epidemics, and the hazards faced by healthcare professionals.

A notable finding from the focus group discussions is the scepticism regarding the role of healthcare staff during emergencies. Many participants were surprised to be involved in a focus

Table 2 - Key issues that emerged from the Caserta unit focus group with the number of times each issue was mentioned (occurrence), sorted in descending order.

Occurrence table	
Key issue	**N**
Lack of behavioural models	13
Scepticism about the role of staff during an emergency	12
Unawareness of seismic risk	9
Risk as a sanitary risk	8
Safeguarding of patients	8
Request for training	7
Priority of structural prevention	7
Importance of acting on behaviour	6
Non-structural elements to be secured	5
Anti-earthquake room	5
Need for practical suggestions	5
Personal experience of an earthquake	4
Healthcare staff is not expert in environmental protocols	4
Risk as a probability	3
Importance of promoting knowledge	3
The time issue during an emergency	3
Evacuation plans	3
Irpinia earthquake	3
Risk as damage	3
Concern for the legal responsibility issue implied in seismic risk management	3
Risk is unpredictable	3
Importance of acting on non-structural vulnerability	2
Lack of meeting points	2
Coping capacity showed by staff during the COVID emergency	2
Healthcare staff is overloaded	2
Issues mentioned just one time: “risk as stress”, “seismic risk in the Campania region”, “different risk perception in high hazard and low hazard seismic zones”, “other countries possess more ability than Italy”, “lack ofsspecific knowledge”, “hope that an earthquake won’t occur”, “lack of financing for the Health Service”, “the role of divine Providence”, “earthquakes occur mostly at night”, “fear, sensation of dying during an earthquake”	1

group about seismic risk, indicating both a perceived lack of legal responsibility and a sense of helplessness in the face of an earthquake. Concerns were raised about potential additional legal responsibilities related to seismic prevention, seen as an extra burden on already overworked hospital staff.

Key observations and recommendations are discussed below.

Lack of awareness. The focus group revealed a general lack of seismic risk awareness, with few participants able to describe the seismic characteristics of the Caserta area. In the group discussion there was a strong emphasis on structural vulnerability, with many believing that the vulnerability of buildings, especially older structures, accounts for most of the damage during an earthquake.

Need for behavioural models and protocols. The absence of behavioural models and practical protocols was emphasised, highlighting the need for clear guidance. This is reflected in the word cloud representation (Fig. 9b), which showed frequent use of modal verbs like "must," "should," and "can," indicating a sense of necessity and duty.

Perceived self-efficacy. The group exhibited low levels of perceived self-efficacy, feeling powerless in the face of an earthquake and sceptical about their role during an emergency. Promoting self-efficacy could increase community resilience, as self-efficacy is one of the most studied cognitive factors influencing disaster preparedness (Adams *et al.*, 2019): people are more likely to prepare for a disaster if they have confidence in their ability to respond effectively (Paton, 2003).

Non-structural vulnerability. This was underestimated in the Caserta group. Actions to mitigate the seismic risk of non-structural elements may fall, to some extent, within a "do it yourself" framework (Solarino *et al.*, 2021). Promoting an adequate perception of both the seismic risk associated with non-structural elements and the mitigation actions that citizens can take is essential for increasing safety.

Raising seismic risk awareness. Raising seismic risk awareness, which was very low among the Caserta healthcare facility staff, is crucial, as a low awareness of seismic risk significantly impacts community capacity (UNISDR, 2015).

Professional specialisation. Prioritising patient safety is essential. The general perception of risk, which was discussed almost exclusively in terms of healthcare risk, can be converted, through effective communication, into a comprehensive understanding of risk in a healthcare environment. This starts with recognising that a hospital, even before being a healthcare service, is a building whose safety in seismic zones is strategic for risk management.

Legal responsibility. The legal responsibility of healthcare staff in seismic risk education must be considered. A low-risk education of communities reduces decision-makers' ability to address legal responsibility.

Community strength. Finally, the Caserta group showed a strong sense of community, as indicated by the frequent use of the pronoun "we." This collective mindset can be leveraged in implementing effective seismic prevention plans. A strong sense of community has been found to be a positive predictor of preparedness (De Young and Peters, 2016).

These observations highlight the need for comprehensive risk communication strategies that address both structural and non-structural vulnerabilities, enhance self-efficacy, and leverage the strong sense of community within healthcare staff to improve overall preparedness and resilience.

5.3. Key issues of two pilot sites compared

Four major key issues were identified in both the Lecce and Caserta groups, providing important implications for risk communication (Fig. 11). They are here listed with a summary of the possible ways to address them.

1. Awareness of the importance of prevention. Both groups recognised the critical need for proactive measures to mitigate seismic risk. They showed significant interest in scientific aspects, including geological faults, which are closely linked to perceived seismic risk. This finding can be taken as an opportunity to emphasise the importance of prevention and proactive measures in communicating risk, fostering a culture of preparedness and resilience.

2. Training requests. Participants highlighted the lack of standardised models and protocols for seismic risk management and explicitly requested practical training. They proposed that the research team return to conduct a course on seismic risk, indicating a strong demand for hands-on training. Providing hands-on training sessions on seismic risk management can address these training requests and enhance preparedness.

3. Underestimation of seismic risk associated with non-structural elements. Most staff members were initially unaware of the importance of non-structural elements in seismic risk. Once informed, they quickly identified critical areas, demonstrating the impact of awareness. Both groups underestimated non-structural risk, focusing more on structural safety. This underestimation can be addressed by increasing awareness about non-structural seismic risks and providing user-friendly information to promote safer behaviours.

4. Medical staff overload. The heavy workload of medical staff was a significant concern. The demands of healthcare facilities make it challenging to implement informational programs, requiring any intervention plan to accommodate the workers' schedules and needs. Risk communication strategies should be designed to fit within the busy schedules of healthcare staff, so as to ensure interventions are effective without adding to their workload.

These shared issues highlight the need for targeted risk communication strategies to improve seismic resilience in the community.

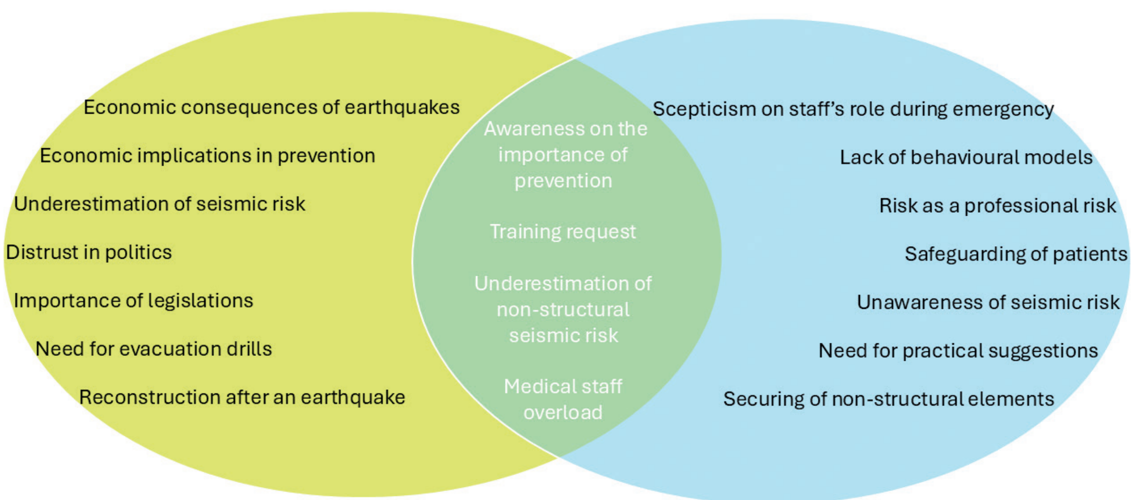

Fig. 11 - Graphic representation of the most recurrent key issues from the two pilot sites, including those shared by both groups (in yellow Lecce; in light blue Caserta).

6. Conclusions

This paper addresses a gap in the literature regarding seismic risk perception among hospital staff, particularly focusing on non-structural elements. It examines the seismic risk perception through two pilot healthcare facilities in Lecce and Caserta, southern Italy, that are areas with seismic hazard ranging from low to moderate. The study is grounded in a qualitative, yet in-depth, assessment of perception conducted through focus group discussions.

Hospital resilience is crucial for risk management in disaster-prone countries like Italy. Resilience is a holistic concept, shaped by various dimensions. Specifically, seismic resilience depends not only on hazard and vulnerability but also on factors such as people's risk perception and awareness. There is a strong correlation between high levels of resilience and an appropriate perception of seismic risk (De Pascale *et al.*, 2017). In Italy, research studies have highlighted a general underestimation of seismic risk (Crescimbene *et al.*, 2016). Although these studies did not focus on non-structural elements and on healthcare facilities, they provide the context for the research presented in this paper.

Assessing the seismic risk perception of healthcare personnel in seismic areas is crucial for enhancing the resilience of both hospitals and the broader community. A significant finding from this pilot study is the urgent need for training among hospital staff, particularly in light of frequent complaints about heavy workloads and the low awareness demonstrated by focus group participants. These insights are essential for developing targeted risk communication that strengthens community resilience to seismic events. By addressing these training needs, we can better align with the broader framework of disaster risk management and improve the coping capacities within affected communities.

Improving risk perception among healthcare workers can significantly enhance preparedness and risk management strategies, ultimately strengthening the overall resilience of hospitals and their surrounding communities.

These preliminary findings pave the way for future research directions. Initially, the results from these focus group sessions could be extended to further sites to better map the seismic risk perception across Italian hospitals. Variables such as different seismicity and hazard levels, social features, and diversity on structural and non-structural elements and their vulnerability, should be taken into account. Furthermore, the qualitative methodology in this study, which provided deep insight into people's daily living experiences and revealed unplanned topics according to a bottom-up approach, opens the doors for future targeted quantitative studies. For example, topics such as self-efficacy, identified as crucial in the Caserta group discussion, and the economic implications of prevention, emphasised in the Lecce group, could be explored in greater detail using quantitative tools such as surveys and questionnaires.

The findings of this study also have a significant practical application, as they provide valuable input for planning future risk communication campaigns in at-risk communities.

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