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Hospitals' Resilience: An Evidence-Based Framework for Sustaining the "*Coping*" Phase in Non-Linear and Continuous Crises

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ABSTRACT

This study investigates the critical domains and factors of resilience that enable hospitals to recover during extraordinary crises, using the COVID-19 pandemic as a case study. Resilience factors are categorized into four performance criteria: robustness, redundancy, resourcefulness, and rapidity, offering an evidence-based framework for evaluating hospital resilience capabilities. The research employs a two-round Delphi method, involving 13 experts from six major hospitals in Lombardy, to identify key factors across eight domains: supply and storage, layout redesign, strategic decision-making, organizational flexibility, HR management, procedures, knowledge management, and information/communication. The study finds that resourcefulness and redundancy were the most significant resilience factors, emphasizing the importance of interdisciplinary collaboration, structured decision-making, and spatial reorganization. The results highlight that adaptability, collaboration, and redundancy are essential for enhancing hospital preparedness and response during health emergencies. This research provides practical insights and a structured framework for hospitals to assess and strengthen their resilience, improving their readiness for future health crises.

1 | Introduction

In recent decades, healthcare systems in Western countries, including Italy, have undergone profound transformations driven by reform processes that have introduced innovative managerial models and roles (Gabutti et al. 2017). The present study is rooted in the broader conceptual framework of organizational resilience, understood as an organization's capability to anticipate, absorb, adapt to, and recover from disruptions (Duchek 2020; Hillmann and Guenther 2021; Giustiniano and Cantoni 2018). This framework has gained significant relevance in healthcare following the COVID-19 pandemic, where hospitals had to demonstrate not only robustness and redundancy but also adaptive capacity and dynamic reconfiguration under stress. Nevertheless, the unprecedented and unforeseen nature of the pandemic in developed economies exposed hospitals to significant unpreparedness in effectively managing the scale and complexity of the crisis (de la Garza and Lot 2022). Many hospitals struggled to maintain critical functions, adapt to rapidly changing conditions, and recover in a timely manner, revealing vulnerabilities in both their inherent robustness and adaptive flexibility (Donelli et al. 2022).

Traditional crisis management literature predominantly conceptualizes shocks as isolated or sudden occurrences, neglecting to offer comprehensive strategies to effectively manage sustained or recurrent crises (Mitroff et al. 1987; Zhong 2014; Tokakis et al. 2019; Sykes and Pandit 2021; Achour et al. 2022).

Recognizing the growing interest in resilience, this study focuses on understanding how hospitals adapt and respond to prolonged crises. To structure this analysis, the study employs a conceptual framework that organizes resilience into key domains and factors (van der Vegt et al. 2015), providing a structured lens for examining hospital responses to prolonged crises. Indeed, the crisis experienced in hospitals during the pandemic challenged the applicability of existing coping mechanisms (Achour et al. 2022; Tokakis et al. 2019; Mitroff et al. 1987) due to its uniqueness and prolonged, non-linear progression.

Despite its unpredictability, the COVID-19 crisis in Italy—particularly in Lombardy—can retrospectively be categorized into three distinct waves: the first wave (February–May 2020), marked by extreme uncertainty and lack of preparedness; the second wave (October 2020–January 2021), characterized by partial adaptation but renewed stress; and the third wave (February–April 2021), during which structural and procedural adaptations were further consolidated (Mori et al. 2020; Sornette 2002). Consequently, there is a clear need for further research that equips hospitals with the capacity to respond more resiliently to prolonged crises, enabling them to better navigate and mitigate the impacts of such protracted and unpredictable disruptions (Kihlström et al. 2022; Pinheiro et al. 2022).

This paper examines the characteristics of non-linear and continuous shocks (Mithani and Kocoglu 2020), where the system remains in a prolonged state of disorientation and instability (Burton et al. 2002), significantly impeding the formulation and implementation of conventional resilience strategies. The objective of this study is to identify and analyze the resilience domains, subdomains, and factors that enabled hospitals to effectively counteract and manage continuous exogenous shocks, such as COVID-19, during periods of extreme stress. Furthermore, the paper aims to systematically classify these resilience factors into four key performance criteria—robustness, redundancy, resourcefulness, and rapidity—and assess the degree to which these factors manifest (Zhong 2014), ultimately developing an evidence-based framework that allows hospitals to position themselves within a structured resilience strategy.

Existing literature primarily focuses on coping strategies for exogenous, one-time shocks that have a well-defined beginning and end (Giustiniano and Cantoni 2018). In contrast, this research investigates coping mechanisms within the context of non-linear and continuous crises, emphasizing the dynamic and evolving nature of such events. Specifically, it explores how hospitals adapt their resilience strategies over time, shifting from immediate response measures to long-term adaptability.

As will be illustrated in the following paragraphs recent systematic literature review by Carbonara et al. (2024) highlights critical gaps in hospital resilience research. Current studies often oversimplify resilience by establishing linear relationships between organizational characteristics and crisis management, failing to capture the complex interactions and synergies between these factors. Furthermore, while key resilience factors such as staff preparedness and communication have been identified, their integration into a cohesive and actionable resilience strategy remains largely unexplored. Additionally, the review underscores the lack of empirical studies based on measurable constructs; most existing research relies on qualitative approaches, leaving hospital resilience a largely conceptual framework in need of operational validation.

This study seeks to address these gaps by offering a structured set of resilience factors that serve as a foundation for bridging the conceptual understanding of resilience with its operationalization within the healthcare system. By identifying critical resilience factors and systematically categorizing them, this paper provides a framework that enables hospitals to assess and enhance their resilience capabilities. In doing so, it extends the existing body of knowledge by shifting the focus from static, one-shot crisis management approaches to dynamic, adaptive, and iterative resilience-building strategies tailored for prolonged and unpredictable healthcare crises. This research contributes to the understanding of how hospitals manage prolonged uncertainty and offers a structured approach for enhancing resilience through robustness, resourcefulness, redundancy, and rapid decision-making, thus advancing crisis management beyond traditional shock-based frameworks (Duchek 2020; Ansell and Boin 2019).

The study employs a two-round Delphi method to identify and validate resilience domains, subdomains, and factors. The first round involves expert interviews, followed by the validation of findings through questionnaires in the second round. Experts from various backgrounds and roles within major hospitals in Lombardy, the region most severely impacted by COVID-19 in Italy, were engaged to ensure that insights were drawn from highly relevant experiences and expertise. A sample of hospitals was selected to represent different management approaches (public and/or accredited private) and sizes among the top performers in terms of production value and revenues generated from hospital admissions and outpatient services between 2019 and 2023.

The main findings reveal that resilience during continuous crises relies heavily on resourcefulness and redundancy, particularly in the domains of layout redesign, strategic decision-making, and supply chain management. Rapid adaptability and interdisciplinary collaboration emerged as core resilience enablers during the most turbulent phases.

The paper is structured as follows. After this introduction, the literature review section presents the concept of resilience, particularly as applied to hospitals dealing with non-linear and continuous disruptions like COVID-19. It highlights the limitations of traditional crisis management models and introduces the resilience criteria of robustness, redundancy, resourcefulness, and rapidity. The section then examines how the intensity of resilience factors varies across different crisis phases, providing a deeper exploration of their application during prolonged healthcare emergencies. This analysis culminates in the formulation of the research questions. The research settings and methodology section follows. The results section presents the identified resilience domains, subdomains, and criteria activated during the coping phase, supported by visual data representations. The discussion section interprets these findings, providing deeper insights into hospital resilience. Finally, the conclusion summarizes the key contributions and implications of the research, offering directions for future study.

2 | Literature Review: Research Gap and Resilience Factors

Resilience in healthcare encompasses a system's ability to anticipate, prepare for, respond to, and recover from crises while maintaining essential functions and performance (Khalil et al. 2022). This concept encompasses not only the robustness of physical infrastructure and clinical operations but also the adaptability of governance structures, workforce flexibility, information systems, and inter-organizational coordination. A resilient healthcare system demonstrates both absorptive capacity (withstanding shocks) and adaptive capacity (adjusting dynamically to changing conditions), thus safeguarding population health in the face of uncertainty, complexity, and systemic stressors such as pandemics and natural disasters.

In the hospital sector, "*coping*" refers to the set of reactive strategies and immediate responses enacted by institutions to absorb and manage external shocks without collapsing operationally. In contrast, "resilience" implies a more dynamic capability that integrates both short-term coping and long-term adaptation, encompassing the hospital's capacity to reorganize, learn, and transform under crisis (Duchek 2020).

A recent systematic literature review on the resilience of hospitals in an age of disruptions (Carbonara et al. 2024) presents several key gaps that hinder a comprehensive understanding of how healthcare institutions can effectively navigate crises. First, most studies establish linear relationships between organizational characteristics (such as structure, practices, and behaviors) and resilience, without exploring the complex interactions and synergies between these factors. This oversimplified approach fails to capture the dynamic and multifaceted nature of hospital resilience. Second, while prior research has identified key resilience components such as staff preparedness, communication, and equipment, it often treats these elements indiscriminately without detailing how they interact to create an integrated resilience strategy. A more in-depth analysis is needed to distinguish and categorize organizational characteristics that enhance resilience.

Additionally, the review underlines a lack of empirical and quantitative validation, with most studies relying on qualitative observational approaches rather than systematic experimental or mixed-method designs, leaving hospital resilience largely conceptual.

Our analysis focuses on the intersection of three critical areas: (1) resilience performance criteria—resourcefulness, redundancy, robustness, and rapidity; (2) crisis contexts—COVID-19, pandemics, and broader healthcare emergencies; and (3) adaptive and preparedness strategies—crisis preparedness, disaster intensity, and adaptive flexibility. By addressing these overlapping domains, this study seeks to identify key factors that enhance hospital and health system resilience, offering insights into how organizations can better navigate crises and improve their long-term capacity to respond effectively to future shocks.

Several studies focused on the critical role played by the supply chain management (Araujo et al. 2022), technology (Tortorella et al. 2022; Sindhu 2022; Barrett 2022; da Rosa et al. 2021; Rubbio et al. 2020), or Human Resources (Chemali et al. 2022; Thude et al. 2019; Bagley et al. 2018). During the turbulent phase of a crisis, where uncertainty and unpredictability are at their highest, supply chain management, particularly in procurement, becomes a critical function. Effective procurement practices ensure the timely acquisition of essential materials, safeguard against supply shortages, and mitigate the impact of external disruptions (Spieske et al. 2022). This function is vital for maintaining operational continuity and meeting shifting demand, often under severe constraints (Srinivasan and Swink 2015).

Additionally, the role of technology is paramount in enabling supply chains to respond quickly and flexibly to changing circumstances (Barrett 2022). Advanced digital tools, including real-time data analytics, automation, and AI-driven decision-making systems, enhance visibility across the supply chain and enable faster and more informed responses to crises (Tortorella et al. 2022; da Rosa et al. 2021). These technologies also facilitate the redesign of processes, allowing for increased efficiency, better resource allocation, and the identification of alternative supply routes when traditional options fail (Rubbio et al. 2020).

Human Resources also play an essential role, particularly in fostering a resilient workforce capable of adapting to the rapidly changing environment of a crisis (Chemali et al. 2022). HR strategies that emphasize flexibility, cross-functional training, and effective leadership are key to navigating periods of heightened volatility. The capacity to manage employee well-being and maintain high levels of engagement during crises is critical for organizational stability and performance (Lengnick-Hall et al. 2011).

Adopting a different perspective, other studies have focused on crisis management strategies or models (Jensen et al. 2022; Khalil et al. 2022). The rapid escalation of cases, compounded by the absence of prior experience in managing such an extensive and prolonged crisis, revealed significant deficiencies in crisis preparedness (Jolgehnejad et al. 2021; Al-Ayed 2019) in hospitals. In the literature, multiple approaches to hospital crisis management have been identified (Emami et al. 2024), each addressing response strategies across various temporal phases (Mithani and Kocoglu 2020). Crisis management frameworks typically divide responses into pre-crisis, crisis, and post-crisis phases, highlighting the importance of preparedness, real-time response, and recovery. Although each phase requires distinct strategies, they are closely interconnected, as the success of post-crisis recovery often depends on pre-crisis planning and the timeliness of actions taken during the crisis itself. Specifically, the present study examines the coping (Mori et al. 2020; Sornette 2002) where hospitals' organizational responses is challenged by a multitude of 'unknowns,' complicating decision-making and forecasting efforts (Asperges et al. 2020; Capolongo et al. 2020; de la Garza and Lot 2022).

Furthermore, the literature underscores the importance of adopting an incremental approach to strategy implementation (Jamal et al. 2020; Cantoni 2014; Håkonsson et al. 2013). Since crises are inherently unpredictable and difficult to plan for, their complex and evolving nature renders a single, standardized response model inadequate (Helfat and Samina 2014). Instead,

management should employ flexible decision-making processes that facilitate rapid adaptation, ideally through modular and scalable procedures and actions (Hung et al. 2022).

In this regard, risk-taking is a key aspect, where crisis management teams must strike a balance between bureaucratic, static models and the need for flexibility (Helfat and Samina 2014). In times of crisis, rigid hierarchical structures and pre-established protocols may hinder the organization's ability to respond effectively. Therefore, flexibility becomes essential, enabling teams to adapt to rapidly evolving conditions. Additionally, crisis situations often necessitate the development of new roles and the creation of innovative organizational structures that allow for more dynamic, real-time decision-making and resource allocation. This adaptability ensures that hospitals can respond efficiently to unexpected challenges while maintaining operational continuity.

2.1 | Unification of Hospital Resilience in Crisis Management

Our study contributes to addressing the aforementioned research gaps by providing a unified, evidence-based framework that synthesizes existing literature and identifies key resilience factors essential for effective crisis response. By clarifying and organizing these factors, we aim to enhance the conceptual clarity of hospital resilience, ultimately facilitating the development of more coherent and adaptable crisis management strategies, while bridging the gap between the conceptual understanding of resilience and its measurable operationalization within the healthcare system.

To effectively assess hospital resilience, this study adopts four performance criteria widely recognized in the literature: robustness, redundancy, resourcefulness, and rapidity (Zhong et al. 2014). These criteria have been validated in disaster and emergency contexts and offer a structured yet flexible lens for analyzing the interplay between structure, processes, and adaptive capacity. The choice of this framework is motivated by its multidimensional nature, which aligns with the study's objective to capture resilience under prolonged, non-linear shocks.

In line with Zhong et al. (2014) each criterion captures a distinct capability of healthcare systems in crisis contexts:

- Robustness (Rb) is the strength or ability of health facilities or health systems to withstand a given level of external shock and the extent to which healthcare functions can be maintained.
- Redundancy (Rd) is the extent to which elements of health facilities or health systems can be substituted to maintain health functions.
- Resourcefulness (Rs) is the ability to identify problems, establish priorities and mobilise resources when disaster occurs.
- Rapidity (Rt) is the speed (in a timely manner) of health facilities or systems with which the level of their full operational function can be achieved through the activities of responsiveness, recovery and adaptation.

Despite established resilience criteria, the literature often overlooks the nature of the shock that triggers crises, such as the unique challenges posed by the COVID-19 pandemic, including sudden surges in patients and resource demands. This gap highlights the need for a more nuanced approach that incorporates the specific contextual factors of crises. Zhong et al. (2014) identified key resilience domains, such as structural and non-structural components, emergency medical functions, and disaster management capacity, but did not address the "intensity" of these factors—how their activation and use vary based on the crisis phase. Understanding this intensity is crucial for hospitals to dynamically adjust their resilience strategies, enabling more effective resource deployment and crisis management. Accordingly, our research questions are as follows:

RQ1. Which resilience domains, subdomains and factors have allowed hospitals to counteract and contain an exogenous and continuous shock like COVID-19 during the turbulence phase of the stress?

RQ2. How can the identified factors be systematically categorized into performance criteria such as robustness, redundancy, resourcefulness, and rapidity?

RQ3. What is the intensity with which these factors manifested?

By applying the four performance criteria of Zhong et al. (2014), the study contributes to filling the gap in the literature concerning how hospitals develop and operationalize resilience strategies in response to prolonged, non-linear crises such as the COVID-19 pandemic. It does so by identifying and classifying resilience factors based on their role and relevance across different phases of the emergency.

3 | Research Settings and Methodology

3.1 | Data Sampling: Territory, Hospitals, Experts

Lombardy's significant role as an epicenter of the outbreak provided a unique and highly relevant context for understanding resilience in healthcare systems under extreme and prolonged pressure.

As shown in Table 1, our analysis deliberately targeted leading hospitals in Lombardy (Italy) due to the region's severe exposure to COVID-19. The Lombardy hospital system is one of the most complex and extensive in Italy, comprising over 200 healthcare facilities, including public hospitals, accredited private institutions, and IRCCS (*scientific institutes for research, hospitalization, and healthcare*). Of these, around 30 are considered large or highly specialized based on size, complexity, and service portfolio. The regional system is structured around both ASSTs (*Territorial Socio-Healthcare Agencies*) and IRCCSs, ensuring a mix of general and specialized care across the territory.

TABLE 1 | Main features of the hospitals investigated, representatives interviewed, and performance variation in revenue from inpatient and outpatient services (2023/2019).

Hospital name	Abb.	City	Funding	Institutional settings[a]	Representative interviewed	Active beds in 2019	Change in revenue from inpatient services (2023/2019)	Change in revenue from outpatient services (2023/2019)
Humanitas Research Hospital	HR	Rozzano (MI)	Private accredited	IRCCS	Supply Chain Director; Chief Medical Officer	564	5%	15%
Humanitas Mater Domini Hospital	HMD	Castellanza (VA)	Private accredited	IRCCS	Chief Medical Officer; Supply Chain Director	150	11%	39%
Grande Ospedale Metropolitano Niguarda	N	Milano	Public	ASST	Chief Financial Officer; Managing Director; Head of Medicine Department	1082	10%	21%
Ca′ Granda Ospedale Maggiore Policlinico	PL	Milano	Public	IRCCS Foundation	Chief Medical Officer	767	13%	19%
San Raffaele Hospital	SR	Milano	Private accredited	IRCCS	Chief Scientific Officer; Chief Medical Officer; Head of the Intensive Care Unit	n.a.	n.a.	n.a.
San Gerardo dei Tintori Hospital	SG	Monza	Public	IRCCS Foundation	Managing Director; Chief Medical Officer	647	4%	2%

[a]ASST—territorial socio-health company; IRCCS—Institutes for Hospitalization and Care of Scientific Character.

The selection of hospitals for this study was based on several key factors, including a diverse range of hospital types and sizes to explore different coping strategies across various funding models and governance structures. Notable hospitals such as Niguarda, San Raffaele, and Humanitas were included to understand how advanced healthcare facilities navigated the crisis and to identify replicable models. Additionally, hospitals like San Gerardo di Monza, known for their expertise in infectious diseases and telemedicine, were chosen to explore the role of specialized services in resilience. Ca' Granda Ospedale Maggiore Policlinico was included for its historical expertise in infectious diseases and its integration with university-level research, providing a valuable interface between clinical practice and academic innovation during the pandemic.

The study also focused on maintaining expert heterogeneity, ensuring a broad range of perspectives from Chief Medical Officers, Supply Chain Directors, Managing Directors, Chief Financial Officers, and heads of critical departments. This multidisciplinary panel enabled a comprehensive examination of both clinical and operational dimensions of hospital resilience. The diverse expertise ensured a well-rounded analysis of resilience strategies across various hospital functions. Experts directly involved in crisis management offered critical insights into decision-making, resource reallocation, and operational adjustments. Notably, the selected hospitals (except San Raffaele, due to unavailable data) recorded increased performance in revenue from inpatient and outpatient services during 2019–2023, demonstrating significant operational resilience in adapting to unforeseen challenges.

As noted by Niederberger and Spranger (2020), cognitive diversity within expert panels is crucial for enhancing the credibility and acceptability of findings, particularly when the panel size is limited. This diversity not only strengthens the data quality but also influences the perceived feasibility of the conclusions.

3.2 | Methodology

This research employs primary data from a two-round Delphi-based study, which involved expert interviews (first round) and questionnaires (second round) to develop assumptions, questions, and validations.

The Delphi technique is recognized for its structured approach to gathering expert consensus, making it particularly effective for exploring complex healthcare issues, especially in uncertain contexts like COVID-19 (de Meyrick 2003; Niederberger and Spranger 2020; Stone Fish and Busby 2005). By involving a panel of experts with diverse perspectives, the method assumes that collective judgment is more reliable than individual opinions, facilitating the identification and validation of key resilience factors for hospitals during the pandemic.

The 13 experts were selected through purposive sampling, based on their senior roles and direct involvement in COVID-19 crisis management within their hospitals. Initial contact was made via institutional email, supported by the research team's professional and academic networks. In some cases, outreach was facilitated through existing collaborations or phone calls. All participants received a formal invitation detailing the study's aims and the structure of the Delphi process.

The first Delphi round consisted of semi-structured interviews guided by open-ended questions (see Appendix A), designed to elicit expert insights on resilience strategies. Upon reaching theoretical saturation (Saunders et al. 2018), a validation questionnaire was administered to the same experts in a second round. Using a five-point Likert scale, participants confirmed, refined, or rejected the identified resilience factors based on their perceived relevance for future health emergencies. Examples of the open-ended questions used in the first-round interviews and the items from the second-round Delphi questionnaire are provided in Appendix A.

A participant dropped out in the second round, leaving 12 experts for the final analysis.

The first round took place between January 1st and April 30th, 2021. On average, each interview lasted approximately 90 min. The second round was conducted from July 1st to October 31st, 2022.

The research applied a framework based on four criteria—robustness, redundancy, resourcefulness, and rapidity—evaluating each factor's role in addressing exogenous and ongoing shocks.

To ensure methodological rigor and consistency in data interpretation, a structured and systematic approach was adopted for data collection and analysis, drawing on established qualitative research protocols (Alsaawi 2014). All interviews were conducted upon obtaining informed consent from participants and were recorded to preserve the integrity and richness of the data. Verbatim transcriptions were subsequently produced, facilitating accurate cross-referencing and collaborative analysis among the research team.

The analytical process began with the development of an initial coding framework aimed at capturing salient themes, concepts, and patterns relevant to the study's objectives (Elliott 2018). This framework served as a guiding structure for the subsequent stages of thematic analysis. Manual coding was employed to remain epistemologically consistent with reflexive approaches (Braun and Clarke 2006), privileging interpretive depth over software-driven efficiency and enabling close engagement with the empirical material.

During the first cycle of analysis, significant expressions—particularly key words and short conceptual phrases—were identified and coded. These first-order codes were subsequently clustered into second-order themes, which captured both established constructs and emerging perspectives, following Gioia's methodological guidance (Gioia 2021).

Throughout the coding and thematic synthesis process, continuous iteration and refinement were prioritized. To ensure consistency and analytical robustness, the research team engaged in multiple rounds of review. Techniques such as code merging, redefinition, and hierarchical clustering were applied to optimize thematic clarity and minimize interpretation bias. This

iterative process ensured that the coding framework evolved in alignment with the complexity of the data, allowing for comprehensive coverage and contextual sensitivity.

In the final phase of analysis, the coded data were systematically interrogated in relation to the variables highlighted in the literature review. This cross-cutting analysis enabled the identification of patterns and divergences in resilience responses, thereby enhancing the explanatory power of the findings.

The results respond directly to the research questions defined in the early part of the study. RQ1, which asks which resilience factors emerged during the pandemic, is addressed by the identification of domains such as layout reconfiguration, HR management, supply and storage strategies, and communication systems. These elements reflect both structural and adaptive components of hospital resilience.

RQ2, concerning the classification of these factors, is addressed through the application of Zhong et al.'s (2014) framework. Each domain has been assigned to one or more of the four performance criteria—robustness, redundancy, resourcefulness, and rapidity—based on expert validation. For example, "layout redesign" reflects rapidity and redundancy, while "knowledge management" primarily represents resourcefulness. This classification allows for a systematized understanding of how hospitals organized their responses.

RQ3 is addressed through the second Delphi round, in which experts assessed the perceived relevance of each factor for future prolongued and non-linear emergencies. High validation scores were observed for cross-functional collaboration, communication protocols, and flexible human resource management—indicating that these factors are not only retrospective findings but also prospective priorities for building resilient health systems.

4 | Results

Following the first round of interviews, in response to RQ1, eight domains of resilience were identified: supply and storage, layout (re)redesign and asset (re)reconfiguration of assets and organizational structure, strategic decision-making, organizational flexibility, Human Resource Management (HRM), procedures, knowledge management and research, and information and communication management. Each domain was further divided into subdomains, which were subsequently delineated into specific factors implemented by the hospital. To answer RQ2, each factor was then traced back to one of the 4 criteria. The results of RQ1 and RQ2 are summarized in Table 2.

It is important to clarify that, in some instances, the specific factors may not have been actively implemented by the hospital but were instead perceived as relevant by the interviewees.

The results for RQ3 are shown in Figures 1–4, detailing the intensity rankings of factors related to resourcefulness, robustness, redundancy, and rapidity. The intensity rankings presented in Figures 1–4 are based on the average scores attributed by Delphi panelists using a five-point Likert scale in the second round. Each factor's mean value represents its perceived relevance.

The results in Figure 1 highlight several initiatives aimed at enhancing resourcefulness in healthcare settings, emphasizing varying levels of importance across individual and systemic actions. Lower-rated factors, such as shift-work self-management, address operational continuity but are not perceived as critical for overall resourcefulness. In contrast, information management, decision-making empowerment, and the implementation of research projects are recognized as key contributors, facilitating efficient knowledge flow and adaptive decision-making. The highest-rated factors—exchange of information between multidisciplinary teams and multi-specialist team building—underscore the pivotal role of collaboration and cross-functional expertise in driving resourcefulness, enabling the organization to effectively tackle complex challenges. In conclusion, the results indicate that resourcefulness is perceived to be driven by factors that enhance collaboration, continuous learning, and the strategic use of knowledge. The focus on interdisciplinary teamwork, structured decision-making processes, and the alignment of research and operational protocols underscores the importance of collective, rather than individual, approaches to fostering resilience and adaptability within the organization.

The results presented in Figure 2 offer insights into factors contributing to the robustness of healthcare systems, with a particular focus on those marked with **—top-down management of communication, management by process, leading by example, and the presence of a crisis unit—that can contribute to both robustness and resourcefulness, depending on the hospital's approach. From a robustness standpoint, these elements provide stability and consistency. Top-down communication ensures clear directives, management by process reinforces operational reliability, leading by example fosters strong leadership, and the crisis unit ensures readiness for emergencies.

Conversely, if the hospital prioritizes adaptability, these same factors can support resourcefulness. Top-down communication can be made more flexible, allowing for rapid adjustments, while management by process can incorporate dynamic changes in response to new challenges. Leading by example can promote adaptability, and the crisis unit can evolve from a reactive to a proactive, innovative force. Thus, these factors are versatile depending on the hospital's predisposition.

The results presented in Figure 3 demonstrate a significant level of redundancy in hospital strategies, which refers to the implementation of overlapping and complementary measures to ensure continuous operation and mitigate the risk of system failure during high-pressure situations. Key examples include the clear separation of COVID ER and COVID-free ER and the segregation of pathways, hospitalizations, and intensive care based on patient severity, which represent redundant physical and operational processes designed to prevent cross-infection and maintain a controlled environment for different patient groups. This layered approach enhances system resilience by ensuring that disruptions in one area do not affect others.

Similarly, the re-allocation of doctors and nurses to COVID and COVID-free wards ensures effective human resource distribution across distinct patient care streams, enhancing both safety and operational flexibility. This is complemented by the hiring of additional doctors and nurses in intensive areas, which

TABLE 2 | Pay attention to the correspondence in line of factors and criteria.

Resilience domains	Subdomains	Factors	Criteria
Supply and storage	(Double) sourcing	Activation of alternative supply channels	(*Rd*)
		Possibility to rely on group purchasing department	(*Rd*)
	Storage	Increase in the storage capacity of PPE, DM and drugs	(*Rd*)
Layout (re)design and (re) configuration of assets and organizational structure	Assets modularity	Quick reconfiguration of the hospital layout	(*Rt*)
		Separation of spaces, paths and COVID and COVID-free departments	(*Rd*)
	Pathways for patient	Clear separation COVID ER and COVID-free ER	(*Rd*)
		Separation of pathways, hospitalizations and intensive care by patient severity levels	(*Rd*)
	Organizational reconfiguration	Institutionalization of new figures (i.e., bed manager)	(*Rs*)
		Presence of a crisis unit	(*Rb/Rs*[b])
Strategic decision making	Frequency of the meetings	High frequency of crisis unit meetings	(*Rs*)
	Speed in decision making	Ability to make decisions quickly	(*Rt*)
	Decision making model	Decision-making empowerment of the individual within a team	(*Rs*)
		Development of a hierarchy of decisions (urgent, important, urgent not important, not urgent not important, not urgent important)	(*Rs*)
Organizational flexibility	Re-allocation and increase of medical and nursing staff	Re-allocation of doctors and nurses to COVID and COVID-free wards	(*Rd*)
		Hiring of extra doctors and nurses in the intensive areas	(*Rd*)
	Operational decision-making empowerment	Shift-work self-management	(*Rs*)
		Lead by example	(*Rb/Rs*[b])
	Organizational culture	Quick reconfiguration of the organizational structure	(*Rt*)
		Management by process	(*Rb/Rs*[b])
Human Resources Management	Work organization mode	Multi-specialist team building	(*Rs*)
	Training	Use of training systems and platforms	(*Rs*)
	Compensation policies	Redefinition of compensation and remuneration systems	(*Rs*)
Procedures	Development of new protocols	Rapid development of new protocols	(*Rt*)
	Spread of protocols	Exchange of information between multidisciplinary teams	(*Rs*)
		Multimedia use to spread protocols	(*Rs*)
		Exchange of data and information with the international scientific community	(*Rs*)
Information & Communication Management	Collection of information	Use of staff dedicated to collecting information (Bio Angels)	(*Rs*)
		Creation of data collection and processing systems (intranet, e-mail boxes, ...)	(*Rb*)
		Verification of sources authoritativeness in order to avoid information overload/overflood that would slow down the decision-making processes	(*Rs*)
	Information sharing model	Top-down management of information communication	(*Rb/Rs*[b])

(Continues)

TABLE 2 | (Continued)

Resilience domains	Subdomains	Factors	Criteria
Knowledge Management & Research	Research as a catalyst of knowledge	Hospital dimension large in scale and wide number of different specialties[a]	(*Rd*) (*Rs*)
		Activation/implementation of research projects to consolidate and capitalize knowledge	(*Rs*)
		Linking therapeutic protocols to research protocols	(*Rs*)
		Exploitation of scientific research as a catalyst for sharing knowledge and team cohesion	

[a]Explanatory of the existing portfolio of skills in the organization and therefore propaedeutics to the research.
[b]These factors can be placed under the Robustness criteria. Conversely, if there is a hospital predisposition, they can be placed under the Resourcefulness criteria.

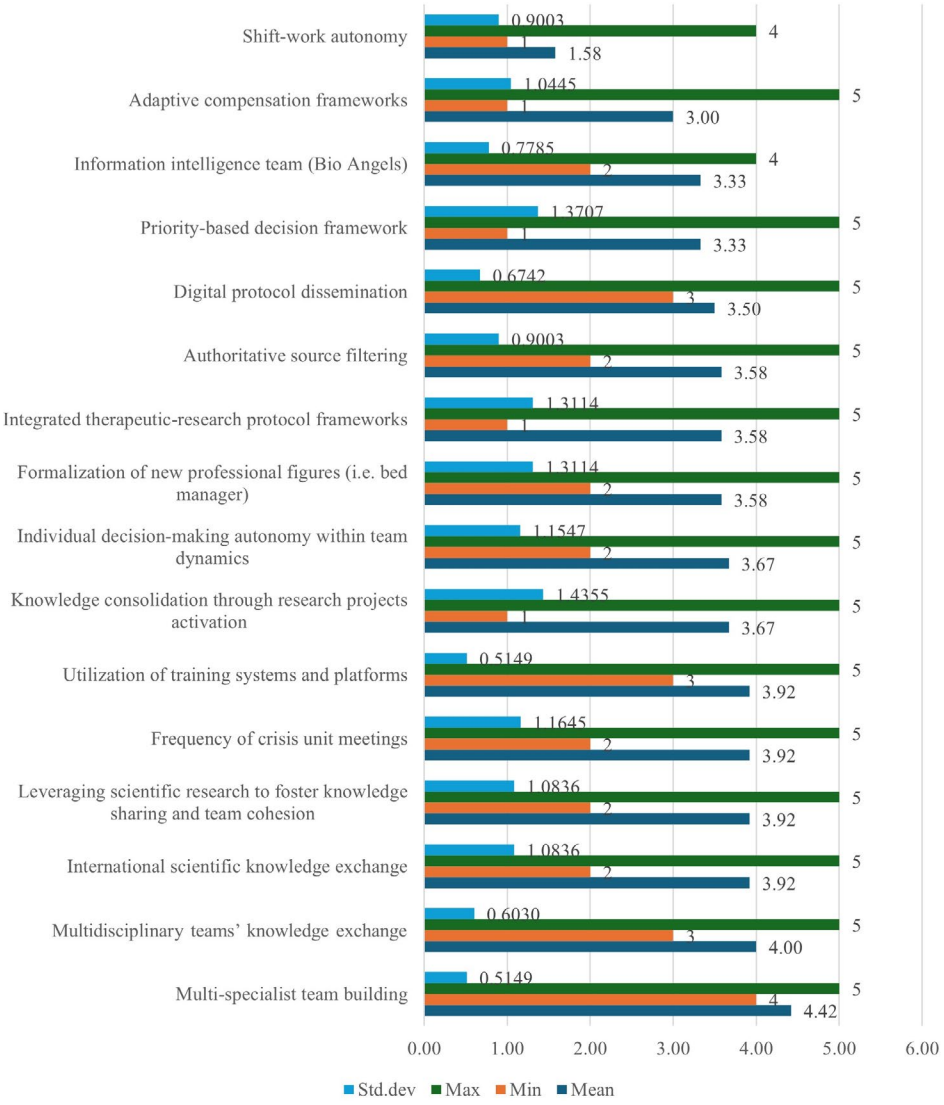

FIGURE 1 | Intensity ranking of the factors pertaining to resourcefulness.

provides a buffer to accommodate surges in patient numbers while maintaining staff well-being. These overlapping human resource strategies help hospitals manage patient inflows without compromising care standards.

In the area of supply chain management, the activation of alternative supply channels and reliance on group purchasing departments reinforce redundancy by ensuring that, in the event of a disruption in one supply chain, the hospital can still access essential materials. Procurement should be fast, flexible, and multisourcing. This is further bolstered by increased storage capacity for PPE, drugs, and medical devices, which provides an internal reserve for critical supplies, protecting against external supply chain failures.

In contrast, hospital dimension, while important, appears less critical for redundancy, as scalability alone does not guarantee flexibility or adaptability during a crisis.

The results shown in Figure 4 underscore the critical role of rapidity in hospital responses to crises. Each of the highlighted factors demonstrates the importance of swift adaptation to maintain operational effectiveness and patient safety.

The quick reconfiguration of the hospital layout is rated as the most critical factor in terms of rapid response. This reflects the necessity of physical flexibility within hospital environments, allowing spaces to be quickly adapted to accommodate different patient needs, particularly in separating infected and non-infected individuals. The high rating emphasizes how spatial adaptability is a cornerstone of hospital resilience during emergencies.

Both the quick reconfiguration of the organizational structure and the ability to make decisions quickly also rank highly, indicating that organizational agility and swift decision-making are key to responding effectively in dynamic and uncertain conditions. These factors highlight the importance of decentralized decision-making and adaptive leadership, which enable rapid shifts in resource allocation, staffing, and protocol adherence to match emerging challenges.

The rapid development of new protocols, while slightly lower than the others, still indicates a strong need for flexibility in clinical and operational guidelines. The ability to create and implement new protocols quickly is essential for addressing novel challenges and ensuring that staff and patients can adapt to evolving circumstances with minimal disruption.

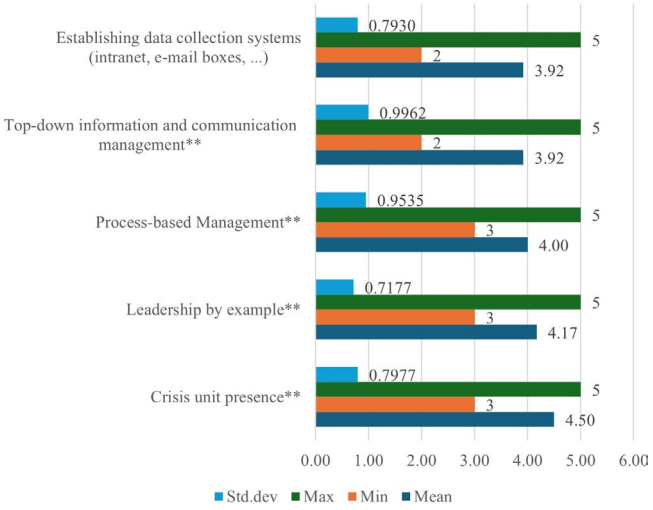

FIGURE 2 | Intensity ranking of the factors pertaining to robustness.

5 | Discussion

The matrix proposed by Zhong et al. (2014) reveals significant differences in the key factors for hospital resilience when comparing one-shot shocks and continuous shocks.

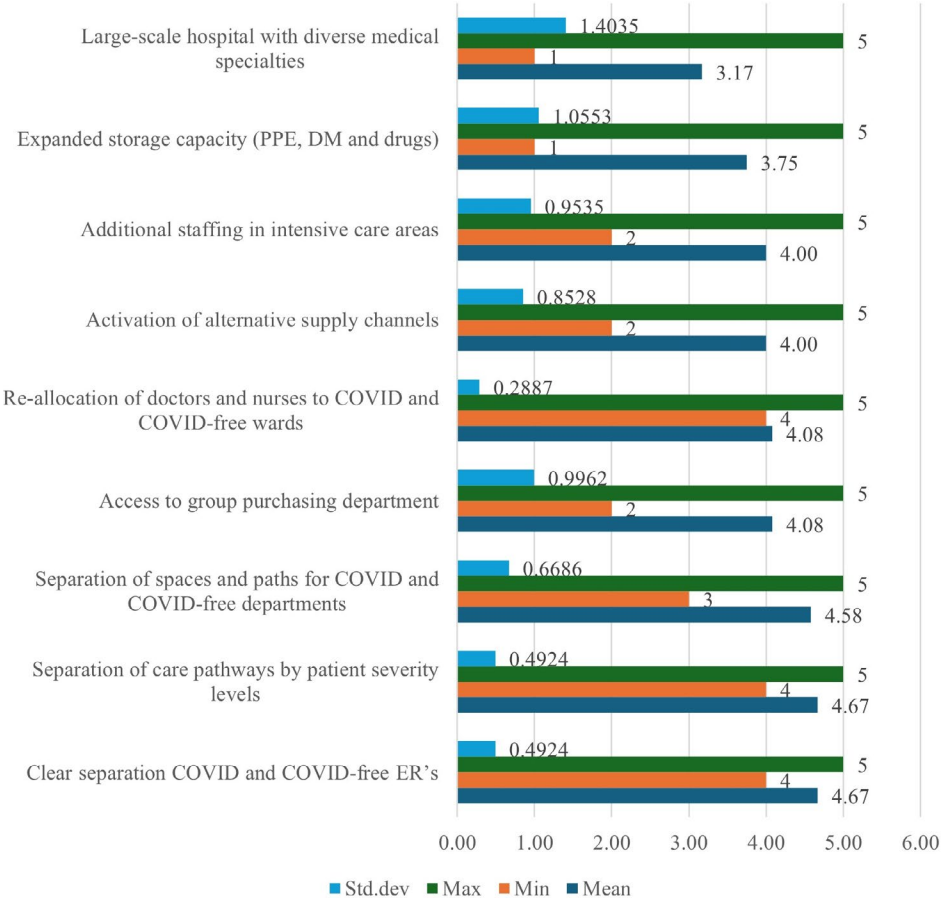

FIGURE 3 | Intensity ranking of the factors pertaining to redundancy.

Most resilience factors are linked to resourcefulness and redundancy dimensions, followed by rapidity. According to Zhong et al. (2014), robustness and rapidity are considered "ends," while resourcefulness and redundancy are regarded as "means." The analysis of the collected data indicates that, during the coping phase, when hospitals were primarily focused on counteracting and containing the disruptions caused by COVID-19, the "means" were more critical than the "ends." This shift emphasizes the importance of adaptability and the capacity to mobilize resources effectively during a crisis.

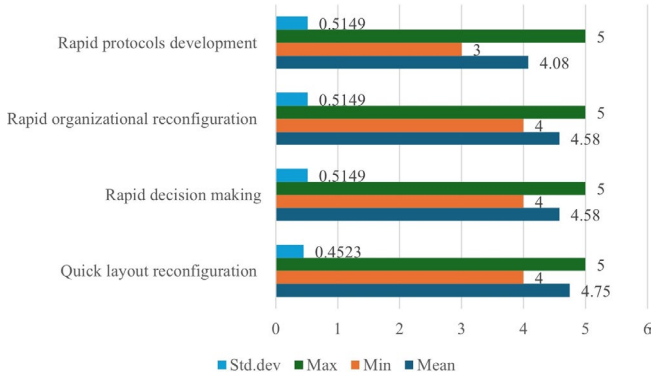

FIGURE 4 | Intensity ranking of the factors pertaining to rapidity.

The findings of this study extend Zhong's work by providing valuable insights into the complex, multi-dimensional nature of hospital resilience. It offers an analysis of resilience factors approached from two complementary perspectives: linking them to performance criteria and aligning them with specific resilience domains. This dual approach allows for a deeper understanding of how different factors contribute to resilience at both the strategic and operational levels, providing a more comprehensive framework for evaluating hospital performance during crises.

Furthermore, this study goes beyond Zhong's research by suggesting that different factors may manifest with varying intensity during the turbulence phase.

To provide a clearer connection between the empirical findings and the research questions, Table 3 summarizes how the research questions were addressed by the study's findings. RQ1 focused on identifying key resilience domains, RQ2 linked these

TABLE 3 | Mapping of research questions to related findings.

Research question	Related findings
RQ1	Eight resilience domains were identified through expert interviews and inductive analysis: Layout and asset redesign, Strategic decision-making, Human Resources Management, Organizational flexibility, Supply and storage, Communication and Information Management, Knowledge Management and Research, Procedures and protocols.
RQ2	These domains were mapped onto Zhong et al.'s (2014) four performance criteria to assess their relevance. The performance criteria often overlap across multiple domains or factors, and the associations are not always one-to-one (see Table 1).
RQ3	The Delphi method confirmed the perceived importance of several factors for guiding future resilience planning: • **Resourcefulness:** ◦ Collective and interdisciplinary approaches ◦ Multidisciplinary teamwork and collaboration ◦ Structured and adaptive decision-making ◦ Integration of research with operational protocols ◦ Knowledge sharing • **Robustness:** ◦ Process management ◦ Leadership by example ◦ Centralized crisis unit ◦ Adaptation of processes in agile contexts • **Redundancy:** ◦ Physical separation of COVID and non-COVID areas ◦ Flexible staff reassignment ◦ Multi-sourcing strategies and increased stockpiles • **Rapidity:** ◦ Fast redesign of spaces and structures ◦ Quick and decentralized decision-making ◦ Immediate implementation of protocols ◦ Timely adaptation of workflows and resources • **Cross-cutting factors:** ◦ Physical and organizational adaptability for operational continuity and infection control ◦ Organizational agility and rapid crisis response.

domains to established performance criteria, and RQ3 validated the relevance of these factors through expert consensus.

The section offers a detailed discussion of the performance criteria and their manifestation in the coping phase. Regarding resourcefulness, the data strongly suggest that hospital resilience is driven by collective, interdisciplinary approaches rather than individual efforts. The emphasis on interdisciplinary teamwork, structured decision-making processes, and the alignment of research with operational protocols highlights the need for cohesive and collaborative action. By fostering these collective mechanisms, hospitals are better equipped to leverage diverse expertise and respond effectively to dynamic challenges. This approach not only facilitates knowledge sharing but also supports adaptive decision-making, enabling organizations to remain flexible and proactive in managing uncertainties. The integration of multidisciplinary teams allowed hospitals to tackle complex problems more creatively and efficiently, demonstrating the value of collaboration in building resilience.

In terms of robustness, the study identifies management by process, leading by example, and the presence of a crisis unit as the most significant factors. These elements are foundational in ensuring that hospitals can withstand external shocks while maintaining critical functions. Management by process provides structured, predictable frameworks for operational continuity, while leading by example fosters strong leadership that guides teams through crisis situations with confidence and clarity. The crisis unit, acting as a centralized decision-making body, ensures that the hospital can respond quickly and effectively to emerging threats. These factors, however, exhibit a certain degree of versatility depending on the hospital's context and predisposition. In more adaptive environments, for instance, management by process may be supplemented with agile methodologies, and crisis units can evolve into proactive hubs that drive innovation and risk mitigation strategies. Therefore, robustness in this context is not static but adaptable, influenced by the hospital's broader organizational culture and strategic orientation.

Redundancy plays a crucial role in hospital crisis preparedness, particularly through spatial organization, human resource allocation, and supply chain strategies. The deliberate embedding of redundant systems ensures multiple layers of protection to prevent critical failures during intense pressure periods. For example, the clear separation of COVID and non-COVID zones, the reallocation of staff to COVID-specific and COVID-free wards, and the activation of alternative supply channels reflect a well-coordinated, systematic approach to risk mitigation. These overlapping measures enable hospitals to maintain operational continuity even when specific resources or personnel are strained. Redundancy in the supply chain—evidenced by reliance on multisourcing and increased storage capacity for PPE and medical supplies—further ensures that hospitals are not left vulnerable to external disruptions. This redundancy ensures that if one pathway or resource fails, backup systems can absorb the impact and maintain care continuity.

Regarding rapidity, hospitals demonstrated impressive capacity to reconfigure physical spaces and adapt organizational structures swiftly, which was essential for maintaining operational effectiveness and patient safety. The ability to make quick decisions was consistently rated highly across the data, highlighting the critical role of decentralized decision-making in dynamic, fast-changing environments. Hospitals that could implement new protocols quickly, reallocate resources, and adapt workflows in real-time proved to be far more resilient in managing the pandemic's demands. This speed of adaptation across both physical and organizational dimensions was fundamental to their success. The rapid reconfiguration of hospital layouts, particularly the creation of dedicated COVID and non-COVID zones, enabled effective infection control, while the quick restructuring of teams ensured that staffing shortages were addressed without compromising care quality.

When discussing the relationship between factors and domains, it becomes clear that layout (re)design and (re)configuration of assets and organizational structures is the domain where factors exhibit the highest intensity. This domain consistently emerges as a critical area due to its capacity to rapidly adapt physical spaces and organizational frameworks, ensuring operational continuity. The strong emphasis on this domain reflects its central role in enabling hospitals to respond effectively to evolving challenges. The quick reconfiguration of hospital layouts is a critical factor due to its strong association with the need for rapid spatial reorganization. This factor plays a pivotal role in ensuring that hospitals can quickly adapt their physical spaces to meet evolving demands during crises. By enabling swift adjustments to accommodate different patient needs, such as separating infected from non-infected individuals, this factor helps maintain operational functionality and enhances infection control. Its relevance lies in ensuring that hospitals remain flexible and responsive in high-pressure situations, contributing to overall resilience.

The high rating reflects the essential role physical adaptability plays in ensuring both operational continuity and effective infection control, demonstrating its pivotal contribution to overall resilience.

Factors such as clear separation of COVID and non-COVID ERs and the separation of pathways, hospitalizations, and intensive care also rank highly. These factors reflect the relevance of redundancy in physical spaces for infection control and patient flow management.

Strategic decision-making, particularly the ability to make decisions quickly, is another highly rated factor under the rapidity criterion. This emphasizes that not only physical adaptability but also organizational agility—the ability to respond quickly and decisively—is vital for resilience in high-pressure scenarios.

These findings align with recent advancements in the literature on organizational resilience, which frame resilience as a dynamic, capability-based construct rather than a static outcome (Duchek 2020; Hillmann and Guenther 2021). Duchek (2020) conceptualizes resilience as a sequential process involving anticipation, coping, and adaptation, which matches the progression observed in hospital responses during the pandemic's turbulence phase. In our case, resourcefulness and redundancy played a foundational role in supporting adaptation, while

rapidity and robustness ensured continuity of operations under sustained stress. Moreover, Hillmann and Guenther (2021) emphasize the importance of both planned and emergent learning mechanisms in resilience building—a dynamic also reflected in the high intensity of factors like knowledge management, interdisciplinary collaboration, and rapid protocol development observed in our data. Thus, this study extends the literature by providing empirical grounding to these theoretical perspectives within the highly complex and time-sensitive domain of hospital crisis management.

6 | Conclusions

This study has demonstrated that the intensity with which resilience factors—robustness, redundancy, resourcefulness, and rapidity—manifest plays a crucial role in healthcare emergency responses, particularly in the context of continuous, non-linear crises like the COVID-19 pandemic. Our findings highlight that resilience strategies emphasizing resourcefulness and redundancy are pivotal in maintaining operational continuity under prolonged stress, with rapid decision-making proving equally essential.

Moreover, we discovered that:

- The highest-rated factors generally fall under the domains of layout redesign and strategic decision-making, highlighting the critical role of physical reconfiguration and rapid decision-making during crises;
- Redundancy-related factors dominate in the top rankings, suggesting that hospitals place significant importance on having backup systems in spatial organization and care pathways to handle unexpected surges and ensure operational continuity but also in purchasing and in hiring and allocating staff;
- Rapidity-related factors also score highly, reinforcing that speed of adaptation—whether through organizational restructuring or quick decision-making—is a cornerstone of hospital resilience.

The observed relationship among factors, domains, and their respective rating hierarchies indicates that effective hospital resilience strategies are contingent upon an integrated and balanced approach. Specifically, the findings suggest that rapid adaptability and the establishment of redundant systems, both within physical infrastructure and organizational processes, operate synergistically to enhance the robustness of crisis management mechanisms. These insights provide a robust framework for benchmarking hospital resilience, enabling healthcare institutions to identify strengths, gaps, and areas for improvement in their preparedness for future crises. Ultimately, hospitals that integrate these dynamic resilience factors into their strategic planning will be better equipped to handle the unpredictable nature of future health emergencies.

The findings of this study present significant and innovative practical implications that can greatly enhance hospital resilience, particularly in the context of adapting to ongoing and future crises. A major contribution of this research is the development of a novel framework, providing hospitals with a foundation to formulate their coping strategies and implement appropriate mitigation factors.

Unlike traditional frameworks that primarily address isolated shocks, it facilitates continuous monitoring of a hospital's capacity to manage dynamic disruptions, thus embedding resilience into routine operations.

In conclusion, this study underscores the need for hospitals to embrace the inherent paradox between stability and flexibility within their resilience frameworks. Rather than perceiving crisis management as a purely reactive function, hospitals should adopt a proactive approach that reconciles long-term strategic foresight with the capacity for real-time operational adaptability. This requires the development of flexible risk prevention plans and dynamic processes that can adjust to evolving conditions, while maintaining the structural stability necessary for continuity. Managing this paradox—simultaneously pursuing robustness and agility—positions hospitals not only to withstand future crises but to thrive in complex, unpredictable environments.

The main limitation of this study is the relatively small hospital sample. Future research should expand it to validate these findings and explore the post-turbulence "rebooting" phase in greater depth.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Appendix A

Track for First Round Interviews

Guidelines for Interviews—Phase 1 of the Project

For each resilience indicator, one or more questions are suggested for use in the interview protocol. The proposed topics aim to identify priority dimensions for exploration, without claiming to be exhaustive. During the interviews, respondents may also highlight additional aspects deemed critical for emergency management.

Physical Spaces, Equipment, and Infrastructure

1. The ability to rapidly reconfigure hospital areas and wards appears to have been a decisive factor enabling Lombardy hospitals to deliver a timely and effective response to the crisis. Which types of equipment and infrastructure required relocation, and is it possible to define an index or metric of their mobility?
2. Which physical spaces required redesign or functional requalification to ensure operational continuity?
3. To what extent did pharmaceutical stockpiles and inventories of medical devices (MDs) contribute to emergency responsiveness? Are there observable trends indicating a structural change in stock management practices?
4. Did procurement and replenishment processes for goods and medical equipment (e.g., electronic platforms) reveal advantages or critical issues that could inform future improvements?

Human Resources and Workforce Adaptability

5. Human capital appears to have been another pivotal factor in ensuring organizational resilience. Which of the following attributes of healthcare personnel do you consider to have been most determinant?
   - Functional flexibility and multi-skilling
   - Willingness to rotate across roles beyond the formal job description
   - Availability to interrupt leave and return to service during the crisis
   - Orientation toward internal and inter-organizational collaboration
   - Ability to manage psychological stress and cognitive load
   - Robust individual technical preparedness
   - Strong team-working capability
6. To what extent did the COVID-19 emergency necessitate a reconfiguration of organizational models regarding the deployment of professional competencies (e.g., introduction or enhanced role of case managers)?
7. In the current post-emergency scenario, is there an attempt to revert to pre-crisis organizational practices, or have new work modalities and lessons learned been institutionalized or are in the process of consolidation?
8. Concerning emergency recruitment strategies, to what extent was the inclusion of retired professionals and/or individuals without prior experience effective and operationally valuable during the acute phase of the emergency?
9. Which professional profiles demonstrated the highest degree of redeployability within the emergency care continuum?
10. To what extent were staff members adequately prepared to handle sudden and unanticipated emergencies?
11. How was responsiveness ensured in decision-making, resource mobilization, and operational deployment during both the acute crisis phase and subsequent recovery? What is the current operational status regarding outpatient schedules and elective surgical activity?

Governance and System Coordination

12. What insights can be drawn regarding system governance and the degree of centralization during the emergency? How do you assess the effectiveness of national and civil protection coordination? Had the system formally and substantively adopted and periodically updated strategic frameworks and contingency plans for emergency prevention and management?
13. How effective was the integration between the healthcare system and the volunteer sector in strengthening emergency response capabilities?

Information Management and Communication

14. Information sharing: To what extent did information flow seamlessly across hierarchical levels within the organization and among external stakeholders? Which specific tools or mechanisms proved most effective in facilitating timely communication?
15. Did staff consistently have access to actionable and accurate information necessary to address the abrupt onset of the emergency?
16. What role did information governance and external communication strategies play in crisis management?

Financial Autonomy and Resource Availability

17. What timelines and modalities were adopted to resume elective care pathways once the peak of the crisis had subsided?
18. To what extent does the availability of adequate financial resources constitute a determinant for both post-crisis recovery and the management of protracted emergency scenarios?

Hospital–Community Integration (Primary Care and External Stakeholders)

19. What role did general practitioners (GPs) effectively play in supporting continuity of care and managing patient flows during the emergency?
20. Which interdependencies with other actors within the socio-healthcare system proved most critical or presented the greatest challenges?

Appendix B

Validation Questionnaire

Validation questionnaire for resilience factors	
Please fill in the grey fields	
Name and Surname	
Role	
Which of these resilience factors (already in place or newly activated) enabled the organization to cope with the COVID-19 emergency?	Select the values from the drop-down menu
Activation of alternative supply channels	
Possibility to rely on group purchasing department	
Increase in the storage capacity of PPE, DM and drugs	
Quick reconfiguration of the hospital layout	
Separation of spaces, paths and COVID and COVID-free departments	
Clear separation COVID ER and COVID-free ER	
Separation of pathways, hospitalizations and intensive care by patient severity levels	
Presence of a crisis unit	
Institutionalisation of new figures (i.e., bed manager)	
Ability to make decisions quickly	
High frequence of crisis unit meetings	
Decision-making empowerment of the individual within a team	
Development of a hierarchy of decisions (urgent, important, urgent not important, not urgent not important, not urgent important)	
Re-allocation of doctors and nurses to COVID and COVID-free wards	
Hiring of extra doctors and nurses in the intensive areas	
Shift-work self management	
Lead by example	
Quick reconfiguration of the organizational structure	
Management by process	
Multi-specialist team building	
Redefinition of compensation and remuneration systems	
Use of training systems and platforms	
Hospital dimension large in scale and wide number of different specialties	
Activation/implementation of research projects to consolidate and capitalize knowledge	
Linking therapeutic protocols to research protocols	
Exploitation of scientific research as a catalyst for sharing knowledge and team cohesion	
Rapid development of new protocols	
Exchange of information between multidisciplinary teams	
Multimedia use to spread protocols	
Exchange of data and information with the international scientific community	

Validation questionnaire for resilience factors	
Use of staff dedicated to collecting information (Bio Angels)	
Creation of data collection and processing systems (intranet, e-mail boxes, ...)	
Verification of sources authoritativeness in order to avoid information overload/overflood that would slow down the decision-making processes	
Top-down management of information communication	
Other ... specify	
Other ... specify	
Other ... specify	
Other ... specify	
Other ... specify	
In your opinion, how important do you consider the following resilience factors in coping with a prolonged health emergency?	*Select the values from the drop-down menu*
Activation of alternative supply channels	
Possibility to rely on group purchasing department	
Increase in the storage capacity of PPE, DM and drugs	
Quick reconfiguration of the hospital layout	
Separation of spaces, paths and COVID and COVID-free departments	
Clear separation COVID ER and COVID-free ER	
Separation of pathways, hospitalizations and intensive care by patient severity levels	
Presence of a crisis unit	
Institutionalization of new figures (i.e., bed manager)	
Ability to make decisions quickly	
High frequency of crisis unit meetings	
Decision-making empowerment of the individual within a team	
Development of a hierarchy of decisions (urgent, important, urgent not important, not urgent not important, not urgent important)	
Re-allocation of doctors and nurses to COVID and COVID-free wards	
Hiring of extra doctors and nurses in the intensive areas	
Shift-work self management	
Lead by example	
Quick reconfiguration of the organizational structure	
Management by process	
Multi-specialist team building	
Redefinition of compensation and remuneration systems	
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Hospital dimension large in scale and wide number of different specialties	
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Validation questionnaire for resilience factors	
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Use of staff dedicated to collecting information (Bio Angels)	
Creation of data collection and processing systems (intranet, e-mail boxes, ...)	
Verification of sources authoritativeness in order to avoid information overload/overflood that would slow down the decision-making processes	
Top-down management of information communication	
Other ... specify	
Other ... specify	
Other ... specify	
Other ... specify	
Other ... specify	