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RESEARCH ARTICLE

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Enhancing hospital resilience and planning capacity in scenarios of crisis using group decision-making and interpretive structural modeling

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Abstract

Hospitals, as critical infrastructures, confront multifaceted challenges during crises, ranging from natural disasters to pandemics. Initially, these facilities must secure essential emergency support functions and, subsequently, expedite their recovery from any adverse impacts. Hospital resilience, influenced by numerous variables and assessed through various evaluation criteria, remains enigmatic in terms of relationships and hierarchy among these factors. By integrating group decision-making and interpretive structural modeling, this study delves into determinants of practices bolstering hospital resilience from an internal management perspective. While the empirical results offer insights specific to the study context, the primary contribution is in the innovative methodology that shifts the emphasis from mere outputs to the intrinsic value of the process itself. Consequently, a hierarchical model of hospital resilience emerges, enriching insights into hospital resilience and highlighting the intricate balance between methodological rigor and tangible application, additionally serving as a blueprint for similar context-specific investigations. The research culminated in a consolidation session with an external expert, who assessed the model's applicability as a tool for generating new knowledge about developing hospital resilience management. Advantages and limitations are also discussed.

This paper explores the integration of group decision-making and interpretive structural modeling to develop a hierarchical model of hospital resilience, emphasizing the intricate relationships among various determinants and offering a structured framework for enhancing hospital management practices during crises.

KEYWORDS
group decision making (GDM), hospital management, hospital planning capacity, hospital resilience, interpretive structural modeling (ISM)

Key points

- Hospitals face multifaceted challenges during crises, necessitating enhanced resilience and planning capacity.
- The study integrates group decision-making (GDM) and interpretive structural modeling (ISM) to decipher determinants and interrelationships affecting hospital resilience.
- A hierarchical model emerges from the research, providing a structured framework for understanding and strengthening hospital management during crises.
- The research employed innovative methodologies, emphasizing the value of the process in generating insights into hospital resilience.
- An external expert assessment validates the model's applicability, underscoring its potential as a tool for advancing hospital resilience management.

1 | INTRODUCTION

Hospitals are complex organizations that provide a wide range of continuous healthcare services to the public, so experts often see hospitals as having quite diverse attributes and qualities. Common external analytical perspectives include production functions, technical and biopharmaceutical capabilities, information systems, and institutional and network concepts associated with multiple-service providers and healthcare hubs (Cristian, 2018; Djellal & Gallouj, 2007; Yuan & Ferreira, 2022). From an internal point of view, hospitals are a combination of physical and administrative structures (Abrantes et al., 2022; Harris, 1977; Xue et al., 2019).

Recent years have seen an increase in disaster frequency and devastating results (Ferreira et al., 2022; Michel-Kerjan, 2011), including natural catastrophes, pandemics, and terrorism. The impacts are often more pronounced in areas lacking in preparedness but containing large populations and fragile healthcare infrastructure (Achour et al., 2014). Healthcare systems vital role in developing and strengthening resilience in the face of disasters has become self-evident (Cristian, 2018). Given these trends, researchers have developed the concept of hospital resilience as a way to understand this situation (Cristian, 2018; Xue et al., 2019; Zhong, Clark, et al., 2014a).

In hospital administration, internal and external variables are intertwined (Rosko, 1999; Yuan & Ferreira, 2022), which underscores the importance and challenges of determining the best way to improve hospital management practices. These factors are evaluated using different sets of indicators, thereby increasing the difficulty of analyzing and rationalizing specific logic models when seeking to enhance hospital resilience and planning capacity. The present study examines significant factors and their key interrelationships to develop a structural model and identify important ways to improve hospital resilience.

Researchers have found that exploring the variables and interconnections that optimize hospital resilience and planning capacity can be quite complex, as professionals with expertise in this domain often have subjective viewpoints. As a result, studies need to combine the knowledge and skills of multiple decision-makers and include a wide and deep range of diverse voices, especially considering the increasing frequency and severity of crises affecting healthcare infrastructures globally. Consequently, the primary objectives of this study are to: (1) explore the determinants of practices that enhance hospital resilience from an internal management perspective; (2) employ group decision-making (GDM) and interpretive structural modeling (ISM) methods to identify and understand the critical variables and their interrelationships that contribute to hospital resilience; (3) develop a hierarchical model based on the identified determinants and interrelationships, aiming to provide a structured framework for understanding and strengthening hospital resilience management; and (4) evaluate the applicability of the developed model as a tool for generating new knowledge and insights into hospital resilience management, with the input and assessment of an external expert.

The present investigation thus applied two approaches to exploring the hospital-resilience decision problem. The first was a GDM process that identified critical determinants and their interrelationships. This procedure facilitated the definition of decision criteria and the construction of the relationship matrix needed to apply ISM (Cheng et al., 2007). The decision-making process elicited experts' opinions via the nominal group technique (NGT) and generated a consensus based on their shared expertise and experience. The second method was ISM, which enabled an analysis and delineation of the hierarchical structure of the different variables' interrelationships. This technique transformed the factors and links defined in the previous procedure into a binary matrix. ISM and *matrice d'impacts croisés multiplication appliquée à un classement* (MICMAC) analyses were then carried out to complete the model. The final model created can help policymakers understand more fully the pathways to—and mechanisms behind—strengthening hospital resilience.

During the research, social distancing restrictions were imposed because of the coronavirus disease-19 (COVID-19) pandemic in China, and the expert panel members and the researchers were separated by a significant geographical distance. As a result, the NGT procedure had to be conducted online. The same quality of communication was maintained in the virtual interactions as in face-to-face sessions, and the online sessions were organized to facilitate the participants' open discussions and share in-depth stories, especially about sensitive topics (Woodyatt et al., 2016; Yuan & Ferreira, 2022). All the meetings thus enabled a thorough exploratory study of hospital resilience. As a result, our study advances resilience theory, emphasizing the interdisciplinary nature of resilience research and showcasing methodological innovation. On the managerial front, using the GDM–ISM–MICMAC approach, our findings provide actionable insights for hospital administrators in strategic planning, staff training, and policy formulation.

The following section provides a critical review of the relevant literature. The third section then discusses in-depth the research's theoretical foundations and methodologies. The fourth section describes the decision-making process and compilation of findings. The final section concludes this paper with managerial implications, limitations, and potential future studies.

2 | LITERATURE REVIEW AND RESEARCH GAPS

The word resilience is derived from the Latin word *resilio*. Merriam-Webster's online dictionary defines resilience in two ways: (1) a form's ability to recover its normal size and shape after deformation, especially when caused by compressive stress; and (2) an entity's capacity for recovering from or adjusting easily to misfortune or change. In academic contexts, the concept of resilience is currently applied in a great variety of interdisciplinary research on interactions between people and nature (Klein et al., 2003; Xue et al., 2019), including in psychology, psychiatry, and sociology. Resilience is also a key term in biological fields of study, including, among others, genetics, epigenetics, endocrinology, and neuroscience (Herrman et al., 2011; Yuan & Ferreira, 2022).

Wald et al. (2006) note that resilience was first examined by researchers focused on maltreated children's learning processes. The term has since been used to describe three phenomena: (1) good developmental outcomes despite a high-risk status; (2) sustained competence under stress; and (3) recovery from trauma. Each condition entails protective factors or mechanisms that moderate reactions to stressful situations or chronic adversity (Werner, 1995). In individuals, resilience may appear in both preceding and succeeding circumstances connected with turning points that take people away from a maladaptive life path to an adaptive trajectory (Rutter, 1993; Stennett et al., 2022).

Resilience studies thus started with individual scenarios, but resilience serves a purpose in diverse systems (e.g., group, community, family, or ecological) regardless of the personal factors involved. Researchers have conceptualized resilience as an interactive capacity, with traditional theories focusing on equilibrium as a steady state and emphasizing resistance to disturbances and speed of return to equilibrium (Pimm, 1984). Other approaches concentrate on the extent to which systems can mitigate or absorb a disturbance that may change their structure and behavior (Holling et al., 1995).

The United Nations' "*International Strategy for Disaster Reduction*" (UNISDR, 2004, pp. 16–17) defines resilience as "*the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure*". After decades of debate, resilience has "*become an umbrella concept for a range of system attributes rather than a practical policy or management tool*" (UNISDR, 2004, pp. 16–17). Natural disasters, technological catastrophes, terrorism, unknown viruses, and other destabilizing factors have led researchers to focus on resilience's role in organizational recovery in the real world.

A history of interdisciplinary cross-development contributed to making the concept of a resilient hospital increasingly complex, and experts' understanding of resilience in this context became deeper and more diversified. However, the existing communication mechanisms still did not support dialog between varied fields of study. The absence of scholarly interactions impeded the formation of multidisciplinary theories in resilience research on challenging scenarios, even for hospitals with good reputations for valid investigations (Stennett et al., 2022; Varela et al., 2023).

Hospital resilience was first introduced at the World Conference on Disaster Reduction as a way to ensure that all new hospitals have enough resilience to allow them to remain functional in crises (Albanese et al., 2008). An international consensus has thus been reached on the importance of building resilient hospitals, but researchers have yet to develop a standardized conceptualization. Cristian (2018), for example, asserts that hospital resilience is these facilities' ability to withstand, absorb, and respond to disasters—while maintaining critical functions—and then return to each hospital's initial state or adapt to a new status quo. Aburn et al. (2016) describe hospital resilience as the level of support and structure available to individuals or communities and their ability to gain access to help in crises. Zhong, Clark, et al. (2014b), in turn, define this concept as hospitals' capacity to resist, absorb, and cope with shocks and deal with related surges in healthcare needs. The current study conceptualized hospital resilience as, at the minimum, hospitals' ability to return to achieving accepted healthcare norms or even go beyond those standards in extraordinary situations. Resilience should further include coping with unexpected short-period emergencies, such as major epidemics and earthquakes.

Researchers have expressed different views on whether chronic external constraints should be included in the long-term states that arise from unexpected emergencies. For instance, Sternberg (2003) argues that disasters are a subset of crises and that hospital resilience can take on different meanings in response to major disasters and other catastrophes. Various scholars have also asserted that the organizational resilience of public hospitals should include the ability not only to recover from short-term emergencies but also to absorb, adapt, change, and innovate (e.g., Xue et al., 2019; Yuan & Ferreira, 2022). Cimellaro and Piqué (2016) similarly maintain that resilience is both short and long term. Shirali et al. (2016) additionally divide this concept into phases and point out that organizational resilience should include—besides responding to crises—predicting disasters, monitoring threats, and post-event reflecting and learning.

Overall, resilience is a systematic concept. The most fundamental core competency in hospital resilience is the capacity to provide emergency medical services and ensure key parts of regular healthcare services in times of crisis, followed by the ability to recover or break past the original status quo after crisis mitigation. A more integrated view comprises a higher level of resilience that consists of predicting, responding to, recovering from, and growing as a result of unstable conditions.

The literature review conducted for this study also explored the role and value of developing hospital resilience in the context of disasters and crises. Turner and Pidgeon (1997) assert that no universally accepted definition of disaster exists, but all catastrophes clearly involve threats of injury and loss of life. Researchers have additionally classified these events as natural or human-made disasters and determined that standard management procedures should be maintained throughout relief processes.

A crisis, in turn, is "*an abnormal situation which presents some extraordinary, high risk to business and which will develop into a* [… disaster] *unless carefully managed*" (Shaluf et al., 2003, p. 29), so crises require managers to make immediate decisions in critical situations. Crisis in Chinese (i.e., *wei-ji*) translates as a combination of "danger" and "opportunity". The concept of crisis can thus also embrace the expectation that the risks, if overcome, will generate new life for businesses.

Following the 2014 Ebola outbreak in West Africa, the vulnerability of healthcare systems attracted widespread attention around the world. Since then, experts have focused on building these systems' resilience to withstand shocks caused by different events (e.g., natural disasters, infectious diseases, or mass injuries), thereby making this a leading topic in global health policy research and disaster reduction (World Health Organization, 2016). Resilient health systems protect human lives and deliver good health outcomes for all during and after crises (Masten, 2001). Hospitals are the basic units of these systems, and their overall resilience ultimately requires hospitals to be resilient in order to respond to and deal with public health emergencies more adequately.

Hospitals are complex social systems that are significantly improved by adequate organizational coordination, effective integration of members' attitudes and motivations, and good interpersonal relationships (Varela et al., 2023; Yuan & Ferreira, 2022). However, hospitals should constantly be updated, which generates new complications and challenges (Ferreira et al., 2022; Georgopoulos & Matejko, 1967). Events also create new complexities through interactions between these systems' various entities and components and the external environment.

The hospital operation network consists of a large number of demand points and hierarchies of supply nodes and equipment terminals, and each entity exhibits different traffic variability and spatial dispersion patterns. First, hospitals consist of numerous organization nodes, including facilities and equipment interconnections, resource demand and supply, space allocation, and other collaborative efforts that ensure these facilities' normal operations. Each node differs from the others, does its own job in the network, cooperates with others in time and space, and depends on other nodes, thereby forming the essential basis for network synergy. The dynamic relationships between hospitals' nodes form the infrastructure needed to cope with and manage risks and crises caused by external and internal changes. Second, the informal social networks formed by healthcare activities have different stakeholders (e.g., physicians, patients, and upstream suppliers) linked to resources, information, and financial flows. These actors engage in collaborative behaviors and supply and demand relationships that ensure health systems can always maintain a dynamic regulation of networks and participate in frequent environmental interactions (Jha & Epstein, 2010). Last, the shape of hospital operation network is constantly changing in response to the external environment. One typical manifestation of these changes is sudden variations in medical service supply or demand in the market. For example, the COVID-19 pandemic had a profound impact on public healthcare, as the surge of patients led to an exponential increase in the demand for inpatient beds, intensive care units, ventilators, protective clothing, and other resources (Çipi, Ferreira, et al., 2023; Ferreira et al., 2022; Varela et al., 2023; Xue et al., 2019).

Beck (2009) helped develop the famous risk society theory, which covers the immeasurable risks and human-made uncertainties associated with the triumph of innovativeness that characterizes the human condition at the beginning of the 21st century. Individuals' existence and position in the world increasingly require an understanding of the cost of handling catastrophic risks. Current environments are full of volatility, uncertainty, complexity, and ambiguity, and emergencies with high risks and significant consequences (e.g., COVID-19) are likely to become more frequent and grow in size and impact (Worley & Jules, 2020). When crises occur, they follow Murphy's law in terms of causing maximum destruction and damage (Bell, 1989).

Substantial challenges can arise for healthcare entities (e.g., hospitals) and even entire health systems due to uncertainty about demand (Boutsioli, 2010), supply capacity (Franco & Alfonso-Lizarazo, 2020), and public health emergencies (Mays et al., 2009). New emerging, unknown, or overlooked risks may present the greatest obstacles to the resilience of operational systems. For instance, the rapid flow of resources and information in current hospital networks makes them especially complex, so administrators cannot anticipate problems in advance of crises such as major infectious disease events, occupational hazards, and environmental contamination events.

The flow patterns of these networks are so complex that managers barely have time to issue early warnings, implement timely controls, and create effective responses, whose absence can easily exacerbate the enormous impacts of large-scale public health crises. External factors further affect the internal elements of hospital operational systems and greatly increase the complexity of planning and scheduling. Thus, establishing resilient hospitals has become crucial to ensure their successful management and evolution.

As stated previously, hospital resilience has become an increasingly crucial concept in international health and development contexts (Stennett et al., 2022). However, a consensus has not yet been reached on the comprehensive conceptual framework needed to measure hospitals' core competencies (Zhong, Clark, et al., 2014b). Evaluation systems provide programmatic guidelines that ensure that each hospital can prepare appropriately for handling emergency situations under crisis conditions, but the literature offers few well-established assessment systems.

One traditional approach used by hospitals to meet challenges is emergency preparedness based on a staff, stuff, space, and systems (i.e., 4S) framework (Harris et al., 2021). This framework defines the required healthcare professionals, medication, other supplies, physical rooms and environments, and integrative systems. Another standard method was proposed by Zhong, Hou, et al. (2014), which consisted of 4 domains and 12 subdomains and was validated in 41 tertiary hospitals in Shandong Province, China. Cristian (2018) suggests that the latter framework can be a starting point for reaching a broad consensus on the core elements of hospital resilience and categorizes this method as a system development approach. Figure 1 presents this framework in greater detail.

Kruk et al. (2017) analyzed the lessons learned from the 2014 Ebola outbreak and selected the concept of resilience as the best way to integrate greater dynamism and speed into health systems. The authors developed the conceptual framework for a health systems resilience index composed of five capacities: being integrated; adaptive; aware; diverse; and self-regulating. To build up these capabilities, health systems must plan and invest in both fast (e.g., protective products and surveillance) and slow variables (e.g., health professionals and information systems). Resilient systems are able to reduce life loss, mitigate adverse health consequences, and minimize socioeconomic disruption (Kruk et al., 2015).

Fallah-Aliabadi et al. (2020) reviewed 32 articles and the guidelines produced by 1794 related studies to identify indicators of hospital disaster resilience. The authors collected and categorized the indicators into 3 domains (i.e., constructive, infrastructural, and administrative resilience) and 27 subdomains. Constructive resilience is dependent on hospital buildings. Infrastructural resilience comprises nonstructural elements that facilitate hospital functions, while administrative resilience is based on disaster management activities.

Zhang et al. (2019), in turn, affirm that the capacity to absorb, adapt, reform, and innovate forms the core of organizational resilience and that public hospitals' collective action framework should be built on these facilities' assets, sociality, and collective action. Public hospitals need to integrate resilience into daily practices and operations of hospital control systems and explore the sources of organizational resilience according to the specificities of each hospital. Achour et al. (2014) further surveyed 66 hospitals that had dealt with earthquakes in Japan, focusing on these facilities' dependence on external systems and dividing resilient hospital systems into physical and social factors. These systems face three major challenges: (1) the vulnerability of healthcare facilities to natural disasters; (2) the low performance of alternative resources; and (3) a failure to guarantee healthcare supplies through disaster resilience legislation.

In addition, Nuzzo et al. (2019) searched 1108 articles and identified 77 key documents that describe 16 strong indicators of health systems' resilience. The latter include infrastructure, transportation,

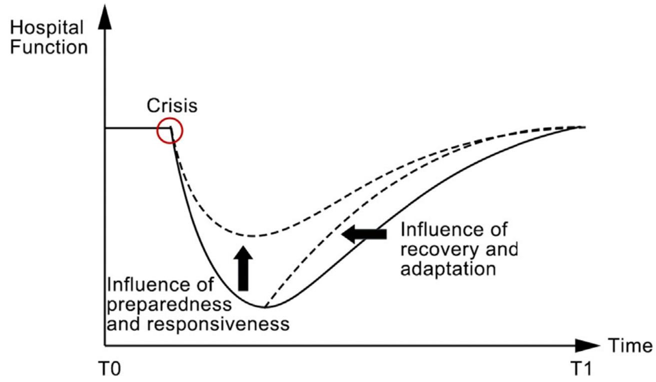


FIGURE 1 Hospital recovery process. *Source*: Adapted from Zhong, Clark, et al. (2014a). [Color figure can be viewed at wileyonlinelibrary.com]

leadership plans, barriers to healthcare access, crisis financing, and changed standards of care. The authors also emphasize the need to increase efforts to promote health security and strengthen health systems worldwide.

Barbash and Kahn (2021) suggest that, during the COVID-19 crisis, resilient hospitals had four characteristics. The first was the ability to ensure high-quality care despite the surge of COVID-19 patients by providing, for example, specific fully-staffed wards with doctors and associated healthcare staff who could provide appropriate, guideline-compliant care. If these wards were unavailable, resilient hospitals could quickly and safely transfer these patients to hospitals that had the relevant units. The second characteristic was the capacity to treat waves of COVID-19 patients, especially those requiring cancer treatment, emergency cardiac care, and trauma surgery, while maintaining pre-pandemic patient-care standards. The third was the ability to ensure the general patient population had access to care within the scope of regular services, to continue elective surgery, and to avoid exacerbating health disparities during the pandemic. The last characteristic was to protect frontline healthcare workers' well-being—while maintaining all the above capacities—by not only ensuring adequate personal protective equipment but also making staff feel valued and connected to the mission of their organization. The review of the existing literature on relevant concepts ensured that the present study could carry out more valuable, well-directed research, which the remaining sections describe in greater detail.

3 | METHODOLOGY

This study uses a two-step approach to develop a decision-support model that can more effectively strengthen hospital resilience. First, a GDM process was applied in an online group session to structure the theoretical framework grounded in the findings of the literature review. Second, the framework and data were analyzed in the online group session, using ISM–MICMAC to complete the hospital resilience model.

3.1 | Group decision making

Multi-attribute problems require multiple decision-makers to choose the best solution from different alternatives based on a predefined set of criteria (Tzeng & Huang, 2011). GDM takes place when two or more experts—each with his or her own perceptions, attitudes, and motivations—acknowledge that a common problem exists and seek to reach a collective decision (Delgado et al., 1998; Weck et al., 2022). GDM allows specialists in different areas to pool their wisdom to deal with increasingly complex problems. Extensive participation is needed for experts to form constructive collective opinions on the issues in question, which facilitates the identification of problems and produces more appropriate decisions before any action plans are implemented.

Researchers have reached diverse conclusions about the best size for decision-maker groups. In groups with 6–12 members, individuals' involvement decreases as the size increases, but the 6-member size is conducive to the emergence of internal leadership (Bass & Norton, 1951). Other studies have confirmed that, in groups with 5–12 members, the larger the number is, the more resistant the participants become to reaching a consensus (Hare, 1959). In groups of between two and six people, the decisions' quality becomes better and more consistent as the number of members increases (Ziller, 1957). Borgatta and Bales (1955) also found that groups of six individuals experience greater solidarity and tension release. In addition, Cummings et al. (1974) report that the quality of collective solutions is positively correlated with group size.

GDM methods typically include four techniques. The first is brainstorming, in which ideas are generated through free association and published to inspire other ideas and serve as reference points. Everyone has complete freedom to express their views without fear of being embarrassed or criticized by others (Brahm & Kleiner, 1996). The second is the Delphi method, which was created in the early 1950s by the RAND Corporation (Dalkey, 1969). This technique enables experts to participate in solving problems as an anonymous mass. Delphi uses multiple iterations to develop a consensus between specialist decision-makers on a particular issue (Hsu & Sandford, 2007). The third is the NGT, which includes restricting discussion and interpersonal communication among group members in collective decision-making. When groups meet to make decisions, members must first make individual decisions, express their opinions separately, and then participate in a group discussion. The group is constrained by the NGT to produce structured, explicit output (Cantrill et al., 1996). The final technique is the stepladder technique, in which GDM is achieved by the continuous superposition of members' opinions. This technique precludes any decision-makers from becoming unwilling to express their views directly due to group pressure (Rogelberg et al., 1992).

Technology has had a significant impact on how people discuss problems. Since the 1960s, technologists and policymakers have discussed issues using remote distributed GDM via computer networks. Face-to-face decision-making is probably best when decisions require complex thinking and subtle multiparty negotiations and when problems are ill-defined. However, distributed decision-making can make decision-making fairer and more efficient and purify interactions by removing irrelevant sources of bias such as personal charisma (Bastos et al., 2023; Kiesler & Sproull, 1992; Weck et al., 2022).

ISM is a GDM-related research approach developed to decompose complex systems into smaller subsystems and then construct a complex structural model of the overall system (Duperrin & Godet, 1973). ISM thus has the advantage of being a more structured and systematic approach to exploring the multifactor decision problem of how to strengthen hospital resilience. The next subsection describes ISM in greater detail.

3.2 | Interpretive structural modeling

ISM systematically applies various basic tenants of graph theory, combining conceptual, theoretical, and computational approaches to expose complex background relationship patterns for sets of variables (Malone, 1975; Warfield, 1973). It analyzes systems' structure, decomposing the complex, messy links between system units into a clear, multilevel structure and clearly representing their interconnections (Attri et al., 2013; Çipi, Ferreira, et al., 2023). ISM offers great advantages in terms of describing systems' characteristics as this method presents its results as skeleton diagrams that are intuitive and concise. ISM is now widely used in systems engineering because of the clear understanding it provides of system factors' causal hierarchy and ladder structure.

Warfield (1973) first developed ISM to facilitate the harnessing of people's knowledge and experience to decompose a complex socio-economic system into various smaller subsystems with the help of computers, thereby forming a structural model of even complex systems. The resulting model is characterized by multilevel recurrence. Attri et al. (2013) reviewed studies that applied ISM and defined six steps to follow when using this approach. The authors concluded that ISM integrates varied contrasting perspectives and methodologies, so it provides a more systematic, efficient procedure that can deal with complexities. ISM is easier for decision-makers to use as it also offers practical guidelines and examples of how to formulate structural models and graphic frameworks. This method can further serve as a learning tool for deepening researchers' understanding of systems' internal components and relationships. In addition, ISM emphasizes the influence of scenarios and contexts on the analytical process, which, from a general systems theory point of view, means that the specific environment of the analysis systems will change how their structure is depicted.

ISM generates conceptual models that are widely used in, among other areas, transportation, education, healthcare, natural disaster risk control, technology and performance assessment, risk management and control, standards development, product and service systems, supplier development and management, supply chain management, and mobile payments (e.g., Kumar & Goel, 2022; Raj et al., 2008; Thakkar et al., 2006; Varela et al., 2023). This method is popular because it can represent ambiguous ideas as intuitive structural relationships, thereby enabling more objective analyses of problems. Two core elements of

ISM calculations are the construction of reachability matrices (RMs) and inter-level partitioning of concept sets, but these steps become tedious when frequent intersection operations are needed to deal with a large number of system components. Multilevel recursive structural models can be formed only after decomposing these complex systems into subsystem elements based on decision makers' practical experience and knowledge and with the help of computers.

ISM applications have three facets (Huerga et al., 2015) of which the first is identifying the influence of system elements. That is, each variable's effect on a system is not only related to the elements directly connected to that factor but also to the elements indirectly connected to the same variable. ISM can reveal the direct or indirect influence of relevant factors in a concise, intuitive way, which reflects these elements' role in the system as a whole. The second facet is analyzing systems' overall structure so that the final results can be represented by a skeleton diagram containing all the elements identified. This diagram can clarify the direct and indirect logical relationships between the factors of each system and that system's overall structure as a topological hierarchy that is intuitive and easy to understand. The last facet is analyzing the potential causes of system problems. These issues are related to systems' overall structure and the logical relationships between elements, and ISM skeleton diagrams can represent this structure and the logical interrelationships of relevant factors quite precisely. Thus, this method clearly expresses system problems through logical structures, thereby facilitating the discovery of problems' internal logic. Figure 2 is a flow chart of ISM procedures.

ISM calculations can be carried out using statistical software such as Statistical Package for Social Sciences and MATLAB software. This method is applied in the six steps described in the following subsections.

3.2.1 | Step 1

The first step is to identify the research question and the elements of the analysis system. ISM thus starts by identifying the problem and structuring the decision-support system and then analyzes the target system's variables that are closely related to the research problem by dividing up and disassembling the system. Finally, the list of system elements is created.

3.2.2 | Step 2

The second step is to define the contextual interrelationships of the system variables. For example, if element *A* influences element *B*, the relationship between *A* and *B* can be delineated. This assessment process examines the logical links within the analysis system or their possible outcomes, which provides the basis for subsequent steps.

3.2.3 | Step 3

The third step is to develop an adjacency matrix $L = Ln \times n$, which is a structural self-interaction matrix (SSIM) (Kannan et al., 2009). This matrix is based on the associations of the system elements, in which

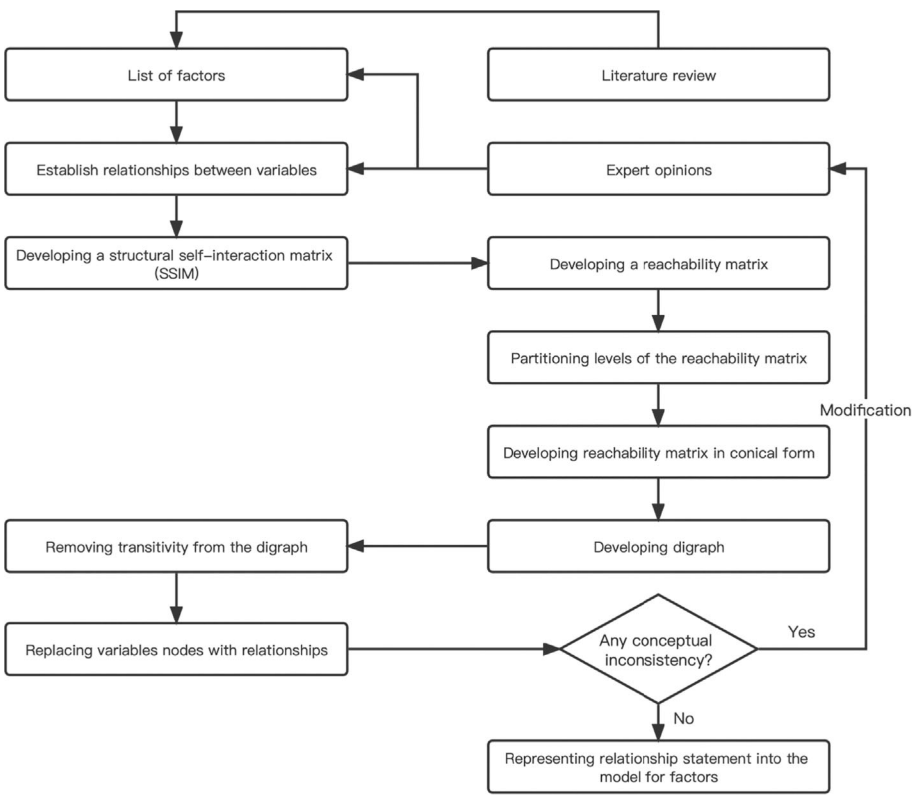


FIGURE 2 Flow chart of interpretive structural modeling procedures. *Source*: Adapted from Attri et al. (2013).

n is the number of identified variables. The value of L_{ij} indicates whether a relationship exists between system elements as defined by Equation (1):

$$L_{ij} = \begin{cases} 0: i \text{ and } j \text{ are unrelated} \\ 1: i \text{ has an effect on } j \end{cases}. \tag{1}$$

3.2.4 | Step 4

The fourth step is to construct an RM based on adjacency matrix L. The RM shows whether two elements are reachable (i.e., whether the direct or indirect influence is present between these variables). For instance, a direct influence relationship can exist between elements A and B and an indirect influence link between elements A and C (Dubey & Ali, 2014), which means A can reach B and C. In the RM, R_{ij} indicates whether any two variables are reachable, as shown in Equation (2):

$$R_{ij} = \begin{cases} 0: i \text{ cannot reach } j \\ 1: i \text{ can reach } j \end{cases}. \tag{2}$$

3.2.5 | Step 5

The fifth step is to create multilevel partitions. The structure of the system's levels is determined by a cyclical procedure that focuses on the RM's intersection with a prior set matrix. If e_i denotes the ith element, then all the reachability set elements can be reached by element $P£$. The prior set, in turn, comprises all the variables that e_i can reach. More specifically, this procedure first defines reachability set $R(e_i)$ and prior set $A(e_i)$ based on the RM and then determines the intersection of the reachable and prior sets for each element $R(e_i) \cap A(e_i)$, respectively. Finally, the level partitions are placed according to the location of element e_i.

3.2.6 | Step 6

The last step is to develop a digraph and ISM model. The ISM diagram of the system is generated based on the variables' hierarchical structure and the correlations between them.

3.3 | MICMAC

MICMAC analysis was also included in this study. The MICMAC technique was developed in the 1970s (Hussain, 2011) as a way to multiply matrices and apply the results in structural analysis of indirect interrelationships (Duperrin & Godet, 1973). Researchers can use MICMAC to identify three categories of variables and their direct effects through indirect connections. The categories are: (1) variable X affects Y; (2) variable Y affects Z; and (3) X and Z have no direct effect but have an interrelationship through Y so that changes in X affect Z. This type of analysis is also known as gray area exploration (Dubey & Ali, 2014).

The MICMAC method, in combination with ISM, is suitable for conducting varied types of research: (1) exploring relationships between factors; (2) classifying variables according to their driving or dependence power; and (3) developing hierarchical structural models of the links between factors (Janssen et al., 2019). Over the years, scholars have refined the ISM–MICMAC technique to identify essential factors and structural systems to provide a clearer understanding of multiple issues (e.g., Dewangan et al., 2015; Dubey & Ali, 2014; Mangla et al., 2013). This method has also often been applied in managerial research throughout the healthcare industry (Kumar et al., 2019; Kumar & Sharma, 2018; Rathi et al., 2023).

The primary goal of a MICMAC analysis is to inspect and differentiate between variables based on their driving and dependence power (Mandal & Deshmukh, 1994) and then separate them into four quadrants. The first is autonomous factors that have neither strong dependence nor strong driving power. The second quadrant is dependent elements that have strong dependence but weak driving power. The third is linkage or relay variables that have strong dependence and driving power. The fourth quadrant is independent or influence factors with weak dependence but strong driving power (Agrawal, 2019).

In summary, the literature has increasingly emphasized the importance of hospital resilience management and development in response to unexpected health-related events. Exploring this topic requires researchers to specify crucial influential elements and their interactions. One quite effective approach is to create models that include multiple variables. GDM techniques, especially NGT, can generate many ideas and useful conclusions that poorly structured group brainstorming approaches fail to produce (Stech & Ratliffe, 1985). NGT facilitates the collection and discussion of experts' theoretical knowledge and substantive experience and, thus, the identification and assessment of determinants in decision-support systems, thereby providing the basic materials for model building. ISM, in turn, is used to explore hierarchical relationships between complex variables, with the added advantage of offering empirically robust structuring procedures. This technique enables decision-makers to analyze action plans or policies by helping the relevant experts identify areas of policy action that have strong impacts or provide extra leverage when pursuing particular goals (Attri et al., 2013).

The present study specifically focused on enhancing hospital resilience and planning capacity, which requires identifying multivariable structural features, so ISM was an appropriate choice. Using the factors identified in previous steps, a group of expert decision-makers negotiated with each other to form a consensus about the degree of influence present between these variables and to create a matrix of their interrelationships. Extrapolation calculations were carried out with the matrix data to form a hierarchy of the determining factors and map the direction of their influence. Concurrently, MICMAC analysis evaluated the variables' role within the decision-support system to clarify how to optimize hospital resilience. The ISM–MICMAC method can thus clarify and visualize the relationships and functional impacts of key components on hospital resilience and ultimately provide guidance to those seeking to improve hospital administration practices.

While the methods employed in this study have been used in other research contexts, their combination is novel in the realm of hospital resilience management.

4 | RESULTS AND DISCUSSION

This section describes the process of examining the factors influencing hospital resilience and planning capacity based on the methodologies and procedures described in the previous section. A structured online discussion platform made possible the application of the selected GDM techniques to identify key determinants before conducting the ISM–MICMAC analysis. The resulting model clarified the hierarchical relationships among the most influential factors and, thus, the best substantive improvements. Finally, a consolidation session was carried out with a neutral expert who evaluated and commented on the proposed model's feasibility and applicability.

4.1 | Hospital resilience determinants

The GDM methodology described previously was applied to identify the main factors that strengthen hospital resilience and planning capacity. This approach facilitated the extraction and compilation of the expert panel's professional experience, knowledge, and opinions via a group discussion, thereby providing a larger, more diverse set of perspectives and ideas (Tindale et al., 2003). To apply the GDM techniques, specialists were first recruited for the current study to define a structured set of factors that met the requirements of ISM. Salmeron (2009) suggests that an expert panel should consist of 5–18 members, so the present research's panel comprised 8 experts with extensive experience in related fields. Notably, all participants were based in China and had more than a decade of professional experience in areas relevant to hospital resilience. They were fully familiar with hospital-resilience projects, enhancing the depth and relevance of their contributions to the evaluation process. While participants were chosen for their professional expertise, they joined the panel voluntarily, and we ensured that each held a significant decision-making position.

Although our selection process emphasized expertise and experience over representativeness, it is worth noting that the primary focus of the group meetings was on the process itself. The goal was to foster meaningful discussions and insights rather than to derive generalizations about hospital resilience management. While our findings are context-specific, the methods, when applied correctly, can be effective with different panels or in varying contexts (cf. Bell & Morse, 2013). This flexibility is also a strength of our proposal, ensuring that each analytical system developed is tailored to the specific characteristics of each country, region, and/or hospital.

TABLE 1 Determinants identified by expert panel.

Code	Determinants
IN01	External policy
IN02	Hospital size
IN03	Ability to react to atypical events
IN04	Leadership
IN05	Hospital operations and balanced resources
IN06	Balance between normal and emergency modes
IN07	Hospital classification
IN08	Hospital organizational capacity
IN09	Technological level
IN10	Hospital early warning system

Abbreviation: IN, initiative.

The initial phase of the first online session involved defining determinants of enhanced hospital resilience and planning capacity, which was enabled by NGT and multi-voting. To begin the discussion, a facilitator/moderator asked the panelists a trigger question: "*Based on your experience and expertise, which factors influence hospitals' resilience and planning capacity?*". The eight experts then suggested a series of essential determinants, which were recorded and organized using Excel by another facilitator.

After presenting their ideas, the panel members decided on an initial list of 22 influential factors. To meet ISM requirements, a facilitator used Tencent Meeting software to set up a voting session to condense the list to the most essential determinants. Each expert selected the 10 factors they considered the most important and representative to be the focus of subsequent discussion and analysis of their interrelationships. As shown in Table 1, the expert panel's voting resulted in a final set of 10 determinants.

4.2 | ISM application

After the 10 determining factors were identified, the second phase of the first session required the expert panel to apply ISM to quantify the relationships between the variables. According to Raut et al. (2017, p. 37), "[t]*he ISM process transforms unclear, poorly articulated mental models of systems into visible, well-defined models useful for many purposes*". The panel next constructed an SSIM, which helped them reach a consensus on the nature of interrelationships between determinants. The ISM technique facilitated the experts' assessment of the influence between the factors and specification of the contextual relationships that affect the determinants involved, namely how each factor interacts with the other variables (Attri et al., 2013).

The facilitators first explained how ISM can be used to define the connections between different variables. The panel then coded the 10 factors by identifying them as IN01 through IN10 and entered them in an Excel sheet to develop the SSIM. This matrix depicted the factors' one-to-one correspondence (i.e., as matrix cells). The Excel sheet was used to develop and record the experts' subsequent

TABLE 2 Determinants' contextual relationships.

Symbol	Meaning
V	IN_i has a direct influence on IN_j.
A	IN_j has an inverse influence on IN_i.
X	IN_i and IN_j have a bidirectional influence on each other.
O	IN_i and IN_j are unrelated.

Abbreviation: IN, initiative.

consensus after they discussed the relationships between the determinants. The ISM technique provided four possible categories of links between variables IN_i and IN_j, represented by V, A, X, and O. These symbols' meanings are given in Table 2.

The expert panel shared and analyzed their knowledge about each contextual relationship one by one and reached relatively congruent conclusions. The decisions were compiled using the SSIM by one of the facilitators. Table 3 presents the SSIM created by the panel members.

As noted in the earlier description of ISM Step 3 (see Section 3.2.3), the next step was to construct a binary matrix (i.e., the initial RM [IRM]) based on the SSIM. The result is shown in Table 4. The calculations made for this matrix are as follows:

1. If the symbol for the relationship between IN_i and IN_j in the SSIM is *V*, then (IN_i, IN_j) in the IRM becomes 1 and (IN_j, IN_i) becomes 0.
2. If the symbol for the link between IN_i and IN_j in the SSIM is *A*, then (IN_i, IN_j) in the IRM becomes 0 and (IN_j, IN_i) becomes 1.
3. If the symbol for the connection between IN_i and IN_j in the SSIM is *X*, then (IN_i, IN_j) in the IRM becomes 1 and (IN_j, IN_i) also becomes 1.
4. If the symbol for the association between IN_i and IN_j in the SSIM is *O*, then (IN_i, IN_j) in the IRM becomes 0 and (IN_j, IN_i) also becomes 0.

Transitivity analysis was conducted for each variable in the IRM using Warshall's (1962) algorithm (cf. Ahmad & Qahmash, 2021; Çipi, Fernandes, et al., 2023). The result for each determinant was integrated into a new matrix to form the final RM (FRM), which is presented in Table 5. The items marked with an asterisk are those that were previously zeros.

In the subsequent partition analysis, the reachability set for each hospital resilience and planning capacity determinant was obtained from the FRM's vertical relationships, and the antecedent set was taken from the horizontal connections. The reachability set included each variable and the factors it drives, while the antecedent set comprised each determinant and the factors on which it depends. Level 1 variables represent the highest level of the decision-support system structure, and these determinants do not influence other factors (Kannan & Haq, 2007). Any subsequent level *n* uses data from the intersection set, excluding factors from the previous level. These levels are the basis of the final ISM model (Singh & Kant, 2008) (see Table 6).

A structural model was next derived from the above FRM for this study. Any relationship between IN_i and IN_j is shown by an arrow that points from IN_i to IN_j. The graph generated is termed the initial directed graph or initial digraph (Raut et al., 2017). After all transitivity was eliminated from the initial digraph, the final digraph could be constructed (see Figure 3).

MICMAC analysis further classified the variables into four quadrants according to the difference between the factors' driving and dependence power (i.e., I = autonomous determinants; II = dependent; III = linkage; and IV = independent) (Janssen et al., 2019). The present study used the totals of the FRM's rows and columns to calculate the driving and dependence powers of each variable for the MICMAC analysis (see Figure 4).

This procedure concluded the workgroup with the expert panel. The following subsection provides a focused discussion of the findings.

4.3 | Consolidation, discussion, and recommendations

After the results were obtained, an online consolidation session was held with an additional expert from Southern Medical University in Guangzhou, China. This specialist had not participated in the expert panel session, so he was considered neutral and thus able to provide an objective professional opinion about the research conducted.

After a brief introduction of the results, this expert was asked to comment on the methods and findings. He agreed that the topic under study is important, especially in the context of the aftermath of the COVID-19 pandemic, so the development of hospital resilience is extremely relevant. He also observed that the ISM method facilitated the experts' analysis of and consensus about critical elements, as well as producing holistic hierarchical results based on empirically rigorous techniques.

However, the interviewee mentioned shortcomings that need to be addressed. First, the proposed model may reflect synergies between elements or unclear conceptual boundaries, which could affect hospital administrators' identification of determinants in practice, so these issues need to be addressed in further research. Second, the model is mainly qualitative, and the level of significant effects among the variables can be defined better by conducting quantitative studies of these relationships based on, for example, questionnaires. Third, researchers may want to apply additional relevant theoretical models to enhance the credibility and empirical validity of the proposed model. Last, this model could be challenging to implement and test in hospitals due to administrators' resistance, the complexity of operations, and the substantial uncertainty created by emerging crises.

In response to these comments and suggestions, the expert was informed that the present study's approach is process-oriented and constructivist, which means that the procedures followed, when correctly adjusted, can be used by different panels or in varied contexts. Bell and Morse (2013, p. 962) describe this approach as having "*less emphasis on outputs per se and more focus on process*". In addition, the proposed model is realistic in that it can accommodate new information at any time. Comparative in-depth research can thus be carried out in varied hospitals to strengthen the present results.

TABLE 3 Structural self-interaction matrix constructed.

	IN01	IN02	IN03	IN04	IN05	IN06	IN07	IN08	IN09	IN10
IN01		O	V	O	V	V	O	O	V	V
IN02			V	O	V	V	X	V	V	O
IN03				A	A	X	A	A	A	V
IN04					V	V	A	V	O	V
IN05						V	A	A	O	O
IN06							O	A	A	A
IN07								V	V	O
IN08									O	V
IN09										O
IN10										

Abbreviation: IN, initiative.

TABLE 4 Initial reachability matrix developed.

	IN01	IN02	IN03	IN04	IN05	IN06	IN07	IN08	IN09	IN10
IN01	1	0	1	0	1	1	0	0	1	1
IN02	0	1	1	0	1	1	1	1	1	0
IN03	0	0	1	0	0	1	0	0	0	1
IN04	0	0	1	1	1	1	0	1	0	1
IN05	0	0	1	0	1	1	0	0	0	0
IN06	0	0	1	0	0	1	0	0	0	0
IN07	0	1	1	1	1	0	1	1	1	0
IN08	0	0	1	0	1	1	0	1	0	1
IN09	0	0	1	0	0	1	0	0	1	0
IN10	0	0	0	0	0	1	0	0	0	1

Abbreviation: IN, initiative.

TABLE 5 Final reachability matrix created. [Color table can be viewed at wileyonlinelibrary.com]

	IN01	IN02	IN03	IN04	IN05	IN06	IN07	IN08	IN09	IN10	Dr pw
IN01	1	0	1	0	1	1	0	0	1	1	6
IN02	0	1	1	1*	1	1	1	1	1	1*	9
IN03	0	0	1	0	0	1	0	0	0	1	3
IN04	0	0	1	1	1	1	0	1	0	1	6
IN05	0	0	1	0	1	1	0	0	0	1*	4
IN06	0	0	1	0	0	1	0	0	0	1*	3
IN07	0	1	1	1	1	1*	1	1	1	1*	9
IN08	0	0	1	0	1	1	0	1	0	1	5
IN09	0	0	1	0	0	1	0	0	1	1*	4
IN10	0	0	1*	0	0	1	0	0	0	1	3
Dp Pw	1	2	10	3	6	10	2	4	4	10	

Abbreviations: Dp Pw, dependence power; Dr Pw, driving power; IN, initiative.
*stands for "identified transitivity"

5 | CONCLUSION

This study sought to discover the factors underlying and optimizing ways to strengthen hospital resilience and planning capacity, which is quite a complex endeavor. One challenge to overcome is that resilience is difficult to measure directly. Another issue is that subjectivity is always present in observations made by professionals and managers with ample practical experience, making a single consistent conclusion difficult to reach on this topic. An effective approach to finding appropriate solutions is to develop a structured decision-support model that integrates multiple factors. This study, therefore, constructed a hierarchical model of ways to increase hospital resilience.

TABLE 6 Level partitioning of final reachability matrix.

	Reachability set	Antecedent set	Intersection set	Level
IN01	1–3–5–6–9–10	1	1	3
IN02	2–3–4–5–6–7–8–9–10	2–7	2–7	5
IN03	3–6–10	1–2–3–4–5–6–7–8–9–10	3–6–10	1
IN04	3–4–5–6–8–10	2–4–7	4	4
IN05	3–5–6–10	1–2–4–5–7–8	5	2
IN06	3–6–10	1–2–3–4–5–6–7–8–9–10	3–6–10	1
IN07	2–3–4–5–6–7–8–9–10	2–7	2–7	5
IN08	3–5–6–8–10	2–4–7–8	8	3
IN09	3–6–9–10	1–2–7–9	9	2
IN10	3–6–10	1–2–3–4–5–6–7–8–9–10	3–6–10	1

Abbreviation: IN, initiative.

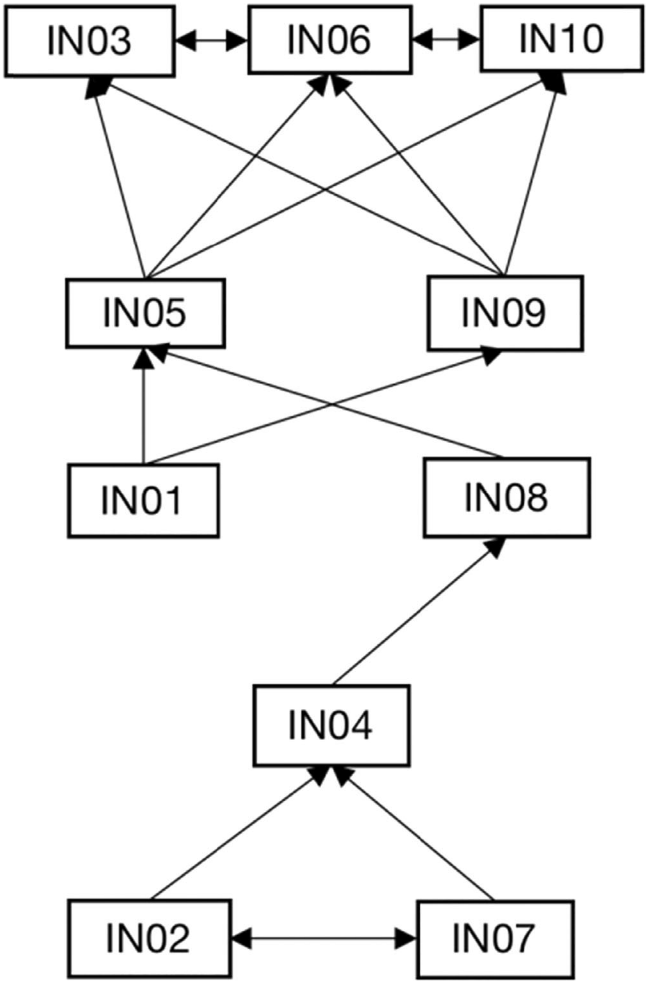


FIGURE 3 Final interpretive structural modeling model derived from final reachability matrix.

The proposed model was created using ISM to incorporate crucial determinants into the analysis system and study the interconnections and impacts of these factors on efforts to enhance hospital resilience and planning capacity. The MICMAC technique was also used to analyze how determinants interact with the system. In the NGT procedure, the expert panel presented and exchanged ideas based on their expertise and healthcare industry experience. The GDM techniques applied neutralized the effects of subjective personal preferences and allowed the panel to draw vital insights from their group discussion. Indeed, GDM captured a spectrum of expert opinions, fostering a holistic grasp of the intricate facets of hospital resilience. ISM–MICMAC allowed for a systematic framework to decipher and chart the intricate interplay among diverse determinants, proffering a hierarchical blueprint pivotal for hospital-resilience management.

After the factors were identified, the selected methods synthesized the experts' reflections on the significant implications of each determinant and extrapolated the interactions among the variables by transforming the SSIM into an FRM. These ISM procedures created the final model, which was evaluated by an external expert and policymaker. The first level in the model includes the factors IN03, IN06, and IN10, and the second level contains IN05 and IN09, placing these five determinants at the top of the hierarchy. These five variables most directly reflect and affect hospital resilience, so they are crucial to ensuring operability. The MICMAC analysis also highlighted most of these variables, indicating that they have strong dependence power. IN01 and IN08 appear at the third level and IN04 at the fourth level, which means these are key factors that affect hospital resilience and influence the variables at the top of the structure. Managers have a more profound role to play at the model's fifth level since IN02 and IN07 can influence the underlying reasons hospital resilience exists. Overall, IN02, IN07, IN01, and IN04 have strong driving power, which means decision-makers need to pay the most attention to these determinants.

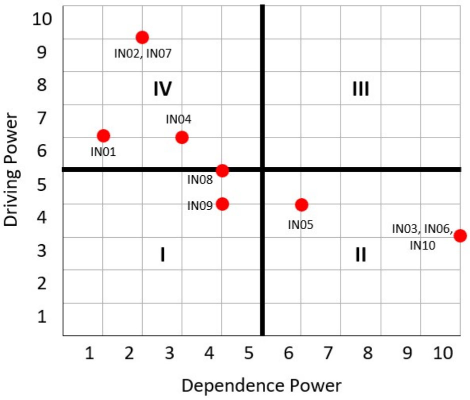
Following this, hospitals in regions prone to natural disasters could use our findings to refine their emergency response protocols, potentially resulting in quicker and more coordinated disaster relief efforts. In addition, healthcare policymakers might adopt our recommendations, such as implementing cross-training programs for medical staff to enhance adaptability during crises or utilizing telemedicine technologies to improve remote patient care and alleviate pressure on physical resources.

Hospital executive officers should prioritize a balance between normal and emergency modes, the ability to react quickly to

FIGURE 4 MICMAC analysis results. [Color figure can be viewed at wileyonlinelibrary.com]

	Dp Pw (x)	Dr Pw (y)	Type	Quadrant
IN01	1	6	Independent	IV
IN02	2	9	Independent	IV
IN03	10	3	Dependent	II
IN04	3	6	Independent	IV
IN05	6	4	Dependent	II
IN06	10	3	Dependent	II
IN07	2	9	Independent	IV
IN08	4	5	Autonomous	I
IN09	4	4	Autonomous	I
IN10	10	3	Dependent	II

Abbreviations: Dp Pw, dependence power; Dr Pw, driving power; IN, initiative.



emergencies, early warning systems, and daily operations. These variables have the most immediate impacts on hospital resilience, so they can function as specific measures of this aspect of healthcare facilities. The present findings match the results of previous theoretical studies (cf. Çipi, Ferreira, et al., 2023; Varela et al., 2023), and the proposed analysis system provides reliable indications of hospital resilience levels. Administrators can produce quantitative ratings of the aforementioned elements to set appropriate goals for strengthening their hospital's resilience and planning capacity. These determinants also belong to the dependent factor quadrant in the MICMAC analysis, which suggests a powerful, underlying chain of influence runs through them.

The ISM model further highlights the variables with strong driving power. The results suggest that the effects of the identified factors start at the most fundamental level and move upward, ultimately having a critical impact on hospital resilience. These determinants include hospital size, classification, leadership, and external policy. The larger a hospital is, the more likely it is to have well-rounded departments with adequate medical staff and thus satisfy patients' needs, which indicates that managers need to increase their hospital's size. However, our findings also indicate that overemphasizing size can aggravate operational issues and even lead to sloppy management practices, thereby endangering hospital survival. Concurrently, excessive size may have a significant siphoning effect on neighboring medical resources, which is not conducive to developing an adequate hierarchical diagnosis and treatment system. Hospital expansion should thus be moderated to avoid these negative impacts. Hospital classification is similarly a fundamental determinant associated with size. When hospitals grow to a certain size, their classification can improve (e.g., going from a secondary to a tertiary hospital), especially for public hospitals, which implies improved resource allocation and talent attraction. However, hospital classification is linked to serving local healthcare needs, so this variable is constrained by systematic healthcare planning.

Hospital administrators' leadership is quite crucial, and the larger hospitals become and the higher their category is, the more competency their managers need to demonstrate. Hospital executive officers with a stronger voice affect organizational capacity and influence determinants at other levels of the decision-support model. Hospital decision-makers should, therefore, maintain a clear organizational perspective and strategic vision to provide the leadership needed to strengthen hospital resilience.

External policy is also fundamental to healthcare facilities' planning capacity. The policy is often an administrative factor outside of hospitals' control in many geographical areas. The external policy is a significant component of these facilities' operating model, clinical norms, and audit requirements. The analysis model reveals that hospital operations and technological level are governed by external policy. Hospital administrators should, therefore, monitor policy and management norms continuously and, in a timely fashion, seek to ensure that their hospital is well-regulated with regard to emergency measures and resilience.

Overall, on the managerial front, our findings offer actionable insights for hospital administrators in strategic planning, staff training, and policy formulation using the GDM–ISM–MICMAC approach. Theoretically, our study advances resilience theory, showcases methodological innovation, and emphasizes the interdisciplinary nature of resilience research.

This study was constrained by specific conditions and subjective variables, so the research had various limitations. First, the expert panel included members from different subfields related to hospital resilience management, but to keep the research population consistent and facilitate communication, the specialists were all recruited from China. These experts also had a background primarily in public hospitals or institutions. Consequently, the results and findings are aligned more closely with an internal perspective on the Chinese healthcare system. Second, the research was additionally based on the general characteristics of Chinese hospitals. Specifically, public hospitals are significantly outperformed by social capital-related healthcare providers, but the expert panel's discussion reflected public hospitals' viewpoint. For instance, hospital classification affects these facilities' level of financial investment and, thus, other variables. The situation in private hospitals may differ. The present findings thus reflect particular geographical and institutional realities, which could make the proposed model less applicable to other countries. Research conducted in other settings may produce different findings. This limitation reflects this study's constructivist approach and methodologies. The results, nonetheless, provide an analysis model built on professionals' ideas of the decision problem's structure, which should facilitate hospital administrators' understanding and implementation of strategies and action plans focused on strengthening hospital resilience. Third, the proposed model incorporated a specific list of determinants that was refined and compressed, leaving out many other variables proposed by the expert panel. This process, on the one hand, facilitated the construction of a more widely applicable model, but, on the other hand, the final result comprises a macroscopic study of resilience's determining factors. Additional studies are needed to strengthen the findings by exploring the internal rationale of each variable and defining more specific determinants. Last, the present results concentrate on hospital administration elements, but to improve hospital resilience, researchers also need to conduct a comprehensive exploration of this decision problem from other perspectives. Given these limitations, future studies must delve into more subtle spheres and relationships to compile a holistic, realistic model of hospital resilience improvement.

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CONFLICT OF INTREST

The authors declare that they have no conflicts of interest related to this work.

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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