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Infrastructure to Culture: A Qualitative Case Study of Hospital Disaster Preparedness Using Hospital Safety Index as Contextual Assessment

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ABSTRACT

Introduction: Hospitals are expected to remain fully functional during disasters; however, many facilities continue to face structural, operational, and organizational constraints that limit their resilience. The Hospital Safety Index (HSI) provides a standardized metric for assessing a facility's capacity to withstand and operate during emergencies, yet limited studies in Indonesia have integrated HSI assessments with qualitative insights from frontline staff. This study examines disaster preparedness at PKU Muhammadiyah Gamping Hospital, a Type B teaching hospital in Yogyakarta, to generate a comprehensive understanding of its strengths and vulnerabilities.

Methods: This study employed a qualitative case study approach to explore hospital disaster preparedness within its organizational context. Semi-structured interviews were conducted with 12 purposively selected informants from clinical, technical, and managerial units. Qualitative data were analyzed thematically using NVivo.Additionally, Hospital Safety Index (HSI) scores obtained from a retrospective assessment conducted in June 2025, using the 2015 HSI module, were used as contextual reference information. The HSI findings were not integrated analytically but served to complement and contextualize the qualitative insights on organizational preparedness.. ,

Results: The hospital achieved an overall HSI score of 0.69 (Category A), indicating a high likelihood of remaining functional during disasters. Structural (0.68) and non-structural (0.77) components demonstrated strong performance, supported by reliable utilities, protective installations, and adequate logistics. In contrast, emergency and disaster management scored lower (0.59, Category B), reflecting outdated disaster plans, uneven staff awareness of emergency procedures, limited training frequency, and the absence of a designated disaster preparedness budget. These quantitative findings were further reinforced by qualitative insights, which highlighted gaps in committee activation, surge capacity planning, and routine simulation exercises, although external coordination with fire services, police, and the Muhammadiyah hospital network emerged as a key strength.

Conclusion: This study suggests discrepancy the possibility between physical resilience and organizational readiness in the study hospital. While findings are context-specific, they suggest that strengthening leadership commitment, institutionalizing disaster financing, updating preparedness plans, and embedding regular multidisciplinary training may enhance operational resilience in similar healthcare settings.

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INTRODUCTION

Hospitals play a critical role in disaster response; however, they are also highly vulnerable during such events. Damage to infrastructure can significantly disrupt the continuity of patient care. Technical failures, such as damage to water and electricity facilities, are often a major threat during disasters (1,2). The concept of Disaster Safe Hospitals (DSH), promoted by the World Health Organization (WHO), emphasizes that hospitals must remain accessible and functional at maximum capacity during and after disasters (3). This framework integrates three core components—structural safety, non-structural safety, and functional preparedness which are essential for ensuring health system resilience (4).

Disaster preparedness refers to the capacity of a hospital to anticipate, respond to, and recover from disaster events through planning, resource allocation, and coordination mechanisms (5,6) (framework Emergency WHO 2017, United Nations Office for Disaster Risk Reduction 2015). Hospital resilience extends this concept by emphasizing the ability of health systems to absorb, adapt, and transform in the face of shocks while maintaining essential functions (7,8). Organizational readiness, in this context, refers to the preparedness of internal systems, leadership, and workforce to effectively implement disaster response strategies (9,10). The Disaster Safe Hospital (DSH) framework operationalizes these concepts into three domains: structural safety, non-structural safety, and functional preparedness (3). In this framework, the structural and non-structural components primarily represent the physical and technical capacity of the hospital, while functional readiness reflects the readiness of the organization, including leadership, coordination, and decision-making processes.

In recent decades, the intensity and frequency of disaster emergencies have significantly increased globally, both due to natural disasters, climate change, and human-induced events. This trend underscores the importance of hospital resilience, given the crucial role hospitals play in pre-disaster preparedness, during disaster response, and post-disaster recovery (11–13). Previous studies have shown that despite adequate structural and non-structural preparedness, significant gaps often remain in functional aspects such as emergency planning, coordination mechanisms, and additional capacity (14,15). These Functional subsystems are integral to disaster response systems, focusing on preparedness, mitigation, and recovery. These include monitoring, resource reserves, medical protection, and warning systems. The functional dimension also impacts how tasks are dynamically assigned during disasters (16,17). This highlights the need to expand the focus beyond infrastructure to address overall organizational preparedness.

Developing countries face the challenge of achieving disaster-resilient hospitals is further compounded by systemic constraints. Older infrastructure or buildings, limited financial capacity, and weak institutionalization of disaster risk reduction practices continue to undermine hospital preparedness. Studies in Lebanon and Iran revealed persistent deficiencies in disaster preparedness, including limited staff training, inadequate knowledge of national guidelines, and vulnerabilities in both structural and non-structural components. Furthermore, coordination, logistics, and communication management during emergencies remain challenge (18–20) These findings suggest that the existence of a formal plan does not necessarily translate to effective preparedness, especially in resource-constrained environments.

In Indonesia, these challenges are also evident. Despite increasing attention to disaster risk reduction, many hospitals still face limitations in infrastructure, financing, and system integration (21). Assessments using the HSI in several regions indicate that many hospitals remain in Category B, reflecting a moderate level of safety with significant risks to operational continuity during a disaster(21). This indicates a persistent gap between structural capacity and functional preparedness, which can hamper effective response, particularly in high-risk areas. Indonesia is among the world's most disaster-prone countries, facing a wide range of hazards, including earthquakes, floods, volcanic eruptions, and pandemics. Experiences such as the 2004 Aceh tsunami demonstrate that rebuilding physical infrastructure alone is insufficient without ensuring consistency in the quality and integration of risk-aware design(22). Although national policies are increasingly aligned with global frameworks such as the Sendai Framework for Disaster Risk Reduction, challenges remain in translating these commitments into coherent and operational health system strategies. In particular, the lack of integration of public health resilience into national development planning and the absence of a comprehensive risk data system continue to limit evidence-based decision-making and coordinated preparedness efforts (23,24).

Despite significant global attention to disaster-resilient hospitals, studies have largely focused on structural and non-structural dimensions, often measured through tools such as the Hospital Safety Index. However, limited evidence exists on how these structural components translate into organizational preparedness and functional performance in real-world settings. This gap remains acute in low- and middle-income countries, where resource constraints and system fragmentation can hinder infrastructure integration and organizational preparedness. Furthermore, studies in Indonesia examining hospital disaster preparedness in relation to organizational preparedness, particularly within faith-based hospital networks, are still limited. Faith-based hospitals, including those within the Muhammadiyah–'Aisyiyah network, play a significant role in Indonesia's healthcare system. These institutions often serve large populations and are actively involved in both routine care and emergency response. However, there is limited empirical evidence examining how such hospitals implement the Disaster Safe Hospital framework, particularly in terms of integrating structural, non-structural, and functional components into their operational systems. This study aims to examine how structural and non-structural preparedness, as assessed by the Hospital Safety Index score, relates to organizational disaster preparedness in a faith-based hospital setting. This contributes to the literature on health system resilience and offers practical insights for strengthening disaster preparedness in similar contexts.

METHOD

Study Design

This study employed a qualitative case study design to explore the implementation of the Disaster Safe Hospital framework within a Muhammadiyah hospital. A case study approach was selected to enable an in-depth understanding of organisational processes, contextual factors, and system-level dynamics influencing disaster preparedness in a real-world setting. The case study design allows for the integration of multiple data sources (interviews, documents, and observations) to capture the complexity of disaster preparedness as an organizational phenomenon.

Study Setting

The study was conducted in a Muhammadiyah-affiliated hospital in Indonesia, which serves as part of a large faith-based healthcare network. The hospital was purposively selected due to its active engagement in disaster preparedness initiatives and its strategic role in providing healthcare services in a disaster-prone region. This context is particularly relevant as faith-based hospitals operate within unique organisational and network structures that may influence preparedness and coordination mechanisms.

Participants and Sampling

Participants were selected using purposive sampling to ensure representation of key role who involved in this hospital disaster preparedness, including clinical, technical, managerial, and support staff. The inclusion criteria focused on individuals with direct experience or responsibility in disaster preparedness planning and implementation. A total of 12 informants were included, which was considered sufficient for in-depth qualitative case study. Data collection continued until thematic saturation was achieved, defined as the point at wich no new themes or meaningful insights emerged from additional interviews. Saturation was assessed iteratively throughout the data collection process by continuously reviewing interview transcripts, comparing emerging codes across participants, and monitoring redundancy in the data. Preliminary coding was conducted alongside data collection to identify when similar patterns and themes began to recur across different informants. Saturation was considered reached when subsequent interviews yielded no substantially new information and existing themes were consistently reinforced.

Data Collection

Data were collected using multiple complementary methods to ensure a comprehensive and in-depth understanding of hospital disaster preparedness. Primary data were obtained through in-depth, semi-structured interviews with key informants, while secondary data were derived from document reviews and field observations. This multi-source approach enabled triangulation and enhanced the robustness of the findings.

Interviews were conducted between May 17 to June 3, 2025, in a face-to-face format within a private setting in the hospital to maintain confidentiality and minimise disruptions. Each interview lasted approximately 30 to 60 minutes and was audio-recorded with participants' informed consent. A semi-structured interview guide was used to facilitate consistency while allowing flexibility to explore emerging insights.

The interview guide covered several key domains, including: 1) participants' awareness and perceptions of disaster risks within the hospital's catchment area; 2) their knowledge and experiences related to the hospital disaster plan, standard operating procedures (SOPs), and evacuation routes; 3) the preparedness of structural and non-structural systems, including utilities, medical equipment, and pharmaceutical supplies; 4) involvement in and reflections on training activities, drills, and simulation exercises; and 5) coordination mechanisms with external stakeholders, such as fire services, police, local universities, and other healthcare facilities.

In addition to interviews, relevant institutional documents—including hospital disaster preparedness plans, policy guidelines, and standard operating procedures—were reviewed to contextualise and validate participants' accounts. Observations of hospital practices and simulation activities, where available, were also conducted to capture real-time implementation and operational dynamics.

Field notes were documented immediately after each interview and observation to record contextual information, environmental conditions, and non-verbal cues that could enrich data interpretation. These notes were used alongside interview transcripts and document data during the analysis process. The use of multiple data sources (interviews, document review, and observations) was intended to support methodological triangulation and enhance the depth and credibility of findings.

Assessment Tool: Hospital Safety Index (HSI)

The HSI data in this study was taken in June 2025 using the checklist in the second edition of the HSI module issued by WHO PAHO in 2015. This checklist is the latest checklist issued by WHO PAHO. This Ceklis/ instrument (HSI Modul 2015) aims to evaluate a hospital's likelihood of remaining functional during and after disasters (3). The HSI provides a comprehensive assessment of hospital safety across structural, non-structural, and organizational dimensions. The HSI assessment of PKU Muhammadiyah Gamping Hospital, based on the 2015 HSI module checklist, was conducted by a medical student (first author), accompanied by a lecturer (second author) and a member of the PKU Muhammadiyah Gamping Hospital Occupational Health and Safety (K3) team. The K3 team reviewed the student's assessment results and provided recommendations and approved for presentation as research findings. The assessment involved structured evaluation of hospital facilities, systems, and organisational preparedness using standardized checklists. These scoring results were conducted close to the interview period. In this study, HSI scores are used as contextual reference data rather than contemporaneous measurements.

The HSI consists of four modules. Module 1 (Hazard Identification) documents the range of potential hazards affecting the hospital, such as natural disasters, technological hazards, and public health emergencies; this module provides contextual information and is not included in the scoring. Module 2 (Structural Safety) evaluates the physical integrity and resilience of the hospital building, including its ability to withstand hazards such as earthquakes and extreme weather conditions. Module 3 (Non-Structural Safety) assesses critical systems and components, including utilities (electricity, water, medical gases), equipment, furnishings, and safety installations such as fire protection and evacuation systems. Module 4 (Emergency and Disaster Management) examines organisational preparedness, including disaster plans, standard operating procedures (SOPs), coordination mechanisms, staff training, simulation exercises, logistics, and financial arrangements.

The overall HSI score ranges from 0 to 1 and classifies hospitals into three safety categories (3,25)：Category A (HSI > 0.66), indicating a high likelihood of maintaining functionality during disasters; Category B (HSI 0.36–0.65), indicating moderate resilience with potential operational disruptions; and Category C (HSI ≤ 0.35), indicating a high risk of loss of functionality. These classifications provide a practical framework for assessing hospital resilience and identifying priority areas for strengthening disaster preparedness.

Data Integration

This study employed a qualitative case study approach, with the Hospital Safety Index (HSI) incorporated as contextual data. Integration was undertaken at the interpretation stage, where qualitative findings were considered

alongside HSI results to develop a more comprehensive understanding of hospital disaster preparedness. The qualitative data provided in depth insights into organisational processes and practices, while the HSI offered a structured reference for assessing key preparedness domains, including structural, non-structural, and emergency management aspects. Both of the data sources were used in a complementary manner. Qualitative themes were interpreted in relation to relevant HSI domains to explore areas of convergence and difference. This approach reflects an interpretive integration within a qualitative case study, in which quantitative data are used to support contextual understanding rather than to establish direct comparison or validation.

Data Analysis

Data were analyzed using thematic analysis, following an inductive approach. The analysis followed several iterative stages, including data identification, initial coding, categorization, and theme development. All interview transcripts were read repeatedly to generate initial codes, which were then organized into broader categories and themes. NVivo 12 was used to support data organization and management, making the coding process more systematic and transparent. Initial coding was conducted independently by two researchers (first and second authors). Interview transcripts and findings were then shared and discussed online, with any differences in interpretation discussed, themes developed, and reflections made throughout the analysis, ensuring transparency and trustworthiness of the findings. Next, codes were grouped into categories and developed into broader themes through team discussions involving all authors. Regular analytical meetings were held to review emerging themes, ensure coherence between categories, and refine interpretations. An audit trail was maintained throughout the analysis to document coding decisions, theme development, and changes made during the analytical process. This approach increased the transparency and reliability of the findings.

Trustworthiness

To ensure the rigour of the study, several strategies were employed. Data triangulation was applied by comparing findings across interviews, documents, and observations to strengthen consistency. Member checking was conducted by sharing summary findings and transcript data with the teams to confirm the accuracy of interpretations.

Ethical Considerations

This study was conducted in accordance with established ethical research standards. All data were handled confidentially, with recordings securely stored, identifying details removed, and participants assigned codes to protect their identity. These measures helped maintain the credibility and integrity of the study. Informed consent was obtained from all participants prior to data collection, and the confidentiality of participants' information was strictly maintained throughout the study. Ethical approval was granted by the Ethics Committee of PKU Muhammadiyah Gamping Hospital (No. 038/KEP-PKU/II/2024).

RESULTS

Qualitative Findings

This section presents the characteristic of study participant to provide contextual grounding for the subsequent analysis. A total of twelve informants participated in the study, representing clinical, technical, managerial, and support units across the hospital. This diversity allows for a comprehensive analysis of disaster preparedness from multiple organizational perspectives. The overall characteristics of the informants are presented in Table 1.

Table 1. Characteristics of Informants

Informant Code	Gender	Age	Years of Service	Position/Unit	Role in Hospital Disaster Preparedness
INF-01	M	25	3	Radiographer	Ensures radiation protection, knowledge of SOP evacuation routes
INF-02	F	26	1	Midwife	Responsible for maternal and newborn safety, monitoring with CCTV
INF-03	M	29	5	Sanitation Supervisor	Manages hospital water supply and sanitation systems

Informant Code	Gender	Age	Years of Service	Position/Unit	Role in Hospital Disaster Preparedness
INF-04	M	50	28	Maintenance Supervisor	Oversees electricity and generator backup systems
INF-05	M	30	3	Security Staff	Handles fire extinguishers, hospital security
INF-06	M	35	9	ICU Supervisor	Oversees ventilator maintenance, patient evacuation roles
INF-07	M	36	8	Emergency Room Supervisor	Aware of evacuation drills and previous simulations
INF-08	M	34	8	Medical Services Manager	Disaster command structure, external coordination
INF-09	F	50	10	Pharmacy Supervisor	Maintains essential medicine stock and pharmacy SOP
INF-10	M	39	16	Laboratory Supervisor	Contributes to daily operational safety routines
INF-11	M	49	20	Security Supervisor	Knowledge of emergency codes (red, blue, black, pink), fire extinguishers training
INF-12	F	55	30	Accounting and Finance Manager	Provides additional insights on SOPs and drills

The distribution of informants across roles revealed distinct patterns in how disaster preparedness is understood and implemented within the hospital. Clinical staff emphasized continuity of care and patient safety during surge situations, while technical staff focused on infrastructure reliability and system functionality. Conversely, managerial informants highlighted challenges related to hospital governance, coordination, and resource allocation. These differences illustrate that preparedness differs across organizational levels, reflecting variations in responsibilities, operational priorities, and decision-making roles. These variations indicate that preparedness is experienced differently across functional units, shaped by specific roles and operational priorities. These role-based differences also reflect variations in how specific dimensions of preparedness are prioritized and experienced across the organization. These differences suggest that preparedness is not only unevenly distributed but also shaped by unit-specific operational demands.

These qualitative insights provide contextual understanding of the hospital's preparedness profile. The Hospital Safety Index (HSI) score for PKU Muhammadiyah Gamping Hospital was 0.69 (Category A), indicating a high likelihood of maintaining functionality during disaster events. However, variation across HSI domains was observed: structural (0.68) and non-structural (0.77) components demonstrated strong performance, while emergency and disaster management scored lower (0.59, Category B), suggesting vulnerabilities in organizational preparedness. The thematic findings may provide possible explanations for these patterns, particularly by highlighting gaps in governance, coordination, and surge capacity that are not fully captured through structural assessment alone.

Theme 1: Infrastructure and Logistics Preparedness

Informants consistently emphasized that reliable infrastructure forms the backbone of disaster preparedness. Backup electricity, water supply, and pharmaceuticals as key enablers of disaster preparedness.

> *"If the power goes out, the generator will start automatically within 11 seconds" (INF-04, Maintenance Supervisor).*

The findings suggest the presence of absorptive capacity, defined as the ability of a system to maintain core functions during disruptions. Document review confirmed the presence of backup generators, water storage systems, while observations indicated that these systems were operational and regularly maintained. Water reserves managed

by sanitation staff were described as sufficient for at least two days, supported by the municipal water utility company (PDAM) and ground tanks. Similarly, pharmacy staff expressed confidence in their capacity to maintain medicine supplies for up to three to six months.

> *"For three days the stock is more than enough… some medicines are stored for up to three or six months" (INF-09, Pharmacy Supervisor).*

These findings align with the strong HSI structural score (0.68, Category A), the alignment between structural and non-structural domains (HSI Modules 2 and 3), which encompass physical and system-level readiness, which is consistent with investment in resilient infrastructure and logistics. However, qualitative data indicate that despite strong absorptive capacity, mechanisms to scale up or adapt services under extreme demand remain limited.

Theme 2: Safety and Protection Systems

Participants highlighted the presence of multiple protective measures to ensure patient and staff safety. Radiology rooms were described as being lined with lead to minimize radiation exposure, and maternity wards were equipped with CCTV for newborn safety.

> *"In radiology, the walls are lined with lead so that radiation exposure is limited to the patient" (INF-01, Radiographer).*

Security personnel confirmed the widespread availability of portable fire extinguishers across the hospital and reported that training in their use had been conducted. Emergency codes (*Code Red, Blue, Black, Pink*) were in place and known by several departments.

> *"There are codes for emergencies: red for fire, blue for cardiac arrest, black for security threats, and pink for baby abduction" (INF-11, Security Supervisor).*

However, not all staff across units demonstrated the same level of familiarity with these codes or procedures. Security and technical staff demonstrated a better understanding, while other departments were less aware of the details or had not consistently engaged in training. This variation indicates gaps in organizational learning and internal coordination, indicating that the presence of safety systems does not always translate into consistent operational readiness. This finding appears to be consistent with the HSI non-structural score of 0.77 (Category A), indicating a robust safety infrastructure but requiring more consistent staff engagement and training for better implementation. It also aligns with the non-structural safety domain (HSI Module 3) but reveals limitations in translating system availability into workforce readiness.

Theme 3: Disaster Planning and SOPs

Despite the presence of a Hospital Disaster Plan (HDP), several participants expressed concern that it was outdated (last revised in 2018) and limited in scope. Some SOPs were reported to focus narrowly on evacuation, without broader operational continuity.

> *"The SOP only follows the evacuation route at the back… there's no further guidance" (INF-01, Radiographer).*

Hospital managers described a clear command structure within the plan, but frontline staff reported inconsistent awareness and implementation across departments. An informant noted that the hospital lacked a dedicated disaster budget, which limited the ability to update the plan, conduct regular drills, and allocate resources for emergency preparedness. Document analysis confirmed the presence of disaster plans but also revealed outdated content and limited integration across departments.

"There is no specific budget allocated for disaster preparedness" (INF-12, Accounting and Finance Manager).

This finding reflects weaknesses in organizational governance and preparedness, particularly in translating formal policies into actionable practices. The lack of a dedicated budget for disaster preparedness further limited implementation. This finding may help to explain the lower HSI score of 0.59 (Category B), given the lower performance observed in the HSI emergency management domain (Module 4).

Theme 4: Human Resources and Training

Human capacity was considered both a strength and a gap. A disaster management committee existed, with staff roles clearly designated during emergencies through helmet color codes.

"The red helmet is for the leader extinguishing fire, white for patients, yellow for documents, and blue for equipment" (INF-06, ICU Supervisor).

Some staff reported that the committee had become inactive over the past year, and training was conducted irregularly.

"In the last year, the disaster management committee has not been active because the chair was not engaged" (INF-08, Medical Services Manager).

This reflects limited adaptive capacity, particularly in maintaining organizational processes such as training, simulations, and leadership engagement. Clinical staff raised concerns about surge capacity, while managerial staff emphasized constraints in planning and resource allocation. These findings suggest that even when roles are formally defined, the lack of a continuous learning system can impact adaptive responses.

Theme 5: External Coordination and Networking

Collaboration with external agencies emerged as a strong enabler of preparedness, also serve as a key strength. Informants confirmed the existence of MoUs with fire services and police, and described simulations conducted with external stakeholders.

"We already have an MoU… during simulations we invited the fire department to test hydrants" (INF-08, Medical Services Manager).

In addition, the hospital benefits from being part of the Muhammadiyah health network, with access to support from other hospitals and volunteer organizations such as Medical Assistance Team and Nursing Care Club Emergency during emergencies. These findings reflect strong coordination capacity and network-based resilience, extending preparedness beyond the hospital's internal systems. This suggests that external networks can partially offset internal organizational limitations.

Theme 6: Challenges and Gaps

Despite these strengths, systemic gaps persist. Staff highlighted the outdated HDP, the inactivity of the K3 committee, and irregular disaster drills. ICU staff further recalled shortages of ventilators and oxygen during the COVID-19 pandemic.

"We faced serious shortages of ventilators and even oxygen during COVID" (INF-06, ICU Supervisor).

These findings illustrate the gap between absorptive capacity (infrastructure) and adaptive capacity (organizational systems). Qualitative data provides contextual insights into why vulnerabilities persist in

organizational preparedness. This finding may be consistent with the B rating in HSI Module 4 (score 0.59, vulnerability index 0.41).

Summary of Findings

Overall the findings indicate that PKU Muhammadiyah Gamping Hospital has established a solid foundation for disaster preparedness, particularly in its structural and non-structural domains. Both areas were rated Category A in the Hospital Safety Index (HSI), supported by reliable infrastructure, stable utility systems, adequate water reserves, well-maintained equipment, and protective measures such as fire extinguishers, evacuation routes, and radiation-safe installations. Strong logistical capacity—especially in pharmaceutical stock availability—and established external partnerships with fire services, police, and the Muhammadiyah hospital network further reinforce this baseline resilience.

However, adaptive capacity remains limited, particularly in governance, training continuity, and coordination processes. Organizational preparedness remains the hospital's most significant area of vulnerability. The lower HSI score for emergency and disaster management (Category B) aligns with qualitative findings that revealed several systemic deficiencies: outdated disaster plans, uneven staff awareness of emergency codes, irregular or infrequent drills, and an inactive disaster management committee over the past year. The results indicate that disaster preparedness is not evenly distributed across organizational roles. Clinical, technical, and managerial units experienced preparedness differently, reflecting fragmented implementation across the system. Staff also recalled operational constraints during the COVID-19 pandemic, including shortages of ventilators and oxygen, highlighting gaps in emergency capacity planning.

Overall, these findings suggest a discrepancy between the hospital's physical resilience and its organizational preparedness. These findings suggest that hospital resilience is shaped not only by structural preparedness but also by the effectiveness of organizational systems, leadership, and coordination mechanisms.

DISCUSSION

This study suggests a potential gap between structural readiness and organization within the study hospital. While the Hospital Safety Index (HSI) score (Category A) indicates relatively strong performance in structural and non-structural domains, qualitative findings highlight challenges related to governance, coordination, and training continuity. In line with these qualitative findings, the HSI score on organizational preparedness for emergency and disaster management remains relatively weaker, reflected in the lower score (Category B). These vulnerabilities were particularly evident in disaster governance, training systems, and operational coordination. Such imbalances may lead to disruptions in evacuation processes, communication, and the delivery of essential services during disasters, thereby increasing risks for both patients and healthcare workers (26,27). Evidence from previous studies supports this finding. Research conducted in hospitals in Yogyakarta reported similarly low scores in emergency management despite prior exposure to major disasters, suggesting that disaster experience alone does not necessarily translate into improved preparedness without structured and sustained interventions (21). The discrepancy observed in this study underscores that hospital preparedness cannot be fully understood through structural indicators alone. Organizational factors play a decisive role in determining whether hospitals can effectively respond to and recover from disaster events. Evaluation frameworks such as the Hospital Safety Index (HSI) emphasize that, beyond infrastructure, functional and organizational components—including inter-facility collaboration and crisis planning—are equally essential for ensuring comprehensive disaster readiness (28).

The findings of this study indicate that absorptive capacity appears more developed than adaptive capacity within the study hospital. This is reflected in the reported resilience of infrastructure systems, including backup power, water, and logistics readiness. However, this resilience primarily relates to maintaining basic operations and does not necessarily indicate the ability to scale up or adapt services to increased demand. This study suggests that disaster preparedness may extend beyond physical infrastructure and can be partly understood as an organizational capability within the study context. adaptive capacity—the ability to adjust processes, mobilize human resources, and coordinate response efforts—remains limited. Constraints in communication and coordination may delay disaster response, particularly in centralized systems where prolonged communication pathways can reduce overall effectiveness (29). This imbalance suggests that infrastructure readiness has not been fully complemented by strengthened governance

systems, training continuity, and institutional learning processes. As a result, preparedness may remain partial, potentially affecting service continuity during large-scale emergencies. Hospitals operate as complex organizations embedded within broader governance systems, and their resilience depends on effective coordination across interconnected infrastructures and external institutions. Weak integration and unresolved governance boundaries may hinder hospital functioning during emergency situations (30,31). Furthermore, only a limited number of hospitals appear to complete the full learning cycle from past disaster experiences to inform and improve organizational practices. This indicates that continuous learning has not yet been systematically embedded within institutional processes (32).

A study conducted across six hospitals in Australia applied the Hospital Safety Index (HSI) to assess disaster resilience and reported consistently high HSI scores, suggesting a generally strong level of preparedness. However, persistent vulnerabilities were identified in critical utilities such as electricity and water supply, reflecting challenges that are also commonly observed in developing country settings (33). In contrast to the Australian study, which primarily relied on HSI scores as an indicator of preparedness, the present study integrates quantitative assessment with qualitative insights from frontline staff. This approach provides a more comprehensive and context-sensitive understanding of hospital resilience. This extends existing literature by demonstrating that resilience cannot be adequately assessed without incorporating organizational and cultural dimensions. It reveals that strong performance in structural and non-structural domains does not automatically translate into effective operational readiness, particularly when governance mechanisms and workforce preparedness are not equally strengthened(34). Furthermore, while high-performing work systems may positively influence governance performance, the strategic readiness of human resources is often insufficient to fully mediate this relationship. This finding highlights the need for balanced workforce capacity development alongside structural improvements (34) .An organization's ability to flexibly adapt roles, tasks, and workspaces is crucial for enhancing hospital resilience. Inter-organizational collaboration also enhances hospital responsiveness in the face of disasters (35). In addition, behavioral dimensions, such as transformational leadership, also contribute to hospital resilience by fostering innovation, effective communication, and rapid decision-making (36).

The findings of this study are broadly consistent with evidence from other low- and middle-income countries (LMICs), which have reported challenges in functional preparedness despite relatively adequate infrastructure. In this case differences in resources, workforce capacity, and health system from organization may influence preparedness, relate to this study show that training can improve hospital resilience by addressing gaps between infrastructure, critical systems, and non-structural safety measures. For instance, a study in Ethiopia found that the average hospital disaster preparedness score was only 54.75%, with logistics and financial capacity identified as the weakest domains (43.33%) (36). Similarly, RSUD Cilincing in Indonesia demonstrated adequate infrastructure—such as electricity, water supply, and ventilation systems—indicating good structural readiness, yet continued to face significant challenges in human resource management and logistics (37). Qualitative findings in this study provide additional context for understanding these patterns, while the HSI score indicates relatively strong structural and non-structural capacity, the findings suggest that organizational factors such as leadership, coordination, and training may influence preparedness.

This result indicate a critical limitation of relying solely on quantitative indices such as the HSI without examining the underlying organizational dynamics. Effective disaster management requires more than infrastructural adequacy; it depends on comprehensive planning frameworks, such as a Hospital Disaster Plan, that integrate policies, human resource capacity, and infrastructure readiness. Strong leadership and the establishment of dedicated disaster management teams are essential components of this process, although gaps in individual awareness and engagement often persist (38).

This study also underscores the importance of external coordination and network-based resilience in supporting hospital preparedness. Collaboration with fire departments, police services, and the Muhammadiyah hospital network emerged as a significant strength, enhancing the hospital’s capacity to respond to emergencies beyond its internal resources. These findings suggest that coordination across multiple sector including as government agencies, non-governmental organizations, and network-based resilience may play an important role in disaster response. However, previous studies have identified three main challenges to coordination: information exchange, operational challenges, and structural barriers. Furthermore, inadequate training and untrained personnel can worsen

coordination. Complex reporting structures and fragmented or incomplete information further limit access to critical information (39). These findings highlight the potential role of health system coordination and cross-sectoral collaboration in shaping hospital preparedness. Similar experiences have been reported in other settings, during the COVID-19 pandemic in Ahmedabad, India, coordination between municipal authorities and multiple sectors helped address shortages of hospital beds, oxygen, and essential medicines., Municipal authorities collaborated with multiple sectors—including education, engineering, and private stakeholders—to address shortages of hospital beds, oxygen, and essential medicines. This coordinated approach enabled the continuity of healthcare delivery during the crisis (40). Moreover, hospital resilience is closely linked to community resilience. The neglect of community-based care, as observed in Lombardy, led to hospital overload during the crisis, highlighting the consequences of weak system integration (41). Strengthening these networks can serve as a strategic pathway to compensate for internal limitations, particularly in resource-constrained settings. In addition, effective disaster response depends heavily on resource and logistics planning. Factors such as transportation coordination, material supply, and community engagement play a critical role in determining the effectiveness of emergency supply chains (42).

From a practical perspective, these findings underscore the need to shift from an infrastructure-focused approach toward a more holistic, systems-oriented model of disaster preparedness. Hospitals should prioritize systematic updates of disaster plans, institutionalize multidisciplinary training, and ensure dedicated financial allocation to sustain preparedness efforts. Hospitals that embrace a culture of continuous learning are better positioned to adapt to changing conditions and implement best practices. This includes effective knowledge management, strong managerial support, and the availability of information technology infrastructure to support learning and decision-making processes (43). Overall, this study contributes by providing a more contextualized understanding of hospital disaster preparedness through the combination of HSI assessment and qualitative insights. The findings suggest that, within this setting, preparedness may be influenced not only by infrastructure but also by organizational and coordination processes. However, given the scope of the study, these findings should be interpreted as context-specific and not generalized beyond similar settings. Furthermore, this study also contributes to the literature in two main ways. Methodologically, it demonstrates the value of using the Hospital Safety Index alongside qualitative approaches to provide a more contextualized understanding of hospital preparedness, while acknowledging that these data sources are not directly comparable. Empirically, it provides insights from a faith-based hospital setting, which remains underrepresented in disaster preparedness research, particularly in low- and middle-income countries.

Limitations and Cautions

This study has several limitations. First, this study was conducted in a single hospital, which limits the generalizability of the findings. While the case study design enables contextual depth, the results should be interpreted as illustrative rather than representative of all hospital settings in Indonesia. Second, the use of qualitative methods introduces potential subjectivity. Although rigor was strengthened through triangulation, member checking, and peer debriefing, participants' accounts may still be influenced by recall bias or social desirability, particularly when discussing organisational weaknesses. Third, although the Hospital Safety Index (HSI) data were collected over a relatively short period, the module used was still the old 2015 module. This may not include new potential hazards, and current safety procedures. Therefore, the findings should be interpreted as context-specific rather than broadly generalizable.

Recommendations for Future Research

Future research could usefully build on this study by exploring similar questions across multiple hospital settings within comparable health system contexts, allowing a more nuanced understanding of how disaster preparedness varies by institutional characteristics and local risk profiles. such work may take an exploratory approach by combining contextual indicators like updated HSI assessments with organisational and behavioural insights to better illuminate how structural readiness translates into everyday practice. Longitudinal perspectives may also help trace how preparedness evolves over time in response to policy changes, leadership dynamics, and real-world events. In addition, selectively incorporating practical performance indicators such as response processes, coordination, and service continuity alongside examination of interventions and collaborative networks, including

faith-based systems, could offer grounded and context-sensitive insights to strengthen disaster response in similar settings.

CONCLUSION

This study provides a contextual understanding how the Disaster Safe Hospital (DSH) framework is implemented within a Muhammadiyah hospital, highlighting both strengths and area that may require further attention. The finding suggests that while structural and non-structural components appear relatively well established, challenges remain in functional aspects such as governance processes, simulation practice, surge capacity, and coordination across units. These results indicate that, within this setting, disaster preparedness may extend beyond infrastructure and involve organizational processes that support readiness and response in practice. Variations in training, coordination, and staff engagement observed in this study further suggest that preparedness is experienced differently across organizational levels.

These findings studies point to the potential value of strengthening organizational processes alongside infrastructure, through regularly updating disaster plans, improving training activities, and enhancing coordination mechanisms. However, these considerations should be understood as context-specific and exploratory rather than broadly generalizable. Given the single-case design, the findings are not intended to represent all hospital settings, but they may offer insights for similar contexts. Further multi-site research would be valuable to better understand how structural and organizational aspects of preparedness interact across different health system environments.

AUTHOR CONTRIBUTION STATEMENT

MZA and EL made substantial contributions to the study conceptualization, research design, supervision of data collection, data analysis, interpretation of findings, and manuscript preparation. YP contributed to data interpretation, manuscript drafting, and alignment with the journal's formatting and submission guidelines. YW and CR provided critical feedback and substantive revisions to improve the manuscript. MAS served as the guarantor of the study and takes responsibility for the integrity of the work as a whole.

CONFLICT OF INTEREST

All authors declare that there are no potential conflicts of interest that could have influenced the neutrality of this study. The authors explicitly state that they have no financial or personal relationships with any entities that could have inappropriately influenced the objectivity of the research.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The use of artificial intelligence tools in this study was limited to supporting the literature search process, specifically to identify relevant manuscripts aligned with the research topic, and to assist in improving clarity and language quality in English writing. All substantive academic content, data interpretation, and conclusions were developed by the authors. Qualitative data analysis was conducted using NVivo 12 software.

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