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Hospital Disaster Resilience in Indonesia: An Evidence-Based Synthesis of Flood and Earthquake Preparedness

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Indonesia is one of the most disaster-prone countries in the world due to exposure to earthquakes, floods, tsunamis, volcanic eruptions, and climate-related hazards. Hospitals play a critical role in maintaining healthcare delivery during disasters, yet their resilience capacity varies. This study synthesized evidence on hospital disaster resilience in Indonesia, focusing on preparedness for flood and earthquake hazards. An evidence-based descriptive synthesis was conducted using peer-reviewed studies, national reports, policy documents, and international guidance. Findings were analyzed across four resilience domains the Hospital Safety Index: structural and non-structural safety, emergency management systems, continuity of essential services, and governance and policy integration. The review found that improvements in hospital resilience were most evident in governance, disaster management planning, and policy integration, largely driven by accreditation requirements and national disaster risk reduction initiatives. However, structural resilience remains insufficient in many facilities, particularly regarding seismic preparedness and non-structural mitigation measures. Flood preparedness is more advanced than earthquake preparedness because hydrometeorological hazards occur more frequently. Persistent vulnerabilities were identified in continuity of essential services, including electricity, water supply, sanitation systems, and healthcare waste management. Although disaster preparedness plans are increasingly available, operational readiness through emergency exercises remains inconsistent. Overall, hospital disaster resilience in Indonesia remains uneven, characterized by stronger administrative preparedness than infrastructural and functional resilience. Strengthening disaster-safe hospitals requires integrated resilience frameworks, climate-resilient health infrastructure, sustained investment in emergency preparedness, enhanced workforce capacity, and stronger implementation of disaster risk reduction policies across the healthcare system to ensure service continuity during future emergencies and disasters.

Keywords: Disaster preparedness, Earthquake, Flood, Hospital resilience, Hospital safety index

INTRODUCTION

Indonesia is among the countries most vulnerable to disasters globally because of its geographical location within the Pacific Ring of Fire and its exposure to multiple hydrometeorological hazards. Earthquakes, tsunamis, floods, volcanic eruptions, landslides, and extreme weather events occur frequently and have substantial impacts on public health systems and healthcare infrastructure. The increasing frequency and intensity of climate-related hazards further amplify disaster risks, particularly for health facilities that are expected to remain operational during emergencies (Badan Nasional Penanggulangan Bencana, 2023; Miranda et al., 2023; World Health Organization, 2026).

Hospitals represent critical components of health system resilience because they provide emergency

medical services, continuity of care, referral functions, and coordination support during disasters. The ability of hospitals to maintain functionality during and after disasters directly influences morbidity, mortality, and recovery outcomes among affected populations (Lestari et al., 2022; Mojtahedi et al., 2021). However, multiple disaster events in Indonesia have demonstrated that hospitals themselves are highly vulnerable to structural damage, service disruption, utility failures, and operational collapse. The 2006 Yogyakarta earthquake, the 2009 Padang earthquake, the 2018 Palu earthquake and tsunami, and recurrent flooding events across major urban areas revealed substantial weaknesses in healthcare facility preparedness and resilience (Chand & Loosemore, 2013; Cimellaro et al., 2010; Lugten & Hariharan, 2022).

The concept of hospital disaster resilience has therefore become increasingly important within disaster risk reduction, environmental health, and health system strengthening frameworks. The World Health Organization (WHO) defines resilient healthcare facilities as facilities capable of resisting, absorbing, adapting to, and recovering from hazard impacts while maintaining essential health services (Organization, 2022). Hospital resilience extends beyond structural safety and includes emergency management capacity, continuity of essential services, governance systems, workforce preparedness, environmental health protection, and organizational adaptability (Husaini et al., 2025; Sari et al., 2023; Sherman et al., 2023).

Several studies have evaluated hospital preparedness and resilience in Indonesia using different frameworks, including the Hospital Safety Index (HSI), emergency management assessments, organizational resilience models, and disaster preparedness indicators (Andini et al., 2023; Aulia et al., 2025; EL-Matary et al., 2026; Lestari et al., 2022; Sari et al., 2023). Recent evidence also highlights the importance of climate-resilient healthcare facilities as part of broader health system adaptation strategies in disaster-prone countries (Organization, 2022; World Health Organization, 2026). Nevertheless, existing evidence remains fragmented across different hazards, regions, and resilience domains. Most studies focus on specific facilities, individual preparedness components, or localized disaster contexts, limiting broader understanding of hospital resilience challenges at the national level (Andini et al., 2023; Sari et al., 2023).

Given the growing disaster burden and the strategic role of hospitals in health security, a comprehensive synthesis of current evidence is needed. This study therefore aims to synthesize available evidence regarding hospital disaster resilience in Indonesia, focusing on flood and earthquake preparedness across structural safety, emergency management, continuity of essential services, and governance dimensions. The findings are expected to contribute to evidence-informed strategies for strengthening disaster-resilient healthcare systems in Indonesia.

METHODS

Study Design

This study employed an evidence-based descriptive synthesis approach to examine hospital disaster resilience in Indonesia. The synthesis integrated findings from peer-reviewed research articles, national policy documents, technical reports, and international guidance relevant to hospital preparedness and resilience for flood and earthquake hazards. The study was designed to identify recurring resilience challenges, preparedness gaps, and policy priorities across the Indonesian healthcare system.

Identification and Selection

A structured search was conducted using Google Scholar, Scopus, ScienceDirect, Garuda, World Health

Organization repositories, Ministry of Health publications, and National Disaster Management Agency (BNPB) reports. Evidence published between January 2017 and March 2026 was considered eligible. Search terms included combinations of "hospital resilience", "hospital disaster preparedness", "Hospital Safety Index", "disaster-safe hospitals", "flood preparedness", "earthquake preparedness", "healthcare infrastructure", "climate-resilient healthcare facilities", and "Indonesia". Sources were included if they:

- (1) assessed hospital preparedness, safety, resilience, or emergency management;
- (2) addressed flood, earthquake, climate-related, or all-hazard preparedness;
- (3) were conducted in Indonesia or directly relevant to Indonesian healthcare systems;
- (4) provided empirical findings, resilience indicators, policy analyses, or preparedness frameworks.

Studies focusing exclusively on non-healthcare infrastructure or lacking sufficient methodological description were excluded.

Selection Process

The literature search initially identified 68 potentially relevant records from scientific databases, institutional repositories, and official organizational websites. After removing duplicate records and screening titles and abstracts for relevance, 31 sources were assessed for eligibility through full-text review. Following application of the predefined inclusion and exclusion criteria, 15 sources were included in the final synthesis. The included sources consisted of peer-reviewed journal articles, World Health Organization guidance documents, national policy reports, and disaster preparedness assessments directly relevant to hospital resilience in Indonesia. Although this study was not designed as a formal systematic review, the identification, screening, eligibility, and inclusion stages followed a transparent evidence selection process to improve methodological rigor and reproducibility, as shown in figure 1.

Data Extraction and Synthesis

Relevant findings were extracted and organized according to four resilience domains adapted from the World Health Organization Hospital Safety Index framework and subsequent resilience literature (World Health Organization, 2025; Zhong et al., 2014):

1. Structural and Non-Structural Safety
2. Emergency Management Systems
3. Continuity of Essential Services
4. Governance and Policy Integration

Data extraction focused on recurring themes, reported preparedness strengths, identified vulnerabilities, and recommended resilience interventions. Findings from multiple sources were synthesized narratively to identify common patterns and evidence convergence across studies.

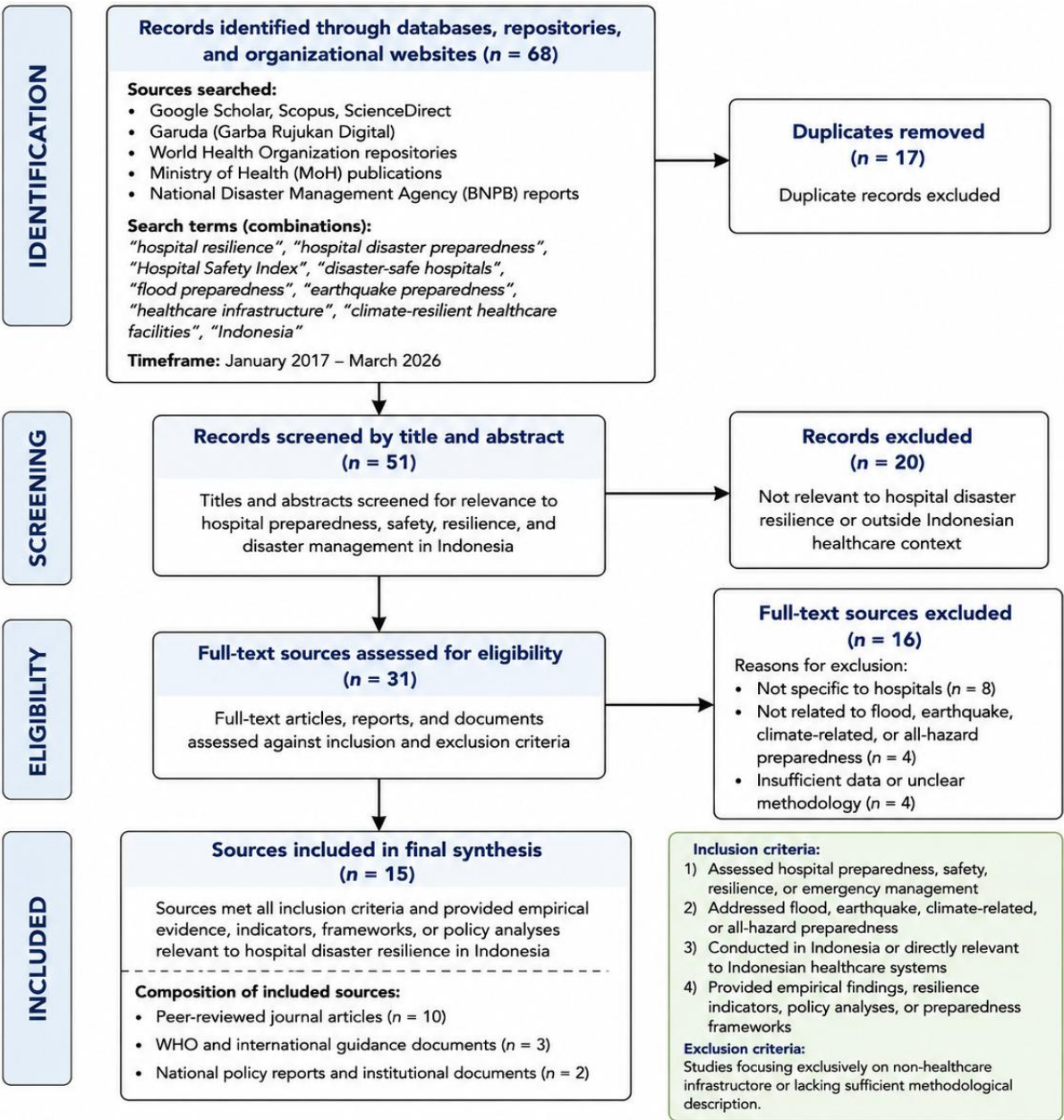


Figure 1. PRISMA-style Flow Diagram of Evidence Selection Process

Evidence Appraisal

To enhance the credibility of the synthesis, all included sources were appraised based on methodological transparency, relevance to hospital disaster resilience, and direct applicability to the Indonesian healthcare context. Greater weight was assigned to peer-reviewed studies, World Health Organization publications, Hospital Safety Index-based assessments, and official government reports. Sources with limited methodological description or insufficient relevance to hospital preparedness and resilience were excluded from the synthesis. The appraisal process was intended to ensure that the synthesized findings reflected the most credible and policy-relevant evidence available rather than providing a formal quality scoring assessment.

Analytical Approach

The analysis followed a thematic synthesis approach. Evidence was compared across studies to identify consistencies and differences in reported preparedness levels, resilience capacities, and implementation challenges. Particular attention was given to flood and earthquake preparedness because these hazards represent major threats to healthcare infrastructure in Indonesia. The synthesis aimed to generate an integrated understanding of hospital disaster resilience rather than produce pooled quantitative estimates.

Ethical Consideration

The study utilized publicly available literature and institutional documents and therefore did not require ethical approval involving human participants.

RESULTS AND DISCUSSION

Overview of Evidence

The reviewed evidence consistently identified four major dimensions influencing hospital disaster resilience in Indonesia: structural and non-structural safety, emergency management systems, continuity of essential services, and governance and policy integration. Although preparedness initiatives have expanded substantially during the last decade, important resilience gaps remain across multiple domains (table 1).

Structural and Non-Structural Safety

Deficiencies in structural and non-structural safety were reported across nearly all included studies, making this the most frequently identified area of concern. Common problems included limited seismic retrofitting, inadequate protection of critical equipment, and vulnerabilities in building components essential for maintaining hospital functionality during disasters. Hospital Safety Index assessments conducted in different Indonesian settings revealed substantial variation in safety performance, reflecting differences in infrastructure quality, maintenance capacity, and disaster risk exposure. These challenges were reported more frequently for earthquake preparedness than for flood preparedness, particularly among older healthcare facilities.

Emergency Management Systems

Most of the included studies described the existence of disaster preparedness plans, emergency committees, and incident management structures within hospitals, suggesting that preparedness has become a recognized component of hospital governance. Formal emergency plans, disaster committees, and incident management structures were commonly reported across healthcare facilities. Nevertheless, the operationalization of these arrangements remained inconsistent. Several studies described limited implementation of routine drills, simulation exercises, and competency-based training, suggesting that preparedness frameworks are often more developed on paper than in practice.

Continuity of Essential Services

A recurring concern across the reviewed studies was the fragility of essential support systems required to sustain healthcare delivery during emergencies. Weaknesses were most frequently reported in electricity supply, water security, communication infrastructure, healthcare waste management, and logistics continuity. These vulnerabilities increase the risk of service disruption during prolonged disasters and may compromise patient safety and infection prevention measures.

Governance and Policy Integration

Among the four resilience domains, governance and policy integration showed the strongest evidence of

progress. Disaster preparedness requirements have increasingly been incorporated into accreditation standards, national disaster management policies, and health sector resilience initiatives. Recent climate-resilient healthcare initiatives supported by international and national stakeholders further demonstrate growing policy commitment toward resilient health infrastructure. Nevertheless, implementation remains variable across regions, reflecting differences in institutional capacity, resource availability, and local leadership.

Integrated Evidence Synthesis Across Resilience Domains

Table 1 brings together evidence from the included studies and illustrates how hospital resilience in Indonesia is shaped by the interaction of infrastructure conditions, operational preparedness, essential support systems, and governance capacity. Across the reviewed studies, structural and non-structural safety emerged as one of the most persistent challenges, particularly regarding seismic preparedness and disaster-resistant infrastructure. Multiple Hospital Safety Index assessments reported substantial variation in safety performance across facilities, with earthquake resilience consistently reported as weaker than flood preparedness because of limited retrofitting measures and aging infrastructure (Lestari et al., 2022; Mojtahedi et al., 2021; Sari et al., 2023). Emergency management systems were generally more developed than structural preparedness. Most hospitals have established disaster preparedness plans and emergency management structures; however, several studies identified limitations in operational preparedness (Andini et al., 2023; Lestari et al., 2022).

The reviewed evidence also identified continuity of essential services as a major vulnerability. Studies consistently highlighted risks associated with electricity disruption, insecure water supply, sanitation failures, communication breakdowns, and healthcare waste management challenges during emergencies (Lestari et al., 2022; Organization, 2022; World Health Organization, 2026). These findings indicate that hospital resilience depends not only on physical infrastructure but also on the capacity to maintain critical support systems during prolonged disasters. Governance and policy integration represented the strongest resilience domain. National accreditation standards, disaster risk reduction frameworks, and climate-resilient healthcare initiatives increasingly recognize hospital resilience as a strategic priority (Andini et al., 2023; Miranda et al., 2023; World Health Organization, 2026). Nevertheless, evidence indicates substantial variability in implementation capacity across regions and healthcare facilities, reflecting differences in institutional resources, technical expertise, and local leadership.

Table 1.
Evidence-to-Policy Framework for Strengthening Hospital Disaster Resilience in Indonesia

Resilience Domain	Evidence from Reviewed Studies	Key Challenges	Policy Implications
Structural and Non-Structural Safety	Multiple studies reported deficiencies in seismic retrofitting, non-structural mitigation, and disaster-resistant infrastructure. Structural vulnerabilities remain more prominent for earthquake hazards than flood hazards (Lestari et al., 2022; Mojtahedi et al., 2021; Sari et al., 2023).	Aging infrastructure, inadequate mitigation investment, limited retrofitting capacity	Prioritize hospital infrastructure upgrading, seismic strengthening programs, and integration of disaster-resistant design standards
Emergency Management Systems	Disaster preparedness plans and emergency management structures are increasingly available; however, routine drills, simulations, and competency-based training remain inconsistent (Andini et al., 2023; Lestari et al., 2022; Sherman et al., 2023).	Administrative preparedness exceeds operational readiness	Strengthen workforce preparedness through mandatory disaster simulations, drills, and regular emergency response exercises
Continuity of Essential Services	Recurrent disruptions affecting electricity supply, water systems, sanitation, communication infrastructure, and healthcare waste management were consistently identified across the reviewed studies. These findings are consistent with previous conceptualizations of hospital resilience that emphasize structural safety, organizational capacity, adaptability, and continuity of essential services (Fallah-Aliabadi et al., 2020; Lestari et al., 2022; Organization, 2022; Sherman et al., 2023; World Health Organization, 2025, 2026; Zhong et al., 2014).	Utility disruptions threaten patient safety and service continuity	Integrate environmental health systems, resilient utility infrastructure, and continuity planning into hospital resilience frameworks.
Governance and Policy Integration	Hospital accreditation systems, national disaster risk reduction frameworks, and climate-resilient healthcare initiatives increasingly support resilience planning (Andini et al., 2023; Miranda et al., 2023; Organization, 2022; World Health Organization, 2026).	Uneven implementation across institutions and regions	Strengthen accountability mechanisms, financing strategies, monitoring systems, and intersectoral coordination

Despite differences in study design and setting, the reviewed literature consistently identified a similar set of factors influencing hospital resilience, including infrastructure safety, emergency management capacity, continuity of essential services, and governance effectiveness. Structural and non-structural safety emerged as the most frequently reported vulnerability, particularly in relation to seismic preparedness, retrofitting capacity, and protection of critical infrastructure components. Hospital Safety Index assessments conducted in several Indonesian provinces identified substantial variation in safety performance across facilities, indicating uneven resilience capacity across regions (EL-Matury et al., 2026; Lestari et al., 2022).

Evidence related to emergency management systems suggests that disaster preparedness planning has become increasingly institutionalized within hospitals. Nevertheless, operational preparedness remains inconsistent, and workforce competency development.

Multiple studies highlighted a persistent gap between administrative preparedness and operational response capability (Andini et al., 2023; Lestari et al., 2022).

Across the reviewed evidence, continuity of essential services was consistently identified as a critical determinant of hospital functionality during disasters. Electricity supply, water security, sanitation systems, communication networks, logistics management, and healthcare waste systems were repeatedly cited as areas requiring additional investment and resilience planning (Fallah-Aliabadi et al., 2020; Lestari et al., 2022; Organization, 2022; World Health Organization, 2025, 2026; Zhong et al., 2014).

Governance and policy integration demonstrated the strongest level of evidence convergence. National accreditation standards, disaster risk reduction policies, and climate-resilient healthcare initiatives increasingly recognize resilience as a strategic healthcare priority. However, implementation capacity remains highly variable

across healthcare institutions and geographic regions (Andini et al., 2023; Miranda et al., 2023; World Health Organization, 2026).

Structural and Non-Structural Safety

The prominence of structural and non-structural vulnerabilities across the reviewed studies highlights a persistent challenge in translating disaster risk awareness into infrastructure resilience. While disaster preparedness policies have expanded considerably in Indonesia, physical upgrading of healthcare facilities appears to have progressed more slowly. This imbalance is particularly important in earthquake-prone regions, where structural failure can rapidly escalate into service disruption, workforce displacement, and loss of critical care capacity. International resilience research similarly demonstrates that structural integrity remains a prerequisite for maintaining continuity of care during major disasters (Chand & Loosemore, 2013; Cimellaro et al., 2010; Fallah-Aliabadi et al., 2020; Zhong et al., 2014).

The findings also suggest that resilience should not be interpreted solely as the capacity of a building to withstand physical damage. Non-structural components—including medical equipment, communication systems, utility networks, and internal operational infrastructure—play an equally important role in determining whether hospitals remain functional during emergencies. Consequently, resilience investments should extend beyond building reinforcement to encompass the broader systems that support healthcare delivery.

Emergency Management Systems

The contrast between documented preparedness plans and limited implementation of drills or simulations indicates that administrative readiness has advanced more rapidly than practical response capability. In many facilities, preparedness appears stronger when assessed through policies and documentation than when evaluated through operational testing and workforce performance. Accreditation requirements may encourage the establishment of disaster committees and preparedness documentation, yet they do not necessarily ensure sustained investment in simulation-based learning, workforce competency development, and emergency response testing. This finding highlights a common challenge in resilience governance: institutional preparedness can appear robust when measured through administrative indicators while remaining vulnerable when assessed through operational performance during real-world emergencies.

Continuity of Essential Services

A recurring pattern across the reviewed studies was the vulnerability of essential support systems that allow hospitals to remain operational during disasters. While structural damage often receives greater attention, interruptions in electricity, water supply, sanitation, communication, and waste management can be equally disruptive to healthcare delivery. Reliable access to electricity, water, sanitation, medical gases,

communication systems, and healthcare waste management is fundamental to maintaining hospital functionality during disasters. When these support systems fail, hospitals may remain structurally intact yet still lose the ability to provide safe and effective care. This distinction is particularly important because disruptions in water, electricity, sanitation, or communication systems can rapidly undermine clinical operations even in facilities that experience little physical damage. The increasing emphasis on climate-resilient healthcare facilities further reinforces the need to integrate environmental health infrastructure into resilience planning (Organization, 2022; Sherman et al., 2023; World Health Organization, 2026).

Governance and Policy Integration

The relative strength of governance and policy mechanisms compared with infrastructural preparedness reveals an important characteristic of resilience development in Indonesia. The pattern observed across the reviewed studies suggests that resilience development has been led largely by regulatory and institutional reforms. Accreditation standards, preparedness policies, and disaster risk reduction frameworks have expanded considerably, whereas investments in physical infrastructure and operational capacity have progressed at a slower pace. This pattern is not unique to Indonesia and has been observed in several low- and middle-income settings where policy development often precedes resource-intensive implementation efforts (Fallah-Aliabadi et al., 2020; Zhong et al., 2014). The challenge therefore lies not in the absence of policy frameworks but in ensuring their consistent translation into operational capacity. Differences in financing, technical expertise, institutional leadership, and regional governance continue to influence preparedness outcomes across healthcare facilities. Strengthening accountability mechanisms and linking resilience indicators to routine performance monitoring may help bridge the gap between policy commitment and practical implementation.

Implications for Hospital Resilience in Indonesia

Taken together, the reviewed studies indicate that hospital resilience has become an increasingly important policy priority within the Indonesian health system. However, resilience gains have not progressed uniformly across domains. While governance arrangements and preparedness planning have advanced substantially, structural safety, operational readiness, and continuity of essential services continue to demonstrate greater variability across facilities. These findings underscore the importance of translating policy commitments into measurable improvements in infrastructure performance, workforce capability, and healthcare service continuity during disasters.

Reframing Hospital Resilience in Indonesia

An important pattern emerging from this synthesis is the uneven progression of resilience development across domains. Governance frameworks, accreditation systems, and disaster preparedness policies have advanced

substantially during the past decade, reflecting increased institutional recognition of disaster risk and climate-related health threats. In contrast, improvements in structural safety, operational readiness, and continuity of essential services appear to have progressed more gradually.

This divergence suggests that resilience development in Indonesia has thus far been driven primarily by policy reform and organizational governance rather than by comprehensive transformation of healthcare infrastructure and operational capacity. While regulatory progress represents an essential foundation, resilience ultimately depends on the ability of healthcare facilities to maintain functionality under adverse conditions. Consequently, future resilience strategies should place greater emphasis on translating policy commitments into measurable improvements in infrastructure performance, workforce readiness, and service continuity.

Rather than viewing preparedness, infrastructure, and governance as separate domains, a systems-based resilience perspective may offer a more effective framework for strengthening healthcare facilities in disaster-prone settings. Such an approach recognizes that disruptions rarely occur within a single domain and that hospital functionality depends on the interaction between physical infrastructure, organizational capacity, environmental health systems, and adaptive governance mechanisms.

This study has several limitations. First, the synthesis relied on published evidence and policy documents rather than primary field observations. Second, the reviewed studies used heterogeneous methodologies, limiting direct comparability across findings. Third, publication bias may have influenced the available evidence base. Fourth, the synthesis focused primarily on flood and earthquake preparedness and may not fully represent resilience challenges associated with other hazards. Finally, the findings should be interpreted as evidence-informed insights rather than quantitative estimates of national preparedness levels.

CONCLUSION

This evidence-based synthesis demonstrates that hospital disaster resilience in Indonesia has improved considerably in governance, policy development, and institutional preparedness during the past decade. Nevertheless, substantial challenges remain in structural safety, operational readiness, and continuity of essential services. The reviewed evidence consistently indicates that flood preparedness measures are more widely implemented than earthquake resilience measures, particularly regarding structural mitigation and seismic retrofitting. Although disaster management plans have become increasingly integrated into hospital governance systems, regular training, simulation exercises, and emergency response testing remain inconsistently implemented. Hospital resilience should therefore be understood as a multidimensional capacity that extends beyond compliance with accreditation requirements. Strengthening disaster-safe hospitals in Indonesia requires

sustained investment in resilient infrastructure, continuity of critical utilities, workforce preparedness, environmental health systems, and climate adaptation measures. Future policy efforts should prioritize integrated resilience frameworks capable of supporting healthcare service continuity before, during, and after disasters.

By strengthening these domains simultaneously, Indonesia can enhance the resilience of its healthcare system and improve its capacity to respond effectively to future disasters, climate-related emergencies, and public health crises.

SUGGESTION

Policymakers should develop standardized national hospital resilience frameworks aligned with disaster risk reduction and climate adaptation strategies. Investment in seismic retrofitting, continuity of essential services, and operational preparedness should be prioritized.

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