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An emergency response framework for improving crisis management in facilities: PLS-SEM approach

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Abstract

Purpose – Emergency response systems often face inadequate infrastructure, poor coordination and limited preparedness, hindering crisis management during disasters. Addressing these challenges is essential for enhancing resilience and response capabilities. This study aims to develop an integrated emergency response framework for facilities.

Design/methodology/approach – This study employed a quantitative research approach to gather data on emergency response infrastructure in Ghana. A structured questionnaire survey led to 159 responses from facility managers, engineers, architects, building inspectors, quantity surveyors and National Disaster Management Organisation officials. The sample was selected from 43 districts, municipalities and metropolitan areas using purposive and convenience sampling. Data were analysed using descriptive and inferential statistics, including means, standard deviations, normalisation values and partial least squares structural equation modelling (PLS-SEM).

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Findings – The study identified two main factors affecting emergency response: technical (risk monitoring, forecasting, risk knowledge) and non-technical (preparedness, recovery capabilities, warning dissemination, response capacity). PLS-SEM demonstrated that risk knowledge, forecasting, preparedness and recovery capabilities significantly enhance emergency outcomes, such as saving lives and protecting property, emphasising the practical value of the framework.

Practical implications – The frameworks offer guidance to policymakers, emergency managers and infrastructure planners in designing emergency response strategies, improving stakeholder coordination, optimising resource allocation and enhancing communication networks.

Originality/value – This study contributes to the body of knowledge by using PLS-SEM to develop an emergency response framework for facilities. It combines crisis and facility management concepts to improve emergency response in facilities.

Keywords Emergency response, Disaster risk management, Disaster preparedness, Disaster risk reduction, Resilience

Paper type Research paper

1. Introduction

Sub-Saharan Africa's emergency response infrastructure (ERI), particularly in disaster management and healthcare, requires improvement to effectively meet the needs of its rapidly growing population (Zhou *et al.*, 2024; Adjei *et al.*, 2025a; Abudu *et al.*, 2025a). Modern societies depend heavily on complex infrastructure systems, including utilities, telecommunications and financial networks, which support economic activities and social stability (Dudenhoeffer *et al.*, 2006). However, these infrastructures are vulnerable to both anthropogenic and natural hazards, making effective emergency response and rapid recovery essential for maintaining socioeconomic well-being. Resilient infrastructure enables communities to withstand disruptions and maintain stability during crises (Sharma and Gardoni, 2018). Governments, non-governmental organisations (NGOs) and community leaders, therefore, play a critical role in developing policies and systems that enhance preparedness and response to threats such as disasters and terrorist attacks (Adjei *et al.*, 2025b).

ERI comprises interconnected systems of hardware, software, equipment, facilities, personnel, procedures and communication mechanisms that support coordinated emergency management (Sharma and Gardoni, 2018). These systems are essential for protecting lives, safeguarding assets and ensuring the continuity of critical services (Dudenhoeffer *et al.*, 2006). Within the built environment, facilities such as commercial buildings, educational institutions, healthcare centres and public spaces often accommodate large populations, making them particularly vulnerable during emergencies.

Several incidents illustrate the risks associated with inadequate emergency response systems in facilities. For example, a stampede at a train station in Bihar, India, injured 58 people, while a nightclub stampede in Yaoundé, Cameroon, resulted in 16 deaths and several injuries (Ye *et al.*, 2024). Similarly, China records approximately 200,000 fires annually, with about 30% occurring in buildings, posing severe risks such as burns, suffocation and smoke poisoning during evacuation (Wang *et al.*, 2024). These events emphasise the need for effective emergency response mechanisms to ensure safety during crises like fires, earthquakes, floods or terrorist attacks (Adjei *et al.*, 2025b). This study focuses on emergency response initiatives within facilities, highlighting the need for coordinated systems to manage risks, support evacuation and enhance disaster response.

Although previous studies have examined emergency response systems and disaster management practices (Abudu *et al.*, 2025b; Matveev *et al.*, 2021; Dudenhoeffer *et al.*, 2006), many focus on individual components such as infrastructure resilience, evacuation planning or coordination mechanisms. Limited empirical research integrates both technical and non-technical factors influencing emergency response effectiveness within facilities. There is limited research using partial least squares structural equation modelling (PLS-SEM) to explore relationships in emergency response. PLS-SEM effectively analyses interconnected constructs and develops predictive frameworks. This study uses PLS-SEM to develop a framework for evaluating emergency response in facilities, integrating technical and non-technical aspects to enhance crisis management and disaster preparedness.

2. Literature review

2.1 Emergency response frameworks in the built environment

An emergency response system is a network of physical, organisational and technical systems coordinated to manage and mitigate emergencies, ensuring public safety, property rights and security (Wang *et al.*, 2022; Dwarakanath *et al.*, 2021; Gilmore and DuRant, 2021). Myeong *et al.* (2020) emphasise the importance of smart governance and stakeholder involvement in enhancing city services and democratic values. The Smartopia Centre in Gimpo utilises big data and the Internet of Things to enable proactive disaster safety, aligning with the Sendai Framework's 2030 goal to improve multihazard early warning systems.

The Sendai Framework for Disaster Risk Reduction 2015–2030 outlines four priority areas to build resilience by preventing and reducing disaster risks (Bello *et al.*, 2021). Effective disaster risk management (DRM) policies must address key risk dimensions, including vulnerability, capacity, exposure, hazard characteristics and environmental factors, to ensure a comprehensive pre-disaster assessment, prevention, mitigation, preparedness and response. These principles are also relevant to earthquake emergencies, where rapid damage assessment, early warning systems and coordinated evacuation and rescue operations are essential for minimising casualties and infrastructure losses.

Wang *et al.* (2022) developed a framework for assessing emergency response capacity, focusing on government spending, public safety, education, transportation and healthcare. Fekete *et al.* (2020) highlighted efforts in Iran to enhance disaster resilience through improved DRM and governance. Gupta *et al.* (2022) and Zualkernan *et al.* (2019) introduced an artificial intelligence, Internet of Things and cloud-based framework for emergency operations to enhance information dissemination and resource readiness. Bello *et al.* (2021) emphasised a multisectoral approach to DRM and resilient recovery. Integrating DRM into national planning is essential to developing better policies.

Sukhwani *et al.* (2019) developed a flood disaster management framework focusing on knowledge, technology and institutions. The knowledge aspect assesses flood-risk understanding among agencies and communities, while the technology aspect involves accurate monitoring and warning systems.

The study utilises Perera *et al.*'s (2020) emergency response framework, which includes technical components (risk knowledge, monitoring, forecasting) and non-technical components (warning dissemination, communication, preparedness, response capabilities). It employs systems and resilience theories to explore the interconnectedness of emergency response systems in facilities (Chen *et al.*, 2017). Systems theory focuses on component interactions, and resilience theory addresses the anticipation and recovery from disruptions (Son *et al.*, 2020).

2.2 Research gaps

Existing studies have developed frameworks for DRM and emergency response systems (Sukhwani *et al.*, 2019; Wang *et al.*, 2022; Bello *et al.*, 2021). However, many focus mainly on technological systems or institutional governance, with limited integration of both technical and non-technical components at the facility level. This research highlights gaps in ERI, particularly in the non-technical aspects. Most frameworks also analyse emergency systems at national or city levels, with less attention to emergency response in individual facilities and the built environment.

Additionally, few studies have empirically validated integrated emergency response frameworks using quantitative modelling approaches such as PLS-SEM, despite the conceptual contributions of previous studies (Perera *et al.*, 2020; Sukhwani *et al.*, 2019; Abudu *et al.*, 2026). This study, therefore, addresses this gap by developing and empirically testing an integrated ERI framework that combines technical and non-technical factors influencing emergency response effectiveness in facilities.

2.3 *Conceptual framework for emergency response infrastructure*

The proposed framework in Figure 1 addresses both technical and non-technical components of ERI. The framework was developed based on the constructs identified in the reviewed literature, as no single comprehensive model exists for assessing ERI in facilities. These constructs were organised conceptually to guide the empirical analysis using PLS-SEM.

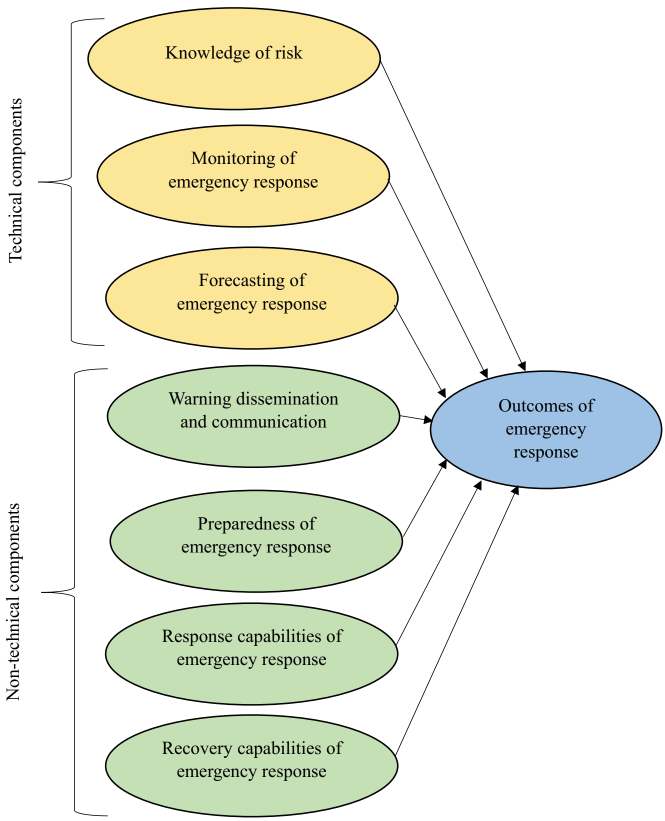

Figure 1. Proposed emergency response framework
Source: Authors' Construct, 2025

Disaster risk is determined by the type of hazard, vulnerability, exposure and capacity. Effective management requires identifying hazards, understanding community vulnerabilities and utilising resources. A holistic approach is vital for planning and mitigation. Monitoring systems (Gilmore and DuRant, 2021; Abudu *et al.*, 2025a), including street security and traffic surveillance (Sukhwani *et al.*, 2019), use technologies to improve public safety and emergency response (Myeong *et al.*, 2020; Khan *et al.*, 2020). Community and religious involvement enhance preparedness and resilience (Damaševičius *et al.*, 2023).

Advanced tools and methodologies are employed to predict disaster events (Basher, 2006), integrating meteorological (Damaševičius *et al.*, 2023), geological (Kedia *et al.*, 2022) and environmental data to provide timely alerts and improve preparedness (Nick *et al.*, 2023). Disaster risk reduction (DRR) depends on comprehensive data analysis to identify patterns, develop strategies (Cvetković *et al.*, 2021) and reduce future risks. Assessing disaster situations involves monitoring hazards, evaluating immediate effects and analysing real-time data. Social media and digital platforms support disaster preparedness through real-time communication, training and centralised databases (Sutton *et al.*, 2024; Damaševičius *et al.*, 2023). Effective DRR needs stakeholder cooperation, social and gender inclusion, clear policies, community involvement, infrastructure investment and education.

Emergency response capabilities rely on skilled personnel, advanced technology (Wang *et al.*, 2022; Damaševičius *et al.*, 2023), communication systems (Myeong *et al.*, 2020) and coordinated planning. Effective responses include alert systems, evacuations and rescue operations using GPS and cameras (Fekete *et al.*, 2020; Gupta *et al.*, 2022; Bello *et al.*, 2021). Post-disaster assessments enhance readiness by identifying gaps in disaster risk reduction strategies (Cho and Choi, 2024). Recovery involves damage assessment (Nick *et al.*, 2023), rehabilitation (Mukhopadhyay, 2023) and community compensation (Mensah-Bonsu, 2022). Strengthening recovery requires addressing vulnerabilities and improving coordination (Cho and Choi, 2024). Documenting damage aids in resilient rebuilding (Sutton *et al.*, 2024; Wu *et al.*, 2022).

Resilient reconstruction integrates risk reduction, infrastructure strengthening and land-use improvements (Gupta *et al.*, 2022; Wang *et al.*, 2022). Effective recovery depends on cooperation among government, NGOs, private sectors and communities to ensure inclusive planning and resource allocation (Cvetković *et al.*, 2021; Perera *et al.*, 2020; Tanesab, 2020; Nick *et al.*, 2023). Public investment in resilient infrastructure and community programs enhances long-term recovery and risk mitigation (Fekete *et al.*, 2020; Bello *et al.*, 2021). Adaptation strategies must evolve continuously, incorporating new technologies, updated policies and lessons from past disasters (Sutton *et al.*, 2024; Than *et al.*, 2020).

3. Methodology

This study used a quantitative approach to assess and develop a framework for emergency response in Ghanaian facilities, enabling measurable data collection and analysis of variable relationships for evidence-based conclusions. A survey design with structured questionnaires was utilised to gather data from professionals, including facility managers, engineers, architects, quantity surveyors, building inspectors, and National Disaster Management Organisation (NADMO) officials, across 43 districts, municipalities and metropolitan assemblies in the Ashanti Region. The target population comprised 516 professionals involved in facility planning and disaster response. This number was determined from official records of facility management departments and NADMO offices across the study area, representing the full population of professionals for the study. The sample size for the study was 159, which is further justified for PLS-SEM analysis. According to Lu and Lu (2025), most PLS-SEM studies use a sample size of 100; however, larger sample sizes yield more accurate predictions. A pilot study with 30 participants from district assemblies and academia validated the data collection tools. Purposive and convenience sampling were used to select experienced professionals for the study.

Data were collected through a structured questionnaire divided into two sections. The first section gathered demographic information, including educational qualifications, professional roles, facility types and years of experience (see Table 1). The second section consisted of Likert-scale items (1 = *strongly disagree* to 5 = *strongly agree*) assessing factors influencing emergency response systems, covering technical aspects such as risk knowledge and monitoring (Table 2), non-technical factors such as warning dissemination and preparedness (Table 3) and outcomes of ERI (Table 4). After collection, the data were cleaned, coded and normalised using Min-Max scaling. Analysis was conducted using SPSS and AMOS, with descriptive statistics summarising respondent profiles. Mean values ranked the importance of variables measured on the 5-point Likert scale, reflecting average perceptions.

Table 1. Background characteristics of respondents

Background characteristics	*N*	%
Highest qualification		
Certificate	8	5
Diploma	16	10.1
Master’s degree	28	17.6
Higher national diploma	52	32.7
Bachelor’s degree	55	34.6
Total	159	100
Roles		
Facilities managers	3	1.9
Architect	1	0.6
NADMO officials	12	7.5
Engineer	106	66.7
Quantity surveyor	28	17.6
Building inspector	9	5.7
Total	159	100
Types of facilities mostly worked on		
Educational facilities	19	11.9
Commercial facilities	67	42.1
Residential facilities	14	8.8
Religious facilities	22	13.8
Industrial facilities	5	22
Recreational facilities	22	13.8
Health care facilities	10	6.3
Total	159	100
Work experience		
1–5 years	48	30.2
6–10 years	31	19.5
11–15 years	29	18.2
16–20 years	21	13.2
21–25 years	30	18.9
Total	159	100

Source(s): Fieldwork, 2025

Table 2. Technical factors that influence emergency response in facilities

Code	Technical factors	Mean	SD	NV	Rank
KOR	Knowledge of risk				
KOR1	Understanding disaster risk in its dimensions	4.08	0.954	1.000*	1
KOR2	Risk identification	4.08	0.900	1.000*	2
KOR3	Environmental conditions of risk	4.03	0.990	0.762*	3
KOR4	Vulnerability of risk factor	3.96	1.081	0.429	4
KOR5	Hazard characteristics of risk	3.92	1.025	0.238	5
KOR6	Capacity of risk factor	3.89	1.037	0.095	6
KOR7	Exposure of risk	3.87	0.998	0.000	7
MER	Monitoring of emergency response				
MER1	Disaster monitoring	4.30	0.919	1.000*	1
MER2	Traffic monitoring	4.30	0.938	1.000*	2
MER3	Monitoring of street security	4.28	0.913	0.962*	3
MER4	Communication and networking in disasters	4.26	0.902	0.925*	4
MER5	Recognising and analysing disaster risk	4.26	1.028	0.925*	5
MER6	Data management and analysis of disasters	4.20	0.973	0.811*	6
MER7	Crime watch monitoring systems (CCTV and drone monitoring)	4.16	0.920	0.736*	7
MER8	Risk assessment of a disaster	4.14	0.927	0.698*	8
MER9	Community engagement in monitoring disasters	4.01	1.000	0.453	9
MER10	Religious institution involvement in monitoring disasters	3.89	1.037	0.226	10
MER11	Provision of monitoring devices and sensors	3.77	1.063	0.000	11
FER	Forecasting of emergency response				
FER1	Data management and analysis of past and present disasters for disaster risk reduction management	3.99	0.934	1.000*	1
FER2	Creation of a system for the prediction of disaster events	3.84	0.986	0.444	2
FER3	Assessing the current situation of disaster occurrence for disaster risk reduction management	3.83	1.045	0.407	3
FER4	Identifying problems associated with pre-disaster management measures	3.81	1.062	0.333	4
FER5	Predicting trends of disaster occurrence for disaster risk reduction management actions	3.72	1.050	0.000	5

Note(s): The * denotes factors with higher normalisation values (NV), highlighting the most influential items
Source(s): Fieldwork, 2025

Table 3. Non-technical factors that influence emergency response in facilities

Code	Non-technical factors	Mean	SD	NV	Rank
WDC	Warning dissemination and communication				
WDC1	Institutions' and organisations' awareness of pre-disaster information for disaster risk reduction management	3.89	0.965	1.000*	1
WDC2	Creation of a database for easy accessibility of risk information and ease of communication	3.87	1.017	0.949*	2
WDC3	Social media broadcasting of disaster information for readiness and preparedness	3.84	1.010	0.872*	3
WDC4	Involvement of religious and social institutions in the pre-disaster stage for effective disaster risk reduction management	3.53	1.011	0.077	4
WDC5	Platformisation of early warning systems in various cities, institutions, and communities	3.50	1.130	0.000	5
PER	Preparedness of emergency response				
PER1	Enforcement translation of disaster risk policies	4.18	0.934	1.000*	1
PER2	Disaster risk reduction plan and platforms for various cities or communities	4.04	1.078	0.708*	2
PER3	Capacity building in disaster risk reduction management in various institutions, organisations and communities	4.00	1.293	0.625*	3
PER4	Gender and social inclusiveness in disaster risk reduction management	3.91	1.009	0.438	4
PER5	Investing in disaster risk reduction for resilience at both national and local levels	3.88	1.245	0.375	5
PER6	Inclusive of religious and social institutions in disaster risk reduction management	3.87	1.068	0.354	6
PER7	Institutional communication and awareness in disaster risk reduction management	3.84	0.875	0.292	7
PER8	Community participation in disaster risk reduction management	3.79	1.186	0.188	8
PER9	Stakeholders' cooperation for disaster risk reduction management	3.75	1.263	0.104	9
PER10	Inclusive disaster risk reduction in the educational curriculum	3.70	1.267	0.000	10
RSER	Response capabilities of emergency response				
RSER1	Creation of assessment measures for post-disaster event(s) for resilience measures of disaster risk reduction management	3.98	0.984	1.000*	1
RSER2	Rescue of lives and properties by emergency responders in the event of a disaster	3.94	0.950	0.800*	2
RSER3	Communication and networking between rescue teams and victims in disaster catastrophes for effective and sound rescue	3.92	0.759	0.700*	3
RSER4	Setting of optimal search and rescue plan for disaster risk reduction management at both national and local levels	3.92	0.827	0.700*	4
RSER5	Provision of devices and sensors for the speedy detection and rescue of victims in emergencies	3.78	0.854	0.000	5
RCER	Recovery capabilities of emergency response				
RCER1	Assessment of damage and losses for resilient rebuilding of the disaster risk reduction management plan and strategies	3.95	0.863	1.000*	1
RCER2	Resilient public investment for post-disaster	3.89	0.952	0.860*	2
RCER3	Multi-stakeholders' coordination for post-disaster recovery plans, policies and implementation	3.81	0.931	0.674*	3
RCER4	Planning for resilient reconstruction and rehabilitation for post-disaster recovery	3.73	0.891	0.488	4
RCER5	Adaptation measures of disaster risk reduction and disaster risk management	3.60	1.080	0.186	5
RCER6	Planning for a resilient recovery for post-disaster	3.52	1.113	0.000	6

Note(s): The * denotes factors with higher normalisation values (NV), highlighting the most influential items
Source(s): Fieldwork, 2025

Table 4. Outcomes of emergency response infrastructure in facilities

Code	Outcomes of emergency response (OER)	Mean	SD	NV	Rank
OER1	Protect lives and properties	4.20	0.940	1.000*	1
OER2	Enhance the resilience of the population, assets, and operations	4.17	0.894	0.786*	2
OER3	Enhance collaboration between civil society and government in policy design and implementation	4.15	0.943	0.643*	3
OER4	Reduce vulnerability to disaster	4.12	0.903	0.429	4
OER5	Ensure coherence between national and local capacities	4.09	0.874	0.214	5
OER6	Improve the speed and efficiency of emergency response	4.09	0.913	0.214	6
OER7	Enhances economic resilience	4.06	0.905	0.000	7
OER8	Facilitate communication between disaster victims and communities	4.06	1.017	0.000	8

Note(s): The * denotes factors with higher normalisation values (NV), highlighting the most influential items
Source(s): Fieldwork, 2025

PLS-SEM was used to validate the framework and examine structural relationships, making it suitable for analysing complex models with multiple latent constructs in emergency response systems and crisis management. Goodness-of-fit was evaluated using root mean square error of approximation (RMSEA; ≤0.08), comparative fit index (CFI) and Tucker–Lewis index (TLI; ≥0.90), and Chi-square/df (≤3; Savalei and Bentler, 2006). Content validity was ensured through expert reviews, whereas construct validity was confirmed via factor analysis. Ethical standards were maintained through voluntary, anonymous participation and adherence to Institutional Review Board protocols, with clearance number IREC 287/24.

4. Results

The Results are presented in two parts: first, respondents' ratings of technical, non-technical and outcome factors (Tables 2–4); second, analysis of critical factors and their interrelationships informing the PLS-SEM model.

4.1 Background characteristics

This section summarises the demographic profile of respondents, as shown in Table 1, including education, professional roles, facility types and work experience. Most respondents are well educated, with many holding bachelor's degrees or Higher National Diplomas, and a significant number holding master's degrees. Engineers represent the largest group (66.7%), followed by quantity surveyors, NADMO officials and building inspectors, whereas facilities managers and architects are underrepresented. This occupational imbalance can lead to sampling bias, underrepresenting facility managers and architects. While focusing on technical roles aids in studying emergency response systems, it limits the generalisability of findings across all groups in facility management and disaster response.

Out of 225 distributed questionnaires, 159 valid responses were retained for analysis after screening. The remaining were excluded due to not meeting the requirements for PLS-SEM analysis. Table 1 provides the background characteristics of these 159 usable responses, which constitute the final data set for the study. Respondents primarily work in commercial facilities (42.1%), with additional experience in religious, recreational and educational facilities, while healthcare and industrial facilities are less represented. Experience levels also vary across respondents, bringing diverse professional perspectives to the analysis.

4.2 Descriptive statistics of the technical factors that influence emergency response in facilities

This section presents the descriptive statistics of the technical factors influencing the effectiveness of emergency response in facilities. Mean scores and normalisation techniques were used to rank these factors, while standard deviation is presented only to indicate variability in responses, as shown in Table 2.

Table 2 highlights that knowledge, monitoring and forecasting factors are all important for effective DRR in facilities. Within knowledge of risk, understanding disaster dimensions, risk identification and environmental conditions emerged as the most critical areas. Monitoring factors, such as disaster and traffic monitoring, along with street security surveillance, were particularly influential. Forecasting factors emphasised the importance of data management and analysis of past and current disasters. Overall, 12 technical factors, including risk understanding, monitoring, communication networks, risk assessment and data management, were identified as critical (normalisation values ≥ 0.60) for strengthening ERI.

4.3 Descriptive statistics of the non-technical factors that influence emergency response in facilities

This section presents descriptive statistics for non-technical factors influencing emergency response effectiveness in facilities, using mean scores, standard deviations and normalisation to rank these factors (Table 3). Ranking within each sub-construct was based on normalised values, with ties resolved by prioritising lower standard deviations.

The analysis identified four key non-technical dimensions impacting emergency response: communication, preparedness, response capabilities and recovery. Critical factors included awareness of pre-disaster information, risk policy enforcement, post-disaster assessments and damage evaluation for resilient rebuilding. Thirteen critical factors highlighted the importance of effective communication, policy enforcement, capacity building, coordinated rescue operations and stakeholder collaboration to enhance Ghana's ERI.

4.4 Descriptive statistics of the outcomes of emergency response infrastructure in facilities

This section presents the descriptive statistics for the outcomes of ERI, including average scores, standard deviations and normalisation values used to rank the outcomes (Table 4). When indicators shared the same mean or normalisation value, rankings were determined based on the standard deviation, with lower deviations receiving higher ranks.

Respondents rated the outcomes of ERI highly, emphasising the importance of protecting lives and properties, enhancing the resilience of populations and assets and fostering collaboration between civil society and government. Other notable outcomes, including reducing vulnerability and ensuring coordination between national and local capacities, were also strongly supported. These findings underscore the vital role of integrated systems in achieving both immediate protection and long-term disaster management.

4.5 Structural equation modelling of the relationship between the factors

The measurement model assessment in the SEM was conducted in two stages. First, confirmatory factor analysis was performed using IBM SPSS AMOS 24 and EQS 6.2 to assess model fit and estimate key indices, as well as R-squared values. The second stage, based on Hair *et al.* (2016), applied PLS-SEM quality checks, including reliability tests (Cronbach's alpha and composite reliability), indicator reliability (factor loadings), convergent validity (average variance extracted, AVE), and discriminant validity (Fornell-Larcker criterion).

The study reported on seven model fit indices, namely, χ^2/df, CFI, incremental fit index (IFI), normed fit index (NFI), TLI, standardised root mean square residual (SRMR) and RMSEA, which were used to assess the model fit (adequacy). The normed chi-square recorded good fit ($1.691 < 3$) at the initial analysis. It was observed that the initial indices for CFI, IFI, NFI and TLI were 0.862, 0.861, 0.722 and 0.854, respectively. The indices fell below recommended thresholds, prompting model modifications to include correlated error terms. After correlation, the indices improved: CFI (0.918), IFI (0.919) and TLI (0.912) met the 0.90 threshold. The RMSEA recorded $0.051 < 0.08$, indicating an acceptable model fit, and the 95% CI ranged from 0.046 to 0.056 within an acceptable range (<0.08). These results confirm that the measurement model achieved an acceptable fit for structural analysis. Correlated error terms were introduced based on theoretical relationships among similar items within the same latent constructs, such as monitoring disaster risk and communicating disaster information, as per Hair *et al.* (2016). This approach enhanced model fit indices while preserving construct validity.

4.5.1 The relationship between emergency response systems in facilities and emergency response outcome. This section evaluates the hypothesised relationships between key factors influencing emergency response in facilities and the overall emergency response outcome (OER). After validating the measurement model, the structural model was assessed using key indicators, coefficient of determination (R^2), predictive relevance (Q^2), path coefficients and the statistical significance of relationships to determine the model's explanatory power and the strength of inter-construct influences as illustrated in Figure 2.

From the results in Table 5, the coefficient of determination (R^2) for the factors influencing the effectiveness of emergency response was significantly high at 79.4% (R^2 = 0.794 and adjusted R^2 = 0.781). The Q-square value for the model was 0.782, indicating that the model's predictive power was highly relevant.

The path analysis revealed that several factors significantly influence ERI. Risk knowledge showed the strongest effect ($\beta = 0.637$, $Z = 8.847$, $p < 0.05$), as presented in Table 5. Other significant predictors were forecasting ($\beta = 0.277$, $Z = 4.291$, $p < 0.05$), warning dissemination and communication ($\beta = 0.245$, $Z = 5.131$, $p < 0.05$), preparedness ($\beta = 0.280$, $Z = 7.482$, $p < 0.05$) and recovery capabilities ($\beta = 0.300$, $Z = 4.616$, $p < 0.05$). These findings indicate that both technical and non-technical components contribute to strengthening ERI in facilities.

The hypothesis testing results show that *H1* (Preparedness), *H3* (Recovery capabilities), *H4* (Warning dissemination and communication), *H5* (Risk knowledge) and *H7* (Forecasting) significantly influence ERI and therefore support the proposed framework. In contrast, *H2* (Response capabilities) and *H6* (Monitoring) were not statistically significant.

5. Discussion of findings

Path analysis showed that response capabilities and risk monitoring had limited effects on Ghana's ERI. In contrast, preparedness, recovery capabilities, warning dissemination, communication, risk awareness and forecasting had strong positive impacts, emphasising their crucial roles in enhancing emergency performance. Understanding hazards and vulnerabilities is crucial for decision-making and operational readiness. Integrating localised risk data and socio-economic assessments into emergency planning enhances targeted mitigation and resource allocation (Sukhwani *et al.*, 2019; Abudu *et al.*, 2025a). Ongoing monitoring and evaluation in Disaster Management Systems are vital for predicting threats and coordinating timely responses (Khan *et al.*, 2020).

Similarly, forecasts showed a statistically significant positive effect on ERI, with a path coefficient of 0.277, a z-value of 4.291 and a p-value of less than 0.05. Accurate forecasting with early warning systems and real-time data enhances emergency systems' ability to anticipate and respond to disasters. Advanced technologies facilitate pre-emptive actions, like evacuations and resource mobilisation, reducing vulnerability and boosting resilience

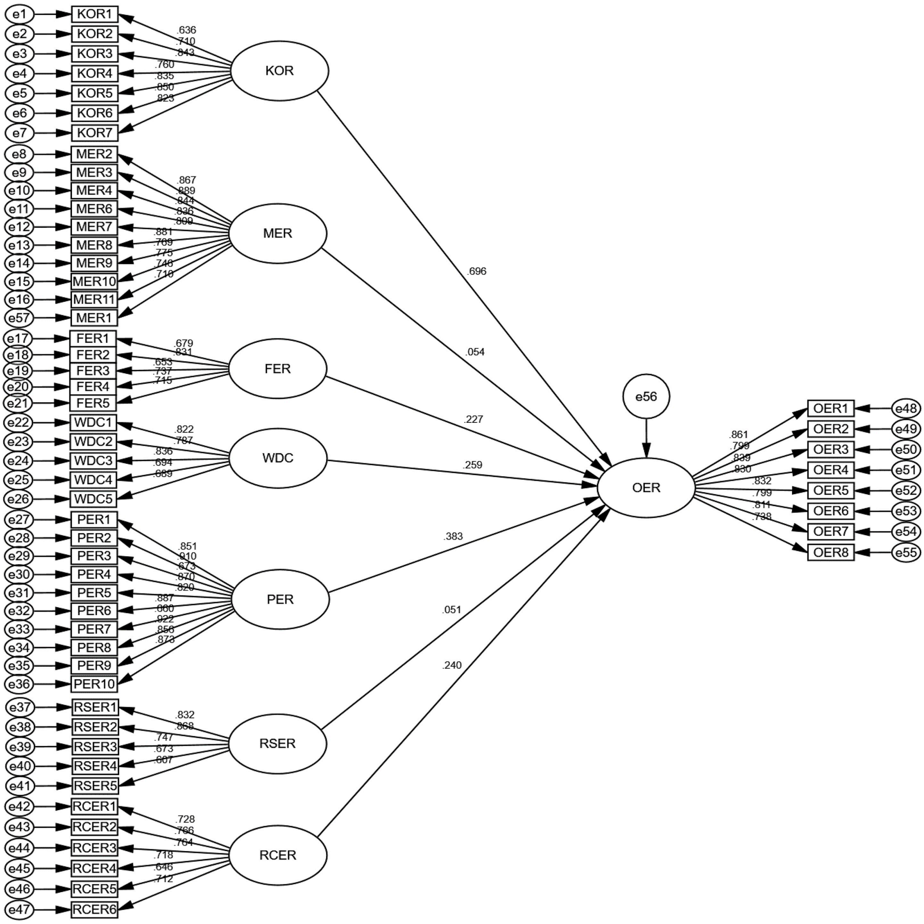

Figure 2. Path analysis of the factors influencing emergency response in facilities
Source: Fieldwork, 2025

(Basher, 2006; Abudu *et al.*, 2025b). The evolution of forecasting from theoretical modelling to real-time application has enhanced DRM, improving preparedness in emergencies. Effective forecasting relies on integrating geological and environmental data to provide timely alerts and support strategic planning (Khan *et al.*, 2020; Damaševičius *et al.*, 2023).

The findings shown in Table 5 indicate a statistically significant positive link between warning dissemination, communication and ERI, with a path coefficient of 0.245, a z-value of 5.131 and a p-value below 0.05. Timely communication and effective warning dissemination are crucial for emergency response. Reliable networks ensure critical information reaches stakeholders quickly, aiding coordination and reducing delays, highlighting the importance of structured communication in DRM (Cvetković *et al.*, 2021). Effective communication involves sharing hazard information, educating the public, engaging stakeholders and maintaining updated databases. In Ghana, challenges such as

Table 5. Path coefficients of the factors influencing emergency response

Path			Unstandardised coefficient	Standardised coefficient	Std. Error	Z-value	*R*-square	*p*-value
KOR	→	OER	0.637	0.696	0.072	8.847	0.794	<0.001
MER	→	OER	0.052	0.054	0.044	1.177		0.239
FER	→	OER	0.277	0.227	0.065	4.291		<0.001
WDC	→	OER	0.245	0.259	0.048	5.131		<0.001
PER	→	OER	0.280	0.383	0.037	7.482		<0.001
RSER	→	OER	0.048	0.051	0.045	1.070		0.285
RCER	→	OER	0.300	0.240	0.065	4.616		<0.001

Source(s): Fieldwork, 2025

limited public awareness and weak information flow can weaken early warnings (Mensah-Bonsu, 2022; Than *et al.*, 2020). However, technological innovations, including automated alerts and social media, are enhancing emergency communication (Dwarakanath *et al.*, 2021; Mukhopadhyay, 2023). Effective risk communication should be inclusive and context-sensitive, ensuring clear and credible messaging (Abudu *et al.*, 2025c). Throughout the disaster cycle, strategies integrated into training, hazard databases and mobile alerts can enhance preparedness (Tanesab, 2020; Kedia *et al.*, 2022; Damaševičius *et al.*, 2023). Additionally, involving local religious and social organisations in awareness programs can strengthen community preparedness and resilience (Sutton *et al.*, 2024).

Preparedness is linked to improved ERI, with a significant path coefficient of 0.280 (z-value: 7.482, $p < 0.05$). Comprehensive preparedness enhances the effectiveness of emergency systems. Facilities that focus on planning, resource allocation and training respond better to disasters, reducing impact and recovery time. Poor preparedness can have serious consequences, as seen in Germany during the 2021 floods (Nick *et al.*, 2023), and developing regions are particularly vulnerable due to inadequate structures and planning (Mensah-Bonsu, 2022). Essential elements such as hazard forecasting, early warning systems and risk assessments are crucial for timely responses (Cvetković *et al.*, 2021). Preparedness efforts require both technical infrastructure, like shelters and logistics centres (Mukhopadhyay, 2023), and institutional capacity, including community engagement and risk communication (Perera *et al.*, 2020). Challenges such as poor governance and low public awareness can hinder effectiveness. Inclusive engagement of government, civil society and marginalised groups is vital for effective disaster risk reduction (Nick *et al.*, 2023; Perera *et al.*, 2020). Promoting preparedness through education and community networks strengthens grassroots resilience (Ntim, 2023; Sutton *et al.*, 2024). Additionally, aligning national DRR strategies with localised implementation protocols improves clarity and resource mobilisation. Investment in early warning systems, resilient infrastructure and localised mitigation remains fundamental to long-term preparedness (Bello *et al.*, 2021; Damaševičius *et al.*, 2023).

The study emphasises the strong connection between recovery capacity and effective emergency response initiatives (ERI). Key efforts, such as infrastructure repair and psychosocial support, are vital for restoring normalcy after disasters (Cho and Choi, 2024). Prompt damage assessments and legal disaster declarations are essential for recovery planning (Mensah-Bonsu, 2022; Cho and Choi, 2024). Pre-disaster planning guides rebuilding strategies, whereas accurate assessments enhance recovery (Fekete *et al.*, 2020; Gupta *et al.*, 2022). Investment in resilient infrastructure and adaptable recovery policies promotes sustainable disaster management (Cvetković *et al.*, 2021; Sutton *et al.*, 2024). The non-significant results for response capabilities (*H2*) and monitoring (*H6*) suggest these factors may not directly affect ERI in the studied area. Response capabilities are reactive and vary by institution, but monitoring systems may lack integration into emergency management frameworks. These findings highlight the need for improved institutional coordination, technological integration and capacity development to enhance ERI.

6. Managerial and policy implications

The study provides practical insights for facility managers and policymakers to strengthen ERI. Managers should prioritise risk knowledge, forecasting systems and effective communication platforms to improve preparedness and response capacity within facilities.

From a policy perspective, government agencies should enhance disaster risk reduction policies, early warning systems and stakeholder coordination. The proposed framework offers a practical guide for strategic planning, policy development and investment decisions to improve crisis management and resilience in facilities.

7. Conclusions

This study developed the factors influencing ERI in facilities using a PLS-SEM approach. The results demonstrate that both technical and non-technical components are critical for strengthening crisis management systems. The structural analysis shows that risk knowledge, forecasting, warning dissemination and communication, preparedness and recovery capabilities significantly influence ERI effectiveness. In contrast, response capabilities and monitoring were not statistically significant in the model. These findings highlight the importance of integrating disaster risk, predictive systems, policy enforcement, communication mechanisms and coordinated recovery planning to enhance facility-level emergency response.

Based on these results, the study proposes a framework for modernising ERI that combines technical elements, such as risk assessment, monitoring and forecasting, with non-technical dimensions, including institutional preparedness, communication systems and recovery planning. This integrated approach provides a structured, measurable basis for improving disaster preparedness, guiding policy development and supporting strategic investment in resilient infrastructure. The framework strengthens crisis management by enhancing institutions' ability to protect lives, safeguard critical assets and improve coordination across stakeholders.

This study is limited to professionals within selected districts, municipalities and metropolitan assemblies in the Ashanti Region of Ghana, which may affect the generalisability of the findings to other contexts. In addition, the analysis relies on questionnaire data, which may introduce perception bias. Future research could expand the geographical scope, incorporate longitudinal data and explore the role of emerging technologies and community-based approaches in further improving ERI systems.

References

Abudu, H.D., Mewomo, C.M., Adjei, K.O. and Bondinuba, F.K. (2025a), "Challenges In emergency response infrastructure: a systematic literature review", *Journal of Civil Engineering, Science and Technology*, Vol. 16 No. 2, pp. 269-279, doi: 10.33736/jcest.8972.2025.

Abudu, H.D., Mewomo, C.M., Adjei, K.O. and Bondinuba, F.K. (2025b), "Assessing emergency response systems and their impact on infrastructure resilience: a literature review", *In, Proceedings of the International Conference on Construction Business and Project Management Conference 2025(CBPMC)*, University of Cape Town, pp. 425-431.

Abudu, H.D., Mewomo, C.M., Adjei, K.O. and Bondinuba, F.K. (2025c), "A systematic review of the mitigating factors for emergency response in facilities", *CIB Conferences*, Vol. 1 No. 1, p. 187, doi: 10.7771/3067-4883.1856.

Abudu, H.D., Mewomo, C.M., Adjei, K.O., Bondinuba, F.K. and Liphadzi, M. (2026), "The influence of technical and non-technical emergency response systems on infrastructure resilience", *Journal of Construction Business and Management*, Vol. 8 No. S1, pp. 30-47, doi: 10.15641/jcbm.8.S1.1923.

Adjei, K.O., Abudu, H.D., Nana-Addy, E. and Musonda, I. (2025a), "The motivation for occupants' adoption of hidden emergency exits in buildings", *Engineering, Construction and Architectural Management*, Vol. 32 No. 13, pp. 133-147, doi: 10.1108/ECAM-04-2023-0326.

Adjei, K.O., Liphadzi, M., Bondinuba, F.K. and Bonney, S.O. (2025b), "Unveiling the barriers hindering occupants' adoption and utilisation of concealed emergency exits in facilities", *Facilities*, Vol. 43 No. 15-16, 16-31, doi: 10.1108/F-09-2024-0120.

Basher, R. (2006), "Global early warning systems for natural hazards: systematic and people-centred", *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, Vol. 364 No. 1845, pp. 2167-2182, doi: 10.1098/rsta.2006.1819.

Bello, O., Bustamante, A. and Pizarro, P. (2021), "Planning for disaster risk reduction within the framework of the 2030 Agenda for sustainable development", available at: https://hdl.handle.net/11362/46639 (accessed 18 May 2026).

Chen, W., Zhai, G., Fan, C., Jin, W. and Xie, Y. (2017), "A planning framework based on system theory and GIS for urban emergency shelter system: a case of Guangzhou, China", *Human and Ecological Risk Assessment: An International Journal*, Vol. 23 No. 3, pp. 441-456, doi: 10.1080/10807039.2016.1185692.

Cho, H. and Choi, N. (2024), "Analysing vulnerabilities of disaster risk management systems of local governments in South Korea: Evidence from National Audit Office Reports", *Systems*, Vol. 12 No. 3, p. 76.

Cvetković, V.M., Tanasić, J., Ocal, A., Kešetović, Ž, Nikolić, N. and Dragašević, A. (2021), "Capacity development of local self-governments for disaster risk management", *International Journal of Environmental Research and Public Health*, Vol. 18 No. 19, p. 10406.

Damaševičius, R., Bacanin, N. and Misra, S. (2023), "From sensors to safety: internet of emergency services (IoES) for emergency response and disaster management", *Journal of Sensor and Actuator Networks*, Vol. 12 No. 3, p. 41.

Dudenhoeffer, D.D., Permann, M.R. and Manic, M. (2006), "CIMS: a framework for infrastructure interdependency modelling and analysis", *In Proceedings of the 2006 Winter Simulation Conference*, *IEEE*, pp. 478-485, doi: 10.1109/WSC.2006.323119.

Dwarakanath, L., Kamsin, A., Rasheed, R.A., Anandhan, A. and Shuib, L. (2021), "Automated machine learning approaches for emergency response and coordination via social media in the aftermath of a disaster: a review", *IEEE Access*, Vol. 9, pp. 68917-68931, doi: 10.1109/ACCESS.2021.3074819.

Fekete, A., Asadzadeh, A., Ghafory-Ashtiany, M., Amini-Hosseini, K., Hetkämper, C., Moghadas, M. and Kötter, T. (2020), "Pathways for advancing integrative disaster risk and resilience management in Iran: needs, challenges and opportunities", *International Journal of Disaster Risk Reduction*, Vol. 49, p. 101635, doi: 10.1016/j.ijdrr.2020.101635.

Gilmore, J.N. and DuRant, M. (2021), "Emergency infrastructure and locational extraction: Problematizing computer-assisted dispatch systems as a public good", *Surveillance and Society*, Vol. 19 No. 2, pp. 187-198, doi: 10.24908/ss.v19i2.14116.

Gupta, S., Modgil, S., Kumar, A., Sivarajah, U. and Irani, Z. (2022), "Artificial intelligence and cloud-based collaborative platforms for managing disaster, extreme weather and emergency operations", *International Journal of Production Economics*, Vol. 254, p. 108642, doi: 10.1016/j.ijpe.2022.108642.

Hair, J.F., Jr, Sarstedt, M., Matthews, L.M. and Ringle, C.M. (2016), "Identifying and treating unobserved heterogeneity with FIMIX-PLS: Part I–method", *European Business Review*, Vol. 28 No. 1, pp. 63-76, doi: 10.1108/EBR-09-2015-0094.

Kedia, T., Ratcliff, J., O'Connor, M., Oluic, S., Rose, M., Freeman, J. and Rainwater-Lovett, K. (2022), "Technologies enabling situational awareness during disaster response: a systematic review", *Disaster Medicine and Public Health Preparedness*, Vol. 16 No. 1, pp. 341-359, doi: 10.1017/dmp.2020.196.

Khan, A., Gupta, S. and Gupta, S.K. (2020), "Multi-hazard disaster studies: monitoring, detection, recovery, and management, based on emerging technologies and optimal techniques", *International Journal of Disaster Risk Reduction*, Vol. 47, p. 101642, doi: 10.1016/j.ijdrr.2020.101642.

Matveev, A.V., Maximov, A.V. and Zadurova, A.A. (2021) Simulation model of emergency evacuation in case of fire in a nightclub", In *IOP Conference Series: Earth and Environmental Science*, Vol. 720 No. 1, p. 012019, doi: 10.1088/1755-1315/720/1/012019.

Mensah-Bonsu, E. (2022), "A critical review of the disaster management system in Ghana", *ADRRI Journal (Multidisciplinary)*, Vol. 31 No. 2, pp. 88-110, doi: 10.55058/adrrij.v31i2%20(8),% 20 April,%202022-June.894.

Mukhopadhyay, A. (2023), "Artificial intelligence for emergency response", arXiv Preprint, doi: 10.48550/arXiv.2306.10068.

Myeong, S., Kim, Y. and Ahn, M.J. (2020), "Smart city strategies-technology push or culture pull? A case study exploration of Gimpo and Namyangju, South Korea", *Smart Cities*, Vol. 4 No. 1, pp. 41-53, doi: 10.3390/smartcities4010003.

Nick, F.C., Sänger, N., van der Heijden, S. and Sandholz, S. (2023), "Collaboration is key: exploring the 2021 flood response for critical infrastructures in Germany", *International Journal of Disaster Risk Reduction*, Vol. 91, p. 103710, doi: 10.1016/j.ijdrr.2023.103710.

Ntim, N.S. (2023), "Mainstreaming disaster risk reduction in the curriculum of colleges of education in Ghana", *Open Journal of Educational Research*, Vol. 3 No. 1, pp. 17-27, doi: 10.31586/ojer.2023.627.

Perera, D., Agnihotri, J., Seidou, O. and Djalante, R. (2020), "Identifying societal challenges in flood early warning systems", *International Journal of Disaster Risk Reduction*, Vol. 51, p. 101794, doi: 10.1016/j.ijdrr.2020.101794.

Savalei, V. and Bentler, P.M. (2006), "Structural equation modeling. The handbook of marketing research: uses, misuses", *Future Adv*, Vol. 330, p. 36.

Sharma, N. and Gardoni, P. (2018), "Modelling the time-varying performance of electrical infrastructure during post-disaster recovery using tensors", In *Routledge Handbook of Sustainable and Resilient Infrastructure*, Routledge, p. 263.

Son, C., Sasangohar, F., Neville, T., Peres, S.C. and Moon, J. (2020), "Investigating resilience in emergency management: an integrative review of literature", *Applied Ergonomics*, Vol. 87, p. 103114, doi: 10.1016/j.apergo.2020.103114.

Sukhwani, V., Gyamfi, B.A., Zhang, R., AlHinai, A.M. and Shaw, R. (2019), "Understanding the barriers restraining effective operation of flood early warning systems", *International Journal of Disaster Risk Management*, Vol. 1 No. 2, pp. 1-19, doi: 10.18485/ijdrm.2019.1.2.1.

Sutton, J., Olson, M.K. and Waugh, N.A. (2024), "The warning lexicon: a multiphased study to identify, design, and develop content for warning messages", *Natural Hazards Review*, Vol. 25 No. 1, p. 04023055, doi: 10.1061/NHREFO.NHENG-1900.

Tanesab, J.P. (2020), "Institutional effectiveness and inclusions: public perceptions on Indonesia's disaster management authorities", *International Journal of Disaster Management*, Vol. 3 No. 2, pp. 1-15, doi: 10.24815/ijdm.v3i2.17621.

Than, Z., Kyi, T. and Kraas, F. (2020), "Institutional preparedness for multiple risks in yangon, Myanmar", *Journal of the Myanmar Academy of Arts and Science*, pp. 61-74.

Lu, M. and Lu, W. (2025), "Review of structural equation modelling (SEM) application in construction management", *Engineering, Construction and Architectural Management*, doi: 10.1108/ECAM-08-2024-1161.

Wang, H., Ye, H., Liu, L. and Li, J. (2022), "Evaluation and obstacle analysis of emergency response capability in China", *International Journal of Environmental Research and Public Health*, Vol. 19 No. 16, p. 10200.

Wang, K., Huang, G., Yu, H., Jiang, H. and Gao, X. (2024), "A novel data-driven triangular-type staircase layout design in personnel safety evacuation in high-rise buildings", *Journal of Building Engineering*, Vol. 84, p. 108429, doi: 10.1016/j.jobe.2023.108429.

Wu, Y., Lin, Z., Liu, C., Huang, T., Chen, Y., Ru, Y. and Chen, J. (2022), "Resilience enhancement for urban distribution network via risk-based emergency response plan amendment for ice disasters", *International Journal of Electrical Power and Energy Systems*, Vol. 141, p. 108183, doi: 10.1016/j.ijepes.2022.108183.

Ye, R., Li, J., Lu, H., Wang, J., Pan, Y. and Wang, Y. (2024), "A study on the arch mechanism of pedestrian evacuation and congestion alleviation strategies at building exits", *Journal of Building Engineering*, Vol. 88, p. 109159, doi: 10.1016/j.jobe.2024.109159.

Zhou, Y., Wang, Y., Li, C., Ding, L. and Wang, C. (2024), "*Automatic Generative Design and Optimisation of Hospital Building Layouts in Consideration of Public Health Emergency*", *Engineering, Construction and Architectural Management*, Vol. 31 No. 4, pp. 1391-1407, doi: 10.1108/ECAM-08-2022-0757.

Zualkernan, I.A., Aloul, F.A., Sakkia, V., Al Noman, H., Sowdagar, S. and Al Hammadi, O. (2019), "An IoT-based emergency evacuation system", In 2019 IEEE International Conference on Internet of Things and Intelligence System (IoTaIS), *IEEE*, pp. 62-66, doi: 10.1109/IoTaIS47347.2019.8980381.

Further reading

Alam, E. and Ray-Bennett, N.S. (2021), "Disaster risk governance for district-level landslide risk management in Bangladesh", *International Journal of Disaster Risk Reduction*, Vol. 59, p. 102220, doi: 10.1016/j.ijdrr.2021.102220.

Al Kurdi, O.F. (2021), "A critical comparative review of emergency and disaster management in the arab world", *Journal of Business and Socio-Economic Development*, Vol. 1 No. 1, pp. 24-46, doi: 10.1108/JBSED-02-2021-0021.

Al-Wathinani, A.M., Barten, D.G., Borowska-Stefańska, M., Gołda, P., AlDulijan, N.A., Alhallaf, M. A., … and Goniewicz, K. (2023), "*Driving Sustainable Disaster Risk Reduction: A Rapid Review of the Policies and Strategies in Saudi Arabia*", *Sustainability*, Vol. 15 No. 14, p. 10976.

Delaney, A. and Kitchin, R. (2023), "Progress and prospects for data-driven coordinated management and emergency response: the case of Ireland", *Territory, Politics, Governance*, Vol. 11 No. 1, pp. 174-189, doi: 10.1080/21622671.2020.1805355.

Kalogiannidis, S., Toska, E., Chatzitheodoridis, F. and Kalfas, D. (2022), "Using school systems as a hub for risk and disaster management: a case study of Greece", *Risks*, Vol. 10 No. 5, p. 89, doi: 10.3390/risks10050089.

Kankanamge, N., Yigitcanlar, T., Goonetilleke, A. and Kamruzzaman, M. (2020), "How can gamification be incorporated into disaster emergency planning? A systematic review of the literature", *International Journal of Disaster Resilience in the Built Environment*, Vol. 11 No. 4, pp. 481-506, doi: 10.1108/IJDRBE-08-2019-0054.

Khalid, M., Awais, M., Singh, N., Khan, S., Raza, M., Malik, Q.B. and Imran, M. (2021), "Autonomous transportation in emergency healthcare services: framework, challenges, and future work", *IEEE Internet of Things Magazine*, Vol. 4 No. 1, pp. 28-33, doi: 10.1109/IOTM.0011.2000076.

Li, Y., Hsu, E.B., Pham, N., Davis, X.M., Podgornik, M.N. and Trigoso, S.M. (2022), "Developing public health emergency response leaders in incident management: a scoping review of educational interventions", *Disaster Medicine and Public Health Preparedness*, Vol. 16 No. 5, pp. 2149-2178, doi: 10.1017/dmp.2021.164.

Merz, B., Kuhlicke, C., Kunz, M., Pittore, M., Babeyko, A., Bresch, D.N., … and Wurpts, A. (2020), "Impact forecasting to support emergency management of natural hazards", *Reviews of Geophysics*, Vol. 58 No. 4, p. e2020RG000704, doi: 10.1029/2020RG000704.

Peixoto, J.P.J., Costa, D.G., Portugal, P. and Vasques, F. (2024), "Flood-resilient smart cities: a data-driven risk assessment approach based on geographical risks and emergency response infrastructure", *Smart Cities*, Vol. 7 No. 1, pp. 662-679.

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