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Designing a Decision-Making Model for Emergency Evacuation of Hospitals in Crisis Conditions

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A B S T R A C T

This study aimed to design a comprehensive and empirically validated decision-making model for the emergency evacuation of hospitals in crisis conditions, integrating environmental, institutional, and threat-related variables. This applied research employed a mixed-methods design. In the qualitative phase, data were gathered through semi-structured interviews with seven crisis and hospital management experts, combined with thematic analysis using Braun and Clarke's six-step method and supported by MAXQDA software. These interviews, along with an extensive literature review, were used to identify themes and build the initial conceptual model. The quantitative phase involved the development and distribution of a validated researcher-made questionnaire, which was administered to 440 healthcare managers, decision-makers, and crisis specialists. Factor analysis, Cronbach's alpha, and structural equation modeling (SEM) using LISREL were employed to assess the model's validity, reliability, and predictive power. The findings confirmed the significance of three primary dimensions—external environment, hospital-related factors, and threats/crises—in shaping emergency evacuation decisions. The coefficient of determination (R^2) for the external environment and hospital factors was 0.90 each, indicating very high explanatory power, while threats and crises showed a moderate R^2 of 0.45. All 59 questionnaire items had strong factor loadings, and Cronbach's alpha values for each construct exceeded 0.94, confirming the tool's reliability. Path analysis demonstrated statistically significant direct effects: external environment ($\beta = 0.59$, $t = 26.47$), hospital factors ($\beta = 0.55$, $t = 31.03$), and threat/crisis conditions ($\beta = 0.45$, $t = 15.90$). The study presents a validated, multidimensional model for hospital evacuation decision-making that reflects both theoretical soundness and practical applicability. The model offers a structured approach for healthcare systems to improve emergency preparedness and response capacity by aligning institutional readiness with external and situational demands.

Keywords: *Hospital evacuation, crisis decision-making, emergency preparedness, structural equation modeling, disaster management, healthcare resilience.*

1. Introduction

In an era marked by increasing frequency, intensity, and complexity of disasters—both natural and man-made—the

capacity of healthcare systems to respond effectively has emerged as a vital concern in public health and emergency management. Hospitals, as critical infrastructures, are not only central to managing mass casualties but also highly vulnerable entities themselves. In crisis situations such as earthquakes, floods, pandemics, fires, or acts of terrorism, hospitals must make rapid, evidence-informed decisions regarding evacuation, resource allocation, and continuity of care. The success or failure of these decisions can determine the survival of both patients and personnel, underscoring the urgent need for structured, context-sensitive evacuation models that integrate hospital-specific, environmental, and incident-based variables (Boin & McConnell, 2007; Yaghoubi et al., 2017).

Despite significant global attention to hospital preparedness, the lack of a coherent decision-making framework for hospital evacuation remains a serious gap, particularly in developing countries with complex health governance structures. The COVID-19 pandemic starkly highlighted these deficiencies, exposing how uncoordinated responses and weak institutional resilience can exacerbate risks to both healthcare workers and patients (Afulani et al., 2021; Ahmady et al., 2020). A robust decision-making model must account not only for physical and infrastructural considerations but also for procedural clarity, external coordination, and the dynamic nature of disaster scenarios. In this context, disaster preparedness must shift from passive contingency planning to active decision architecture built on systematic data and scenario-based projections (Nguyen et al., 2022; Velner et al., 2023).

The decision to evacuate a hospital is inherently multidimensional and involves weighing the severity of the threat, internal hospital resilience, external environmental conditions, and the capabilities of local emergency systems. However, decision-making during crises often unfolds in high-pressure, time-sensitive conditions, where ambiguity and risk amplify the likelihood of error. This calls for a systemic model that facilitates rapid, yet informed, judgments rooted in both qualitative judgment and quantitative data (Cuthbertson, 2023; Ortíz-Barrios et al., 2020). The process must also integrate ethical imperatives—ensuring that patient safety, dignity, and continuity of care remain uncompromised even in the most volatile circumstances (Cuthbertson, 2023).

One of the critical limitations in current hospital evacuation frameworks is the lack of interoperability between internal hospital protocols and the broader urban crisis management systems. When these systems fail to communicate effectively, logistical bottlenecks, redundancy of roles, and information asymmetries can arise, reducing the effectiveness of emergency response (Pudineh et al., 2022; Un et al., 2023). Moreover, empirical evidence indicates that hospitals often lack the analytical tools to prioritize actions based on severity, proximity, and cascading impacts of threats (Essien & Petrounias, 2022; Ghandi & Roozbahani, 2019). As such, decision models must also incorporate geospatial data, critical infrastructure interdependencies, and social variables that influence access, evacuation, and post-disaster recovery (Nguyen et al., 2022; Siddiqi et al., 2023).

In the Iranian context, studies have documented a notable gap between policy formulation and operational readiness in hospital-based disaster response (Hossein-Sadrabadi, 2023; Jannat et al., 2022). While strategic documents may outline evacuation protocols, practical implementation often suffers from unclear delegation of authority, inadequate training, and outdated infrastructure. In this regard, modeling decision-making as a function of hospital capacity, environmental constraints, and incident typology becomes not just an academic exercise but a policy imperative (Amjadi & Rahmani, 2014; Rad & Kojouri, 2021). The current study addresses this gap by designing an integrated decision-making model tailored to the structural realities and operational dynamics of hospitals in crisis-prone regions.

Hospital evacuation planning also involves psychological, cultural, and professional dimensions. The stress on healthcare staff, moral dilemmas in prioritizing patients, and disruptions in communication channels all contribute to decision fatigue and reduced situational awareness (Afulani et al., 2021; Argyriadis et al., 2023). Organizational culture, leadership style, and institutional memory from previous incidents significantly influence the effectiveness of real-time decisions. Transformational leadership, for example, has been shown to improve organizational resilience and team cohesion in disaster settings by promoting adaptive thinking and decentralized problem-solving (Mohtady Ali et al., 2023; Velner et al., 2023).

At the same time, models for decision-making in hospital evacuations must be scalable and modular, able to accommodate various scenarios ranging from partial to full evacuations and from isolated incidents to large-scale systemic crises. Tools such as the Analytical Hierarchy Process (AHP), when applied in emergency management, have proven effective in evaluating multiple criteria and selecting the most appropriate response pathways (Maksimović, 2024). Multi-criteria decision-making

(MCDM) approaches are especially relevant in dynamic environments where resources are constrained, and trade-offs are inevitable (Ortíz-Barrios et al., 2020). Incorporating such tools within the proposed model strengthens its practical utility and facilitates its implementation across diverse hospital settings.

In designing a comprehensive model, this study also draws from interdisciplinary insights on resilience theory, health governance, and public policy. For instance, studies have emphasized that the resilience of a health organization depends not only on its technical capabilities but also on legal frameworks, community trust, and continuous staff training (Boin & McConnell, 2007; Hossein-Sadrabadi, 2023). Resilient systems are characterized by their ability to anticipate, absorb, and adapt to shocks, which in the case of hospitals, includes having well-trained personnel, robust communication systems, and predefined evacuation pathways (Fühner et al., 2021; Velner et al., 2023). The integration of such resilience-building components within the decision-making model ensures that the response to crises is not merely reactive but strategically proactive.

Moreover, the study is informed by the lessons of real-world hospital evacuations, both successful and failed, to ensure that the proposed model is grounded in empirical realities. Case studies show that failures in decision-making are often due to over-centralization, delayed information flows, and fragmented command structures (Ahmady et al., 2020; Nguyen et al., 2022). Conversely, hospitals that fared better during disasters often had flexible structures, predefined command hierarchies, and strong inter-institutional collaboration (Afulani et al., 2021; Un et al., 2023). The model thus emphasizes role clarity, information transparency, and cross-sectoral coordination as essential design principles.

Additionally, ethical considerations cannot be sidelined in hospital evacuation planning. Decisions about who should be evacuated first, how resources should be distributed, and what constitutes acceptable risk must align with ethical frameworks that respect human rights and uphold professional obligations (Argyriadis et al., 2023; Cuthbertson, 2023). This study incorporates ethical decision-making as a component of the model, recognizing that crisis situations often present difficult trade-offs that require transparent and principled resolution mechanisms.

Finally, this research contributes to both theory and practice by offering a validated model that bridges strategic preparedness with operational decision-making in hospital evacuation. Drawing on a mixed-methods approach—including qualitative interviews with crisis experts and quantitative validation through structural equation modeling—the study integrates evidence from diverse fields to build a comprehensive, adaptable, and context-relevant decision framework. In doing so, it aims to enhance institutional readiness and reduce uncertainty in one of the most critical domains of disaster response: the emergency evacuation of healthcare facilities (Essien & Petrounias, 2022; Fazeli Veisari et al., 2021; Rad & Kojouri, 2021; Siddiqi et al., 2023).

In sum, hospital evacuation is a multidimensional challenge that requires integrative thinking, technical precision, and ethical clarity. This study addresses the pressing need for an empirically grounded, theoretically informed, and operationally viable model for decision-making under crisis conditions.

2. Methods and Materials

This study adopts an applied research design aimed at creating a practical decision-making model for emergency evacuation in hospitals during crisis scenarios. The final model is intended to be applicable across various healthcare institutions and policymaking centers in the health system. The research methodology is mixed-method in nature, combining both qualitative and quantitative approaches to ensure a comprehensive understanding of the issue. The qualitative phase is exploratory and relies heavily on thematic content analysis, while the quantitative phase is confirmatory and analytical in structure.

In the qualitative phase, participants were selected purposefully through quota sampling to ensure the inclusion of key stakeholders with rich insights into hospital crisis management. The targeted participants included experts in hospital disaster management, public health governance, and policy decision-making in the healthcare domain. Seven highly experienced professionals from academic and managerial positions were interviewed until theoretical saturation was reached, indicating no new concepts were emerging from additional interviews.

The quantitative phase focused on a broader population consisting of healthcare managers, administrators, and decision-makers within the Iranian health system, particularly those affiliated with the Social Security Organization (SSO) hospitals. Initially, 81 individuals meeting the criteria of experience and relevance to the domain were surveyed using structured questionnaires. However, to enhance the statistical power of structural

equation modeling (SEM) and reduce sampling error, a bootstrapping technique was employed to increase the final sample size to 440, using random resampling from the initial respondents. This allowed for more robust path analysis and model validation.

The scope of the research spans across public hospitals under the Social Security Organization and other medical centers in Iran. The temporal boundary of the study covers the years 2020 to 2024, ensuring that the data reflect contemporary practices in crisis decision-making. The thematic focus encompasses organizational management, public policy, crisis management, and emergency evacuation planning.

Data collection was conducted through multiple channels to ensure methodological triangulation and increase data reliability. In the qualitative phase, data were gathered from two primary sources: literature review and semi-structured interviews. The literature review drew upon scholarly articles, official documents, books, and web-based sources related to crisis management, evacuation protocols, and decision-making in hospital settings. These materials served as the foundation for developing interview questions that were aligned with the objectives of the study.

The semi-structured interviews were conducted using a researcher-designed interview protocol containing 12 open-ended questions. The structure allowed flexibility for interviewees to elaborate on their experiences and perspectives while maintaining focus on key variables. This method enabled the researcher to explore hidden patterns, meanings, and relationships among concepts relevant to emergency evacuation decisions. Thematic analysis followed the six-phase Braun and Clarke approach, which includes familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. MAXQDA software was used to facilitate the coding and thematic organization of qualitative data.

In the quantitative phase, a researcher-developed questionnaire was employed to test and validate the initial conceptual model derived from qualitative findings. The questionnaire was constructed based on insights gained from interviews and literature, ensuring alignment with the core components of emergency evacuation decision-making. Care was taken to ensure the clarity, neutrality, and interpretability of the items, avoiding leading or confusing wording.

To establish content validity, the questionnaire underwent expert review using Lawshe's Content Validity Ratio (CVR) method. A panel of 10 subject matter experts was consulted to assess the necessity of each item on a three-point Likert scale. Items with a CVR value exceeding 0.62 were retained, in line with Lawshe's threshold for content validity. The aim was to ensure that the questionnaire adequately captured the domain of interest.

Reliability testing of the questionnaire was conducted using Cronbach's alpha to determine internal consistency. The results confirmed the reliability of all subscales: 0.998 for external environment, 0.995 for hospital components, 0.949 for threats and crises, and an overall alpha of 0.995 for the entire instrument—indicating excellent internal consistency across all dimensions.

Data analysis was performed in two distinct phases to accommodate the mixed-method design. In the qualitative phase, thematic analysis using Braun and Clarke's six-step method was employed. These steps included repeated reading of the data, generating initial codes, organizing codes into potential themes, refining those themes, defining the scope and content of each theme, and finally, reporting the themes. Thematic coding was conducted both at the semantic (explicit) and latent (implicit) levels, allowing for a deep and nuanced understanding of the evacuation decision-making process. The qualitative data analysis was supported by MAXQDA software to enhance analytical accuracy and transparency.

In the quantitative phase, statistical analysis was conducted using LISREL software to perform structural equation modeling (SEM). This approach enabled the researchers to test the hypothesized relationships among variables identified in the conceptual model. The analysis focused on examining the paths between latent constructs and verifying the model's goodness-of-fit. By integrating the bootstrapping technique with SEM, the analysis benefited from increased statistical robustness and reduced sampling bias. The empirical validation provided by this analysis was essential in confirming the reliability and relevance of the conceptual model derived in the qualitative phase.

In sum, this study employed a sequential exploratory design in which qualitative exploration informed the development of a conceptual framework that was subsequently tested and refined through quantitative analysis. The use of triangulated data sources, expert validation, and robust analytical techniques ensured the scientific rigor and practical relevance of the proposed emergency evacuation decision-making model for hospitals during crisis situations.

3. Findings and Results

The initial phase of this study involved extensive qualitative analysis aimed at identifying the core components and dimensions of hospital emergency evacuation decision-making under crisis conditions. By analyzing expert interviews and reviewing relevant literature, the research team extracted a thematic network that captures the underlying structure of the decision-making model. The themes and sub-themes derived from the qualitative data were categorized under three major dimensions: Crisis and Incident, Hospital, and External Environment. Each dimension was further broken down into key components and related thematic codes, representing the critical variables influencing evacuation decisions. These formed the basis for designing the questionnaire used in the quantitative phase and ultimately informed the structural modeling of inter-variable relationships.

Table 1

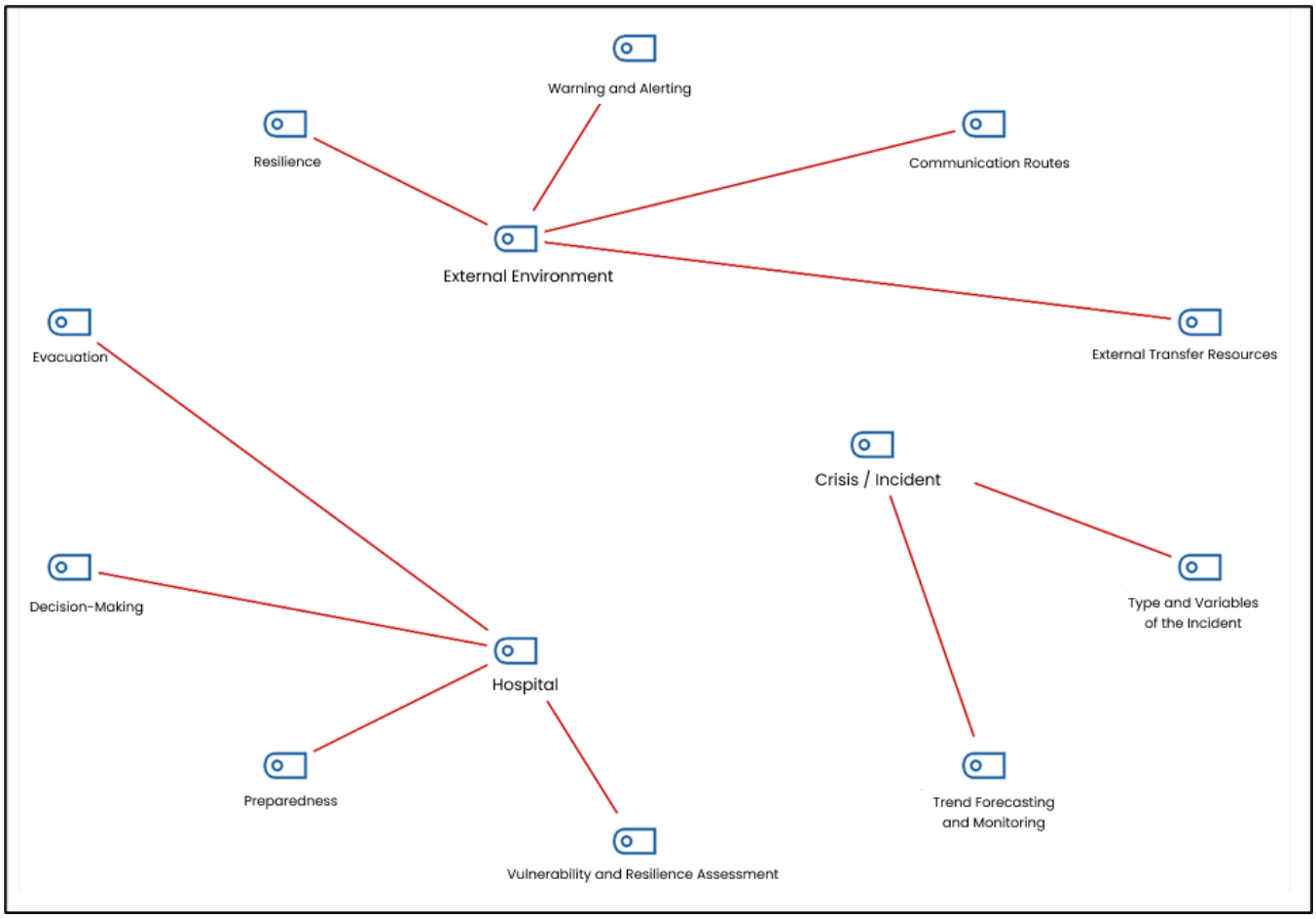
Thematic Network of Hospital Emergency Evacuation Decision-Making Model

Dimension	Component	Themes
Crisis / Incident	Type and Variables of the Incident	Type of incident, location, duration, scope, intensity, time of onset
	Trend Forecasting and Monitoring	Identifying situations, forecasting impact on hospital and society
Hospital	Vulnerability and Resilience Assessment	Hospital structure and physical space, critical medical equipment, electricity, backup generators, medical gases, water, steam and energy, chillers and boilers, hospital security, communication, information, and data backup
	Preparedness	Defined roles, responsibilities, hospital incident command system, drills, scenario planning
	Decision-Making	Decision-making context, decision methods, decision process, speed, and decision-makers
	Evacuation	Types of evacuation, evacuation models, evacuation process, evacuation methods, individual and group variables in evacuation, emergency evacuation planning
External Environment	Resilience	Community safety, buildings and structures, infrastructure
	Warning and Alerting	Communication channels, source reliability, frequency and quantity of alerts, certainty, clarity, message appropriateness and timing
	Communication Routes	Access to other centers, traffic conditions, hospital entry/exit access
	External Transfer Resources	Transport equipment, availability, and readiness

This thematic analysis led to the development of an initial conceptual model that encapsulates the multifaceted nature of emergency evacuation decision-making in hospitals during crises. The Crisis and Incident dimension highlights the necessity of understanding the type and predictability of disasters and their likely impacts. The Hospital dimension underscores internal readiness, infrastructural resilience, and procedural efficiency regarding evacuation protocols and decision processes. Finally, the External Environment dimension emphasizes the influence of external infrastructure, warning systems, and logistics on the feasibility and timing of evacuations. The resulting model was then subjected to quantitative validation through a structured questionnaire, with input from healthcare managers and crisis professionals. This two-stage approach ensured that the conceptual model was grounded in both theoretical relevance and practical expertise.

Figure 1

Conceptual Model



The demographic profile of the respondents in this study reflects a balanced yet diverse representation of professionals involved in hospital crisis management and healthcare decision-making. Out of a total of 440 participants, 256 individuals (58%) were male, and 184 (42%) were female, indicating a moderate gender imbalance in favor of male respondents. The age distribution shows that a significant portion of the sample was middle-aged, with the highest concentration (22%) in the 52–57 age group, followed closely by those over 57 years (21%) and those aged 47–52 (18%). Only 9% of the respondents were within the youngest age bracket of 32–37 years. In terms of work experience, the majority had substantial professional tenure, with 24% having between 21–24 years of experience, and 23% between 18–21 years. Notably, even those with over 24 years of experience comprised 16% of the sample, highlighting the inclusion of seasoned experts. Regarding educational attainment, most respondents held postgraduate qualifications, with 47% having a master's degree and 13% holding a doctorate. Meanwhile, 40% possessed a bachelor's degree. This demographic composition suggests that the study's findings are based on insights from a highly experienced and academically qualified group of decision-makers in the healthcare crisis response sector.

Table 2

Factor Loadings of the Questionnaire Items (Communalities)

Item Code	Initial	Extraction	Item Code	Initial	Extraction
VAR00001	1.000	0.945	VAR00031	1.000	0.914
VAR00002	1.000	0.911	VAR00032	1.000	0.913
VAR00003	1.000	0.960	VAR00033	1.000	0.940

VAR00004	1.000	0.943	VAR00034	1.000	0.932
VAR00005	1.000	0.929	VAR00035	1.000	0.923
VAR00006	1.000	0.925	VAR00036	1.000	0.932
VAR00007	1.000	0.939	VAR00037	1.000	0.924
VAR00008	1.000	0.947	VAR00038	1.000	0.945
VAR00009	1.000	0.938	VAR00039	1.000	0.957
VAR00010	1.000	0.937	VAR00040	1.000	0.925
VAR00011	1.000	0.926	VAR00041	1.000	0.948
VAR00012	1.000	0.934	VAR00042	1.000	0.839
VAR00013	1.000	0.952	VAR00043	1.000	0.951
VAR00014	1.000	0.926	VAR00044	1.000	0.924
VAR00015	1.000	0.922	VAR00045	1.000	0.813
VAR00016	1.000	0.917	VAR00046	1.000	0.927
VAR00017	1.000	0.936	VAR00047	1.000	0.925
VAR00018	1.000	0.939	VAR00048	1.000	0.898
VAR00019	1.000	0.929	VAR00049	1.000	0.936
VAR00020	1.000	0.952	VAR00050	1.000	0.868
VAR00021	1.000	0.929	VAR00051	1.000	0.902
VAR00022	1.000	0.915	VAR00052	1.000	0.624
VAR00023	1.000	0.940	VAR00053	1.000	0.820
VAR00024	1.000	0.947	VAR00054	1.000	0.903
VAR00025	1.000	0.955	VAR00055	1.000	0.910
VAR00026	1.000	0.936	VAR00056	1.000	0.864
VAR00027	1.000	0.942	VAR00057	1.000	0.927
VAR00028	1.000	0.934	VAR00058	1.000	0.810
VAR00029	1.000	0.940	VAR00059	1.000	0.886
VAR00030	1.000	0.946			

The results of the factor loadings analysis for all 59 questionnaire items, as shown in Table 2, indicate that the extracted communalities are within an excellent range, with most values exceeding 0.90 and approaching 1.000. This confirms that each item strongly correlates with the underlying factors, and none of the indicators required removal. The high extraction values signify that a large proportion of each item's variance is explained by the common factors identified in the analysis. Moreover, all item t-values were above the critical value of 1.96 at the 95% confidence level, providing statistical support for the reliability of the instrument. The results affirm the validity of the constructed questions for assessing the three core dimensions of the model: external environment, hospital preparedness, and crisis events and incidents. These findings, supported by the scree plot criterion indicating eigenvalues greater than 1, verify the underlying structure of the proposed model and confirm the integrity of the measured constructs.

Table 3

Coefficient of Determination (R^2) for Main Factors

Main Factors	R^2 Coefficient	Interpretation
External Environment	0.90	Very Good
Hospital	0.90	Very Good
Threats, Accidents, Disasters, and Crises	0.45	Moderate

The coefficient of determination (R^2) values indicate the explanatory power of each main factor in predicting emergency evacuation decision-making. Both the External Environment and Hospital dimensions demonstrated high R^2 values of 0.90, reflecting a very strong influence on the dependent variable. This suggests that these two domains are key predictors of evacuation decisions under crisis conditions. In contrast, the Threats, Accidents, Disasters, and Crises factor had a moderate R^2 value of 0.45, indicating a weaker yet still meaningful explanatory role in the model. Collectively, these results affirm the model's capacity to explain substantial variance in decision-making processes.

Table 4

Cronbach's Alpha Results for Constructs and the Full Questionnaire

Main Constructs	Cronbach's Alpha	Reliability Status
External Environment	0.998	Confirmed
Hospital	0.995	Confirmed
Threats, Accidents, Disasters, and Crises	0.949	Confirmed
Entire Questionnaire	0.995	Overall Reliability Confirmed

Cronbach's alpha values across all constructs reveal exceptionally high internal consistency within the developed instrument. The External Environment and Hospital dimensions showed near-perfect reliability scores of 0.998 and 0.995 respectively, while the Threats, Accidents, Disasters, and Crises factor also maintained a strong reliability coefficient of 0.949. The overall reliability of the questionnaire reached 0.995, confirming that the instrument is statistically robust and dependable for measuring the variables relevant to emergency evacuation decision-making in hospital contexts.

Table 5

Hypothesis Testing Results

Hypothesis	Path Coefficient	t-value	Significance
Direct impact of External Environment on emergency evacuation decision-making	0.59	26.47	Significant and Confirmed
Direct impact of Threats, Disasters, and Crises on emergency evacuation	0.45	15.90	Significant and Confirmed
Direct impact of Hospital factors on emergency evacuation decision-making	0.55	31.03	Significant and Confirmed

The results of hypothesis testing provide strong empirical support for all three proposed relationships in the conceptual model. The External Environment had the strongest standardized path coefficient (0.59) with a highly significant t-value (26.47), highlighting its dominant role in influencing evacuation decisions. Similarly, Hospital-related factors showed a robust effect (0.55, t=31.03), while the Threats and Crises dimension had a moderately strong yet still significant impact (0.45, t=15.90). All three hypotheses were statistically confirmed, supporting the validity of the proposed decision-making model under crisis scenarios.

4. Discussion and Conclusion

The findings of this study provide compelling evidence in support of a structured and multi-dimensional model for decision-making in the emergency evacuation of hospitals during crises. The model incorporates three major dimensions—*external environment*, *hospital-related factors*, and *threats and crises*—each of which demonstrated significant predictive power in influencing evacuation decisions. Quantitative analysis confirmed the strength of these relationships, with the *external environment* and *hospital factors* each yielding a coefficient of determination (R^2) of 0.90, indicating very strong explanatory power. The dimension of *threats, accidents, and crises* exhibited a moderate R^2 value of 0.45, underscoring its relevance but also pointing to its dependence on contextual variables. Furthermore, the validity and reliability of the instrument were strongly confirmed, as evidenced by high Cronbach's alpha values across all subscales and the full scale, with values exceeding 0.94.

These findings reinforce previous literature that underscores the importance of external environmental factors in emergency response planning. For instance, Siddiqi et al. (2023) highlighted that robust community-based emergency preparedness and external communication channels significantly enhance hospital response efficiency during crises (Siddiqi et al., 2023). Similarly, Velner et al. (2023) emphasized the role of organizational resilience within health institutions, suggesting that external environmental stability—ranging from infrastructure to reliable early-warning systems—acts as a critical enabler for informed decision-making under duress (Velner et al., 2023). In this study, components such as alert systems, transport networks, and external transfer logistics were among the highest loading variables, indicating their perceived importance among crisis managers and hospital administrators.

Hospital-related factors also emerged as key drivers of evacuation decision-making. This finding is consistent with

prior research showing that internal preparedness, infrastructure resilience, and human resource readiness form the backbone of effective hospital evacuation systems (Ortíz-Barrios et al., 2020; Rad & Kojouri, 2021). Ahmady et al. (2020) have noted that transitions in hospital operational modes, especially during pandemic emergencies, are often hindered by unclear structural roles and outdated communication systems (Ahmady et al., 2020). Our study echoes this by highlighting the relevance of internal components such as backup power supplies, scenario-based training drills, clear decision-making hierarchies, and defined evacuation protocols. The significant path coefficient for this dimension ($\beta = 0.55$, $t = 31.03$) further validates its role in effective decision-making.

Although the *threats and crises* dimension had a comparatively lower R^2 value, its influence was still statistically significant. The factor loading analysis showed that subthemes such as the type of hazard, time of occurrence, and intensity still played a critical role in shaping evacuation strategy. However, these factors alone were not sufficient predictors of evacuation decision-making unless mediated by hospital readiness and external coordination mechanisms. This finding aligns with research by Boin and McConnell (2007), who argued that understanding the nature of the threat is necessary but insufficient without an accompanying assessment of institutional capacity and decision-making agility (Boin & McConnell, 2007). In the context of this study, the moderate explanatory power of the threat-related factors suggests that response decisions are not solely reactive to the nature of the crisis but are more influenced by the system's readiness to absorb and adapt to the shock.

From a methodological standpoint, the triangulation of qualitative and quantitative methods provided a rich basis for model development. Interviews with experts allowed for deep exploration of hospital evacuation dynamics, while structural equation modeling helped validate the proposed model empirically. The high factor loadings across all 59 questionnaire items support the robustness of the constructs. These findings reflect the growing consensus in the literature that mixed-method designs offer superior insights in complex crisis research (Cuthbertson, 2023; Fazeli Veisari et al., 2021). The convergence of qualitative themes with quantitative validation provides both theoretical coherence and operational utility to the developed model.

Moreover, the results align with calls in the literature for decision-making models that integrate technical, organizational, and ethical dimensions. Argyriadis et al. (2023) emphasized the psychological burden and moral complexity faced by healthcare workers during evacuation scenarios, which must be factored into any model of decision-making (Argyriadis et al., 2023). Our model addressed this by including variables related to role definition, communication, and preparedness, thus enabling faster and more ethical decision-making. Similarly, Mohtady Ali et al. (2023) emphasized the role of transformational leadership in enhancing hospital resilience—a principle reflected in our emphasis on clear decision hierarchies and distributed authority (Mohtady Ali et al., 2023).

The confirmed hypotheses further consolidate the multidimensionality of evacuation decision-making. The direct and significant effect of external environmental conditions ($\beta = 0.59$, $t = 26.47$) and hospital factors ($\beta = 0.55$, $t = 31.03$) on decision-making confirms the interdependence between these domains. Essien and Petrounias (2022) have advocated for artificial intelligence–based frameworks that integrate environmental data and hospital metrics to facilitate faster decisions in crises (Essien & Petrounias, 2022). Although the current model does not yet include AI components, its structural flexibility allows for the integration of decision-support systems in future iterations.

The validity of the measurement model was supported not only by statistical indices but also by the conceptual clarity provided by the thematic analysis. The framework adopted from Braun and Clarke enabled the identification of deeply embedded themes, some of which—such as ethical clarity and decision speed—are often overlooked in conventional evacuation planning. This attention to latent dimensions aligns with Un et al. (2023), who emphasized that perceptual performance metrics—how people interpret and act under stress—are just as important as procedural compliance in emergencies (Un et al., 2023).

Despite its contributions, the study is not without limitations. First, although the sample size was expanded through bootstrapping to 440, the study was primarily focused on hospitals affiliated with the Social Security Organization in Iran, potentially limiting generalizability to other healthcare systems with different organizational cultures or infrastructure capabilities. Second, while the mixed-method approach enriched the model, qualitative data were primarily collected from expert interviews, excluding the perspectives of frontline healthcare staff such as nurses and paramedics who often play crucial roles in evacuation. Finally, the quantitative model, though robust, does not yet account for the dynamic evolution of crises over time or the

influence of real-time data, which could enhance the model's predictive capacity in rapidly changing scenarios.

Future research could expand the scope of the model by including different types of hospitals (private, rural, military) and conducting cross-national comparisons to assess its adaptability in diverse contexts. Longitudinal studies could also be conducted to examine how decision-making evolves across different stages of a disaster—from onset through peak to recovery—and how institutional learning shapes future responses. Incorporating AI-driven decision-support systems, real-time geospatial analytics, and digital simulations could enhance the operational relevance of the model. Additionally, the perspectives of patients, families, and low-level staff could be integrated to add ethical and emotional dimensions to the understanding of evacuation processes.

To enhance emergency preparedness, healthcare institutions should implement the proposed decision-making model as a standardized component of their disaster management protocols. Scenario-based training, interdisciplinary drills, and multi-agency coordination exercises should be regularly conducted to reinforce the model's operational principles. Hospitals should also establish dynamic communication systems that link internal units with external agencies, ensuring seamless information flow during crises. Most importantly, decision-making protocols should be integrated into legal and policy frameworks to ensure accountability, clarity, and institutional alignment in times of crisis.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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