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Assessing Barriers to Hospital Resilience in War and Conflict Settings: A Fuzzy AHP Approach

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Abstract

This study aimed to identify the primary barriers that undermine the resilience of hospitals operating in war and conflict environments and to prioritize these barriers according to their importance. Hospital resilience has become an important research area in recent years due to the increasing attacks and system vulnerabilities in terms of ensuring the continuity of healthcare services under crisis conditions. In the study, the Fuzzy Analytical Hierarchy Process (AHP) method, which is a multi-criteria decision-making method that can provide reliable prioritization under uncertainty conditions, was used to address the limited number of research gaps in the literature on the subject. The data obtained from eight experts selected through purposive sampling method were analyzed by following the Fuzzy AHP steps. The findings reveal nine key barriers. The highest priority barrier was identified as "Interruptions in the supply of medicines, medical supplies and oxygen" (0.2300), followed by "Healthcare worker loss and retention" (0.1348) and "Weak governance/coordination and financing fragility" (0.1287). The conclusions show that for the sustainability of health services in war and conflict environments, the supply chain must be secured, health workers must be protected and retained, and governance and financial sustainability must be strengthened. The study contributes to the literature by providing an evidence-based prioritization framework for policy makers and managers to increase hospital resilience under crisis conditions.

Keywords: *Hospital resilience, War and conflict environments, Supply chain disruption, Healthcare workers, Fuzzy AHP*

Öz

Bu çalışma savaş ve çatışma ortamlarında faaliyet gösteren hastanelerin dayanıklılığını zayıflatan temel engelleri belirlemek ve bu engelleri önem derecelerine göre önceliklendirmek amacıyla gerçekleştirilmiştir. Hastane dayanıklılığı, kriz koşullarında sağlık hizmetlerinin sürekliliğini sağlaması bakımından son yıllarda artan saldırılar ve sistem kırılganlıkları nedeniyle önemli bir araştırma alanı haline gelmiştir. Çalışmada, konuya ilişkin literatürde bulunan sınırlı sayıdaki çalışma boşluğunu gidermek üzere, belirsizlik koşullarında güvenilir önceliklendirme yapabilen çok kriterli karar verme yöntemlerinden Bulanık Analitik Hiyerarşi Prosesi (AHP) yöntemi kullanılmıştır. Amaçlı örnekleme yöntemiyle seçilen sekiz uzmandan elde edilen veriler Bulanık AHP adımları izlenerek analiz edilmiştir. Bulgular dokuz temel engeli ortaya koymaktadır. En yüksek önceliğe sahip engel "İlaç, tıbbi sarf ve oksijen tedarikinde kesintiler" (0,2300) olarak belirlenmiş, bunu "Sağlık çalışanı kaybı ve elde tutamama" (0,1348) ve "Yönetişim/koordinasyon zayıflığı ve finansman kırılganlığı" (0,1287) izlemiştir. Sonuçlar, savaş ve çatışma ortamlarında sağlık hizmetlerinin sürdürülebilirliği için öncelikle tedarik zincirinin güvence altına alınması, sağlık çalışanlarının korunması ve elde tutulması ile yönetişim ve finansal sürdürülebilirliğin güçlendirilmesi gerektiğini göstermektedir. Çalışma, kriz koşullarında hastane dayanıklılığını artırmaya yönelik politika yapıcılar ve yöneticiler için kanıta dayalı bir önceliklendirme çerçevesi sunarak literatüre katkı sağlamaktadır.

Anahtar Kelimeler: *Hastane dayanıklılığı, Savaş ve çatışma ortamları, Tedarik zinciri kesintisi, Sağlık çalışanları, Bulanık AHP*

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Introduction

The multilayered impacts of crises necessitate rethinking the resilience of health systems and positioning them at the center of societal existence. War and conflict profoundly impact the functioning of health systems, threatening the continuity, accessibility, and security of healthcare services. In recent years, war and conflict worldwide have led to a significant increase in attacks on healthcare facilities and healthcare workers. These attacks not only damage physical infrastructure but also directly disrupt healthcare delivery (WHO, 2024).

In 2024, the number of reported incidents of violence against or obstruction of healthcare services during war and conflict reached an all-time high. In 2024, 3.623 incidents targeting healthcare services were identified, representing a 15% increase compared to 2023 and a 62% increase compared to 2022 (SHCC, 2025). These incidents result in the deaths of hundreds of healthcare workers and the interruption of treatment for thousands of patients. Conflicts in the Middle East and Africa, in particular, have caused significant losses (WHO, 2024). Intense and persistent violence against healthcare services in Lebanon, Myanmar, Palestine, Sudan, and Ukraine not only increases the demand on healthcare systems in these regions but also negatively impacts healthcare facilities. This not only leads to physical destruction but also negatively impacts patient safety, staff morale and continuity of care (SHCC, 2025). Accordingly, the resilience of hospitals, which constitute the largest and most important share among healthcare facilities, in crisis situations, or in other words, their capacity to survive, emerges as a crucial issue.

Hospital resilience is defined as the capacity of hospitals to continue providing services under extraordinary circumstances such as crises, disasters, wars, or conflicts (Khalil et al., 2022). In other words, it is the ability of hospitals to emerge stronger from challenging circumstances by maintaining the positive nature of their operations (Wulff et al., 2015). It refers to the ability to anticipate potential threats, overcome undesirable events, and facilitate organizational change to maintain healthcare services (Luke et al., 2023). Resilience does not only mean the preservation of physical infrastructure; it also encompasses human resources, managerial skills, supply chain management, and the continuity of social trust (Aburn et al., 2016). Barasa et al. (2018) consider the resilience of health systems through three capacities: absorption (tolerating current shocks), adaptation (adjusting to changing conditions) and transformation (structural and administrative renewal). Transformational capacity, in particular, is considered a critical dimension for sustainable healthcare services in crisis situations such as wars and conflicts (Mohtady Ali et al., 2023; Khalili et al., 2023).

Studies on this topic reveal various obstacles affecting hospital resilience. Khalil et al. (2022) emphasize that there is no standard approach to conceptualizing and measuring hospital resilience, and therefore, different obstacles may emerge in different contexts. Jolgehnejad et al. (2021) state that the main factors affecting hospital resilience are governance weaknesses, resource inadequacies, and workforce loss. Similarly, Loosemore & Chand (2016) emphasize that the most significant obstacles limiting the resilience of Australian hospitals to extreme weather events are infrastructure deficiencies, financial vulnerabilities, and strategic planning inadequacies. Experiences during the COVID-19 pandemic reveal that the fundamental problem of hospital management is a "lack of resilience," stemming particularly from supply chain disruptions and leadership weaknesses (Ghahramani et al., 2025). Jafari et al. (2023) state that high workloads, inadequate support mechanisms, and security concerns are factors that weaken the resilience of healthcare personnel during the pandemic. The fragility of physical infrastructure and administrative inadequacies are obstacles hospitals face in the context of the climate crisis (Pascale & Jones, 2025).

Research lists the most common obstacles encountered in conflict environments as loss of human resources, logistics and medicine shortages, infrastructure damage and financial constraints (Alameddine et al., 2019; Loosemore & Chand, 2016; Ghahramani et al., 2025; Jafari et al., 2023; Blanchet et al. 2022). In this context, resilience is understood to be not only a technical capacity but also a social and managerial process. Husted &

Dalton (2025) state that the most significant factors weakening the "resilience" of healthcare personnel in high-risk environments are psychosocial pressures and security concerns. In particular, the migration of healthcare workers and their abandonment of their duties due to security concerns directly limits service delivery capacity (Devkota et al., 2023). This situation increases the vulnerability of both the healthcare system and society to crises. These obstacles are of critical importance not only in times of peace but also in war and conflict environments and need to be addressed holistically.

The literature on measuring the resilience of hospital and healthcare systems employs different methodological approaches. Khalil et al. (2022) reveal that the indicators used to measure resilience are heterogeneous and lack standardization in this area. A bibliometric analysis by Cavalieri et al. (2025) indicates that research focuses on four main knowledge clusters: disaster response, information management systems applications, institutional capacity development and evaluation methods. Similarly, Ignatowicz et al. (2023) emphasize that frameworks used to measure resilience are often developed context-independently, thus highlighting the need for scales specific to war and conflict conditions.

In recent years, studies using multi-criteria decision-making techniques to prioritize factors that strengthen or hinder hospital resilience have become increasingly common (Haghighat & Mousavi, 2024; Fallah-Aliabadi, 2022). Ortíz-Barrios et al. (2023) developed a hybrid model combining IF-AHP, IF-DEMATEL, and VIKOR methods to assess hospital disaster preparedness, demonstrating the relationships and importance levels among criteria in a holistic manner. Similarly, Singh & Prasher (2019) emphasize that prioritizing barriers in healthcare systems using Fuzzy Analytic Hierarchy Process (Fuzzy AHP) provides more applicable results for policymakers. The Fuzzy AHP, stands out for its ability to more reliably model decision-makers' judgments in an environment of uncertainty (Gedikli, 2025). This approach allows for the systematic prioritization of barriers that limit hospital resilience by determining the relative importance of different criteria (Liu et al., 2020; Singh & Prasher, 2019).

While the literature on hospital resilience is rapidly expanding, most studies appear to focus on conceptual frameworks or general disaster preparedness. A significant gap remains in measuring resilience and prioritizing debilitating barriers in war and conflict settings. In this regard, the aim of this study is to identify the primary barriers that undermine the resilience of hospitals operating in war and conflict environments and to prioritize these barriers according to their importance. This study systematically addresses this gap using the Fuzzy AHP method and ranks the obstacles that weaken hospital resilience according to their importance. Unlike previous descriptive research, the study offers an evidence-based prioritization framework that integrates operational and managerial dimensions. In this respect, the study provides decision-making support for policymakers and practitioners on strengthening hospital resilience in war and conflict environments.

Method

This study employed a quantitative research design to identify, based on a literature review, the barriers that undermine the resilience of hospitals operating in war and conflict environments and to prioritize them according to their importance. Fuzzy AHP, a multi-criteria decision-making method, was used in the study. This method allows for more reliable results by expressing uncertainty and subjective expert judgments using triangular fuzzy numbers (Saaty, 2008; Chang, 1996; Liu et al., 2020).

The primary research question of the study is: "What are the most critical barriers that undermine hospital resilience in war and conflict environments, and what is their priority under conditions of uncertainty?"

Determination of Criteria

Based on the conceptual framework and literature presented above, the criteria used in this study (barriers affecting hospital resilience) were systematically derived from existing empirical and conceptual research.

The literature reveals that barriers affecting hospital resilience arise at both physical and administrative levels. Frequently cited barriers include governance weaknesses, resource inadequacies, healthcare worker losses, and lack of coordination.

Table 1. Obstacles identified for Fuzzy AHP and their explanations

Obstacle Code	Obstacles	Explanation	Resource
AOH	Attacks and obstructions against healthcare facilities/personnel	Armed attacks, bombings, looting, and threats against healthcare workers directly disrupt the continuity of service delivery.	Abbara et al., 2023; SHCC, 2025; WHO, 2024; WHO 2025a; WHO, 2025b; OCHA, 2025
PFS	Power outages and fuel shortages	Interruptions in energy infrastructure and fuel shortages lead to the shutdown of critical services such as intensive care, operating rooms and the pharmaceutical cold chain.	Mahdi et al., 2025; WHO, 2025a; OCHA, 2025
MSO	Interruptions in the supply of medicines, medical supplies, and oxygen	Disruptions in the flow of medications, supplies, and oxygen cause vital treatments to be delayed or not performed in patient care.	Shore et al., 2022; WHO, 2025b; OCHA, 2025; Ali, 2020; SHCC, 2025; WHO 2025a; WHO, 2024
HRL	Healthcare worker loss and retention	Migration, loss of healthcare personnel due to security concerns and burnout, leads to a shortage of expertise and a serious decrease in service capacity.	Onvlee et al., 2023; Witter et al., 2017; Jafari et al., 2023; Sberro-Cohen et al., 2023; Shmul et al., 2024
WSD	Inadequate water, sanitation, hygiene (WASH) and medical waste management	Deficiencies in access to clean water, hygiene conditions and waste management increase the risk of in-hospital infection and public health threats.	Gnanasekaran et al., 2024; Gebreeyessus et al., 2023; Leal Filho et al., 2023; Lowe et al., 2021
GFF	Weak governance/coordination and financing fragility	Lack of leadership in crisis management, inadequate inter-institutional coordination, and irregular financing limit the sustainability of health services.	Alameddine et al., 2019; Ghahramani et al., 2025; Qaddur et al., 2025; Blanchet et al., 2020; Khalil et al., 2022
OLW	Organizational culture and leadership/management capacity weaknesses	Rigid and traditional organizational structures, inadequate leadership skills and resistance to change hinder rapid and effective responses to crises.	Haghighat & Mousavi, 2024; Mohtady et al., 2023; Husted & Dalton, 2021; Aburn et al., 2016; Wulff et al., 2015
MDS	Mass displacement and sudden surge in demand	Increasing population density due to war and migration waves creates sudden demand pressure that exceeds the capacity of hospitals, reducing the quality of service.	Alameddine et al., 2019; Truppa et al., 2024; Haverkort et al., 2017; Sherwani et al., 2025; Orcutt et al., 2018
LSM	Lack of measurement standards	The lack of standardization in resilience indicators makes accurate prioritization of vulnerabilities and comparison across contexts difficult.	Cavalieri et al., 2025; Ignatowicz et al., 2023; Fallah-Aliabadi et al., 2022; Luke et al., 2022

Furthermore, studies on the COVID-19 pandemic and armed conflicts indicate that supply chain disruptions are a vital factor threatening service continuity. Recent studies on the subject highlight the lack of standardized assessment frameworks for measuring hospital resilience. The nine criteria identified for this purpose are described in Table 1.

The existing literature is quite limited in its systematic prioritization of these barriers under conditions of uncertainty. This study addresses this gap using the Fuzzy AHP method to prioritize barriers that impact hospital resilience in war and conflict environments. This study will make both a methodological and practical contribution, providing scientific evidence to strengthen decision-making processes under crisis conditions.

Research Population and Sample

The research population consists of academics and professional hospital administrators specializing in healthcare delivery in war and conflict environments.

The sample consisted of a total of eight experts: six academics and two professional hospital administrators, using a purposive sampling method.

This sample size corresponds to the ideal number of experts recommended in the literature for AHP applications on specific topics: 5-10 (Campbell et al., 2020; Saaty, 2004; Özdağoğlu & Özdağoğlu, 2007).

Table 2 provides detailed information about the decision-makers.

Fuzzy AHP

The classical AHP method, developed by Saaty (1996), is one of the most widely used multi-criteria decision-making methods. This method allows decision makers to express their priorities among multiple factors through pairwise comparisons

(Meade and Sarkis, 1999; Haliloğlu & Odabaş, 2018; Acer & İnci, 2020). These comparisons utilize the relative importance scale of 1-9, as proposed by Saaty (2008). The relative importance of the criteria is obtained from the eigenvectors of the pairwise comparison matrix.

Table 2. Characteristics of Decision Makers

Decision maker	Profession	Area of Expertise	Professional Experience/ Year
Decision maker 1	Academician	Emergency Aid and Disaster Management	11
Decision maker 2		Emergency Aid and Disaster Management	15
Decision maker 3		Health Management	16
Decision maker 4		Health Management	22
Decision maker 5		Health Management	9
Decision maker 6		Health Management	10
Decision maker 7	Hospital Administrator	Deputy Chief Physician *	18
Decision maker 8		Hospital Manager **	15

**Has served as a physician and administrator in war and conflict zones.*
***He/she is the Hospital Emergency and Disaster Plan Manager.*

Because the classical AHP method cannot fully reflect uncertain and subjective expert judgments, it was extended with fuzzy set theory. This gave rise to the Fuzzy AHP (Buckley, 1985; Kumar & Kumar, 2008). In this study, the Fuzzy AHP method was applied to prioritize obstacles to hospital resilience in war and conflict environments. The Fuzzy AHP application was carried out in accordance with the process shown in Figure 1.

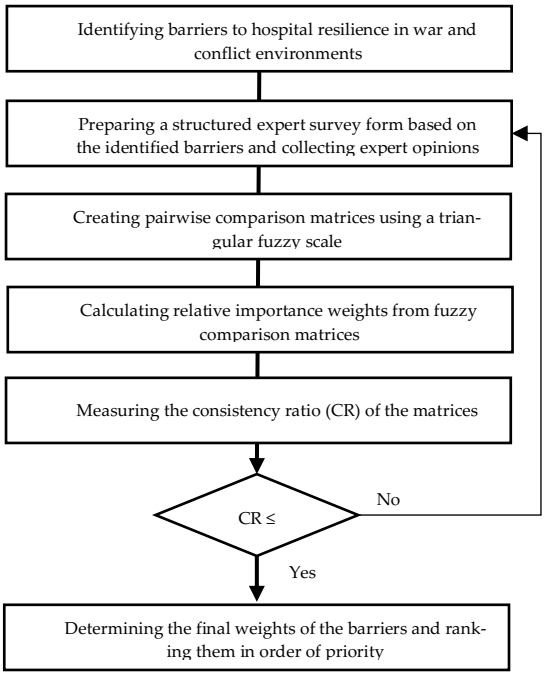

Figure 1. Fuzzy AHP Application

In the first phase, the main barriers to hospital resilience were identified based on the literature review and conceptual framework. Information about the identified barriers is provided in Table 1. These barriers constituted the criteria set defined in the form $C = \{C_1, C_2, \ldots, C_n\}$.

An expert questionnaire form, including pairwise comparisons, was developed based on established criteria, and data was collected from eight experts. Data collection took place between August and September 2025. Eight experts, who were informed in advance and volunteered to participate, participated in the study face-to-face. Participant selection criteria included being an academic with expertise in healthcare delivery in war and conflict environments or a professional hospital administrator with experience in war and work environments. Data were collected from experts using a structured Fuzzy AHP comparison form. The relative importance scale proposed by Saaty (2008) was used in data collection. Fuzzy AHP questionnaire scores range from 1 to 9, with 9 representing Extremely Strong, 7 Very Strong, 5 Strong, 3 Medium Strong, and 1 representing Equal. The Fuzzy AHP questionnaire was administered to participants face-to-face, prompting pairwise comparisons. Participants completed the forms in an average of 20-25 minutes, and the data were compiled by the researcher for Microsoft Excel-based analysis.

Experts are structured to evaluate all criteria and attributes in the form of linguistic variables (Xiaoqiong et al., 2004). Verbal expressions are transformed into triangular fuzzy numbers through fuzzy sets, as shown in Table 3.

Table 3. Triangular fuzzy scales

Linguistic Term	Abbreviation	Relative Importance	Fuzzy Scales	Inverse Fuzzy Scales
Equal	E	1	1,1,1	1/1, 1/1, 1/1
Medium Strong	MS	3	2,3,4	1/4, 1/3, 1/2
Strong	S	5	4,5,6	1/6, 1/5, 1/4
Very Strong	VS	7	6,7,8	1/8, 1/7, 1/6
Extremely Strong	ES	9	9,9,9	1/9, 1/9, 1/9
Intermediate Values	IV	2;4;6,8	1,2,3;3,4, 5;5,6,7;7, 8,9	1/3, 1/2, 1/1; 1/5, 1/4, 1/3; 1/7, 1/6, 1/5; 1/9, 1/8, 1/7

Then, a fuzzy comparison matrix of size *n x n* was created for each expert (Chang et al., 2004).

The fuzzy comparison matrix is given as shown in Equation (1).

$$\tilde{A} = \begin{pmatrix} c_{11}^l, c_{11}^m, c_{11}^u & \cdots & c_{1n}^l, c_{1n}^m, c_{1n}^u \\ \vdots & \ddots & \vdots \\ c_{m1}^l, c_{m1}^m, c_{m1}^u & \cdots & c_{mn}^l, c_{mn}^m, c_{mn}^u \end{pmatrix} \quad (1)$$

The element c_{mn}, which is given $c_{ij}^l, c_{ij}^m, c_{ij}^u$, represents the comparison of the criteria m with criteria n $(i= j=1, 2, 3, \ldots, n)$. Owing to the operational laws of fuzzy, the matrix $\tilde{A}$ can be denoted as Equation (2) by c_{mn} with the corresponding reciprocal values (Sevkli et al., 2012; Tuzkaya & Önüt, 2008).

$$\tilde{A} = \begin{pmatrix} 1,1,1 & \cdots & c_{1n}^l, c_{1n}^m, c_{1n}^u \\ \vdots & \ddots & \vdots \\ \frac{1}{c_{m1}^l}, \frac{1}{c_{m1}^m}, \frac{1}{c_{m1}^u} & \cdots & 1,1,1 \end{pmatrix} \quad (2)$$

One way to estimate fuzzy priorities is to use the logarithmic least squares method. This is the most effective and efficient method, as calculated in Equation (3) and Equation (4). This makes it possible to calculate the triangular fuzzy weights for the variables' relative importance, their feedback, and possible alternatives based on the factors separately (Ramik & Korviny, 2010).

$$w_k^s = \frac{\left(\prod_{j=1}^n c_{kj}^s\right)^{1/n}}{\sum_{i=j}^n \left(\prod_{j=1}^n c_{ij}^m\right)^{1/n}}, s \in \{l,m,u\} \quad (3)$$

$$\widetilde{w}_k = w_k^l, w_k^m, w_k^u \quad k: 1,2,3, \ldots\ldots, n \quad (4)$$

In the defuzzification phase, the fuzzy weights were converted to a single crisp value using the weighted centroid method as shown in Equation (5) (Büyüközkan & Çifçi, 2012; Opricovic & Tzeng, 2003).

$$C_i = \frac{l_i + m_i + u_i}{3} \quad (5)$$

The final importance levels were determined by normalizing the obtained absolute weights as shown in Equation (6) (Opricovic & Tzeng, 2003).

$$w_i = \frac{C_i}{\sum_{r=1}^n C_r} \quad (6)$$

Then, the consistency of expert judgments was measured on the crisp matrices obtained after defuzzification in accordance with the classical AHP method (Equation 7).

$$CI = \frac{\lambda_{\max} - n}{n-1}, \; CR = \frac{CI}{RI} \quad (7)$$

Here, RI is the random consistency index. When CR ≤ 0.10 is met, the matrix is considered consistent; when CR > 0.10, expert evaluations are reconsidered (Saaty, 2013).

The final weights (w_i) obtained in the final stage were ranked from largest to smallest to determine the relative priority of the obstacles. The criterion with the highest weight was considered the primary obstacle that most weakens hospital resilience in war and conflict environments.

Research Limitations

This study has some limitations. The study was limited to a sample size of eight decision-makers. The findings cannot be generalized to a larger group of experts. The study was conducted on nine obstacles, excluding other potential obstacles. Because the study is based on expert judgment, the impact of subjective assessments should not be ignored.

Ethical Aspects of the Research

The study was conducted in accordance with scientific ethical principles and rules. Ethical approval was received for the study from the XXX University Non-Interventional Research Ethics Committee with decision number 1019 dated 14.08.2025.

Findings

This section of the study presents the findings obtained from the Fuzzy AHP analysis for prioritizing obstacles that undermine hospital resilience in war and conflict environments. The study was carried out in accordance with Figure 1, with the process of fuzzification, synthesis and defuzzification of the data obtained from the opinions of decision

makers and the calculation of the final criteria weights.

The identified criteria were evaluated by the decision makers, and comparison matrices were obtained containing their opinions. For example, the decision matrix showing the perception of decision maker 1 is shown in Table 4.

Table 4. Pairwise comparison matrix of criteria (Decision maker 1)

	AOH	PFS	MSO	HRL	WSD	GFF	OLW	MDS	LSM
AOH	E	VS	VS	MS	VS	E	MS	VS	ES
PFS		E	S	VS	E	S	VS	VS	VS
MSO			E	E	MS	VS	VS	MS	ES
HRL				E	MS	S	MS	ES	ES
WSD					E	MS	VS	S	VS
GFF						E	S	MS	MS
OLW							E	ES	S
MDS								E	MS
LSM									E

The importance levels of each criterion comparison in the decision matrices were combined with the opinions of the other seven decision makers and expressed as fuzzy numbers in Table 3. Accordingly, an integrated fuzzy decision matrix was created, containing the consensus opinions of eight decision makers. Triangular fuzzy numbers were calculated for each criterion comparison in the integrated fuzzy decision matrix.

Finally, the fuzzy weights, means, and normalized relative weights of the criteria were calculated. Table 5 presents the final importance weights.

According to the table, the highest priority criterion among the barriers that weaken hospital resilience in war and conflict environments is "Medicine, medical supplies, and oxygen supply interruptions (MSO)". This criterion has a normalized weight of 0.2300, significantly higher than all other criteria. "Healthcare worker loss and retention (HRL)" comes second, with a normalized weight of 0.1348. "Governance/coordination weakness and financing fragility (GFF)" comes third (0.1287). "Power outages and fuel shortages (PFS)" and "Attacks and obstructions against health facilities/personnel (AOH)" were identified as the fourth (0.1257) and fifth (0.1169) priority barriers, respectively. Organizational and environmental factors were rated at a relatively lower priority level. "Organizational culture and leadership/management capacity weaknesses (OLW)" ranked sixth (0.1011), and "Inadequate water, sanitation, hygiene, and medical waste management (WSD)" ranked seventh (0.0970). The final two factors were "Mass displacement and sudden demand surge (MDS)" (0.0658) and "Lack of measurement standards (LSM)" (0.0234).

Table 5. Fuzzy AHP Average and Normalization Weights and Importance Ranking

Obstacle Code	Obstacles	Weight (Average)	Weight (Normalization)	Order of Importance
MSO	Interruptions in the supply of medicines, medical supplies, and oxygen	23,8327	0,2300	1
HRL	Healthcare worker loss and retention	13,9726	0,1348	2
GFF	Weak governance/coordination and financing fragility	13,3327	0,1287	3
PFS	Power outages and fuel shortages	13,0292	0,1257	4
AOH	Attacks and obstructions against healthcare facilities/personnel	12,1154	0,1169	5
OLW	Organizational culture and leadership/management capacity weaknesses	10,4753	0,1011	6
WSD	Inadequate water, sanitation, hygiene (WASH) and medical waste management	10,0544	0,0970	7
MDS	Mass displacement and sudden surge in demand	6,8164	0,0658	8
LSM	Lack of measurement standards	2,4300	0,0234	9

The largest eigenvalue (λ_{max}) was found to be 9.454 in the calculations. The consistency index (CI) calculated using this value was 0.0568. For n = 9, the random consistency index (RI) was taken as 1.45, and accordingly, the consistency ratio (CR) was calculated as 0.0392. Since CR < 0.10, the pairwise comparison matrix was considered consistent.

The normalized weights obtained using the Fuzzy AHP method are presented in Figure 2 using a Pareto chart. The horizontal bars in the chart represent the normalized weights of each barrier, and the red line represents the cumulative percentage of these weights.

Figure 2. Pareto Chart of Obstacles Undermining Hospital Resilience

An examination of the graph reveals that the criteria "Medicine, medical supplies, and oxygen supply interruptions (MSO)," "Healthcare worker attrition and retention (HRL)," "Governance/coordination weakness and financing fragility (GFF)," and "Power outages and fuel shortages (PFS)" account for approximately 60% of the total importance. "Attacks and obstructions against health facilities/personnel (AOH)" and "Organizational culture and leadership/management capacity weaknesses (OLW)" rank fifth and sixth, bringing the cumulative importance to 82%. The less important criteria "Water, sanitation, hygiene and medical waste management (WSD)," "Mass displacement and sudden surge in demand (MDS)," and "Lack of measurement standards (LSM)" account for the remaining 18% of the total.

Discussion

In this study, the key resilience barriers faced by hospitals operating in war and conflict environments were prioritized using the Fuzzy AHP method. The analysis determined that the most important criterion was "Medicine, medical supplies, and oxygen supply interruptions (MSO)", followed by "Healthcare worker loss and retention (HRL)" and "Governance/coordination weakness and financing fragility (GFF)". The least important criterion was "Lack of measurement standards (LSM)".

The findings reveal that supply chain disruptions, specifically interruptions in logistics flows, are the most significant factor threatening the resilience of hospitals in war and conflict conditions. This finding is consistent with the literature and reports from international organizations. It is emphasized that supply chain disruptions are the most significant factors that weaken healthcare services, especially in conflict zones such as Syria, Yemen, and Palestine (Ali, 2020; SHCC, 2025). WHO (2024) emphasizes that shortages of medicine and medical equipment in conflict zones directly impede access to essential healthcare services. Shore et al. (2022) state that disruptions in the supply chain of medicines and supplies under wartime conditions are one of the most critical obstacles that increase mortality and morbidity rates, demonstrating that disruptions to oxygen and essential medications, in particular, have fatal consequences in emergency and intensive care settings. For example, in the Gaza context, OCHA (2025) and WHO (2025a) report that critical shortages of oxygen and fuel in hospitals have brought services to a standstill, forcing hospitals to share supplies among themselves, and prompting WHO to conduct high-risk missions to procure medicines and medical supplies. Similarly, in Ukraine, ensuring continued access to life-saving medical supplies, especially oxygen, is identified as a top priority. Meanwhile, a record increase in attacks on healthcare services further disrupts supply/logistics flows, impacting access to medicines and medical supplies (WHO, 2025b). This situation demonstrates that in war and conflict zones, shortages of medicine and equipment directly disrupt both emergency and routine healthcare services.

Healthcare worker attrition (HRL) poses a critical risk due to the migration or inability of specialist physicians and healthcare professionals to perform their duties due to security concerns. War and conflict environments contribute to the loss of healthcare workers through attacks on healthcare facilities, increased workload, stress, and decreased motivation (Onvlee et al., 2023). Witter et al. (2017) similarly demonstrate that push factors such as employment conditions, security threats, and challenging work environments for healthcare workers trigger migration and departure from the profession. Abbara et al. (2023) report that healthcare workers in Syria are being forced offsite due to flight, displacement, and migration, directly impacting access to and quality of healthcare

services. WHO (2025a), states that many healthcare workers in Gaza have been killed, injured, or forced to flee due to the conflict, emphasizing that remaining healthcare personnel are struggling to cope with the increasing patient load. Sberro-Cohen et al. (2023) report that only 77.4% of hospital staff attended work during the Gaza conflict; they reveal that the reasons for absenteeism were related to the perception that the workplace was more dangerous and to childcare responsibilities. Shmul et al. (2024) emphasize that perceptions of threat negatively impacted the well-being and workplace resilience of healthcare workers during the Hamas attack on Israel in 2023, and that this impacted emergency room staff in particular. These findings clearly demonstrate that human resources are one of the most important resilience factors in crisis situations.

Governance/coordination weakness and financing fragility (GFF) are particularly associated with the equitable distribution of resources, the continuity of health policies, and the failure to ensure inter-institutional coordination. This weakness hinders the effective use of existing resources and amplifies the impact of all other obstacles. In South Sudan, where conflict is intense, the government's limited investment in health leads to continued dependence on international assistance; these obstacles limit coordination and create fragmented service delivery (Qaddour et al., 2024). Similarly, when humanitarian hospital programs in conflict settings are evaluated, it is seen that when local authorities fail to address chronic vulnerabilities, the sustainability of health services is threatened (Tjoflåt & Hansen, 2018). The public healthcare sector was caught more unprepared and strained than the private healthcare sector in the attacks carried out by ISIS in Iraq. This situation demonstrated the limited preparedness and resilience of Iraq's national and local governments (Ibrahim et al., 2021). Truppa et al. (2024) state that studies analyzing healthcare services in war and conflict environments most frequently address governance-focused issues. This highlights the critical role of governance structures in determining resilience outcomes.

According to their findings, power outages, fuel shortages (PFS), and attacks on healthcare facilities and personnel (AOH) stand out as factors that directly disrupt service continuity and hinder vital interventions. Disruptions in the supply chains of conflict-affected hospitals exacerbate existing challenges and place additional burdens on healthcare systems (Lowe et al., 2021). Mahdi et al. (2025) emphasize that only 12 out of 36 hospitals in Gaza are partially operational due to fuel shortages for generators, electricity shortages, or attacks. Fuel shortages, in particular, cause outages in critical hospital units such as operating rooms and intensive care units. WHO (2025a) states that a significant portion of health facilities in Gaza were damaged by attacks and rendered inoperable due to fuel and electricity shortages. This demonstrates that infrastructure and energy security are among the priorities for resilience. The number of attacks on health infrastructure worldwide increased significantly in 2024. These attacks disrupt not only physical infrastructure but also hospital energy systems and the functioning of medical devices (SHCC, 2025). Attacks on health facilities negatively impact hospital resilience by directly harming service capacity, security, and patient safety.

The lower-ranked criteria, namely water, sanitation, hygiene, and medical waste management (WSD), organizational culture and leadership weaknesses (OLW), mass displacement and sudden demand surges (MDS), and lack of measurement standards (OSE), have relatively lower weights. Problems with WASH infrastructure and inadequacies in waste management facilitate the spread of epidemics and create long-term risks. Global studies reveal that one-quarter of healthcare facilities lack basic water services, affecting 1.8 billion people, and 21% of healthcare facilities lack sanitation, particularly in low- and middle-income countries (Gnanasekaran et al., 2024). Gebreeyessus et al. (2022) highlight serious deficiencies in medical waste management in Ethiopia, including inadequate training for waste handlers and a lack of medical waste protocols. Ukraine is a prime example of how war and conflict disrupt medical waste management, negatively impacting the United Nations Sustainable Development Goals and requiring international partnerships for post-war recovery (Leal Filho et al., 2023).

In war and conflict environments, mass displacement and sudden increases in demand severely strain hospital systems and create critical gaps in healthcare delivery. War and conflict lead to mass population displacement and the collapse of healthcare infrastructure (Orcutt et al., 2018). For example, the mass migration caused by the Syrian civil war has caused a sudden and intense increase in demand for healthcare services in hospitals in Turkey. Approximately 50% of hospitals in war and conflict zones are rendered inoperable, creating a destructive cycle where increased demand for surgical care is compounded by reduced healthcare system capacity (Sherwani et al., 2025). Hospitals face significant challenges in managing sudden patient surges during mass events, requiring specialized capacity expansion strategies and demand management approaches (Tariverdi et al., 2018). Some countries have established specialized hospitals to meet their sudden capacity needs. The diversity of these hospitals varies depending on local threat levels, from temporary buffer zones in Europe to fortified structures in conflict-prone areas like Israel (Haverkort et al., 2017).

Research on healthcare delivery in war and conflict zones reveals significant challenges related to inadequate standards and planning. These challenges are particularly compounded when considering detention centers and prisons, where mass casualties and epidemics are often neglected (Echeverri et al., 2025). The lack of standardized competency frameworks leads to under-fulfillment of training requirements and the failure to improve service delivery standards. This leaves healthcare providers facing unpredictable workloads and workplace accidents (Mani et al., 2020). While some hospitals implement important practices in infection prevention, training guidelines, employee motivation, and occupational health and safety in everyday life, comprehensive, evidence-based standards adapted to war and conflict environments are needed (Lowe et al., 2021; Echeverri et al., 2025). The lack of measurement and monitoring mechanisms makes it difficult to evaluate the effectiveness of resilience strategies and creates an information gap in policy development.

This study systematically prioritized the obstacles that weaken the resilience of hospitals in war and conflict environments using the Fuzzy AHP method. The fact that the study findings are based solely on expert opinions creates limitations in terms of validity and generalizability of the results. In particular, the lack of empirical data encompassing experts' experiences across different professional groups, job descriptions, and institution types in war and conflict environments necessitates validation of the obtained prioritization results in a broader context. As emphasized in the literature, while multi-criteria decision-making methods such as AHP can be applied to limited and homogeneous expert groups (Tsyganok et al., 2012), collecting data from a broader and more diversified group of participants is crucial for generalizability of the findings (von Solms, 2011). This makes it valuable that policy and management recommendations are derived from an expert-based model, but also highlights the need to support these recommendations with field experience.

Conclusion

This study was conducted using the Fuzzy AHP method to identify the obstacles that weaken the resilience of hospitals operating in war and conflict environments and to prioritize them according to their importance. The factor that most threatens hospital resilience is “Medicine, medical supplies, and oxygen supply interruptions (MSO).” This is followed by “Healthcare worker attrition and retention (HRL)” and “Weak governance/coordination and financing fragility (GFF).” “Power outages and fuel shortages (PFS)” and “Attacks on healthcare facilities/personnel (AOH)” are critical and follow the first three criteria. The criterion with the least weight is “Lack of measurement standards (LSM).”

In war and conflict environments, the sustainability of healthcare services requires securing the supply chain, protecting and retaining healthcare workers, and strengthening governance and financial sustainability. Furthermore, protecting energy infrastructure, ensuring the security of healthcare facilities, and improving water, sanitation, and hygiene (WASH) services are among the strategies that will contribute to increasing resilience.

To strengthen hospital resilience, limited resources should be prioritized toward drug and supply procurement, human resource continuity, and governance/financial stability. Focusing on critical barriers will have the greatest impact on improving hospital resilience and provide a strategic roadmap for policymakers.

This study makes a unique contribution as one of the few studies to systematically prioritize the obstacles that undermine hospital resilience in war and conflict environments under conditions of uncertainty using Fuzzy AHP. This approach, which integrates operational and managerial dimensions within a single analytical framework, fails to reliably incorporate decision-makers' subjective assessments into the model, enabling clear identification of the critical factors that most significantly undermine resilience. The resulting prioritization provides a scientific basis for policymakers and hospital administrators to direct limited resources to the most effective areas and develop targeted strategies under war and conflict conditions.

Recommendations that strengthen hospital resilience, addressing policy and management priorities simultaneously at the operational and administrative levels, are as follows:

- Emergency stock management systems should be established in war and conflict zones to reduce disruptions in the supply of medicines, medical supplies, and oxygen.
- Local production capacity for critical products should be increased and external dependency should be reduced.
- Regional sharing mechanisms for oxygen and critical supplies should be developed.
- Alternative logistics channels and secure distribution networks should be established.
- Security protocols and physical protection measures should be strengthened to increase employee safety in hospitals.
- Psychosocial support programs should be implemented to reduce trauma, stress, and burnout.
- Incentive models (additional pay, accommodation, security support) should be developed for critical positions.
- Safe transportation and emergency shelter support should be provided to prevent migration and forced departures.
- Inter-institutional crisis coordination mechanisms should be strengthened to ensure the uninterrupted operation of healthcare services.
- Resource allocation should be managed through transparent, traceable, and accountable processes.
- Emergency funding pools specific to war and conflict zones should be established. Joint planning structures should be established between local governments, ministries, and civil society organizations.
- Uninterruptible power supply (UPS) and backup generator capacity should be increased in hospitals to prevent power outages.
- Safe and continuous access plans for fuel supplies should be developed, and alternatives should be planned.
- Protective physical measures should be taken to address the risks of attacks on energy infrastructure.
- Mobile WASH solutions should be installed in war and conflict zones to ensure the continuity of clean water and sanitation.
- Temporary field hospitals or buffer units should be planned for use during periods of peak demand.
- Standard indicators should be developed for measuring resilience.
- Specialized artificial intelligence-supported resilience monitoring systems should be installed during war and conflict periods.
- To increase hospital resilience in war and conflict environments, artificial intelligence-based decision support, forecasting, and early warning systems should be used in all critical processes, and artificial intelligence solutions should be integrated into supply chain management, capacity planning, security monitoring, and resource optimization.

In future research, the prioritization model developed in this study could be tested across different countries and conflict contexts, validated with a larger and more diverse group of experts, used with different MCDM methods (TOPSIS, VIKOR, DEMATEL, or hybrid models), and quantitative findings could be supplemented with qualitative methods. In particular, the development of AI-based resilience measurement tools and their applicability to real-time hospital decision-making are important areas for future research.

Declarations

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Informed Consent: Electronic informed consent was obtained from all participants prior to their involvement in the study. Participation was voluntary, and the confidentiality and anonymity of the participants were guaranteed throughout the study.

Data Availability: Due to privacy and confidentiality considerations, raw survey data are not publicly available. However, de-identified datasets and analysis materials are available from the corresponding author upon reasonable request.

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References

Abbara, A., Rayes, D., Tappis, H., Hamze, M., Wais, R., Alahmad, H., ... & Haar, R. (2023). "Actually, the psychological wounds are more difficult than physical injuries:" a qualitative analysis of the impacts of attacks on health on the personal and professional lives of health workers in the Syrian conflict. *Conflict and health*, 17(1), 48.

Aburn, G., Gott, M., & Hoare, K. (2016). What is resilience? An integrative review of the empirical literature. *Journal of advanced nursing*, 72(5), 980-1000.

Acer, A., & İnci, H. (2020). Personel seçimi sürecinin ahp tabanlı moora yöntemi ile değerlendirilmesi: Liman saha operasyon elemanı seçimi üzerine bir uygulama. *OPUS international journal of society researches*, 16(29 Ekim Özel Sayısı), 3689-3713.

Alameddine, M., Fouad, F. M., Diaconu, K., Jamal, Z., Lough, G., Witter, S., & Ager, A. (2019). Resilience capacities of health systems: accommodating the needs of Palestinian refugees from Syria. *Social science & Medicine*, 220, 22-30.

Ali, E. A. S. (2020). *Providing health care in armed conflict countries: the case of Yemen* (Master's thesis, Hamad Bin Khalifa University (Qatar)).

Barasa, E., Mbau, R., & Gilson, L. (2018). What is resilience and how can it be nurtured? A systematic review of empirical literature on organizational resilience. *International journal of health policy and management*, 7(6), 491.

Blanchet, K., Diaconu, K., & Witter, S. (2020). Understanding the resilience of health systems. In *Health policy and systems responses to forced migration* (pp. 99-117). Cham: Springer International Publishing.

Buckley, J. J. (1985). Fuzzy hierarchical analysis. *Fuzzy sets and systems*, 17(3), 233-247.

Büyüközkan, G., & Çifçi, G. (2012). A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. *Expert systems with applications*, 39(3), 3000-3011.

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., ... & Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. *Journal of research in Nursing*, 25(8), 652-661.

Cavalieri, M., Fontana, S., Guccio, C., Lisi, D., Martorana, M. F., Pignataro, G., & Romeo, D. (2025). Measuring hospital care resilience: a systematic literature review. *The European journal of health economics*, 1-37.

Chang, C. W., Wu, C. R., & Lin, H. L. (2009). Applying fuzzy hierarchy multiple attributes to construct an expert decision making process. *Expert systems with applications*, 36(4), 7363-7368.

Chang, D. Y. (1996). Applications of the extent analysis method on fuzzy AHP. *European journal of operational research*, 95(3), 649-655.

Devkota, N., Gurung, L., Joshi, P., Maharjan, R., Gurung, B., & Karki, U. (2023). Impact of brief psychological intervention on reducing the psychological symptoms after COVID-19 infection among healthcare workers (HCWs) in Nepal. *Journal of psychiatrists' association of Nepal*, 12(2), 12-20.

Echeverri, L., Saade, E., & Ragazzoni, L. (2025). The Imperative for a Comprehensive Medical Planning in Detention Facilities in Conflict Settings. *Prehospital and disaster medicine*, 40(S1), s11-s11.

Fallah-Aliabadi, S., Ostadtaghizadeh, A., Fatemi, F., Ardalan, A., Rezaei, E., Raadabadi, M., & Heydari, A. (2022). Hospital disaster resilience: development of an assessment tool using expert panel and fuzzy analytical network process. *International journal of disaster resilience in the built environment*, 13(5), 554-567.

Gebreeyessus, G. D., Tegegne, B. D., & Ali, A. S. (2023, January). Healthcare waste management protocols challenged by Covid-19: a case study. In *Proceedings of the ınstitution of civil engineers-waste and resource management* (Vol. 176, No. 1, pp. 3-15). Thomas Telford Ltd.

Gedikli, E. (2025). Assessment of Environmental Sustainability Practices in Healthcare Facilities by Employing Fuzzy-AHP. *Acıbadem Üniversitesi Sağlık Bilimleri Dergisi*, 16(3), 475–480.

Ghahramani, S., Bagheri Lankarani, K., Zakeri, M., Ghahramani, S., & Shojaei, P. (2025). Lack of hospital resilience as the main challenge of hospital management during the COVID-19 pandemic: A grounded theory study. *Health services management research*, 38(3), 164-172.

Gnanasekaran, S., Jayaraj, V., B, Y.V., Mohanraj, P.S., Babu, C., Rajendran, N., & Rajendran, V. (2024). A comprehensive evaluation of water, sanitation, and hygiene (WASH) in Health Facilities: A Systematic Review and meta-analysis. *The Journal of hospital infection*.

Haghighat, M., & Mousavi, S. M. (2024). Identifying and ranking of the main organizational resilience indicators in the hospital during the COVID-19 pandemic: A study using fuzzy Delphi technique (FDT) and fuzzy analytical hierarchy process (FAHP). *Heliyon*, 10(5).

Haliloğlu, M., & Odabaş, M. S. (2018). Çok ölçütlü karar vermede AHP yöntemi. *Kilis 7 aralık üniversitesi fen ve mühendislik dergisi*, 2(2), 13-18.

Haverkort, J. M., De Jong, M. B., Foco, M., Gui, D., Barhoum, M., Hyams, G., ... & Leenen, L. P. (2017). Dedicated mass-casualty incident hospitals: an overview. *Injury*, 48(2), 322-326.

Husted, M., & Dalton, R. (2021). 'Don't show that you're scared': resilience in providing healthcare in a UK low-to-medium secure hospital. *Health psychology and behavioral medicine*, 9(1), 84-103.

Ibrahim, S., Al-Dahir, S., Al Mulla, T., Lami, F., Hossain, S. M., Baqui, A., & Burnham, G. (2021). Resilience of health systems in conflict affected governorates of Iraq, 2014–2018. *Conflict and health*, 15(1), 76.

Ignatowicz, A., Tarrant, C., Mannion, R., El-Sawy, D., Conroy, S., & Lasserson, D. (2023). Organizational resilience in healthcare: a review and descriptive narrative synthesis of approaches to resilience measurement and assessment in empirical studies. *BMC health services research*, 23(1), 376.

Jafari, H., Heidari, M., Sadeghi, R., & Heidari-Jamebozorgi, M. (2023). Factors affecting the resilience of hospital medical staff during the COVID-19 pandemic. *Family medicine & primary care review*, 25(1).

Jolgehnejad, A. K., Kahnali, R. A., & Heyrani, A. (2021). Factors influencing hospital resilience. *Disaster medicine and public health preparedness*, 15(5), 661-668.

Khalil, M., Ravaghi, H., Samhouri, D., Abo, J., Ali, A., Sakr, H., & Camacho, A. (2022). What is "hospital resilience"? A scoping review on conceptualization, operationalization, and evaluation. *Frontiers in public health*, 10, 1009400.

Khalili, H., Pandey, J., Langlois, S., Park, V., Brown, R., El-Awaisi, A., ... & Breitbach, A. P. (2023). Forward thinking and adaptability to sustain

and advance IPECP in healthcare transformation following the COVID-19 pandemic. *Internet journal of allied health sciences and practice*, 22(1), 18.

Kumar, V., & Kumar, K. (2008). On the ideal convergence of sequences of fuzzy numbers. *Information sciences*, 178(24), 4670-4678.

Leal Filho, W., Lisovska, T., Fedoruk, M., & Taser, D. (2023). Medical waste management and the UN Sustainable Development Goals in Ukraine: An assessment of solutions to support post-war recovery efforts. *Environmental challenges*, 13, 100763.

Liu, Y., Eckert, C. M., & Earl, C. (2020). A review of fuzzy AHP methods for decision-making with subjective judgements. *Expert systems with applications*, 161, 113738.

Loosemore, M., & Chand, A. (2016). Barriers to building resilience to extreme weather events in Australian hospitals. *Management*, 2, 1201-1210.

Lowe, H., Woodd, S., Lange, I. L., Janjanin, S., Barnet, J., & Graham, W. (2021). Challenges and opportunities for infection prevention and control in hospitals in conflict-affected settings: a qualitative study. *Conflict and health*, 15(1), 94.

Luke, J., Franklin, R. C., Dyson, J., & Aitken, P. (2023). Building toward a disaster resilient health system: a study of hospital resilience. *Disaster medicine and public health preparedness*, 17, e219.

Mahdi, N., Abumeteir, H., Migdad, M., Ashour, E., Abuhadrous, I., & Hassoun, A. (2025). Powerless Under Siege and Devastation: The Struggle for Clean and Affordable Energy in Gaza. In *War on Gaza: Consequences on sustainability and global security* (pp. 95-112). Cham: Springer Nature Switzerland.

Mani, Z. A., Kuhn, L., & Plummer, V. (2020). Common domains of core competencies for hospital health care providers in armed conflict zones: a systematic scoping review. *Prehospital and disaster medicine*, 35(4), 442-446.

Meade, L.M. & J. Sarkis (1999), "Analyzing organizational project alternatives for agile manufacturing processes: An analytical network approach", *International journal of production research*, 37(2), 241-261.

Mohtady Ali, H., Ranse, J., Roiko, A., & Desha, C. (2023). Enabling transformational leadership to foster disaster-resilient hospitals. *International journal of environmental research and public health*, 20(3), 2022.

Onvlee, O., Kok, M., Buchan, J., Dieleman, M., Hamza, M., & Herbst, C. (2023). Human resources for health in conflict affected settings: a scoping review of primary peer reviewed publications 2016–2022. *International journal of health policy and management*, 12, 7306.

Opricovic, S., & Tzeng, G. H. (2003). Defuzzification within a multicriteria decision model. International Journal of Uncertainty, *Fuzziness and knowledge-based systems*, 11(05), 635-652.

Orcutt, M., Shortall, C., & Abbara, A. (2018). Conflict, disasters, and humanitarian response. *Oxford textbook of global health of women, newborns, children, and adolescents*, 49.

Ortíz-Barrios, M., Jaramillo-Rueda, N., Gul, M., Yucesan, M., Jiménez-Delgado, G., & Alfaro-Saíz, J. J. (2023). A fuzzy hybrid MCDM approach for assessing the emergency department performance during the COVID-19 outbreak. *International journal of environmental research and public health*, 20(5), 4591.

Özdağoğlu, A., & Özdağoğlu, G. (2007). Comparison of AHP and fuzzy AHP for the multi-criteria decision making processes with linguistic evaluations. *İstanbul ticaret üniversitesi fen bilimleri dergisi*, 6(11), 65-85.

Pascale, F., & Jones, K. (2025). Existing hospitals' journey into a sustainable and climate-resilient future: barriers and opportunities for estates and facilities management. *Facilities*.

Qaddour, A., Yan, L., Wendo, D., Elisama, L., Lindahl, C., & Spiegel, P. (2025). Leadership and governance, financing, and coordination and their impact on the operationalization of health interventions in the humanitarian-development nexus in South Sudan. *PloS one*, 20(5), e0312788.

Ramík, J., & Korviny, P. (2010). Inconsistency of pairwise comparison matrix with fuzzy elements based on geometric mean. *Fuzzy sets and systems*, 161(11), 1604-1613.

Saaty, T. (1996), *Decisions with the analytic network process* (ANP), ISAHP 96.

Saaty, T. L. (2004). Decision making—the analytic hierarchy and network processes (AHP/ANP). *Journal of systems science and systems engineering*, 13(1), 1-35.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International journal of services sciences*, 1(1), 83-98.

Saaty, T. L. (2013). Analytic hierarchy process. "In *Encyclopedia of operations research and management science* (pp. 52-64)", Springer, Boston, MA.

Safeguarding Health in Conflict Coalition (SHCC). (2025). *Epidemic of violence: Violence against health care in conflict – 2024 report*. Insecurity Insight. https://insecurityinsight.org/wp-content/uploads/2025/04/2024-SHCC-Annual-Report.pdf

Sberro-Cohen, S., Amit, I., Barenboim, E., & Roitman, A. (2023). Resilience, sense of danger, and reporting in wartime: a cross-sectional study of healthcare personnel in a general hospital. *Human resources for health*, 21(1), 81.

Sevkli, M., Oztekin, A., Uysal, O., Torlak, G., Turkyilmaz, A., & Delen, D. (2012). Development of a fuzzy ANP based SWOT analysis for the airline industry in Turkey. *Expert systems with applications*, 39(1), 14-24.

Sherwani, M., Stewart, R., & Samad, L. (2025). The Disproportionate Surgical Burden Borne by Children in Regions of Armed Conflict. *World journal of surgery*, 49(7), 1840-1845.

Shmul, C. S., Berzon, B., & Adini, B. (2024). Navigating crisis: exploring the links between threat perceptions, well-being, individual and workplace resilience among general hospital staff. *Israel journal of health policy research*, 13(1), 69.

Shore, C., Brown, L., Hopp, W. J., & National Academies of Sciences, Engineering, and Medicine. (2022). Causes and consequences of medical product supply chain failures. In *Building resilience into the nation's medical product supply chains*. National Academies Press (US).

Singh, A., & Prasher, A. (2019). Measuring healthcare service quality from patients' perspective: using Fuzzy AHP application. *Total quality management & business excellence*, 30(3-4), 284-300.

TariVerdi, M., Miller-Hooks, E., & Kirsch, T. (2018). Strategies for improved hospital response to mass casualty incidents. *Disaster medicine and public health preparedness*, 12(6), 778-790.

The United Nations Office for the Coordination of Humanitarian Affairs (OCHA). (2025). *Occupied palestinian territory*. https://www.unocha.org/occupied-palestinian-territory

Tjoflåt, I., & Hansen, B. S. (2019). Building resilience in humanitarian hospital programs during protracted conflicts: opportunities and limitations. *Exploring resilience: A scientific journey from practice to theory*, 97-104.

Truppa, C., Yaacoub, S., Valente, M., Celentano, G., Ragazzoni, L., & Saulnier, D. (2024). Health systems resilience in fragile and conflict-affected settings: a systematic scoping review. *Conflict and health*, 18(1), 2.

Tsyganok, V. V., Kadenko, S. V., & Andriichuk, O. V. (2012). Significance of expert competence consideration in group decision making using AHP. *International journal of production research*, 50(17), 4785-4792.

Tuzkaya, U. R., & Önüt, S. (2008). A fuzzy analytic network process based approach to transportation-mode selection between Turkey and Germany: A case study. *Information sciences*, 178(15), 3133-3146.

von Solms, S. (2011). Validity of the AHP/ANP: Comparing apples and oranges. International Journal of the Analytic Hierarchy Process, 3(1).

Witter, S., Wurie, H., Chandiwana, P., Namakula, J., So, S., Alonso-Garbayo, A., ... & Raven, J. (2017). How do health workers experience and cope with shocks? Learning from four fragile and conflict-affected health systems in Uganda, Sierra Leone, Zimbabwe and Cambodia. *Health policy and planning*, 32(suppl_3), iii3-iii13.

World Health Organization (WHO). (2024). *In the line of fire: Protecting health in armed conflict* (7th ed.; Technical document). World Health Organization.

World Health Organization (WHO). (2025a). *Gaza hostilities 2023 - 2025 - emergency situation reports*. https://www.emro.who.int/opt/information-resources/emergency-situation-reports.html

World Health Organization (WHO). (2025b). *Dangerously low medical oxygen supplies in Ukraine due to crisis, warn WHO director-general and who regional director for europe*. https://www.who.int/news/item/27-02-2022-dangerously-low-medical-oxygen-supplies-in-ukraine-due-to-crisis-warn-who-director-general-and-who-regional-director-for-europe

Wulff, K., Donato, D., & Lurie, N. (2015). What is health resilience and how can we build it?. *Annual review of public health*, 36(1), 361-374.

Xiaoqiong, W., Fang, P., Shihuang, S., & Jianan, F. (2004). Trapezoidal fuzzy AHP for the comprehensive evaluation of highway network programming schemes in Yangtze River Delta. In *Fifth world congress on intelligent control and automation* (IEEE Cat. No. 04EX788) (Vol. 6, pp. 5232-5236). IEEE.

Yılmaz, E., & Uslu, Y. (2025). Sağlik hizmetlerinde yapay zeka entegrasyonu: sosyo-teknik faktörlerin swara ve ahp yöntemleri ile değerlendirilmesi. *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 34(Uygarlığın Dönüşümü-Sosyal Bilimlerin Bakışıyla Yapay Zekâ), 94-108.