



POLICY BRIEF

Policy and Strategy Recommendations for Building Resilience in Iran's Medical Education System against Hybrid Warfare: A Macro-Regional Planning Perspective

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Received: 2026-02-08

Revised: 2026-06-09

Accepted: 2026-07-15

ABSTRACT

The occurrence of the twelve-day warfare in Iran and its resultant damages and outcomes on medical science education, compounded by a complex and unique set of economic (sanctions), social, and cultural conditions, prompted researchers to develop a macro-framework. Drawing on global evidence and employing a systems model approach, this framework aims to analyze and enhance the resilience of the higher health education system against potential hybrid warfare, with an emphasis on the role of macro-regional medical science planning areas. Consequently, based on the formulated strategies, policy solutions and recommendations were proposed at the level of macro planning regions and across short-, medium-, and long-term timescales. These proposals target four key subsystems: human resources; technology and infrastructure; management and organization; and the external environment impacting educational processes. Design and activation of a comprehensive program for empowering human resource resilience and robustness, implementation of a psychosocial rehabilitation program for human resources, design and implementation of a comprehensive passive defense program for educational infrastructure, establishing and deploying an emergency educational and clinical service continuity system, designing and activating an education command unit, and establishing and designing a network of the strategic partners were the most important policy implications derived from this study's results. This comprehensive set of programs is designed to serve as a robust framework for strengthening the resilience and robustness of medical science education under hybrid warfare conditions.

Keywords: Resilience, Medical Education, Warfare, Organizational Policy, Regional

Citation: Khandan M, Ebrahimi A, Heydari M, Hoseini Abardeh M, Yazdani Sh, Koohpaei A. **Policy and Strategy Recommendations for Building Resilience in Iran's Medical Education System against Hybrid Warfare: A Macro-Regional Planning Perspective.** Evidence Based Health Policy, Management & Economics 2025; 9(4): 208-27.

Problem and Background

Higher education, as one of the most influential pillars of any society and the most fundamental element of comprehensive development, plays a vital role in societal advancement and the cultivation of specialized and cultivated human capital (1-3). Today, having an effective and efficient higher education system is essential for progress in political, social, economic, and cultural

dimensions, and ultimately, for achieving sustainable development (4).

Universities, as dynamic organizations, are consistently exposed to unstable and uncertain conditions and various risks that may disrupt the achievement of their primary objectives (5). Among higher education institutions, medical sciences education is recognized as one of the most pivotal social systems for realizing sustainable

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health system development in any country (6). In unstable and uncertain conditions, organizations need to develop their adaptive capacity, enabling them to effectively cope with unexpected events, recover from crises, and even ensure future successes. In such contexts, resilience is considered a valuable asset for universities to confront potential risks (7).

In the past decade, the concept of modern or hybrid warfare has emerged in strategic literature, representing a complex and multidimensional threat that utilizes military, media, cyber, economic, and psychological tools to undermine societies and sensitive institutions (8). NATO defines it as a blend of conventional operations, asymmetric tactics, propaganda, disinformation, and psychological operations (9). Healthcare systems and medical education are potential targets of modern warfare and can be directly or indirectly damaged (10). History demonstrates that medical education is inextricably linked to community health (11), and disruptions in this process directly threaten the quality of future health service delivery (12-15).

Studies indicate that war and crises have extensive destructive effects on various educational and psychological dimensions, leading to serious challenges, including: disruption of practical education (16); infrastructural challenges (10, 13, 17); psychological stress (17-19); brain drain and funding shortages (16); inadequate preparedness (18); and difficulties in delivering online education (19, 20). These align directly with the conditions of a potential hybrid warfare scenario for Iran's medical sciences education system. Despite these challenges, global experiences show that resilience acts as a crucial moderating variable that can reduce the severity of negative crisis impacts (21, 22). These findings underscore the necessity for adopting comprehensive and multi-faceted strategies to enhance resilience in: A) investing in technical infrastructure (13, 23); B) supporting mental health (21); C) developing the skills of faculty and stakeholders (20); D) fostering national and international collaboration (16); and E)

strategic planning (18, 24). Inspired by models presented in the academic literature reinterpreted in the context of medical sciences in higher education, the following framework with four main systemic components for strengthening resilience can be outlined:

A. Human: Faculty, students, clinical and administrative staff. B. Technology: Virtual learning systems, medical equipment, digital research infrastructure. C. Organization: Macro-regional structure, university, educational-therapeutic policies and regulations and D. External environment: Social and economic conditions, crises, and national and international laws.

Based on a systems approach informed by a systematic review and thematic analysis, resilience in macro-regions, medical sciences universities, and the entire higher health education system is achieved when the interaction between the human and technological subsystems is designed in a balanced and simultaneous manner, and when these two subsystems can adapt to environmental changes within their organizational and managerial framework. Otherwise, any misalignment between human and technology can render the educational structure fragile and weaken its ability to cope with crises (25-27).

The analysis process in this study was conducted in accordance with the steps proposed by Braun and Clarke and based on a three-month period inductive and semantic approach (27). In the first step, all data were recorded through the full implementation of the focus group sessions (30-90 min) and read several times so that the researchers could gain a deep understanding of their content. In the second step, data were divided into smaller semantic units and open-coded; meaning that the codes were extracted directly from the data and were not influenced by a predetermined theoretical framework. In the third step, similar or related codes were organized into initial themes. Then, in the review phase, these themes were matched to the entire data to ensure both internal coherence and distinction between themes. In the next step,

final themes were defined and named, so that each theme represented a single semantic core of the participants' experiences and perspectives. Finally, an analytical report was developed in which the main themes and the relationships between them were described, based on the research questions and the context under study. Several steps were taken to increase the validity and reliability of the analysis. These included coding the data independently by two researchers and comparing and integrating the results to improve inter-coder reliability, reviewing some of the initial findings by a number of participants (member checking) to confirm that the results matched their actual experiences. Moreover, all stages of the analysis were documented to ensure that the research could be followed up and reviewed by others. Triangulation was also implemented by comparing data from different groups (members, administrators, staff, students) with each other. Thus, content analysis was used in this study as a systematic yet flexible process to accurately and meaningfully identify and explain the various dimensions of resilience in medical universities, based on data obtained from group interactions.

Iran is located in a special geographical location. The existence of very rich resources as well as the country's potential capabilities for sustainable economic, social, and cultural development on the

one hand, and the distinguished spirit of independence on the other, always have the possibility of creating complex and deep crises such as hybrid wars, and consequently, disruption in the usual processes of medical education is likely. Bureaucratic administrative structure, serious shortcomings in the field of good management of resources and capital, challenges in achieving sustainable access to information technology, weaknesses in team working, networking and coordination at the organizational level, as well as the existence of parallel organizations, have made decision-making in the field of crisis management difficult. Researchers believe that without creating the necessary software and hardware infrastructure, the possibility of continuing education in crisis situations, especially during hybrid wars, will be minimal and will not have the necessary quality. Therefore, this research was conducted to raise awareness of the issue and raise awareness among health system managers about the measures that need to be taken.

Global Evidence

The results of the literature review regarding strategies and measures for enhancing educational resilience in conflict-affected regions are presented in the Table 1.

Table 1. Summary of educational resilience strategies by country based on literature

Resilience Strategies	Country
Physical reconstruction of universities, creating a safe educational environment, repatriating elites, restoring academic freedom, strengthening a culture of inquiry, social justice, inclusion of marginalized groups, international collaboration, online education, flexible assessments, organizational resilience strategies, transformational leadership, faculty support, and preparing future leaders.	Syria (28)
Psychological and organizational resilience of students, blended and online learning, emotional support, growth mindset, collaborative coping strategies, legal and technological frameworks, fostering university organizational resilience capacities, self-directed learning, support for displaced students, redesigning the educational ecosystem, competency-based learning, developing digital infrastructure, legal and regulatory reforms, information management systems, artificial intelligence in educational analytics, cloud-based learning platforms, and decision-making dashboards.	Ukraine (13, 15, 23, 29-37)
Inclusive and participatory resilience, positive media representation, education programs for sustainable peace, data analysis and inductive frameworks for promoting educational resilience.	Rwanda (38)
Six-dimensional resilience (infrastructural, political, social, economic, cultural, event-based),	Iran (39-49)

Resilience Strategies	Country
sound governance, disaster risk management cycle (prevention, preparedness, response, recovery), learning from experiences, strengthening mental health, social support, teacher training, and resilience policymaking.	
Strengthening mental health, social support, teacher training, policymaking and resilience frameworks, international collaboration, addressing war impacts, coping with daily stressors, and attention to gender and ethnicity.	Afghanistan (50)
Systematic conceptual framework, identifying individual and environmental factors, resilience assessment tools, training local researchers, community participation, designing flexible educational programs, student resilience through social support, active coping, positive reframing, humor, online education, resource management, and support networks.	West Bank and Gaza Strip (21, 22, 51-54)
Early implementation of blended learning, utilizing local Wi-Fi networks, distributing low-bandwidth educational content, investing in digital infrastructure, faculty training, stakeholder collaboration, and digital resilience.	Yemen (55)
Psychological support for students, attention to gender and time management, strengthening university support systems, mental health monitoring, and training and preparation for coping with war-related stress.	Sudan (16, 56)
System strengthening, crisis forecasting, national planning, prevention and harm reduction, attention to gender and social equity, sustainable investment, dynamic policymaking, applying lessons from the health sector, quality assurance, role of non-profit organizations, preserving student diversity, online education, flexible assessments, faculty support, transformational leadership, and formulating resilience and international reconstruction strategies.	International (10, 19, 24, 57-67)

Policy and Strategies Recommendations for Educational Resilience in Medical Sciences

Based on the identified strategies, policy solutions and recommendations at the macro-regional planning level have been developed across four subsystems: 1) Human Resources, 2) Technology and Infrastructure, 3) Management and Organization, and 4) External Environment affecting educational processes. These programs can serve as a comprehensive framework for strengthening the resilience and robustness of medical sciences universities in the face of hybrid warfare.

1. Human Resources

The Human Resources subsystem, as the central pillar of resilience in the medical education system, plays a decisive role in maintaining educational continuity, psychological well-being, and the sustainability of medical education functions during crises and modern warfare. The strategies and solutions for this subsystem are designed at three levels of resilience management (planning, response, recovery, and lessons learned) and across three timeframes (short-, medium-, and long-term) at the regional level. Based on the strategies;

design (in peacetime) and activation (during threat) of a comprehensive program for empowering human resource resilience and robustness, design of a post-crisis psychosocial and professional rehabilitation program for affected personnel, and establishing protocols for constituting rapid response teams (RRTs) during peacetime are the main recommended strategies in the level of planning. As well as implementation of a psychosocial rehabilitation program for human resources engaged in hybrid warfare (during the threat phase), activation of rapid response teams (during active attack) and execution of emergency evacuation drills with direct participation of students and faculty (during the threat phase) are the main recommended strategies in the level of response. Implementation of a systematic framework for capturing, archiving, and integrating war-derived lessons learned into curricula with a focus on crisis management, first aid, and resilience competencies is the main recommended strategies in the level of recovery, and finally, in institutional learning. Actions/solutions for recommended strategies in every level are considered in three stages: short-term, medium-term, and long-term (Table 2). However,

it should be noted that the main challenges/ limitations for recommendations/ actions/ solutions in the human resources subsystem at the macro-regional level is that human resources have different personalities, behaviors/ habits/ and traits and have different level of health literacy.

In summary, the human resources subsystem is the core of the medical education system's resilience, designed on three key principles: empowerment,

effective response, and organizational learning. This system supports human capital from the preparedness phase through recovery and learning by integrating psychological, practical, managerial, and technological training. Institutionalizing this process will ensure the sustainability of the medical education system against the threats of modern warfare and future crises.

Table 2. Strategies and actionable solutions for the human resources subsystem at the macro-regional level

	Resilience management level	Recommended strategies	Actions		
			Short-term	Medium-term	Long-term
Subsystem of Human Resources	Planning	Design (in peacetime) and activation (during threat) of a comprehensive program for empowering human resource resilience and robustness	• Establish an inter-university "resilient human capital coordination hub" within the macro-region to facilitate personnel exchange during crises. • Implement joint inter-university training modules on psychological and professional resilience, spearheaded by the region's designated flagship university.	• Create a "regional network of human capital resilience specialists" to train master trainers and foster peer-to-peer learning. • Design and pilot a continuous monitoring system for the psychological and functional status of academic and administrative staff across regional universities during periods of threat.	• Found a "regional center for research on health system human capital resilience" with a mandate for applied research and evidence-based regional policy formulation. • Institute a formal mechanism for the inter-provincial rotation and deployment of specialized personnel during declared states of war or major crisis.
	Planning	Design a post-crisis psychosocial and professional rehabilitation program for affected personnel.	Organize macro-regional empathetic listening circles and supportive group activities to foster community healing.	• Conduct data-driven analysis of the crisis response to inform corrective measures for future regional programs. • Host regional feedback workshops to integrate frontline personnel input into policy refinement. • Convene macro-regional crisis experience review panels for structured debriefing.	• Establish a permanent macro-regional center for psychosocial support. • Develop a centralized regional repository for archiving crisis-related data, narratives, and lessons learned.

Planning	Establish protocols for constituting rapid response teams (RRTs) during peacetime.	Oversee the development of regional standardized operating procedures (SOPs) for evacuation, shelter-in-place, voluntary mobilization, psychosocial first aid, and needs assessment.	-----	Implement a continuous review and protocol update cycle informed by macro-regional lessons learned and evolving threat assessments.
Response	Implementation of a psychosocial rehabilitation program for human resources engaged in hybrid warfare (during the threat phase)	Oversee the delivery of structured training modules on psychological resilience and acute stress management, leveraging the region's established network of mental health professionals and clinical psychologists.	Direct the development and dissemination of tailored pedagogical packages designed for distinct stakeholder cohorts (students, faculty, and administrative staff) at the regional level.	---
Response	Activation of rapid response teams (during active attack)	• Mobilize auxiliary support units from universities in lower-risk zones for immediate deployment to high-risk ("red zone") areas. • Establish and manage a pooled inventory of protective gear, pharmaceutical supplies, and emergency relief equipment for shared utilization among regional universities. • Create a secure, dedicated communication channel to facilitate real-time data exchange across the region (e.g., personnel status, casualty reports, and resource requirements).	• Formalize the organizational structure of a regional rapid response network to enable systematic human resource exchange between universities. • Conduct regional after-action review (AAR) sessions to conduct rigorous analysis of operational strengths and weaknesses. • Develop standardized inter-university coordination protocols for the deployment of personnel and equipment under volatile and non-permissive conditions.	• Establish a regional center for training, exercises, and evaluation of rapid response teams. • Institute periodic, multi-university regional drills featuring multi-layered scenarios (e.g., immediate response, mass casualty evacuation, and medical relief operations). • Formulate and enforce regional performance standards for university emergency response teams (UERTs), defining minimum required competencies, equipment benchmarks, and response-time thresholds.

Response	Establish (during threat phase) and operationalize (during active attack) an integrated university emergency shelter and evacuation management system for human resources	• Coordinate with the macro-regional medical sciences education command to integrate and optimize shared access to secure inter-university facilities. • Develop a dynamic regional support geodatabase to enable the rapid relocation of personnel between adjacent universities under threat conditions. • Execute joint macro-regional evacuation drills to practice protocols for mass personnel evacuation and secure transit.	• Establish a regional information-sharing platform for real-time coordination of evacuations and allocation of shared shelters. • Formalize inter-university mutual aid protocols for the temporary reassignment of critical personnel (key faculty, clinical staff, senior leadership) during crises. • Develop shared regional logistical capabilities encompassing emergency transport, lodging, sustenance, and contingency power supply.	• Develop and deploy a regional crisis decision support System (DSS) for predictive analytics and real-time coordination of complex human resource movements. • Institutionalize sustainable resource-sharing consortia among regional universities for shelters and emergency aid. • Establish a regional center of excellence for emergency shelter and evacuation training in medical sciences.
Response	Execution of emergency evacuation drills with direct participation of students and faculty (during the threat phase)	Oversee the delivery of foundational training workshops at the macro-regional level covering essential competencies in first aid, emergency response, wound management, and incident command systems.	Coordinate the implementation of advanced certification courses for designated university leaders and response team members across the region.	Develop and scale evacuation drills into integrated, multi-institutional regional exercises, involving complex scenarios and coordinated command structures.
Recovery and Institutional Learning	Implement a systematic framework for capturing, archiving, and integrating war-derived lessons learned into curricula with a focus on crisis management, first aid, and resilience competencies	• Establish a "regional center for documenting crisis experiences in medical education" to systematically collect and consolidate documentation from universities within the same macro-region. • Convene collaborative deliberation sessions among regional universities to comparatively analyze experiences and identify successful	• Design region-specific educational packages grounded in indigenous resilience models (accounting for variables such as distinct climatic or security contexts). • Establish a regional network of crisis and resilience training instructors to ensure the continuous professional development of human capital across the region. • Evaluate and	• Establish a regional digital archive of lessons learned, encompassing visual records, documentary evidence, and analytical reports, for utilization by future generations of universities. • Implement an annual regional educational resilience assessment system, incorporating a performance-based

	patterns of educational response. • Compile an analytical report detailing the human resource and educational challenges and opportunities arising from the recent crisis, for formal submission to the ministry of health.	iteratively refine methodologies for documentation and knowledge transfer based on systematic feedback from participating regional universities.	ranking of universities. • Designate universities with demonstrably successful crisis response experiences as "regional reference centers for crisis-informed learning".
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2. Technology and Infrastructure

The Technology and Infrastructure subsystem constitutes a critical pillar for sustaining medical sciences education and therapeutic service delivery during modern warfare and hybrid threats. The core objective of this subsystem is to ensure the stability of technical infrastructure, maintain the continuity of educational and clinical services, and enhance technological resilience against diverse hazards. Within this framework, a set of coordinated strategies and actionable solutions are designed and proposed across the three management levels of planning, response, and recovery and institutional learning. Collectively, this subsystem forms the backbone of resilience for the medical education system under contemporary warfare conditions. By focusing on three central themes - passive defense (non-operational defense), emergency hybrid education continuity, and technological transformation of infrastructure - the sustainability of education and healthcare delivery can be guaranteed under all circumstances. In the long-term horizon, the ultimate goal is to establish an intelligent, resilient, and integrated network of the nation's medical sciences universities, capable of continuing education and research - without interruption and with acceptable quality - even amidst the most severe environmental threats and disruptions.

Based on the strategies, design and

implementation of a comprehensive passive defense program for educational infrastructure (during peacetime), and designing resilient and secure virtual learning systems (during peacetime), are the main recommended strategies in the level of planning. Moreover, establishing (during threat) and deploying (during attack) an emergency educational and clinical service continuity system and testing the hybrid education system (during threat) and activating the hybrid education system (during attack) are the main recommended strategies in the level of response. Transformation in infrastructure design, integration of novel technologies (Artificial intelligence, block chain) in crisis management and the enhancement of resilient and robust smart educational infrastructures is the main recommended strategies in the level of recovery and institutional learning finally. Actions/solutions for recommended strategies in every level are considered in three stages: short-term, medium-term, long-term (Table 3). However, it should be noted that the main challenges/limitations for recommendations/ actions/solutions in the technology and infrastructure subsystem at the macro-regional level is that developing countries have great deficiencies and deficit in the budget and appropriation. Funds and financial issues are the main challenge for technology development and transfer as well as infrastructure preparation.

Table 3. Strategies and Action Plans for the Technology Subsystem and Infrastructure at the Macro-Regional Level

Subsystem	Resilience Management Level	Recommended Strategies	Actions		
			Short-Term	Medium-Term	Long-Term
Technology and Infrastructure	Planning	Design and implementation of a comprehensive passive defense program for educational infrastructure (during peacetime).	Develop an integrated regional passive defense master plan	Establish a coordinate the forecasting of alternative energy resources (generators, solar power) at the regional level.	Supervise and coordinate the development of structural hardening guidelines for educational buildings and facilities at the regional level.
	Planning	Design resilient and secure virtual learning systems (during peacetime)	• Conduct a needs assessment of universities across the region. • Design a resilient and secure regional virtual learning system.	Establish regional-level backups for virtual learning systems and critical data.	
	Response	Establish (during threat) and deploy (during attack) an emergency educational and clinical service continuity system	Regional support for mobile clinical and educational equipment; utilize emergency communication technologies for information dissemination.	—	—
	Response	Test the hybrid education system (during threat) and activate the hybrid education system (during attack)	• Establish regional IT support units to provide immediate assistance to affected universities. • Synergize the use of regional servers for storing and hosting educational content. • Conduct a regional educational continuity drill with a scenario involving disruption of communication between universities.	• Establish an inter-university content sharing system to transfer educational content from secure areas to affected zones. • Coordinate with regional technology centers to allocate emergency bandwidth and enhance communication infrastructure. • Provide logistical and technical support to universities engaged in warfare or cyber-attacks	• Establish regional educational technology resilience clusters to facilitate mutual support among universities under threat conditions. • Develop a "regional resilient hybrid education framework" with shared standards for security, content, and communications. • Design a regional content repository for the redistribution of educational resources during crises.

			(dispatch of equipment, technical personnel, and servers)	
Recovery and Institutional learning	Transformation in infrastructure design, integration of novel technologies (Artificial intelligence, block chain) in crisis management and the enhancement of resilient and robust smart educational infrastructures	Establish a regional system for documenting deficiencies and implementing corrective actions in future projects.	• Supervise the reconstruction and modernization of damaged infrastructure with a regional resilience approach; • Redesign technology systems based on past experiences.	Integrate emerging technologies (artificial intelligence, blockchain) regionally to enhance security.

3. Management and Organization

The management and organizational subsystem serves as the central axis for coordination, decision-making, and leadership of the medical sciences education system during modern warfare and hybrid threats. Aimed at strengthening educational governance structures, enhancing managerial coherence, and institutionalizing a culture of organizational learning, this subsystem comprises a set of strategies across three managerial levels: planning, response, and recovery and institutional learning. Collectively, in the long-term horizon, the ultimate objective of the management and organizational subsystem is to transform the nation's medical sciences education system into a learning, networked, and resilient organization - one that not only survives crises but also extracts knowledge and pathways for future improvement from every threat.

Based on the strategies, a macro-regional crisis management, robustness, and resilience system must be designed and implemented in the field of education (during peacetime / threat), a comprehensive legislative system and flexible structures for crisis management (during peacetime) need to be developed, and an education command unit at the national / macro-regional

educational and university levels (during peacetime) should be designed as main recommended strategies in the level of planning. Beside activation of the educational command unit (ECU) at the national, macro-regional, and university levels (during an attack), the main recommended strategies are in the level of response. Implementation of a continuous improvement cycle for crisis management / robustness and educational resilience and institutionalization of organizational learning culture are the main recommended strategies in the level of recovery and institutional learning. Actions/ solutions for recommended strategies in every level are considered in three stages: short-term, medium-term, long-term (Table 4). However, it should be noted that the main challenges/ limitations for recommendations/ actions/ solutions in the management and organization subsystem at the macro-regional level are the followings: management systems success is depending on work flow and flexible process, stakeholder involvement, organizational structure, job and role design, regulations and laws/ education and learnings/ skills and arts/ wisdom and knowledge/ culture and refinement/ as well as constancy and faithfulness. Many of these parameters are incoherent in developing countries.

Table 4. Strategies and Action Plans for the Management and Organizational Subsystem at the Macro-Regional

Subsystem	Resilience Management Level	Recommended Strategies	Actions		
			Short-Term	Medium-Term	Long-Term
Managerial and Organizational	Planning	Design and implement a macro-regional crisis management, robustness, and resilience system in the field of education (during peacetime / threat)	• Define organizational roles and responsibilities in emergency situations; • Establish regional resilience specialized committees.	• Formulate and institutionalize crisis management and resilience policies at the macro-regional level; • Develop and oversee a training plan for regional managers and decision-makers in crisis management; • Design a flexible organizational structure for emergency conditions at the regional level.	Strengthen an organizational culture based on safety, accountability, and learning at the regional level.
	Planning	Develop a comprehensive legislative system and flexible structures for crisis management (during peacetime).	• Establish a regional committee for the coordination of university crisis management to align policies and decisions among universities within the same region. • Develop common protocols for resource distribution and division of management responsibilities under threat conditions. • Design a communication model between university headquarters and the macro-regional headquarters within a hierarchical command structure.	• Develop an inter-university coordination framework for exchanging information, human resources, and managerial support during crises. • Conduct regional workshops on decision-making under uncertainty for senior university administrators. • Establish a regional center for documenting crisis policies and decisions to record lessons learned.	• Establish a regional network of resilient universities to exchange experiences and develop common standards in crisis governance. • Develop a "regional guideline for evaluating the performance of management structures in crises" and update it based on real experiences. • Integrate crisis training centers in universities and create a regional leadership in crisis development consortium.

	Planning	Design an education command unit at the national / macro-regional educational and university levels (during peacetime).	• Establish a regional educational command coordination working group for coordination among universities in the region. • Develop an inter-university role map for distributing roles and responsibilities during an educational crisis. • Define a regional educational command hierarchy and designate the command node. • Design a communication framework between the regional headquarters and university headquarters (command-to-command communication).	• Activate the regional educational command unit (R-ECU) for coordination in implementing curricula, transferring students, and allocating resources. • Conduct regional educational drills to test coordination among member universities under simulated threat conditions. • Design a Regional Educational Alert System for notifying universities of an emergency status. • Develop a standard operational procedure (SOP) for making rapid decisions regarding suspension, modification, or continuation of education.	• Establish a national network of macro-regional education commanders to exchange experiences, lessons learned, and managerial innovations. • Implement a continuous improvement cycle within the regional education command structure. • Utilize performance data to update regional command patterns based on real crisis experiences.
	Response	Activate the educational command unit (ECU) at the national, macro-regional, and university levels (during an attack).	• Activate the regional crisis command and coordination center; • Establish direct communication with provincial and national institutions.	Integrally manage human and financial resources with an emergency prioritization approach (short-term to medium-term) at the regional level.	—
	Recovery and Institutional Learning	Implement a continuous improvement cycle for crisis management / robustness and	Conduct post-crisis meetings (after action review) and evaluate management performance and	Revise structures and processes based on evaluation results (medium-term to long-term) at the	Institutionalize a culture of organizational learning in long-term programs at the regional level.

		educational resilience	policy adjustments during the crisis at the macro-regional level.	regional level.	
	Recovery and Institutional Learning	Institutionalization of organizational learning culture	• Establish a regional knowledge hub for sharing lessons learned among member universities to exchange educational experiences during crises. • Form a regional task force for the comparative analysis of university performance and the extraction of successful models. • Support the publication of case reports and the organization of experience exchange workshops.	• Hold an annual macro-regional educational resilience conference to present university achievements and extract common policies. • Establish a regional center for the analysis of educational crisis data to study trends and predict vulnerabilities. • Integrate lessons learned into regional strategic plans for the development of medical sciences education.	• Establish a regional organizational learning network in medical education for data sharing and managerial innovations. • Integrate successful regional models into national policies and assist in standardizing learning processes. • Annually publish a "regional lessons learned report" with analysis of improvement trends and recommendations for corrective policies.

4) External Environment

The focus of the external environment subsystem is on establishing strategic partnership networks, analyzing the geopolitical environment, and systematic participation. Within the framework of regional resilience networks, universities collaborate with economic institutions to secure financial and logistical support during crises. Moreover the potential use of legitimate international aid and external resources to continue education and rebuild infrastructure is also anticipated. From the viewpoints of recovery and lessons learned after overcoming a crisis, the external environment subsystem plays a significant role in stabilizing inter-organizational cooperation, extracting lessons learned, and institutionalizing sustainable interaction with the external environment. In the short term, the focus is on documenting successful experiences in cooperating with auxiliary, military, and civil institutions.

Analytical reports on how external support was provided during crises are compiled to identify strengths and weaknesses in interactions. In the long term, the relationships between universities and external institutions evolve from a project-based mode to a stable, strategic, and networked one. Establishing sustainable cooperation networks among universities, national institutions, and international organizations provides the necessary foundation for enhancing educational quality, increasing organizational resilience, and expanding the diplomacy of health science. At this level, macro-educational regions become active players in the country's macro educational security system.

Based on the strategies, a network of strategic partners for educational resilience and robustness (during peacetime), a comprehensive geopolitical system for threat forecasting and environmental scenarios (during peace and threat time), and a system for participation in national and regional

non-operational defense programs (during peace and threat time) should be established and designed in the level of planning. Also, (during threat) and launch (during attack) a rapid coordination system for command centers with external in the level of response should be established. Developing a sustainable interaction mechanism between the medical sciences education sector and relevant external environments affects the provision of stable and quality services in the level of recovery and institutional learning. Actions/ solutions for

recommended strategies in every level are considered in three stages: short-term, medium-term, long-term (Table 5). However, it should be noted that the main challenges/ limitations for recommendations/ actions/ solutions in the external environment subsystem at the macro-regional level is: deficiency in suitable networking and cross-unit communication, fragility in coordination among organizations, multiple organizational values, absence of coherence in the organization and solidarity as well as difference in the priorities.

Table 5. Strategies and Action Plans for the External Environment Subsystem at the Macro-Regional Level

Subsystem	Resilience Management Level	Recommended Strategies	Actions		
			Short-Term	Medium-Term	Long-Term
External Environment	Planning	Establish and design a network of strategic partners for educational resilience and robustness (during peacetime).	Strengthen relationships with local communities to enhance social cohesion (short-term to medium-term) at the macro-regional level.	• Develop inter-organizational collaborations with the Ministry of Health, the Red Crescent, and security institutions; • Participate in national and regional non-operational defense programs; • Conduct geopolitical analysis to forecast threats (medium-term to long-term).	Leverage international capacities to enhance the resilience of medical sciences education at the macro-regional level.
	Planning	Design a comprehensive geopolitical system for threat forecasting and environmental scenarios (during peace and threat time).	• Establish a regional center for educational and health threat analysis (regional geo-resilience center) in collaboration with regional medical sciences universities to aggregate data and conduct environmental analysis. • Launch a macro-regional environmental threat monitoring system for sharing	• Develop a regional alert and notification system for coordination among member universities when new threats emerge. • Conduct joint geopolitical research among regional universities focusing on analyzing the impact of security developments on health education. • Define regional coordination protocols for transferring human	• Form a regional health geopolitical analysis network for data sharing, benchmarking experiences, and producing annual reports. • Develop a regional forecasting and response model for threats, designed based on indigenous scenarios. • Active participation of

		data related to warfare, biological crises, cyber-attacks, or disruption of critical infrastructure. • Identify communication routes, referral hospitals, and critical educational points at the regional level, and determine probable scenarios.	resources, equipment, and students during changes in the threat status.	macro-regions in formulating national policies for educational and research security.
Planning	Design a system for participation in national and regional non-operational defense programs (during peace and threat time).	• Establish a macro-regional educational non-operational defense coordination working group composed of member universities in the region. • Exchange experiences among universities in implementing defense programs and document regional strengths and weaknesses. • Conduct joint educational-defense drills among regional universities to assess coordination in maintaining the continuity of education and treatment.	• Design a regional network of cooperating non-operational defense universities for sharing data, educational content, and experiences. • Develop coordinated regional guidelines for responding to emerging threats (cyber, biological, chemical). • Implement regional research projects focusing on assessing the resilience of medical sciences education infrastructure.	• Develop a regional coordination center for Non-operational defense of medical sciences to support neighboring provinces during threats. • Establish a regional database for educational and therapeutic resilience with updated information on spaces and human resources. • Perform a regional role in training support forces and managing the country's educational crisis.
Response	Establish (during threat) and launch (during attack) a rapid coordination system for command centers with external entities.	• Establish emergency communication lines with emergency services, the Red Crescent, and security forces at the regional level; • Utilize regional	Attract economic support and non-governmental external resources, as well as international institutional assistance where possible, at the regional level.	—

			media and social networks for accurate information dissemination and rumor prevention.
Recovery and Institutional Learning	Develop a sustainable interaction mechanism between the medical sciences education sector and relevant external environments affecting the provision of stable and quality services.	Document successful collaborations at the regional level.	• Review interaction policies based on crisis experience; • Record and disseminate experiences to enhance national macro policies in medical sciences education at the regional level. Strengthen sustainable cooperation networks with local, national, and international institutions to enhance resilience at the regional level.

In summary, leveraging the existing macro-regional planning divisions of the country and integrating them into the command model can significantly enhance the resilience of the medical sciences education system. Furthermore, the ten macro-regions of Iran's medical sciences planning can be categorized based on their vulnerability to hybrid warfare. This categorization can ensure the continuity of quality educational service delivery through the geographical relocation of student education.

Conclusion

Based on the reviewed literature and the extraction of solutions, considering the country's conditions to enhance the resilience of medical education in Iran and paying attention to specific challenges such as sanctions, financial restrictions, geopolitical risks, and stressed infrastructure, the researchers under supervision of macro-regional divisions proposed practical solutions that are appropriate to the strategies determined and adapted to the country's internal conditions, and proposed the following categories:

A) **Strengthening domestic digital infrastructure:** Launching independent virtual education platforms, developing e-learning

systems based on domestic servers such as the LMS system with support for offline content, using locally hosted open source tools to reduce dependence on external software, storing educational resources, creating an offline database of reference books, educational videos, and simulation software such as the Iranian surgical simulator. B) **Self-sufficiency in educational equipment:** Domestic production of educational medical equipment, supporting the production of educational mannequins and simulators by knowledge-based, using low-cost alternative methods, replacing expensive equipment with simple tools (for example, using mobile applications to teach anatomy instead of physical models). C) **Flexible educational programs:** Developing crisis-oriented curricula, including courses such as “Resource Management under Sanctions” or “Battlefield Medicine” in curricula, blended learning (face-to-face + virtual), designing courses that can be continued even with internet or power outages (e.g. using pre-downloaded content). D) **Domestic and international networking:** Formation of resilient academic networks, cooperation between medical universities in the country to share resources (such as donating surplus equipment from large universities to small cities), cooperation with non-

sanctioned international institutions, membership in global scientific consortia such as access to free resources. E) **Smart Financing:** University emergency funds, allocating a percentage of university budgets to purchase essential equipment (such as generators or laptops), attracting funds from health NGOs, launching campaigns such as "Every Iranian is a Medical Student Sponsor" to provide scholarships or equipment. F) **Crisis management and periodic exercises:** Developing a resilience roadmap, identifying weaknesses (such as dependence on imported equipment) and designing alternative plans, conducting training exercises, Simulating crisis situations (such as long-term power breakdown) to test the readiness of students and faculty. G) **Psychological support for the educational community:** Setting up free counseling lines, providing psychotherapy services to students and professors to deal with stress caused by sanctions or security threats, individual resilience workshops, training in coping skills with difficult situations (resilience training).

It should be noted that present study was focused on the ten macro-regional divisions. There should be focus on the national planning as well as medical sciences universities with specific excellence, merit, advantages, geopolitical situations and level of risks and crisis for further studies in future.

Ethical considerations

This research was approved by the Ethics Committee of National Agency for Strategic Research in Medical Education (NASR) based on the approval of IR.NASRME.REC1404.046.

Acknowledgements

The authors would like to thank everyone who contributed to the completion of this study .

Conflict of interests

The authors declared no conflict of interests.

Authors' contributions

Concept and design of the study: Sh. Y., M. H. A.,

and A. K. Data gathering: M. Kh., A. E. and A. K. Manuscript writing: M. Kh., A. E., A. K. and M. H. Revision of the manuscript: Sh. Y., and M. H. A. All authors read and approved of the final manuscript.

Funding

This project is funded by the National Agency for Strategic Research in Medical Education (NASR).

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