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Strategic analysis of Iran's climate resilient health system

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Abstract

Introduction Climate change is a long-term systematic climate variability caused by human activities that alters the composition of the global atmosphere. Health systems should be adaptive and resilient to climate change. Hence, this research aimed to strategically analyze the resilience of Iran's health system to climate change.

Method This study utilized a multiple methods approach. First, in-depth semi-structured interviews were conducted with 32 key climate change and health experts to identify the strengths, weaknesses, opportunities and threats of the Iranian health system's resilience to climate change. Purposeful and snowball sampling techniques were used to ensure maximum diversity among the participants. Then, a questionnaire was developed based on the findings of the first stage and was completed by 33 climate change and health experts. Finally, the strategic position of Iran's health system's resilience to climate change was determined using the internal - external factors matrix.

Findings A total of 84 internal factors and 101 external factors were identified that affect the resilience of Iran's health system against climate change. The internal factors were categorized into seven dimensions (i.e., governance and leadership; health financing; health workforce; facilities, equipment and medicines; health information system; health services delivery, and key results). The external factors were categorized into six dimensions (i.e., political, economic, social, technological, environmental, and legal factors). The average score of internal and external factors were 2.47 and 2.12, out of 4 respectively. Iran's health system was found to be in the strategic position of V in terms of resilience to climate change. Therefore, precautionary strategies such as strengthening the climate resilience of healthcare facilities, promoting healthcare facilities' adaptation to climate change, public-private partnership, strengthening the health service delivery system, quality management and cost management, should be implemented to strengthen the resilience of Iran's health system to climate change.

Discussion Iran's health system is facing significant weaknesses and challenges that have hindered its resilience to climate change. Iran's health system can better prepare and respond to the health impacts of climate change, and safeguarding the health and well-being of its population by addressing these challenges and implementing adaptive and resilience strategies.

Keywords Weather, Climate change, Resilience, Health system, Iran

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Background

Climate is the average weather condition of a geographical area over a relatively longer period of time, about 30 years [1]. Some of these meteorological variables are temperature, atmospheric pressure, wind, humidity and precipitation. For example, Iran has four climates: mild and wet on the coast of the Caspian Sea, hot and arid in the central plateau, cold and wet in the west and hot and humid on the northern coast of the Persian Gulf and the Gulf of Oman [2]. Climate has a great influence on our livelihoods and health. However, it undergoes changes over time.

Climate change is a long-term systematic climate variability caused by human activities that alters the composition of the global atmosphere. The United Nations Framework Convention on Climate Change defined climate change as “a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability over comparable time periods” [3]. The increase in the emission of greenhouse gases such as carbon dioxide, methane and nitrogen dioxide caused by human activities is one of the main causes of climate change [4]. The emission of greenhouse gases by trapping the sun’s heat causes global warming and climate change. Earth is warming faster than ever. If serious measures are not taken to reduce greenhouse gases, the average global temperature will increase by 1.5°C between 2030 and 2040 and 4°C between 2080 and 2100 [5].

Climate change causes ice melting, sea level rise, heat waves, storms, floods, droughts and air pollution [6]. The sea level has increased by about 20 cm since 1880 and is expected to increase by another 30 to 122 cm by 2100 [7]. Exposure to heat waves is increasing due to climate change. In 2015 alone, about 175 million people were exposed to heat waves compared to the average of the previous decade. Exposure to excessive heat has wide-ranging physiological effects on humans, leading to disability and premature death. About 70,000 people died in Europe in 2003 as a result of the June–August heat wave event. Also, 56 thousand people died in Russia in 2010 due to extreme heat [8]. An increase of 2 °C compared to the temperature in pre-industrial times has serious negative effects on the environment and human health. For this reason, the international community has agreed to limit the temperature to 1.5 °C to prevent catastrophic health effects and prevent millions of deaths due to climate change. Climate-related disasters cause economic losses of almost hundreds of billions of dollars annually [7].

Iran, with a population of about 85 million people and an area of 1,648,195 square kilometres, is located in the southwest region of Asia [9]. Iran’s climate is mostly

dry and semi-arid, except for the western and northern coastal areas. Iran is very vulnerable to the effects of climate change due to its geographical location, arid and semi-arid weather conditions (80%) and a middle income economy [10]. Iran has one third of the global average rainfall, 3 times the global average evaporation, 3 times the global per capita average of desert, and one third of the global average per capita forest [11]. A large area of Iran is prone to flooding. The central and eastern regions of the country are heavily affected by sand and dust storms. It is predicted that the average annual temperature of the country will increase by 1.5 °C to 5.2 °C from 2071 to 2100. About 30 to 65% of the days of the year are predicted to be very hot during this time period. Climate change will reduce the country’s surface water by 25% by 2030, if the current trend continues [12]. Iran got the lowest rank in Climate Change Performance Index among the 63 countries surveyed in 2023. Iran got a very low score in greenhouse gas emissions, energy consumption and use of renewable energy, and a low score in climate policies [13]. In 2019, Iran ranked eighth in the world in greenhouse gas emissions [14]. The goal of reducing greenhouse gas emissions by 4% by 2030 has been considered for the country [11].

Climate change is one of the biggest threats to health. Climate change affects human health directly by changing the weather pattern (heat waves, storm, flood and drought) and indirectly by changing the quality of water, air and food [10]. The direct effects of climate change include injuries, diseases and deaths resulting from increased frequency and severity of extreme weather events. Heat waves causes diseases such as lethargy, diarrhoea, skin sensitivity, stroke and even death. Air pollution increases death due to respiratory infections, lung cancer and cardiovascular diseases. Furthermore, climate changes lead to changes in the pattern of diseases transmitted through water, food, and vectors [15]. Moreover, climate change threatens the supply of clean air, safe drinking water, nutritious food and safe shelter. Climate change has a negative effect on the availability, quality and diversity of food and causes food and nutrition crises [16]. Climate change causes disruptions in food systems, food shortages and increases in food prices, especially in low- and middle-income countries. Climate changes cause a potential increase in population displacement, decrease in economic growth and aggravation of poverty and increase in mental disorders. Lack of resources leads to displacement of population and increase in conflict and violence. Climate change will disproportionately affect vulnerable groups, including the poor, women, children, the elderly, ethnic minorities, and migrants, especially in low- and middle-income countries [5]. Climate change weakens access to health services and social

support. Malnutrition and displacement caused by climate change exacerbate existing health inequalities.

About 3.6 billion people in the world live in areas highly susceptible to climate change [16]. The World Health Organization estimated that climate change will lead to 250,000 additional deaths per year between 2030 and 2050 [16]. Of these, about 38,000 are due to exposure of the elderly to extreme heat, 48,000 to diarrhoea, 60,000 to malaria, and 95,000 to childhood malnutrition [15]. The direct health costs of climate change are estimated to be between 2 and 4 billion dollars per year by 2030 [16]. It is predicted that the rate of death due to heat in Iran’s elderly people over 65 years old will reach about 16 to 69 cases per 100,000 elderly people in 2080. It was 6 cases per 100,000 elderly in the period of 1961–1990. About 27,178 and 1,147 deaths attributed to outdoor air pollution and indoor air pollution were reported in Iran in 2016 [12].

Iran’s healthcare facilities should be resilient enough and respond well to the health needs of people affected by climate change. On the other hand, they contribute to the production of greenhouse gases. The health sector is responsible for the emission of 4.4% of the global greenhouse gases [17]. Hence, Iran’s health system is facing two challenges: dealing with the health effects of climate change and reducing its contribution to climate change. The health system should adapt to and mitigate the health threats associated with climate change. Therefore, in the short term, the adaptability and resilience of the health system should be strengthened, and in the long term, serious measures should be taken to reduce greenhouse

gas emissions. Adaptive capacity refers to “the ability of healthcare facilities to adapt to climate change to reduce possible damages” [10]. On the other hand, resilience capacity means “healthcare facilities’ capacity and ability to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress, so as to bring ongoing and sustained health care to their target populations, despite an unstable climate” [5].

Figure 1 shows the health effects of climate change using a cause-effect model including Drivers, Pressures, States, Impacts, and responses [18]. This model is suitable for describing environmental health problems from their root causes to their health effects and identifying necessary interventions. The increase in population, especially the urban population, and the excessive consumption of fossil fuels lead to an increase in greenhouse gases in the atmosphere and, as a result, an increase in temperature and a change in rainfall, which will lead to exposure to heat waves, air pollution, drought, storms and floods. Climate change has negative effects on the environment and human health. Therefore, measures should be taken to reduce the risk and increase the adaptability and resilience of healthcare facilities and to provide the health services needed without interruption.

The health system should have high adaptability and resilience to climate change. However, healthcare facilities are very complex multi-specialty organizations [19] that are located in a dynamic, complex and challenging environment [20]. Therefore, there are many challenges in strengthening their adaptability and resilience. The health system of low- and middle-income countries are

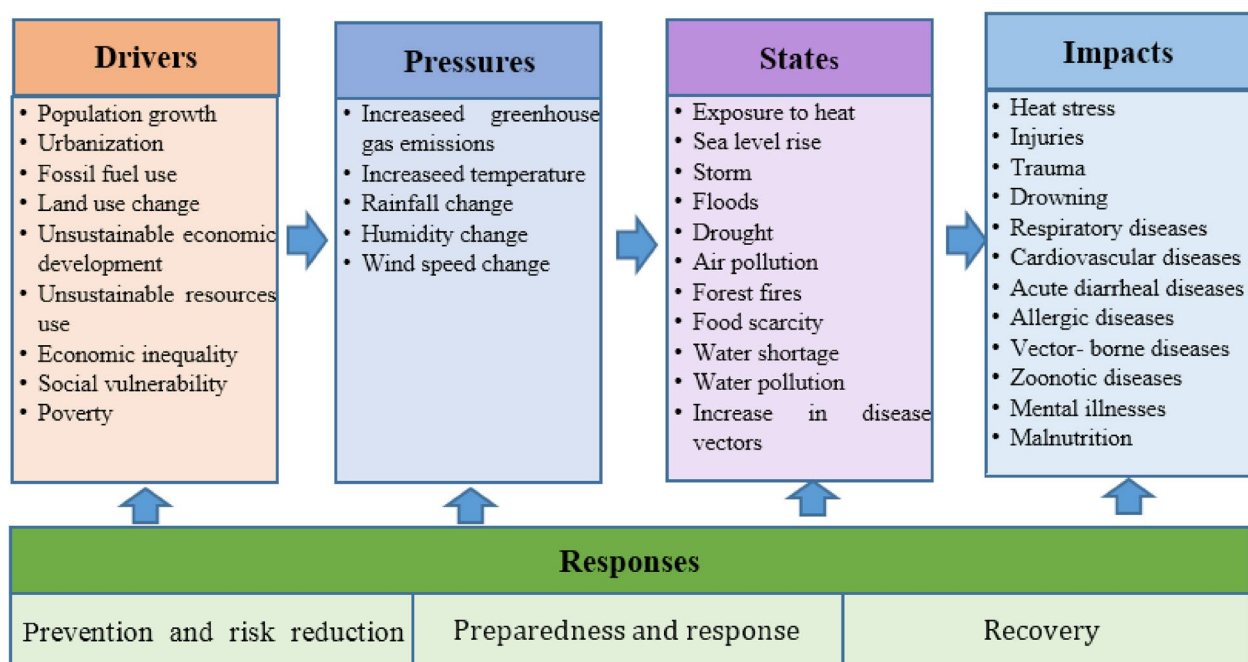


Fig. 1 Conceptual model of the health effects of climate change

facing many challenges in emergency preparedness, controlling the burden of diseases, providing primary care and public health services, and optimal use of resources [5]. An underfunded and understaffed health system makes it difficult to provide health services to those affected by climate change. Iran's health system is vulnerable to the effects of climate change. This study aimed to strategically analyze the resilience of Iran's health system to climate change. The results of the research help health policy makers and managers to use appropriate strategies and measures to strengthen the resilience of healthcare facilities.

Method

This study utilized a multiple methods approach carried out in two phases. The first phase of the research was conducted using interpretive phenomenology method and semi-structured interviews to identify the strengths, weaknesses, opportunities and threats of Iran's health system's resilience against climate change. Policy makers, managers, experts and researchers with sufficient knowledge and experience in health and climate change were invited for an interview. They worked in the Ministry of Health, Ministry of agriculture, Ministry of roads and city planning, President office, Environmental protection organization, National meteorological organization, Atomic energy organization, Planning and budget organization, Universities, Scientific associations, and Research institutes. The interviewees were selected by purposeful and snowball sampling methods with maximum variation.

An interview guide was designed based on the research objectives and the review of relevant literature. The interview guide was pilot tested through three interviews with experts, and their feedback was used to modify the guide. Interviews were conducted either at participants' workplaces or via video call using Skype and WhatsApp software. Interviews continued until data saturation was reached. In total, 32 interviews were conducted. Most of the interviewees were male (78%), in the age range of 41–50 years (47%), had 21–30 years of work experience (44%) and had a Ph.D. degree (69%).

Data analysis was performed concurrently with data collection. Ritchie and Spencer's framework analysis method, including familiarization; identifying a framework; indexing; charting; and mapping and interpretation, was used for data analysis [21]. MAXQDA software was used for coding and data management. The SWOT framework was used to categorize strengths and weaknesses (internal factors) and opportunities and threats (external factors) affecting the resilience of Iran's health system against climate change.

In the second phase of the research, a questionnaire was developed covering those internal and external

factors affecting the climate resilience of Iran's health system. The questionnaire utilized a Likert scale ranging from 1 to 4, with scores indicating very weak or high threat (1), weak or low threat (2), low strength or little opportunity (3), and high strength or more opportunity (4). The questionnaire was completed by 33 climate change and health experts. Then, the strategic position of Iran's health system resilience against climate change was determined using the internal - external matrix.

Various methods were used to guarantee the rigor and trustworthiness of this study. Methods such as sampling with maximum diversity, conducting pilot interviews, spending enough time to conduct interviews, examining the issue from different angles, collecting as much information and evidence as possible, constantly comparing the obtained information, sending the themes and sub-themes to a sample of the interviewees and including their additional comments (member checking), and seeking peers' opinions about the finding (peer debriefing), were used to ensure the credibility and validity of this study. The detailed description of the research environment, the research stages and data collection and analysis methods help the dependability and transferability of the results of this research. The use of qualitative and quantitative methods (triangulation) in this study also helped to strengthen the trustworthiness of the study. The researchers aimed to be as unbiased as possible in all research stages. Methods such as reflexive writing (researcher memos) and collaborative reflexivity were used to guarantee reflexivity on this study.

Ethical considerations of the research included obtaining the ethics code from Tehran University of Medical Sciences, explaining the objectives of the study to the participants, obtaining informed consent, participants' freedom to participate in the research and their right to withdraw, obtaining permission for audio recording, and confidentiality of their personal information.

Results

A total of 29 strengths and 55 weaknesses were identified for Iran's health system's resilience to climate change (Table 1). These internal factors were grouped into 7 dimensions (i.e., governance and leadership; financing; health workforce; facilities equipment and medicines; health information system; health services delivery, and key results).

A total of 18 opportunities and 83 threats were identified to Iran's health system resilience to climate change (Table 2). These external factors were categorized into 6 dimensions (i.e., political, economic, social, technological, environmental, and legal factors).

Accordingly, Fig. 2 shows the conceptual model of a climate-resilient health system.

Table 1 The strengths and weaknesses of Iran's health system's resilience to climate change

| | Strengths | Weaknesses |
|--|--|--|
| Governance & leadership | <ul style="list-style-type: none"> • Health and climate change department at Ministry of Health • Ministry of Health membership in the National Climate change center • Good cooperation with international organizations • Good partnership between health centers and community • Good cooperation with Red crescent organization and the Iran's emergency organization • Annual evaluation and accreditation of hospitals' safety • Emergency operation plan • Health system preparedness in disasters guidelines • Emergency Operation Center (EOC) in the Ministry of Health • Good communication of EOCs and meteorological organization • Incident command system at national and operational levels | <ul style="list-style-type: none"> • Lack of a health national adaptation plan • Insufficient support of policymakers and senior managers • Instability of health managers • Low cooperation of the private sector with the Ministry of Health • Limited use of NGO's capacity • Weak internal coordination about implementing health and climate change programs • Weak external communication of the Ministry of Health • Insufficient laws and policies in health and climate change • Inadequate instructions on preparation & response of the health system |
| Financing | | <ul style="list-style-type: none"> • Lack of sustainable financial resources • Insufficient budget for health and climate change programs • Insufficient financial aid of NGO's |
| Health workforce | <ul style="list-style-type: none"> • Educational departments in health and climate change • Disaster risk management experts • Environmental health experts | <ul style="list-style-type: none"> • Shortage of specialized health workforce • Insufficient experts of health and climate change in health centers • Failure to use experts in related management positions • Inadequate expertise of staff in health and climate change • Lack of incentives for active involvement of staff in health and climate change programs • Weak human resources management during disasters • Inappropriate use of volunteers • Inadequate standard medical response teams • Insufficient teamwork • Inadequate knowledge and ability of managers • Insufficient preparedness training programs • Insufficient disaster risk management exercises |
| Facilities, equipment & medicines | <ul style="list-style-type: none"> • Good capacity to identify and track diseases in disasters • Infrastructure of electronic health records • Environmental health and health in disasters departments • Scientific associations and knowledge-based companies in medical universities • Safe and responsive medical in disasters | <ul style="list-style-type: none"> • Weak supply chain of medicine and equipment • Shortage of the rescue fleet • Insufficient mobile hospitals • Inadequate supplies and equipment stocks • Lack of sufficient reserves of water, etc. • Inadequate cold storage facilities for storing blood • Insufficient domestic production of vaccines, medicines, etc. • Inadequate laboratory equipment and blood banks • Inadequate decontamination equipment for chemical, biological, radiation and nuclear crisis • Poor utilization of telemedicine in pre-hospital services • Little attention to local climate in building healthcare facilities • Inadequate resources, equipment, etc. • Inefficient resources management during emergencies • Low Use consumption equipment |
| Information system | <ul style="list-style-type: none"> • Map of vulnerable areas of healthcare facilities • Electronic health records • Inadequate research policies • Insufficient applied research | <ul style="list-style-type: none"> • Lack of a comprehensive information system • Lack of early warning systems • Insufficient public information during disasters • Data security management challenges • Lack of health information management process for disasters • Limited information sharing among organizations • Inadequate research centers in health and climate change • Inadequate use of data in policy-making |

Table 1 (continued)

| | Strengths | Weaknesses |
|--------------------------|---|--|
| Services delivery | <ul style="list-style-type: none"> • Adequate access to healthcare facilities • Primary healthcare network • Continuous monitoring of water-borne diseases | <ul style="list-style-type: none"> • Limited identification of vulnerable populations • Inadequate capacity-building for health services during crises • Insufficient monitoring of the sewage disposal system |
| Key results | <ul style="list-style-type: none"> • Citizen health insurance coverage • Provision of health services to disaster victims • People access to related healthcare services | <ul style="list-style-type: none"> • Low safety of healthcare facilities • Low satisfaction of the health system performance • Low resilience of society to climate change • Low motivation of healthcare workers to participate in health and climate change programs • Low resilience of health workforce • Weak insurance coverage of healthcare facilities against accidents |

The average score of internal factors for Iran's health system resilience to climate change was 2.47 out of 4 points. Governance and leadership (2.67) and service delivery (2.58) received the highest scores, indicating relative strengths in these areas. However, the dimensions of financing (2.03) and health workforce (2.28) had lower scores, indicating areas of weakness. The average score of external factors was 2.12 out of 4 points. Legal factors (2.50) received the highest score, indicating potential opportunities in these area. On the other hand, economic factors (1.49) and environmental factors (1.67) received the lowest scores (Table 3).

Figure 3 shows the strategic position of Iran's health system's resilience against climate change (i.e., V zone). Therefore, precautionary strategies such as strengthening the resilience of the healthcare facilities to climate change, promoting adaptation of healthcare facilities to climate change, strengthening internal and external partnerships, strengthening the health service delivery system, quality management and cost management, should be implemented to strengthen the resilience of Iran's health system to climate change.

Discussion

This study aimed to strategically analyse Iran's health system's resilience to climate change, and evaluate its strengths, weaknesses, opportunities, and threats. Internal and external factors of the health system affect its adaptability and resilience against the effects of climate change. These internal factors should be improved and strengthened, and those external factors should be modified to facilitate strengthening the health system's resilience to climate change.

The internal factors affecting Iran's health system's resilience to climate change were categorized into seven dimensions, including governance and leadership; financing; health workforce; facilities equipment and medicines; health information system; health services delivery, and key results. The average score of internal factors' resilience to climate change was 62%. Taking measures to strengthen the six building blocks of the health system

helps the climate resilience and environmental sustainability of healthcare facilities and provides the possibility of protecting people's health in an unstable climate. Therefore, the climate adaptation and resilience program should include a set of measures to strengthen these six building blocks of the health system.

Health system governance is defined as "a system of structures, processes, values, regulations, power and authority for effective management of resources, coordination of stakeholders, planning and stewardship of health programs and evaluation of health system performance to promote, restore, and maintain health [22]". Governance, and leadership play a key role in the success of disaster management programs. Health policy makers' and managers' support and involvement, formulation of appropriate disaster management plans, provision of required resources and leadership of the change process are essential [23]. The resilience score of governance and leadership of Iran's health system was 67% (relatively good). Structures were created in the Iranian Ministry of Health for disaster management. Rules and guidelines were written, and relatively good relationships were established with related organizations outside the health system. However, the low stability of managers and as a result, short-term planning, the lack of a national health and climate change policy and a strategic plan to strengthen the resilience of the health system against climate change, the low participation of the private sector in health and climate change activities are among the weaknesses of this building block of Iran's health system.

Other public sectors need to be aware of the scope and scale of the health risks emanating from their sectors. The health sector must strengthen and expand its sphere of influence and operations beyond itself, mainly in relation to health-determining sectors such as water, energy, agriculture and urban planning. These sectors' management is not directly under the control of the health department. However, the development of normative guidelines for determining acceptable levels of exposure to health hazards (e.g., air quality guidelines) is the responsibility of the health sector. The role of monitoring the health

Table 2 Opportunities and threats of Iran's health system's resilience to climate change

| | Opportunities | Threats |
|------------------------------|---|---|
| Political factors | <ul style="list-style-type: none"> • Membership in the UNFCCC • National Office of Climate Change • Disaster management organization • Supreme Council of Health and Food Safety • Legal capacities in climate change • WHO support for health and climate change • The possibility of attracting international grants | <ul style="list-style-type: none"> • Political instability • Inadequate national programs in environment protection • Insufficient government support for climate change programs • Insufficient participation of governmental organizations in health and climate change programs • Insufficient accountability of responsible organizations • Inadequate exchange of experiences and resources • Weak management in climate change resiliency • Insufficient coordination between government and private sectors • Low administrative health in the organizations • Inadequate access to medicine and equipment from abroad • Lack of access to scientific and information resources of the world • Inadequate exchange of international experiences in health & climate change • Inadequate trust in the government • Hard and soft war and confrontation of other countries with Iran • Cyber security threats • Unrest and demonstration |
| Economic factors | | <ul style="list-style-type: none"> • Poor economic growth of the country • High inflation rate • Economic sanctions • Difficulty in global banking to buy drugs and vaccines • High bank interest rate • Low purchasing power of people • Unsustainable economic development |
| Social factors | <ul style="list-style-type: none"> • People's demand for improving climate literacy • Participation of volunteers in climate change resiliency • Research centers and knowledge-based companies | <ul style="list-style-type: none"> • Low population growth • Increase in the elderly • Inappropriate distribution of the population • Unsustainable urbanization • Social inequality • Inadequate education • Low level of physical health of the people • Low level of psychosocial health of the community • Low attention to accident prevention among the people • Risky behaviors in society • Misconceptions in the society • Low attention to the psychological aspects caused by disasters • Low information of people about disasters • Low risk perception in the community • Inadequacy of health literacy of people • Insufficient participatory disaster management • Illegal construction on the riverside • Incoherent public education related to risk reduction • Non-participation of donors in climate change resiliency programs • Inadequate knowledge in accident risk management • Insufficient information sharing among crisis management organizations • Inadequate social networks |
| Technological factors | <ul style="list-style-type: none"> • New technologies in quickly warning of risks | <ul style="list-style-type: none"> • Inadequate infrastructure • Low coverage of communication platforms • Inadequate access of rescue organizations to all areas • Insufficient investment in research & development • Inadequate communication technologies in accident risk management • Lack of integrated accident risk system • Inadequate information exchange between organizations • Disruption in the supply of clean energy for healthcare facilities • Obsolete and polluting industries |

Table 2 (continued)

| | Opportunities | Threats |
|------------------------------|---|--|
| Environmental factors | <ul style="list-style-type: none"> • Good people attitude towards environmental protection • Renewable energy sources • Changing the type of cultivation in agriculture | <ul style="list-style-type: none"> • Global warming and sever climate change • Destruction of the natural ecosystem • Use of wastewater in irrigation • Dust storms, and sandstorms • Air pollution • Flood, and monsoon flow • Land subsidence • Jeopardizing food security and reduced food production • Destruction of agricultural land and turning it into a center of dust • Contamination of water and instability of access to water • High rate of natural disasters in Iran • High rate of man-made disasters in Iran • High rate of emerging and re-emerging diseases in Iran • Unfavorable state of climate change in Iran • Use of non-renewable energy • Pay little attention to native characteristics risk management |
| Legal factors | <ul style="list-style-type: none"> • Existence of protective laws such as clean air law • Mandatory accident insurance for infrastructure of executive bodies • The existence of a national plan risk reduction, preparedness, response and recovery • Support of international organizations in RCC. | <ul style="list-style-type: none"> • Inadequate comprehensive climate change laws and regulations • Insufficient transparency and consistency of climate change laws • Inadequate preparedness, risk reduction and recovery plan • Low attention to climate change resilience in national development plans • Inadequate transparency in governmental organizations' responsibilities about climate change resilience • Inadequate strict laws to control and reduce climate change • Inadequate monitoring systems of risk management actions • Low attention to the integrated management of disasters • Ignoring the laws by some people • Lack of commitment of the executive bodies to the laws • Inappropriate execution of laws and risk managing plans • Insufficient guarantee of law implementation • Failure to periodically review policies, laws and regulations |

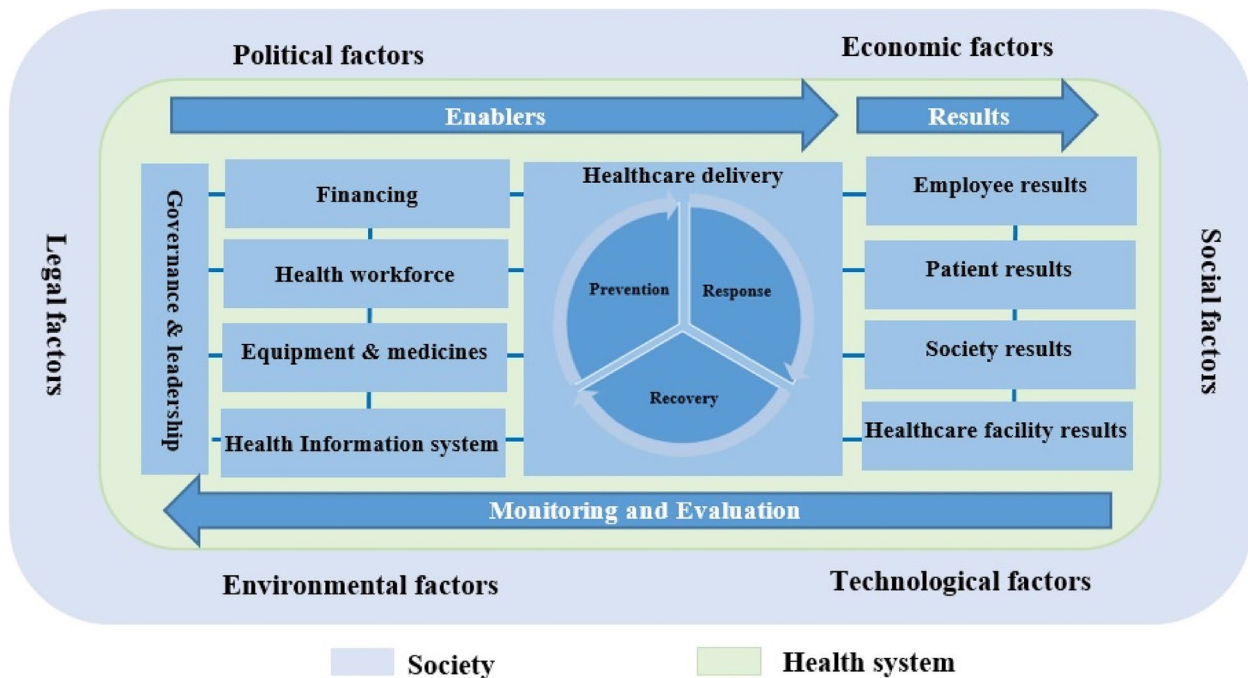


Fig. 2 A conceptual model of a climate-resilient health system

Table 3 The mean score of factors affecting Iran's health system resilience against climate change out of 4 points

| Internal factors | Mean | SD | External factors | Mean | SD |
|-----------------------------------|------|------|---------------------------|------|------|
| Governance and leadership | 2.67 | 0.44 | Political factors | 2.23 | 0.55 |
| Financing | 2.03 | 0.15 | Economic factors | 1.49 | 0.19 |
| Health workforce | 2.28 | 0.32 | Social factors | 2.16 | 0.27 |
| Facilities, equipment & medicines | 2.52 | 0.32 | Technological factors | 2.37 | 0.29 |
| Health information system | 2.36 | 0.29 | Environmental factors | 1.67 | 0.28 |
| Health service delivery | 2.58 | 0.31 | Legal factors | 2.50 | 0.37 |
| Key results | 2.34 | 0.26 | | | |
| Score of internal factors | 2.47 | 0.37 | Score of external factors | 2.12 | 0.48 |

outcomes of other sectors of society is the responsibility of the health sector. Memorandums and agreements should be established between the Ministry of Health and the main stakeholders such as the Planning and budget organization, the Environmental protection organization, the Meteorological organization, the Ministry of Agriculture, the Ministry of Energy and Transportation and their roles and duties in relation to protecting people's health from climate change should be specified.

Health system financing is "the process of collecting, pooling, and allocating financial resources to promote, restore or maintain health" [24]. The resilience score of financing of Iran's health system was 51% (average). Sustainable financial resources have not been considered to reduce the health effects of climate change in Iran. The negative effects of climate change on people's health lead to an increase in health costs. Responding to the growing

needs of people for health services during climate change disasters and strengthening the adaptability and resilience of healthcare facilities requires financial resources. New collaborative and inter-sectoral models should be used to finance the Iranian health system [10].

Providing quality, safe and effective health services requires specialized, committed and motivated employees. The resilience score of workforce of Iran's health system was 57% (average). Employees' shortage, migration of doctors and nurses, limited use of health and climate change experts, low knowledge of staff about climate resilience of healthcare facilities and insufficient in-service training are among the most important challenges of the resilience of Iran's health workforce. Climate change increases the demand for health services. Therefore, the number of health workers, especially those trained in the climate change and health, should be increased. The capacity and resilience of staff should be strengthened to proactively anticipate and respond to climate change. The technical and professional capacity of employees should be developed through training so that they can manage the health risks of climate change. University curricula on climate change and health should be developed and students should be trained in these fields [5].

The resilience score of facilities, equipment and medicine of Iran's health system was 63% (relatively good). Insufficient attention to climate issues in the design and construction of healthcare facilities, vulnerability of healthcare facilities to climate changes, low use of new technologies for the resilience of health care centres, waste of energy and waste of resources in healthcare facilities, inadequate resources and medicines are the most important challenges of this building block of the Iranian health system. The organizational capacity of healthcare

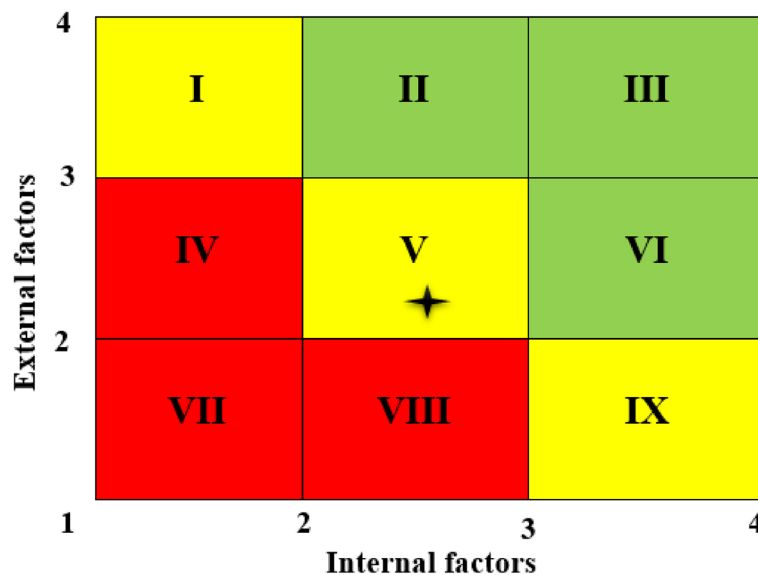


Fig. 3 The strategic position matrix of Iran's health system's resilience against climate change

facilities should be developed for greater adaptation and better response to the effects of climate change. Adaptation to climate change should be considered in the construction and equipping of healthcare facilities. The use of renewable energy, and climate change resistant water, sewage and electricity infrastructures are suggested. In addition, telemedicine should be considered more to reduce the physical activities of healthcare facilities.

The resilience score of information system of Iran's health system was 59% (average). The lack of comprehensive and integrated information system, the lack of a map of the vulnerability of healthcare facilities to climate change, weak information management system, the limitation of sharing data, and the low quality and inapplicability of the conducted research are the main weaknesses of this building block of Iran's health system. The health information system should be strengthened in such a way that the necessary information about the vulnerability of the health system to climate risks, the response capacity of the health system, and the extent of its adaptability and resilience to the effects of climate change are available to managers and health workers for evidence-based decision making [5]. These ongoing assessments provide policymakers and managers with the evidence they need about the nature and scale of health risks from climate change and the most vulnerable populations.

Climate information should be integrated into the surveillance system for diseases attributed to climate change. Data on climate-sensitive environmental hazards and epidemiological trends must be collected, analysed and interpreted in a timely manner to respond to hazards in a timely manner. Therefore, cooperation with Meteorological Organization, Environment Organization and other related organizations is essential for accessing and interpreting weather information properly. Information related to climate change impacts, health system vulnerability, response capacity and emergency preparedness capacity over time should be reported. Timely warnings should be given to managers, media and public so that effective measures can be taken to prevent the negative health consequences of climate change. Research capacity on climate change and health must be supported by relevant multidisciplinary networks, funding and training opportunities. Research findings on climate change and health should be disseminated and used by policy makers [5].

Healthcare facilities are expected to provide high quality, safe and effective health services [25, 26]. Climate change will increase the demand for health services, which may exceed the capacity of healthcare facilities. As a result, people may not be able to get the health services they need. The resilience score of service delivery of Iran's health system was 65% (relatively good). Inadequate attention to the environment determinants

of health, insufficient attention to prevention, and the changing pattern of diseases due to climate change, are the main weaknesses of this building block of the Iranian health system. Advocacy of Ministry of Health to reduce pollutants, formulating and implementing an operational plan to reduce the incidence of diseases and injuries attributed to climate change, increasing the capacity of healthcare facilities, and assessing the need for climate change related health services are some useful solutions to solve these challenges. Health vulnerabilities should be assessed and accordingly, health plans should be developed and implemented [16].

The overall score of Iran's health system resilience to climate change was 59% (average). This performance was related to the resilience of healthcare facilities, employees, patients and society against the effects of climate change. Improving the resilience of Iran's health system against climate change requires strengthening the structures and processes of the health system, i.e. its six building blocks.

The external factors affecting Iran's health system's resilience to climate change were categorized into six dimensions, including political, economic, social, technological, environmental, and legal factors. The average score of external factors was 53%. Evaluating the impact of political, economic, social, technological, environmental and legal factors on the adaptability and resilience of the health system leads to the identification of key issues (opportunities and threats) that managers should consider when strengthening the resilience of healthcare facilities.

Insufficient attention of policymakers and managers to the climate change and its effects, the political and economic sanctions, economic problems, the increase in the unemployment rate, the devaluation of the national currency, aging of the country's population, increase in urbanization rate, polluting industries, use of fossil fuels, increase in global warming, depletion of underground water reserves, and deforestation, are most important factors outside the health system, which leads to the vulnerability of healthcare facilities against climate change. International collaboration development, assigning an independent budget to deal with health effects of climate change, modernization of industries, development of water resources management plan, using technologies that reduce vehicle emissions, and educating and informing the public about the health effects of climate change are solutions to solve these challenges.

The 13th global Sustainable development goal is to take urgent action to deal with climate change and its effects [27]. The United Nations urges countries to take measures to strengthen resilience and adaptation to climate-related risks and natural disasters. The goal is to mobilize \$100 billion annually by 2020 to meet the needs

of developing countries to adapt to climate change and invest in low-carbon development [7]. However, political sanctions have prevented Iran from optimally using international aid. More investment is needed to achieve health goals in other public sectors of the country, such as implementing climate-resilient water safety initiatives, or increasing food security during drought.

The people of the society should be aware of the challenges of the environment around them, be involved in the identification of risks and related decisions, and be empowered to protect themselves effectively. Community groups and leaders must be prepared for local environmental hazards, understand their role in prevention and response, and be aware of effective solutions and resources available to them. Information, stakeholder participation, and effective two-way dialogue are vital for improving the functioning of the health system with society, two-way information exchange and community mobilization. Community empowerment can activate local capacity, increase the range of available information, improve understanding of vulnerability, and build foundations for local resilience.

Limitation

In this research, a multiple methods approach was used for the strategic analysis of the resilience of Iran's health system against climate change. The use of qualitative method led to the identification of strengths, weaknesses, opportunities and threats. In the quantitative part of the study, we asked the opinion of experts about the internal and external environment of Iran's health system using a questionnaire. It is suggested that future studies evaluate the resilience of healthcare facilities using a valid checklist and visiting healthcare facilities.

Conclusion

Climate change causes injury, disease and death. A sustainable, climate resilient health system makes it possible to provide effective health services to people in an unstable climate. Iran's health system is facing significant weaknesses and challenges that have hindered its resilience to climate change. Iran's health system can better prepare and respond to the health impacts of climate change, and safeguarding the health and well-being of its population by addressing these challenges and implementing adaptive and resilience strategies. These strategies should focus on formulating national climate change and health policy and strategic plan, securing policy-makers' and senior managers' commitment and support, developing the capacity and resilience of healthcare facilities and staff, securing sustainable financial resources, enhancing human resources capacity, improving the supply chain of medicine and equipment, enhancing emergency warning systems, building resilience among health

system workers, addressing political instability and economic sanctions, and enforcing environmental laws and regulations. The insights generated from the study can inform policy decisions and actions towards better adaptation to climate change impacts on health.

Abbreviations

WHO World Health Organization
UN United Nations

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Authors' contributions

MA, and AMM participated in the design of the study. TS, AO, IK, and HD conducted interviews. MAA, AMM, TS, PI, AS, MY and MZ undertook the literature review process. All authors conducted the quantitative analysis phase. All authors drafted the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Authors confirm that all experimental protocols were approved by ethics committee of Tehran University of Medical Science (Approval ID: IR.TUMS.MEDICINE.REC.1401.405). Informed consent was obtained from all participants. They were informed that their participation was voluntary. They were able to withdraw their participation at any time without a need for declaring a reason. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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