

An Evaluation of City Vulnerability Based on the Passive Defense Approach; Case Study in Mahabad City, Iran

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Abstract

INTRODUCTION: Nowadays, due to population growth and resource constraints, cities are more vulnerable towards the crisis. Reducing the vulnerability of urban land use, with utilizing new approaches of crisis management such as passive defense, can be useful in creating a secure environment in cities. This is of the most important goals, planners and city managers are going to implement in cities; and how to deal with natural disasters, is of the major concerns of societies. This study aimed to evaluate city vulnerability in Mahabad City, Iran, based on the passive defense approach.

METHODS: In this applied descriptive-analytical research, the Analytic Hierarchy Process (AHP) model was used to analyze the data, and Geographic Information System (GIS) software was used to draw the maps. Then, to clarify the positive and negative features, or the opportunities and the threats, the Strengths, Weaknesses, Opportunities, and Threats (SWOT) technique was applied.

FINDINGS: Based on the AHP model, the highest records were given to vital factors such as networks, fuel storage, water, and electricity, while the lowest records were given to higher education centers. Moreover, based on the SWOT analysis, the most important weaknesses of Mahabad City were as the compact and dense texture of the city, the low width of the most of the passageways, and the aggregation of major activities in the city center.

CONCLUSION: Research results show that in Mahabad City, there is no comprehensive plan to secure citizens. Urban planning by relevant institutions and administrative councils does not fit the physical and human components of the city.

Keywords: Assessment; Vulnerability; Passive Defense; Iran

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Introduction

Throughout history, with refuting in caves and building habitats in accordance with the technological and socio-economic requirements and conditions of the time, including constructing tall ramparts and digging moats, human beings have sought to protect their lives and provide group security (1,2).

Cities are one of the densest human habitats that, because of the presence of humans, require safety in all physical, social, economic, cultural, and managerial aspects as well as all measures that insure human society and its natural and

artificial environment (3). They may be classified according to the area of crisis impact, type of crisis, or area of action to deal with the crisis. In general, crises that endanger urban safety and threaten the city include natural factors, human factors, social and economic factors, and political, spatial, military, and cultural factors (4). Since the beginning of urbanization, the planning, design, and construction of cities have always been accompanied by defense (2).

In developing countries such as Iran where urban infrastructures are being constructed and formed, the need to pay more attention to passive

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urban defense to reduce the amount of damage is of great importance, so disaster preparedness is crucial. Additionally, the proximity of the border provinces with the insecure neighboring countries of Iran such as Afghanistan, Pakistan, and Iraq, and on the other hand, the sectarian wars in these countries can be one of the factors of infiltration of the terrorists to the country and affecting various systems of the country (5).

Passive defense is among the issues that have been addressed in the urban plans and programs in recent years. Currently, in comprehensive urban plans, this includes clear regulations on the location of uses and robustness of structures, which can be applied for any city, not only for the city under study. Today, with the advancement of human knowledge and avarice, the internal and external threats regarding the advancement of the frontier regions are increasing, the rational exposure to which require knowledge, actions, and measures appropriate to modern day science and technology (6). Properly designing development processes as measures of internal security and using a unified and holistic approach to urban sustainable development planning can ensure the survival of frontier cities during aggression or military threats against countries (7-11).

Defense is referred to as protecting individuals' lives, ensuring individuals' security, and safeguarding their territorial integrity and national sovereignty at all times against any conditions, situations, and any aggression (12). Defense is carried out in two ways: (a) Active defense which is the condition and position to defend yourself against an enemy aggression by employing weapons, war equipment, and combat techniques in order to repel the attack. (b) Passive defense which is performed without using war weaponry to defend against the enemy attack and it is aimed at reducing casualties from the attacks (13). Passive defense employs all principles and precautions other than the use of weapons which, by observing and utilizing them, attempts to prevent the infliction of financial losses on equipment, critical and sensitive military and civilian installations, and casualties, or aims to minimize these losses and casualties. Passive defenses appropriate to the conditions and characteristics of the critical points, administrative and residential regions, and other areas of the country, and by applying all the principles and with relatively low costs, can prevent severe

damage to sensitive facilities in the military, industrial, economic, and social centers on which the political independence, national sovereignty, and resistance to enemies depend, in addition to saving the lives of numerous individuals at risk. Passive defense principles include a set of underlying actions by applying which the passive defense objectives can be achieved, including reducing damage, reducing the capability of the detection and targeting of the enemy's offensive systems and weapons, and imposing greater cost to them (14-17).

In most of the world's scientific and military resources, the passive defense principles or issues include the following 6 to 7 actions that should be carefully regarded in the design, planning, and implementation of actions (18). Camouflage, concealment, covering, deception, faction and dispersal, reinforcement of fortification, and information as well as other cases such as location, mobility, shelter, camouflage discipline, protection and retrofitting facilities, and the creation of secure structures since the creation of humans have grown up among the threats and have been developed to cope with these menaces. Some of these threats no longer exist, some are present with more or less intensity, and some of them are new threats. In recent decades, the type of coping with these threats has become more scientific and the probability of incidence of losses and how to cope with them have been clearly specified (19).

Mahabad has a special position given its location in the intersection of three provinces of East Azerbaijan, West Azerbaijan, and Kurdistan, Iran, due to being located in the southwest of Lake Urmia and among the roads of cities of Urmia, Miandoab, Bukan, Naghadeh, and Sardasht (Figure 1). Due to the density and concentration of population and buildings, location on the Mahabad-Maku Fault, as well as its position along Mahabad River and Mahabad Dam, this city is one of the areas that a potential crisis can impose irreparable financial damage to the body of the city and citizen casualties. Therefore, the present study seeks to identify vulnerable areas of the city against humanitarian crises and threats by utilizing passive defense and urban defense.

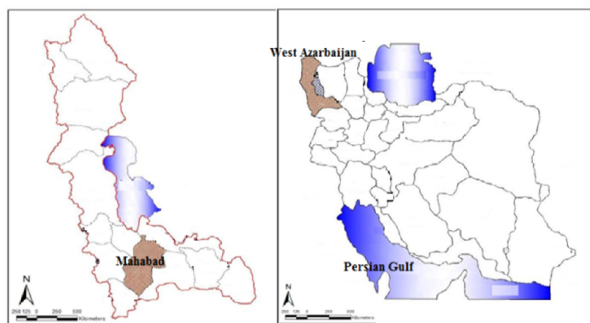


Figure 1. Geographical location map of West Azerbaijan and Mahabad City, Iran

Methods

The present study was of an applied type conducted using the descriptive-analytical method. The data collection method included reviewing texts, sources, books, and articles, surveying maps, interviewing, and observations, and various software and tools were employed in this study for updating and processing the data and spatial information, making, editing, and classifying images, and producing the data outputs. The analytic hierarchy process (AHP) model and geographic information system (GIS) software were utilized to analyze the questionnaire data and drawing maps, respectively.

AHP model: AHP is one of the most well-known multi-criteria decision-making techniques invented by Thomas El Saati in the 1970s (20). This method can be useful when the decision-making process has several options and decision indices. The indices can be quantitative or qualitative. In this study, after identifying the criteria and sub-criteria and scoring each of the five criteria, the importance coefficients of each criterion in relation to the other criteria as well as sub-criteria in relation to each other were analyzed and determined using the AHP method.

Findings

Determination of criteria and sub-criteria: In this study, five criteria and eleven sub-criteria

were identified based on the hierarchical and systematic analysis steps set in the AHP model after selecting the criteria and indices required for the evaluation and analysis, in order to measure the vulnerability in Mahabad City (Table 1).

Determination of the preference coefficient of criteria and pairwise comparison of sub-criteria:

In this study, 25 questionnaires were distributed among urban experts (university professors, municipal and governing staff as well as urban planning graduates), then they were asked to rate the criteria from 1 to 9 based on their increasing level of importance, with the score of the criteria and sub-criteria as well as the scoring manner presented in table 2.

Given the table above, the highest score is associated with the criterion of arteries with a score of 2.37, which itself includes the sub-criteria of communication networks, fuel tanks, power distribution, and water tanks, besides the lowest score is for the support centers (higher education centers).

Determination of the city vulnerability based on the physical criteria

1. City structure: Spatial distribution of elements, combination of elements, and main functions of the city which form the city structure have a pivotal role in the vulnerability of the city to various incidents, specially the enemy attacks. Physical divisions of the city such as neighborhoods, alleys, zones, regions, single-centeredness or multi-centeredness, etc. indicate another form of the city structure, each of which has its own capability to withstand incidents. For instance, in a single-center structure in which the economic and human facilities are concentrated in one part of the city, the vulnerability level is higher compared to the multi-center cities. Moreover, in case of an attack, the single-center cities would surrender in a shorter time.

Table 1. Criteria and sub-criteria for analysis in the analytic hierarchy process (AHP) model

Arteries				Support centers	Military and law enforcement centers	Urban utilities and equipment			Crisis management centers	
A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
Police stations	Higher education centers	Garrisons	Urban facilities	Terminals	Offices	Water tank	Fuel tanks	Power distribution	Hospitals and medical centers	Communication network

Table 2. Final score of each criterion and sub-criterion

Criteria	Vulnerability	Sub-criteria	Vulnerability
Arteries	2.370	Communication networks	2.140
		Fuel tanks	0.063
		Power distribution	0.084
		Water tank	0.087
Crisis management centers	0.160	Offices	0.065
		Hospitals and medical centers	0.095
Military and law enforcement centers	0.105	Garrisons	0.049
		Police stations	0.056
Urban utilities and equipment	0.128	Terminals	0.047
		Urban facilities	0.081
Support centers	0.058	Higher education centers	0.058

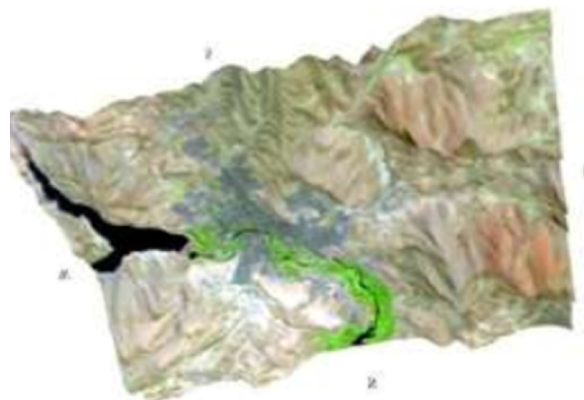
Grid cities such as Tokyo in Japan, Barcelona in Spain, or to some extent Tehran in Iran, with the elongation of the escape way of the complications of the new wars are not appropriate for defense in the event of attack given crossing of the alleys and streets and the necessity to stop in the front side. Therefore, the red light and perhaps the most appropriate map of the passageways and streets to defend the citizens against the new wars are related to the star cities with the nearest way of escape from the city provided for the citizens. The higher the number of the streets with the same origin, the more the options for the non-military population to escape and with decreasing the probability of traffic congestion, the problem of population concentration which is always desirable for the enemy, will be solved, particularly that such passages as the access ways are the primary targets for the enemy (21).

The most important reasons of formation of Mahabad City include Mahabad River (for drinking and agricultural uses) and high and narrow mountains (due to security). For these two reasons, the city of Mahabad has had a stretched structure since its formation. Due to the topographic characteristic of the area and the expansion of construction from both sides, its elongation has now increased as well (Figure 2). This has caused congestion in the middle of the city and heavy traffic at peak times. This traffic congestion inevitably increases fuel consumption and pollution and waste of time, in addition to the lowered threshold of tolerance of the individuals. As a result, Mahabad's stretched structure is a factor in contrast to the sustainability of the city.

City texture

The texture of each city or the same as the shape, size, and combination of the smallest components of the city will also be effective against the

military attacks and natural disasters (22). The city texture can be examined on the basis of various indicators, including regular or irregular, coarse or fine, and dense or dispersed texture, and full and empty spaces.

**Figure 2.** Topographic map of Mahabad City, Iran

A. Regular or irregular texture: It can be said that the vulnerability of the regular or irregular texture vary depending on the type of threat. For example, during an invasion, the regular texture benefits from more possibility of escape and refuge or easier relief, but the irregular texture has a higher level of urban resistance to military attacks. Moreover, because of the tissue irregularity, there is less possibility of planning and successful attacks on the unidentified places, additionally; the civilians have the chance of superiority using the irregular texture. However, any type of urban texture is involved in the escape and refuge capabilities for the residents, relief facilities, cleanup, and even temporary residence (22).

B. Fine-grained and coarse-grained texture: In a definition in order to identify the urban old textures, the Iranian supreme council of

architecture and urban planning introduced segments of less than 200 m² as the criterion for identifying the fine-grained segments. In fine-grained segments, given the low amount of open and safe space for escape and refuge, the human casualties increase in times of crisis. The larger the segment size, first the lower the human casualties and second, the easier relief and temporary residence operations.

C. Dense or dispersed texture: Dense or dispersed texture indicates the position and nature of a location. These textures make the collection noticeable (23). Regarding the structural and population density, the lower this density, the lower the texture vulnerability and the higher the cost of imposing damage for the enemy. Regarding the ratio of the full to empty spaces in cities, due to high land prices on the one hand and the limited land available to be constructed on, on the other hand, in addition, based on the policies regarding limiting the physical development of cities, there is usually a high ratio of areas constructed relative to the empty spaces. The areas in which the ratio of the full to empty spaces is in a moderate or low level, the vulnerability level is low given their good condition of relief after destruction or damage, as well as their capability of easier escape or pass.

Urban texture is the combination of urban spaces and elements in which the natural conditions, especially topography and climate, are replaced by blocks and urban areas in a compact or discrete fashion, with a particular order within the city (24). Basically, the texture of each city reflects the formation and development stages of the city throughout history, with natural factors being one of the major and very important factors shaping the texture of the city. The three factors of land, climate, and water resources are fundamental and important factors of nature that have profound effects on the texture of ancient cities in Iran. Moreover, the texture of each city is a dynamic and changing quantity that determines the physical state of the city and its formation over time. The texture of each city initially determines the physical spatial grading of the city, namely its vacant and densely populated spaces and how they relate to each other as well as their proximity level. Furthermore, the city texture specifies the communication network and pathways through which the main and secondary ways can be identified, and eventually the context

of each city can indicate the spatial distribution of the activities. Each of the physical spaces by their dimensions at the surface and height can represent the type and volume of their particular activity. Empty spaces can often reflect specific urban characteristics (25). The compact and dense texture of the city of Mahabad has made difficulties for the city, and thus it performs poorly in its current form (since 50 years ago) in the field of sustainability. Some of these problems are as follows: When it rains, the upstream floodwater of the perpendicular streets flows into the city's central streets, and the lack of a parallel street to the central street causes flooding. Besides, since in this city most of the streets except the main street, extend from the top of the foothills downward and are perpendicular to the main street, this leads to the slowed commutes in the winter due to freezing, causing the low level of sustainability in the city. General characteristics of Mahabad city texture are as follows:

- The sunshine direction and land side effects as decisive factor in the establishment, expansion, and overall appearance of the city
- Alleyways and main passages parallel to the contour line and often with low width
- Natural bedding leading to distinction and visual richness of the city.
- Dense urban texture and interconnected buildings
- Small and enclosed urban spaces due to the highly cold climate.

For four reasons, cities in mountainous areas are often located in the middle of the foothills and on its south side: First, if the city is positioned downstream of the valley, there is a risk of flooding. Secondly, in the colder night, the heavier air penetrates down the valley and the cold weather is intensified. Thirdly, the north side of the mountain, which has always been in the shade, is not a good place to live. Fourthly, the top side of the mountains is also not suitable for residence because the rugged terrain is usually high at the top of the mountains and the wind intensity is high in this area as well and there is no protection for the city from the wind. Finally, mountain top is distant from the valley where the river flows, hence access to water is difficult.

Evaluation of Mahabad City in relation passive defense

1. Geographical dimension: A. The location of the city of Mahabad in the borderline areas increases the

risk of external threats from its neighbors.

B. The high groundwater level facilitates the contamination of the aquifers and the contaminants can easily enter the water and penetrate the ground.

C. Increasing construction on farms and farmland around the city will erode the region's natural defensive cover.

2. *Physical hierarchy dimension and activities:*

A. There is no proper zoning within the city, so it becomes difficult to control the city when internal disasters occur.

B. The city has been restricted from the north by the agricultural lands and banks of the Yusuf Kand Dam, by the Mahabad Dam Lake from the west, and by the mountains from the east and south.

C. The lack or shortage of open spaces at the neighborhood level to enter quickly in times of crisis and prevent the dangers of falling buildings and the like.

D. The presence of the market in the city center brings together the major economic activities of the city, and in times of disaster the supply of requirements of different parts of the city becomes difficult.

3. *Demographic, social, and cultural issues:*

A. Mahabad is one of the most populated cities in West Azerbaijan Province and as a result, the concentration of population at the time of the disaster increases the number of casualties.

B. The growing trend of urban population as a result of over-migration of people from villages and other cities such as Bukan, Naghadeh, Miandoab, Piranshahr, and cities of Kurdistan Province to this city increases population density.

4. *Dimension of urban facilities and infrastructure issues:* A. All power grid is aerial, causing disruption to the city's electricity grid at times of incidents.

B. There are only two fire stations in the city that cannot provide adequate coverage when necessary.

C. The presence of only one hospital in the city and a shortage of health centers in the surrounding villages, which creates problems for citizens in the event of accidents and need for medical services.

D. The construction of administrative, commercial, and educational buildings with a modernist model increases the risk of invasion to them.

E. Lack of safe buildings and proper shelter for refuge in times of disaster.

G. Lack of attention to passive defense principles in the design and construction of administrative and commercial buildings and complexes under construction.

5. *Dimension of transport network issues:*

A. The meandering structure of routes in most parts of the city, especially in the worn-out areas, makes it difficult to provide relief and evacuation when necessary.

B. Increasing population and construction density in the downtown areas will increase traffic and inefficiency of urban roads in the future.

6. *Dimension of management and executive issues:* A. Failure to address passive crisis management issues and other disasters in the city plans

B. The presence of new managers at the head of the city's organizations and agencies who have little knowledge of crisis management and strategic issues.

Vital and strategic centers of Mahabad City

The prioritization criteria of the points include:

Strategic importance, extent, type and stability of threat, extent of influence, depth of influence in terms of importance in providing city needs, economic value of constructions, greater efficiency with less time and cost.

Critical centers: Centers that, if destroyed in whole or in part, could cause serious crisis, damage and serious harm to the political, guidance, control and command, production, economic, and defense systems with a global level of impact.

Sensitive centers: Centers that, if destroyed in whole or in part, can cause significant crisis, damage, and harm with a regional level of impact.

Important centers: Centers that, if destroyed in whole or in part, cause limited damage to the political, guidance, control, etc. systems with a local level of impact.

The governorate and the municipality are regarded as the beating heart of the city in the management field given their managerial and command performance and need protection in times of crisis. The hospital is regarded as a relief center for people because of its medical coverage for the people. The city market is a hub of activity destruction of which will cripple the city's economy.

Strengths, Weaknesses, Opportunities, and Threats (SWOT) strategic analysis technique

One of the fundamental ways to establish

orderly and efficient communication among the strategic issues is the SWOT method. This technique was first executed in the Volkswagen AG Company, Germany in the early 1970s. The main objective of this technique is to analyze and guide the environment and emphasizes strategic content and focuses on determining the strategic position of the phenomenon in a competitive environment. This method uses the rational and intuitive approach to provide the most important strategic position possible for a phenomenon (26).

This technique is actually the acronym for the four analytical factors: Strengths, Weaknesses, Opportunities, and Threats. In fact, analyzing the strengths and weaknesses of the internal environment and the analysis of opportunities and threats from the external environment and systematic trend that provide support for the decision-making position are the basis of the SWOT qualitative model. SWOT analysis is the systematic identification of the factors that the strategy should best adapt to. The rationale behind this approach is that an effective strategy should maximize the strengths and opportunities of the system, in addition minimizing the weaknesses and threats. If applied correctly, this logic will have excellent results for selecting and designing an effective strategy (26). This technique is based on two main assumptions:

A. Dynamic principle of phenomenon: Each phenomenon has a distinct inner order based on which interacts with its surrounding system and environment, thus the phenomenon always competes with its counterparts for its own development.

B. Opportunity principle: Each phenomenon uses its strengths to take advantage of opportunities in the peripheral environment.

The SWOT model is one of the strategic tools for adapting intra-system strengths and weaknesses to opportunities and threats outside the system. In fact, the SWOT technique provides a systematic analysis to identify these factors and select the strategy that creates the best adaptation among them. From the perspective of this model, an appropriate strategy maximizes the strengths and opportunities and minimizes the weaknesses and threats. In fact, the key point of this model is to analyze the range of all the positional aspects of the system and thus provide a useful framework for strategy selection.

Discussion and Conclusion

Given the documentation reviewed, it seems that Mahabad currently lacks a comprehensive plan to provide security for the city and its citizens at the time of accidents. Although the relevant agencies and administrative councils, including the security council, plan to secure the city, the plans are limited to the political and social considerations and do not address urban planning appropriate to the physical and human components of the city. If this comprehensive plan is prepared, one can witness the continuation of vitality of the physical spatial structures in Mahabad. This comprehensive plan of urban structure can include the following eight dimensions and systems: Urban management system, urban infrastructure system, network of passages and access, physical division system and their centers, major urban land use and activity system, urban physical form system, public space system, and urban landscape system. Therefore, if the crisis management can analyze the social, economic, environmental, physical, managerial, and participatory indicators in the form of the above eight systems, the ground for dynamics assessment of Mahabad will be achievable, thus improving the resilience of the spatial-physical structure of the city. The other point is that the security council and the responsible authorities are more focused on domestic security and have not put the issue of external threats on their agenda. Within the framework of the city plans, including the comprehensive and detailed plan as well as the thematic and local plan presented, including the old city plan has not been addressed as a matter of defense against threats; however, it can be attributed to the stability of the country in recent years as well as the lack of an invasion. However, it is not surprising that wars, like earthquakes and other natural disasters often occur suddenly without giving people an opportunity to think. Therefore, paying special attention to citizens and service needs and how to distribute sensitive and important applications and installations should not be overlooked by the planners. Taking into account the above factors in relation to the security of the city and the citizens, the efficiency of all the above systems requires an efficient and structured system, both in terms of internal and external political and social considerations and urban planning appropriate to the physical and human components for further resilience and

reduction of urban damages. As in essence, the lack of a systematic, efficient, and purposeful system is the biggest challenge in the country's urban planning and programs.

Solutions proposed for key sectors of passive defense in Mahabad City according to its conditions

1. Geographical and climatic solutions

- Maximizing the use of natural and artificial environmental effects in design and location.
- Use of climatic and regional features in the design of important buildings, centers, and facilities.
- Extensive forestry and the use of farms around the city as natural barriers
- Use of urban topography and rough terrain around the city for camouflage and protection

2. Management and executive improvement strategies

- Informing and introducing safe places for people in times of crisis
- Scheduled and periodic urban defense comprehensive plan developed for the city.
- Conducting annual public and administrative exercises to ensure the efficiency of equipment and personnel
- Establishing specific locations and outposts for restoration of buildings

3. Solutions to improve the status of the facilities

- establishing stations near the city and local emergency as well as fire-fighting facilities
- Gas stations in the residential areas should be moved to the appropriate locations.
- Using renewable energy in accordance with the climate characteristics of the region

4. Transport network improvement solutions

- Providing alternative routes when designing and constructing roads for key points of the route such as urban arteries.
- Establishing a communication network in areas where there is a lack of communication access or the area is considered incompatible due to a lack of adequate network access.
- Completion of the city ring-road plan and reducing traffic congestion
- Transfer of passenger and freight terminals to safe and less crowded areas
- Considering several points in the city to establish the helicopter landing and takeoff sites in open spaces or above tall buildings, such as hospitals.

5. Solutions to improve the land use status

- Establishing a single disaster management organization with a specific budget and a unit to

guide and monitor location

- Optimal planning for urban land use location (adaptability and desirability)
- preventing deployment of sensitive and important applications next to each other
- Implementing the principle of dispersal as one of the principles of defense in critical and vital installations.
- The creation of any large office, industrial, or residential complex should be examined taking into account the type and extent of the threats. At this time, all internal and external threats and even natural disasters should be addressed.
- In the construction of all strategic centers, the design actions in the area of defense should be observed in the field of design, architecture, and urban design.
- Dismantling military installations and moving them out of the city
- Large buildings and spaces should be designed to be flexible and multipurpose to make the necessary changes when needed.
- Moving the city fire center to a safe and accessible area.

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Conflict of Interests

Authors have no conflict of interests.

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