



Research article

Urban development criteria with a focus on resilience to pandemics: A case study of coronavirus (Covid-19)

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Abstract: Urban resilience in coronavirus has become a major concern for cities these days. Iran also has not been safe from the destructive effects of this virus in social, economic, physical, governance and management dimensions. According to official statistics, hundreds of thousands of people in Iran have been infected with this virus, and tens of thousands have died so far. Therefore, to measure urban resilience to this pandemic, some criteria and sub-criteria were developed based on the authors' documentary and field studies, and their significance or weights were determined using an analytical-comparative research method using a questionnaire of paired or L-Saati comparisons from the viewpoint of experts in urban sciences and urban development using Analytic Hierarchy Process (AHP) hierarchical analysis in EXPERT CHOICE software. Then, designing a questionnaire with a five-point Likert scale, the satisfaction of Tehran residents with the extracted criteria and sub-criteria was measured, and the correlation between the important criteria in each dimension was assessed using correlation tests in SPSS 16 software. According to the obtained results of AHP analysis and the scores of each sub-criterion, the weight of all criteria was normal. In the next stage, according to the pairwise correlation tests between the important criteria in each dimension from the viewpoint of urban science experts and Tehran residents, it was concluded that the reliability of the correlation between the criteria is 99%. In all the cases, the P-value or the same significance level was less than 0.05, which indicated the significance of the pairwise relations between the variables.

Keywords: urban resilience; pandemics; Corona Virus (Covid-19); criteria

1. Introduction

Today's urban societies, especially developing societies, face a complex range of social, environmental, economic, etc. challenges against natural hazards. In many of these communities, new approaches are needed to cope with these challenges [1].

The coronavirus disease (COVID-19) pandemic has led to dramatic changes in quality of life, bringing to the forefront of the debate the question of planning and design of pandemic-resilient cities [2]. Cities and settlements have been created or built in places that are prone to various natural disasters or man-made disasters due to technological advances. The approach to disaster management and urban management so far has been mostly a confrontation and risk reduction approach. Meanwhile, the concept of resilience is a new concept that is mostly used in the face of unknowns and uncertainties [3].

During the pandemic stage, many urban communities adapt and generally function in crises [4]. The lack of adequate health facilities, insufficient number of health workers, long food supply chains, and limited social security during a pandemic send a message that facing this unknown disaster requires the full participation of the community. Much evidence found that community participation and implementation at a local level can improve effective practices to combat COVID-19 [5]. It is similar to a previous pandemic situation, Ebola, where community participation is an agency to reduce the effect and mitigate the risk of the virus [6].

As time goes on, resilience is encapsulated in the interaction between humans and their environment [7] as a process of learning or transformation that is constantly changing, rather than being set in stone [8]. Adaptive capacity for a community in this understanding is similar to the community adaptability proposed by Matarrita-Cascante et al., which is the community's ability to respond to current and future changes. Interestingly, a community can respond to changes quickly and maintain the system, but some communities are slow to react and disrupt the system. However, if we look back to where COVID-19 started, Wuhan, some communities can be named as vulnerable, alienated and inefficient communities that have lower risk resilience, where spatial resilience constitutes the key influencing factor of COVID-19-susceptible communities compared to three other resilience factors: social, capital and governance [9].

Indeed, some literature to date offers insights related to community resilience and the COVID-19 pandemic based on literature reviews. Fransen et al. used a literature review and an exploratory study to identify pathways within which community resilience initiatives emerge within the government context and eventually concluded that all pathway types face similar barriers, such as funding, weak networks and limited cooperation. Meanwhile, a rapid scoping review highlighted the urgent need for the role of social cohesion and its measurement methodology, instruments and techniques in the context of the global COVID-19 pandemic [10].

In this study, to determine the level of urban resilience against the COVID-19 pandemic, criteria and sub-criteria were formulated based on the documentary and field studies. By identifying the importance of each of the determined criteria and sub-criteria, we can prioritize them in order of priority in planning in different dimensions, physical, economic, social and welfare, management and governance, to improve the resilience of cities against the COVID-19 pandemic and future pandemics. A resilient urban area takes into account infrastructure that is more compatible with upcoming challenges resulting from a pandemic, and it can significantly reduce potential shocks and impacts. The current paper attempts to contribute to filling the void in knowledge on how urban areas contributed to resilience during the COVID-19 pandemic.

2. Theory

2.1. *Urban resilience*

The concept of resilience means the ability to resist or adapt to various shocks, pressures and stresses, and it has been widely used in urban studies [11]. In the most recent definition of urban resilience in recent studies, it refers to the capabilities of an urban system and all its constituting socio-ecological and socio-technical networks at temporal and spatial scales that in the face of disruptions maintain desirable performances or return to them quickly; that is, the ability of urban systems to adapt to change, once a system's adaptive capacity is limited, then its resilience will change accordingly [12].

Urban resilience is a relatively new concept that still lacks a clear definition [13]. The definition of urban resilience generally refers to the ability of a city or urban systems to withstand a wide range of shocks and stresses [14]. This shows that urban resilience ensures not only a system returning to the past state of equilibrium but also the possibility of adapting to changes and further survival of the city in the future [15].

Arefi [16] argues that different areas of the city show different spectra of resistance to changes. In cities, these changes are often caused by economic, cultural and technological conditions. One of the benefits of planning for urban resilience is that there is no need to focus on a specific pattern of urban form or urban development. This flexibility allows for responsiveness and adaptability given the unique circumstances of cities and development plans. This leads to intellectual creativity to think about different ways of achieving resilience without being limited to a specific framework [17].

Resilient societies experience minimal disruption in the course of their lives and economies after disasters [18]. A clear example of urban resilience characteristics is the sample developed as part of the United Nations City Resilience Profiling Tool [19] and is a general guide to a variety of inconsistencies and events. In conceptualizing their framework, the team in the UN-Habitat [19] uses 10 important factors in creating resilience in the city. These important factors are known as holistic measures to include a wide range of considerations [20].

The first factor is that the urban resilience framework should be “measurable” and show the “tangible and intangible realities” that can be converted into qualitative and quantitative data. The second factor is “urban system” which are defined as complex parts of integrated and complex systems, consisting of parts, people and risks, and are managed through effective mechanisms. The third factor is considering “residents”; all those who live, work, visit, or travel in the city and also the associated institutions, organisations, businesses, etc.. that life or are connected to each other. The fourth factor is the importance of “cohesion”, including maintaining support and services, financial flows, and structures, to save people’s lives [20]. The fifth factor is known as a response to pressures and overcoming “shocks and stresses”. These are identified as situations with hazards for the city and those that may be “sudden and slowly destructive, natural or man-made, rare and orderly, predictable or unpredictable”. The sixth factor is the major focus on “transformation,” which refers more to examples of “taking an active and forward-looking attitude that turns challenges into opportunities for growth”. This means methods of progress in transformations that can change the situation by creating incremental transformations and support. The seventh factor is recognition of “sustainability” and its methods, including a wide range of factors of community development, innovations, economic production and service support. The seventh factor is the importance of access, which refers to what ultimately creates a wide range of actions, guidelines, and recommendations; and cases with

generalizability. Finally, these eight factors lead to two important factors: “planning” and “action”. Using appropriate planning methods, we can create effective strategies, strengthen the city to deal with a wide range of vulnerabilities and strengthen the capacity for effective and efficient performance; and through actions, we can provide reliable and constructive assessments to support strategic planning and respond to the situation [20]. The characteristics of resilient cities are summarized based on previous studies (Table 1).

Table 1. Characteristics of resilient cities [21].

No.	Component	Concept	Promoting factors	Goal
1	Stability	Safe and valid, tolerable, reliable	The system having security factors and protection against shocks, the ability to change the decision chain in the face of crisis	Preventing the transmission of damage to other sectors
2	Redundancy	Having adequate excess and precautionary storage capacity	Having excess capacity in sensitive infrastructure and being equipped with a variety of solutions and strategies to solve a problem	Maintaining system operation
3	Consciousness and prudence	The ability to adapt and being cautious	Increasing trust within the system and the ability of the components to self-organize	Being prepared for adaptation and revival
4	Responding to hazards	The ability of the community to move quickly, the ability to decide for reorganization at a given time in times of crisis	Effective communication and inclusive participation	Adaptability to new conditions
5	Revival	Adaptability, correcting the situation and restoration	Increasing the capacities and strengthening the strategies, information and knowledge in implementation of public and business policies and the ability of decision-makers to update given the changes in environmental conditions, discovering knowledge gaps and then organizing research to fill those gaps	Returning the system to its normal operation after a crisis

2.2. Resilience and pandemics

In times of pandemics, there is a need for more urban resilience than the strategic resilience plan. As mentioned earlier, when pandemics occur the conditions are indescribable, and exclusive responses are required. This became apparent some years ago when we developed the first resilient city tool [22].

In general, urban resilience should be realized as the backbone of how cities are managed effectively and profitably, especially in the event of pandemics. There is little preparation (which does not include limited services, equipment and facilities) before the actual outbreak begins. So, most tasks are not necessarily related to preparedness but are immediate and strategic responses that must be developed, outlined and implemented during pandemics. This is why at times of pandemics, like some catastrophic events, vulnerabilities are so high, and cities and communities are at a dangerous level of risk [20].

WHO [23] indicates in its reports that, while guidance in the management of pandemics and responding to outbreaks is clear, the health sector also has a critical role in preventing and minimizing

health consequences in emergencies due to natural, technological and social hazards. In addition to this report, it is important to note that from the perspective of urban management, different sectors should experience the same situation; other sectors related to such incidents intend to respond quickly and appropriately to the emergencies and disruptions resulting from these special events. In other words, the city as a whole becomes a creature that needs to deal with emergencies at several different levels and sectors. By having a resilience plan (for example, in any action-based performance), the city can act more effectively in managing specific events and their negative effects on society [20].

Hence, it is suggested to strengthen urban resilience where we can and where it seems to be possible in certain circumstances (e.g., economic capacities, capabilities, economic background, social issues, etc.). With such a planning approach, we can accelerate the processes of controlling and recovering from pandemics, that is, better management of the spread of the disease and preventing it from turning from an emergency to a disaster [20].

Finally, what needs to be considered is the method of preparation and response in a process. This requires a framework that can be effective in the existing changing situation at the time of pandemics. Therefore, a fundamental action with responsibility by government officials (from several departments), emergency units and emergency medical services and other related stakeholders of the public sector, private bodies, non-governmental organizations (NGOs), community groups and the public are essential. This situation creates new management and an operational ecosystem that requires resilience measures and adaptive capacities [20].

These factors, in addition to having adequate planning measures, require a tangible resilience capacity to be able to act quickly, prepare and respond to situations in the best possible way [20].

2.3. Cities at the times of pandemics

At all stages of pandemics, cities can suffer greatly, and society may need to endure some of these negative effects for some time. However, from a positive perspective, new opportunities have arisen to strengthen urban resilience and urban management [24].

In addition, it is clear that during pandemics, we are faced with a wide range of vulnerabilities, as well as a wide range of affected local groups and individuals who can be even more vulnerable than other local groups and individuals. In most pandemics, depending on their mortality rate and the quality of their response to control and treatment measures, we can identify three distinct categories of vulnerable/local groups that may suffer the most:

- People who are unaware of the conditions and, for any reason, do not know they may be infected or may have the disease/virus. Hence, their delayed response or action at the latest stages may lead to the progression of the disease in their body.
- Those vulnerable sections of the society who are less resistant to diseases/viruses/infections, including the elderly, those with previous health conditions or those prone to high health risks.
- Those communities, cities and even countries that lack health infrastructures and with poorer resilience or those with limited resources and insufficient equipment, emergency units, diagnostic and confirmation tools, medical personnel and related equipment [20].
- The above-mentioned vulnerable groups represent a wide range of groups, from individuals to larger scales of cities or countries (or their clusters). Hence, during pandemics, the alert level rises to a higher level if it spreads or concentrates in poorer countries or areas with minimal health infrastructures/systems and many other related factors that indicate a more vulnerable location.

Therefore, we must consider vulnerable groups and individuals as the first point of our resistance planning [20].

The pandemic has affected many aspects of urban life and has already altered lifestyles [25,26].

2.3.1. Economy

The most notable issue is related to the significance of diversity in urban economic structure, livelihood options of individuals, and operation modes of small-sized and medium-sized businesses. Based on early evidence, lack of diversity is likely to increase the scale of economic decline, thereby reducing the absorption and recovery capacities. For instance, cities that are highly dependent on specific industries such as tourism and hospitality have lost a major income source [27]. Similarly, individuals with limited skills and livelihood options (e.g., dependent on the tourism industry) have suffered significantly from the crisis [28]. Diverse economic structure is also likely to contribute to “self-organization”, which is another key resilience characteristic. For instance, disruptions in global supply chains are likely to have significant impacts on cities that do not feature a diverse economic structure and, therefore, rely heavily on imports for meeting their basic needs [29]. The pandemic has also demonstrated that low-income citizens are hit harder [30]. This has major consequences for the absorption and recovery capacities of cities, as it would be difficult to persuade low-income households, concerned about meeting basic daily needs, to adhere to response measures such as social distancing and “stay at home” orders. Consequently, it will probably take more time to flatten the curve and return to normal functionality. Therefore, more attention to reducing inequalities is needed for better resilience to pandemics and other similar shocks [31].

2.3.2. Environmental management

The lockdowns and travel restrictions designed to contain the spread of the virus brought transportation and industrial activities to a halt in many countries. One of the first observed impacts of these policies and restrictions was air quality improvements in many cities across the world. In particular, pollutants such as NO₂ and CO that are directly linked to the transportation sector were reduced [32,33]. This provides important adaptation lessons for cities to mitigate urban air pollution in the post-COVID era by greening the transportation sector. Furthermore, exposure to pollutants over longer periods of time may weaken the respiratory system of individuals, thereby making them more vulnerable to infectious diseases [34]. Therefore, reducing air pollution also contributes to resilience by improving absorption and recovery capacities of individuals [31].

2.3.3. Governance

Resilient urban governance regimes should involve long-term visioning and scenario making to avoid being surprised by shocks. Early evidence reported in the literature confirms that cities that feature long-term planning cultures and have taken pre-event mitigatory measures have been more successful in responding to the COVID-19 crisis [35]. Long-term visioning ensures sufficient preparation for different types of disasters. This not only mitigates risks but also reduces the overall losses (absorption capacity) and facilitates more rapid recovery through provision of adequate response and recovery equipment and resources. Furthermore, long-term visioning and regular revision of plans

improve adaptive capacity through providing opportunities for learning from experiences. It should be noted that, in addition to absorption and recovery capacities, citizen engagement can also provide adaptation benefits. In fact, lessons learned via engagement in community-based activities are expected to help citizens better respond to future disruptive events. Overall, a smart combination of top-down and bottom-up governance approaches seems to be more desirable for responding to crises such as the COVID-19 pandemic [31].

Doicăr and Crețan have claimed that rising unemployment and the imposition of public health measures have accentuated feelings of resentment against the government. COVID-19 has acted as a framework for the rise of AUR (the Alliance for the Union of Romanians) by making government exertions of power unusually visible, thus dialectically creating a space for the vigorous assertion of populist opposition [36].

COVID-19 shocked the world and provided a particular challenge for populist radical right (PRR) forces [37]. There is some evidence that the COVID-19 pandemic has had particular influence over the rise of the AUR. The pandemic has intensified trends toward growing mistrust of the “mainstream” political class and growing trust in religious leaders, not least because the Coalition government has conspicuously mismanaged public health during the outbreak [36].

2.3.4. Social issues

Soon after the spread of COVID-19, its differential impacts on minorities, the urban poor and other vulnerable groups were exposed. In fact, COVID-19 once again revealed the deep-rooted inequalities that exist in many developing, as well as developed, countries’ cities [38]. Such social inequalities may erode the capacity to contain the spread of the virus (i.e., absorption capacity) and make the recovery period longer. This is due to several factors, such as livelihood insecurity, limited access to clean water, very high density and livelihood dependence on close social interactions in poor settlements and slums that make adherence to “stay home” and social distancing orders challenging [39–41].

Other social factors that are crucial for resilience against adverse events are sense of community and social capital. Obviously, strong sense of community and high levels of social capital increase the likelihood of receiving mutual support during difficult times. Additionally, it can strengthen community-driven initiatives that can complement state-oriented efforts. Furthermore, a strong sense of community may result in better compliance with social distancing and other rules necessary for effective response and rapid recovery [42,43].

2.4. Step-by-step perspective of cities

It is important to summarize how cities respond in the event of pandemics. It may seem that cities are operating normally and without any disruption or unexpected disruption. After searching for more information and using the official announcements that are made for pandemics, we finally find out that the performance of cities has changed a little. Usually, there are only minor effects. With the initial symptoms, we can see few people in public places, the outdoors, shopping malls and crowded areas of the city. As this stage progresses to a more alarming stage in the response stage, other sectors are also affected. The health care system and emergency medical services (EMS) become more vigilant, and operational changes in cities increase with a higher speed. The public sector is affected the most

because many public services gradually reduce their operations or may temporarily stop their tasks. It seems that in the use of public places, transportation in large-scale places, public transportation and other public facilities have decreased further. In the next stage, namely, the “transition phase”, depending on the severity and scale of the pandemic, cities gradually prevent secondary operations. Hospitals and health clinics may become important points. So, they need more support to prevent the spread of the disease in those critical points. At this stage, cities will face major problems as most businesses, industries and retail units may stop (or may be asked to stop). If this happens, apart from the existing effects on society, its effects on the economy will also be more understandable. This will lead to more system failures as cities are facing more disruptions in their functions. At this stage, economic resilience and economic management are very significant for many critical infrastructures and key institutions under pressure. The economic foundation of cities suffers while the community worries about the rapid increase in cases and the mortality rate. At this stage, it is not necessary to close the city, but it may seem necessary if the response rate is not very fast in the early stages. This closing method can be partial to prevent negative effects on more parts. Eventually, the situation should become more stable, and it may end at this stage or peak at a later stage [20].

The two-way “transition” phase usually begins with a moment of pause. This is a critical time for any city, as progress may change the direction. The pandemic could get worse, and this may cause the most damage to the city, as it can stop all operations, and only health institutions and EMS can work. By stopping transportation, food systems and other industries become very vulnerable. If in the transition stage the pandemic has shown signs of improvement, then urban activities can begin slowly at the end of this stage. This process gradually shifts so that the city slowly moves from an alert/emergency to a safer stage of improvement. In the transition phase, if the situation worsens, the pandemic can also change to a catastrophic state with higher risks than anticipated in the response phase. If this happens, the situation needs more support at various governmental levels, and it may turn into a completely closed condition. If it did not happen sooner, this means significant impacts on almost all primary and secondary parts of the city. However, if the situation starts to improve in a stable pattern, the situation will approach the next stage of reduced pandemic [20].

In the “recovery phase”, cities must adopt and implement the maximum level of monitoring and control. For early inhibition, all operations must be stopped or monitored thoroughly and carefully. Cities should not take more risks and can compensate for more vulnerability. Recovery should succeed through full control of the pandemic. Any defect at this stage can potentially prolong the situation and intensify its prevalence, which will ultimately put more pressure on city officials and the entire city operations. After that, it becomes more difficult to maintain the adequate performance of various entities/services. So, it is important to experience a temporary problem rather than long-term troubles. Once a stable state is established (after a certain period), then operations may start gradually, from the primary entities/services to the secondary ones. This gradual change before achieving recovery must be carefully managed, and the conditions must be under complete control. At this stage, the city must strengthen its health systems to ensure increased treatment opportunities and then support the overall process of treatment and recovery. When this happens, the situation gradually progresses toward full recovery of the pandemic. The path to this must be paved with high security, high supervision, a high level of risk management and high resistance to any unexpected changes [20].

With the success in the recovery phase, the community will begin to relax more. Finally, it is transferred to the final stage of “post-recovery”. This occurs when regular operations of various departments, services and extensive systems are visible. It is important that all progress can be seen as

much as possible. Such an approach relieves the sense of distress in the community and assures businesses and industries to plan for their regular activities. At this stage, cohesion is crucial in every aspect and all sectors, because a system in a healthier ecosystem of urban resilience and management can help another. Disorders are expected to be minimized during this stage, and the community needs the highest level of support to ensure initial recovery. At this stage, more public-oriented and community-oriented performance should shape and revive the overall operations of the city. Careful monitoring should remain in place to prevent any unexpected problems. By doing this, we will be able to return all departments to regular operations and maintain the conditions of all systems and services at their original regular patterns. In the last stage after the recovery, the city must resume its flexibility and maintain or improve its main institutions. Finally, the most important thing is the development of a “responsive urban management” [20].

2.5. Progress through responsive urban management

In a broader sense, there are many theories about resilience and its applications [44,45]. However, there is a significant difference between the theoretical aspects of resilience and how it develops in action planning [46,47,20].

Through a better understanding of urban resilience (including a general overview of actions, applications and practices) and multi-sector urban management, a program can be proposed for better responding to and preparedness for disasters and pandemics. From different urban examples, different tools and different frameworks, we learn how to address resilience and urban management from different perspectives or in different situations. Although studying what can be done is important, how to do it in practice should also be studied [20]. The recent unpleasant pandemic of Covid-19 has inspired us to understand resilience from various perspectives, as most of these perspectives are related to the critical state of the pandemic. Most importantly, it is clear that resilience is a key, and city management is the ultimate answer to many functions [20].

Resilience is scenario-based, but it is essential for the city, and how to get out of troubles, including pandemics, is one of those scenarios. Therefore, it is important to note that urban operations cannot be stopped for a long time, and cities cannot be neglected. The more we understand how cities can cope with such events, the more we can improve their resilience and support city management [20].

2.6. Conclusion of theory

Urban resilience tools and measures are essential to respond to the problems and challenges that we anticipate and do not anticipate. Pandemics appear to be an example of specific events that can be harmful in different ways and can increase the burden of managing the entire city. In such cases, this widespread vulnerability affects multiple functions of cities. The prevalence of any disease indicates the uncertain situation of the city. This is unhealthy for the government, institutions, economy, health and, most importantly, the community [20].

Beyond having resilience characteristics, such as flexibility, preparedness, redundancy, adaptability and absorption capability [48], cities need good and resilient governance to deal with the dire situation caused by the COVID-19 pandemic. Unlike natural disasters, which are usually not under human control, the impact of pandemic disasters varies greatly in scale due to different levels of urban preparedness and intervention measure [49]. In this regard, good and resilient governance can be the

key to achieving better urban resilience and to dealing effectively with the consequences of the COVID-19 pandemic in cities. Having a long-term perspective and a participatory view, investing in vital sectors such as healthcare systems, coordinating activities of different sectors and stakeholders and integrating technology, information and knowledge in the cities are essential for timely and effective responses to the consequences of the COVID-19 pandemic [49,26].

3. Review of literature

A brief investigation of the study background can identify the general view of the subject and study gaps.

Sharifi [31] has discussed lessons related to various areas, such as economy, environmental management, governance, social inequality, smart cities, transportation, urban design and the links between the Covid-19 pandemic and the planning, absorption, recovery and adaptation capacities of resilience, emphasizing the importance of pre-event planning, long-term visioning, early response, integrated governance, community empowerment and appropriate use of smart city solutions for resilience against pandemics.

Fransen et al. [50] have conducted a literature review and an international exploratory study to identify pathways within which community resilience initiatives (CRIs) emerge within different governance contexts. The study results identified four pathways: (1) informal bottom-up community initiatives; (2) formal community initiatives emerging out of existing community-based initiatives; (3) initiatives of external actors, often NGOs, universities or governments; (4) networks of organizations that together initiate action in response to COVID-19.

Hamid and Karri [51] have explored the rate of growth of COVID-19 cases in Brunei and highlighted resilient actions that have been taken to mitigate further infection and contain the outbreak nationally. Observations in this paper have served as a reference for notable policies to contain future pandemics and to achieve a sustainable society.

Chen and Quan [52] have worked on a comprehensive evaluation index system for urban resilience under the COVID-19 pandemic scenario considering four dimensions (economy, ecology, infrastructure and social system). They conducted a quantitative evaluation of urban resilience in the Yangtze River Delta of China, revealed its spatiotemporal differences and change trends and proposed targeted strategies for improving urban resilience.

Cheshmehzangi [20] has discussed experiences from global examples, addressing what has worked at the spatial levels of communities and cities and also highlighting the shortfall across multiple sectors of urban systems, and enabled us to identify risks, challenges and pathways and suggest a checklist of what could be done through early preparedness to better city management during the Covid-19 pandemic.

Pandemics are diseases that affect a significant portion of the population. If these diseases spread rapidly to other countries or continents, they are also called global pandemics. Throughout history, pandemics have had a profound effect on societies, economically, culturally and socially. The plague of Justinian, which broke out in 541 AD, can be called the first pandemic. The latest is the coronavirus, and now almost every country in the world is struggling with it.

Studying the pandemics before the outbreak of Covid-19 will help a lot in how to deal with this new virus as well as its management nationally and globally. Thus, the Table 2 shows a summary of

pandemic dates, the numbers of individuals and countries affected and mortality rates of the pandemics or epidemics throughout history.

Table 2. An overview of the pandemics or epidemics throughout history.

Type of pandemic	Pandemic date	Affected regions in the world	Mortality
Plague of Justinian	541 to 750 AD	Byzantine Empire (Eastern Rome) and Sassanid Empire	25 million people (13 to 26 percent of the world's population)
Black plague	1340 to 1351 AD	Eastern lands and throughout Europe	About 200 million people
Smallpox	15th to 17th centuries AD	The United States	About 20 million people (equivalent to 90% of the US population)
Cholera	1817 to 1823 AD	India and neighboring countries	7 million people
Spanish flu	1918 to 1919 AD	All over the world	50 million people
SARS virus	2002 to 2003 AD	China and 26 other countries	774 people
Swine flu	2009 to 2010 AD	The United States	248,500 people
Ebola virus	2014 to 2016 AD	Africa	11,325 people

4. Methods and data sources

The present study seeks to answer two basic questions: What are the criteria and sub-criteria affecting the realization of urban resilience to Covid-19 in Tehran, and how much is the significance and weight of each of these cases from the perspective of urban science experts such as urban designers and planners and citizens? What is the correlation between these criteria? So, the following steps have been taken to answer the above questions:

First, through documentary studies, while reviewing the literature on the subject, using the analytical-comparative method, the significance of the 12 criteria and 36 sub-criteria extracted according to the theories of various urban intellectuals and experts was measured. The selected experts were urban managers, consulting engineers, contractors and university professors who were experienced and knowledgeable about urban projects in the field of urban planning and design in Tehran. The selection of these experts was based on purposeful sampling, and finally, 16 experts were selected to complete the pairwise comparison (L-Saati) questionnaire. The results of experts' opinions using the AHP hierarchical analysis method in EXPERT CHOICE software have been used to score the criteria and sub-criteria in the study, the results of which can be seen in the score column in Table 3. It should be noted that the sum of scores of the sub-criteria of each criterion was equal to one, which indicates the normality of the weight of the sub-criteria to continue studies in the field.

In the next step, to prioritize and measure the significance of the criteria and sub-criteria from the viewpoint of Tehran citizens, a questionnaire including questions related to the extracted criteria was prepared and valued using a five-point Likert scale. This questionnaire was completed based on purposeful sampling by 120 people who were selected completely randomly. Finally, by analyzing the data obtained from the questionnaires, using the pairwise correlation test in SPSS 16 software, the correlation between the criteria of each dimension was measured.

Table 3. Criteria and indicators.

Dimensions	Indicators	Criteria	Orientation	Score
Physical dimension	Transportation infrastructure	Capacity, safety, reliability, integration (connectivity) and transport efficiency	+	0.592
		Affordability of the public transportation	+	0.408
		Access to basic needs and services at different stages (food, water, shelter, energy, health, education)	+	0.372
		Public spaces and public facilities (for recreation, physical activity, etc.)	+	0.101
		Mixed development	+	0.114
		The ratio of high-risk areas to population density	+	0.208
		The ratio of high-risk areas to the area of sensitive sub-uses	+	0.205
	Possibility of rapid and correct reconstruction and repair	Ensuring access to basic services for all and providing support services after disasters	+	0.656
		Existence of plans to deal with possible crises	+	0.344
Economic dimension	Structure	Job density (proximity to housing and work and the transportation area)	+	0.287
		Income (equality, multiple sources, ...), the poverty rate	+	0.713
	Security and stability	Insurance (internal and external) and social welfare	+	0.611
		Stability of prices and incomes, the value of properties	+	0.286
		Tax reduction rate to deal with the effects of the shock	+	0.103
Social and welfare dimension	Socio-economic characteristics	House ownership	+	0.370
		Various individual skills (to mobilize skills in times of disaster)	+	0.630
Dimensions	Indicators	Criteria	Orientation	Score
		Empowerment and employment of vulnerable groups, social bonds, support and social institutions	+	0.723
		Civic and voluntary participation in social networks	+	0.277
		People's physical and psychological health	+	0.146
		Preventive measures to maintain health	+	0.297
		Responsive health measures	+	0.238
		Undefended urban spaces	-	0.127
		Number of working children	-	0.107
		Number of false jobs	-	0.085
Governance and management dimension	Leadership and participation	Strong leadership	+	0.392
		Transparency, accountability, corruption, etc.	+	0.608
	Resource management	Effective resource management (funds, personnel, etc.)	+	0.372
		Skilled personnel and emergency experts	+	0.309
		Population with emergency and recovery skills (first aid, etc.)	+	0.319

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Dimensions	Indicators	Criteria	Orientation	Score
	Contingent planning, emergency recovery	Integration of risk reduction and resilience in development plans and policies and	+	0.207
	and	Recovery and repair speed	+	0.123
		The ongoing process of reviewing and monitoring programs and evaluations	+	0.189
		Standard updated databases and integrated planning, monitoring and evaluation of actions	+	0.200
		Continuous and up-to-date risk assessment; scenarios for another type of infrastructure and services (costs, losses, etc.)	+	0.281
R and D		Innovation and technology updating	+	0.550
		Allocation of funds and facilities for risk research and academic collaboration	+	0.450

5. Results and discussion

5.1. Extraction and analysis of the criteria and sub-criteria

To conceptualize and classify the experimental and field studies conducted on identifying the factors affecting urban resilience in different dimensions, as well as to determine the citizens' behavior and officials' crisis management in an epidemic such as Covid-19 throughout cities, especially Tehran, and to examine as closely as possible the relationship between urban resilience and Covid-19, which has changed all the existing relationships in cities around the world from early 2020 to the present day in 2021, the present study sought to extract the urban development criteria related to resilience against the epidemic in physical, economic, social and welfare dimensions as well as governance and management. Therefore, relying on documentary and field studies, several criteria, along with related sub-criteria, each of which has a positive or negative orientation, were identified. To achieve the objectives of the present study and to determine the significance of each of the criteria extracted in the issue of urban resilience against coronavirus, a pairwise comparison or L-Saati questionnaire was designed by the authors to compare the significance of several sub-criteria in each dimension. Then, 16 experts of urban sciences, including experts in urban development, urban planning and urban design, completed the questionnaire. The results of the experts' questionnaires were analyzed by the AHP hierarchical method using EXPERT CHOICE software, and the score and significance of each sub-criterion were calculated, the results of which can be seen in the score column in the following table. It should be noted that the sum of the weights of the sub-criteria in each general criterion is equal to one, which indicates the normality of the weight of the sub-criteria to continue the study.

5.2. Examination of the correlation between criteria in different dimensions from the viewpoint of Tehran residents

After determining the weight and significance of urban resilience criteria against Covid-19 as well as examining the level of satisfaction of Tehran citizens with them, the correlation between the four significant criteria from the authors' point of view, which have a great impact on urban life in four physical, economic, social, welfare, governance and management dimensions, was analyzed using the correlation test with the help of SPSS 16 software, the results of which are shown in Table 4. The

results of the correlation test that was performed for four criteria in the four studied dimensions show that the reliability of the correlation between the four selected criteria, namely, land use and urban design in the physical dimension, security and stability in the economic dimension, community bonds, support, and social institutions in the social dimension and welfare, as well as leadership and participation in the dimension of governance and management, is 99%; and in all these cases the P-value or the same significance level is less than 0.05, which indicates the significance of the pairwise relationships between the variables.

To describe the obtained correlation coefficients, it can be noted that there are moderate correlations between the criteria of land use and urban design and security and stability; the criteria of security and stability and support and community bonds and social institutions; as well as leadership and partnership criteria and stability and security. Other pairwise correlations have weaker relationship intensity than the above.

Table 4. Correlation test between the criteria.

		Land use and urban design	Security and stability	Community bonds, support and social institutions	Leadership and participation
Land use and urban design	Pearson Correlation	1	0.477**	0.392**	0.390**
	Sig. (2-tailed)		0.000	0.000	0.000
	N	120	120	120	120
Security and stability	Pearson Correlation	0.477**	1	0.496**	0.426**
	Sig. (2-tailed)	0.000		0.000	0.000
	N	120	120	120	120
Community bonds, support and social institutions	Pearson Correlation	0.392**	0.496**	1	0.359**
	Sig. (2-tailed)	0.000	0.000		0.000
	N	120	120	120	120
Leadership and participation	Pearson Correlation	0.390**	0.426**	0.359**	1
	Sig. (2-tailed)	0.000	0.000	0.000	
	N	120	120	120	120

**Note: $p < 0.01$.

So, as is also stated in the international literature studies of the subject, in the four dimensions, physical, economic, social and management (and of course in their sub-sections), the process of resilience against coronavirus must be improved, and the most important components of this improvement in the sector include strengthening access to land uses and services, leisure and green spaces, security and stability of jobs and vulnerable groups, strengthening local institutions and using people's participation in the urban governance process.

According to the international literature reviews that are mentioned as well, since the emergence of the COVID-19 pandemic, its effects are the good opportunity to reflect on the capacity of our cities to deal with shocks. It is notable that to minimize potential losses, we need to enhance our planning

capacity to respond better in the COVID-19 pandemic and coming ones. Urban governance capacity is also an important factor affecting the prevention and control of the COVID-19 pandemic, and urban governance capacity is particularly significant in the late control of the pandemic.

The literature review also showed that a resilient community is a community in which different sectors, especially managerial institutions, social groups and businesses, can work well together to minimize the vulnerability of citizens by reducing the potential infection rate at the first step. They must try to maintain and restore communities' normal function by preparing and supplying essential and required goods, especially medicine and healthcare equipment. In addition, components of different community stakeholders need to work jointly to adapt to the new situation and guide the community towards sustainable development [53].

In the end, urban resilience to pandemics is a multidimensional approach including many criteria and sub-criteria. The impacts of the COVID-19 pandemic are yet to be fully understood, and more related evidence over the level of resilience of our cities during the pandemic will be published in the future.

6. Conclusions

Given that it has not been long since the onset of the Covid-19 pandemic, identification of the different dimensions of urban resilience against this global pandemic has many ambiguous and unknown dimensions. On the other hand, given that there are still many ambiguities and disagreements about the virus itself and its behavior, the ways to deal with Covid-19 and to improve urban resilience in the face of it are difficult. In the present study, given the concepts related to urban resilience, different dimensions and criteria of this concept were adapted based on the opinions of urban science experts and public satisfaction with the conditions and programs in Tehran to deal with Covid-19 damages in all economic, social and welfare, physical, governance and management dimensions.

According to the research process and studies to develop urban development criteria with a focus on resilience against Covid-19, 12 criteria and 36 sub-criteria in four physical, economic, social welfare and governance and management dimensions were extracted and classified. Each of these sub-criteria had a positive or negative orientation and a separate score. The score or weight of each sub-criterion was determined using the AHP hierarchical analysis method and L-Saati (pairwise comparison) questionnaire completed by 16 urban development professors and experts of urban management, consulting engineers and urban contractors, using EXPERT CHOICE software. Finally, the sum of the scores of the sub-criteria showed normality of the weight of the criteria and their relative significance in the research stages. Then, a questionnaire was designed with a five-point Likert scale based on purposive sampling with a statistical population of 120 people selected randomly from among the residents of Tehran to measure the pairwise correlations between the four criteria of the four dimensions that have the greatest impact on citizens' lives. Using SPSS 16 software, reliability of the correlation between the four selected criteria, namely, land use and urban design in the physical dimension, security and stability in the economic dimension, community bonds, support and social institutions in the social dimension and welfare, as well as leadership and participation in the dimension of governance and management, was 99%. In all these cases the P-value or the same significance level is less than 0.05, which indicates the significance of the pairwise relationships between the variables.

It is very necessary to create a combination of citizen-friendly land use, especially on a neighborhood scale at the city level, to increase access to services in crisis conditions (such as the

coronavirus situation) in the physical dimension. Also, in parallel, it should be possible to provide virtual access to services in order to minimize the density of citizens' presence and traffic in case of outbreak of such diseases. Another use that was greatly needed in the coronavirus situation is the use of green and leisure spaces. Many cities with high population density during coronavirus had a severe lack of places for citizens to be in the open air (when people were worried about being in a closed and limited space).

In the field of urban design, it is necessary to create more leisure spaces on the scale of the neighborhoods and the whole city to allow citizens to walk, exercise, play and socialize in a controlled manner (with low population density). In fact, the creation of pedestrian-oriented and entertainment-oriented spaces can be beneficial to solve the mental crises of citizens in the time of coronavirus. However, the data shows that the levels of violence, depression and other mental illnesses have increased significantly during the coronavirus era. Urban design can be a very effective tool in this field: for example, the creation of pedestrian and bicycle paths, sufficient urban sidewalks for sitting outdoors, creation of better ventilation in public spaces with the help of the form and height of buildings and vegetation.

Meanwhile, in the economic dimension, as the results have shown, the promotion of economic security and stability is a priority. The experience of Coronavirus in Iran showed that those who had unstable jobs without insurance and suitable support conditions (such as vendors, daily wage workers) suffered a lot. Basically, poverty is an important factor for being vulnerable in crisis conditions; and some groups, those with low income, women and the elderly, need special economic and social facilities.

In terms of governance and urban management, increasing the participation of citizens can be a great help to improve resilience, especially in the time of coronavirus. For example, it is necessary to report the physical issues and problems of the citizens at the neighborhood scale and social and economic issues and assess their needs and find appropriate solutions. Providing mobile applications for more communication between citizens and city management and offering incentive policies to increase citizen participation can be effective. For example, municipalities can promote citizens' participation by giving points to citizens and offering discounts on services provided by the municipality.

Therefore, regardless of the case study examined in this research, the city of Tehran (the capital of Iran), it seems that the results of this study can be generalized to other urban settlements in the world. Especially in the physical and economic dimensions, the suggestions presented are not based on a specific location, and of course, considering the per capita shortage of urban, green and leisure public spaces in Tehran, they can be useful for such cities.

In fact, in the physical sector, paying attention to increasing the resilience of urban spaces by mixed uses, increasing the public access of citizens and having alternative options in situations where people cannot leave their homes often and suffer psychological crises are important. In the economic sector, it is necessary to promote the stability and security of jobs and pay attention to vulnerable groups during the outbreak of widespread diseases and how to help them.

Also, it seems that one of the points found in this research will be applicable in the path of science in the world. It is necessary to pay attention to local institutions and the cohesion of neighborhoods in crisis conditions, including the coronavirus disease. In the old neighborhoods of Tehran, this social cohesion is useful in solving many neighborhood problems (physical, economic and social), and this is a value that seems to be applicable in other parts of the world.

Finally, according to all the studies and examination of the criteria by urban development experts and professors, as well as Tehran residents, it is concluded that during the coronavirus pandemic, all four dimensions are equally important for urban resilience against this virus. Measures should be taken to increase the level of resilience in all these four dimensions and criteria. Examples of these measures are provided in the form of suggestions as follows:

- Creation and strengthening of the infrastructure required by a smart city
- Redesigning and widening busy spaces such as commercial areas
- Increasing the number of public vehicles such as subway cars and buses to observe social distancing
- Designing pedestrian passages and public spaces for recreation and physical activity
- Designing and implementing programs for mixed development in neighborhoods for easy access to daily needs
- Promoting the ability and planning of officials to deal with and manage the crisis during a pandemic
- Upgrading health and hospital infrastructure to deal with risk
- Empowering the medical staff by anticipating their logical demands during the pandemic

Conflict of interest

The authors declare no conflict of interest.

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