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The Resilience of Egyptian Cities against Health Crises 'Egyptian Pandemic City Tool'

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Abstract The world today, recovering from a pandemic crisis, has witnessed a complete change in everyday challenges and routines. Following the COVID-19 crisis, the world was forced to face the challenge of preserving human life. Today, city planners and urban designers have to establish cities that can mitigate the impact of health problems; in other words, the city's urban product must be more resilient against health problems. The condition of completely shutting down urban areas and transforming them into infirmities has led to great economic and social crises. Economically, the world has lost at least 3.7 trillion dollars, equivalent to 4.4% of the Global Gross Domestic Product (GDP). The present paper aims at developing a tool that has the ability to measure the resilience of the Egyptian urban settlements against pandemic crises; thus, helping planners and urban designers to establish and promote pandemic cities. Based on profound theoretical and analytical studies, the concept of pandemic cities was studied and analyzed composing a list of indicators that illustrate the ability of existing urban settlements to face pandemic crises. Then, based on the findings of an empirical study that targeted Egyptian experts, the most relevant indicators were identified. Using relative importance index (RII), the relative weights of indicators were calculated and utilized as a tool that can measure the resilience of Egyptian urban settlements against pandemic crises.

Keywords Epidemics, Post-Pandemic City, Urban Health City, Sustainable Cities, Urban Crisis Management, Urban Resilience

1. Introduction

Throughout history, viruses and epidemics have killed millions of people, resulting in major crises that have lasted for many years. One of the most difficult aspects of studying epidemics is predicting future trends as: What policies and actions will be required to deal with epidemics? Hence, the urgent need is to establish pandemic-city design and management abilities in order to combat infectious diseases and mitigate health crises.

Corona, the new virus that terrified the whole world, caused unsettled global concern. Since the detection of the disease, schools and universities have ceased teaching activities on their premises, moved to e-education. States have closed their borders and prevented internal movement, travel, as well as domestic and foreign flights. Laboratories have opened their doors and intensified their research and studies. Hence, urban areas have proven their failure to mitigate the impacts of the corona health crises all over the world.

As in many countries of the world, COVID-19 has brought extensive damage in Egypt, the national statistical agency, revealed that 73.5% of families have suffered from a decrease in income, the unemployment rate has increased by 26.2%, also there were a great number of social problems that have appeared such as an increase in family violence and a 20% increase in the divorce rates [1,2,3]. Accordingly, the paper aims to develop a tool, an Egyptian pandemic city tool, which has the ability to increase the urban resilience of Egyptian cities to mitigate health crises situations.

2. Materials and Methods

The research methodology for developing the proposed Egyptian Pandemic City Tool (EPC Tool) is composed of three main parts as presented in figure 1.

- **Part one:** Literature review and theoretical framework

Theoretical studies and analysis were conducted covering features of health crises and the idea and notion of pandemic cities. The studies focus on the integration of the concept and its impact on the urban dimension and product of cities. Accordingly, an initial list of indicators that can measure the resilience of cities urbanism to mitigate health problems was deducted.

- **Part two:** International case studies analysis

In this section, a number of selected international case studies have been studied and analyzed to refine the initial list defining the most important indicators.

- **Part three:** An expert survey conducted as an empirical study

A questionnaire was conducted aiming to define the most appropriate indicators for addressing the situation of the Egyptian urban context, also their relative weights are to be concluded based on the expert’s opinion.

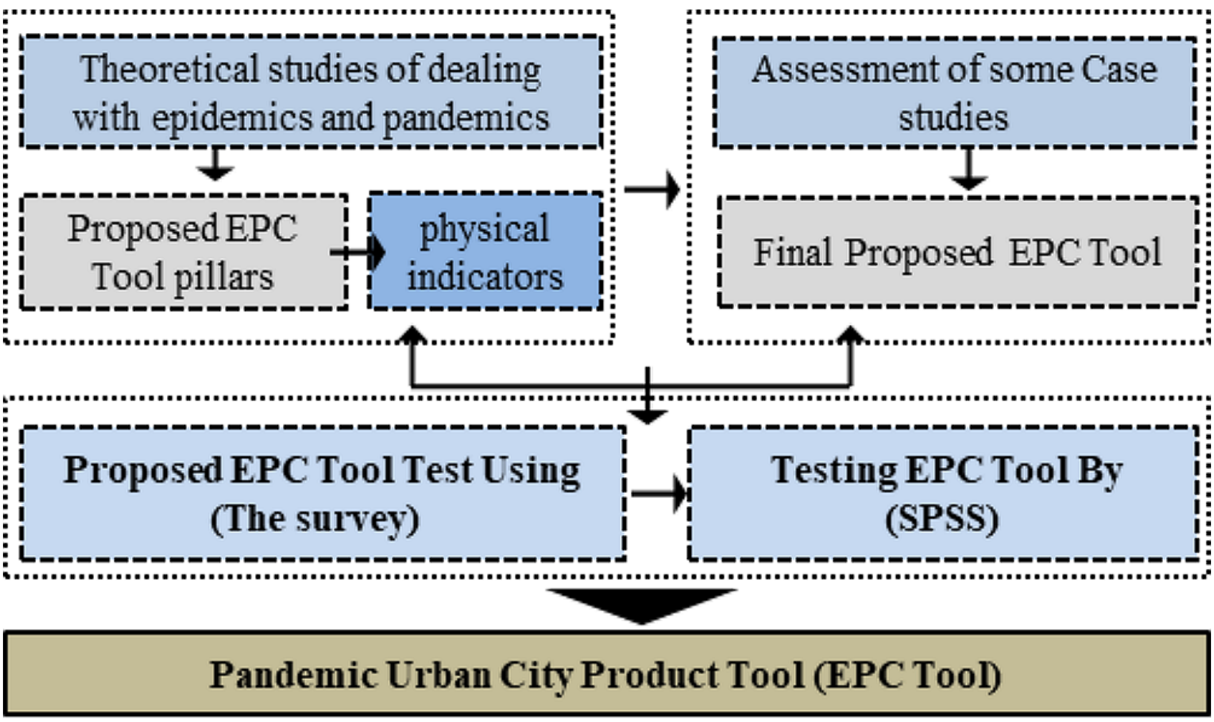
3. Literature Review

3.1. Epidemic and Pandemic Definition

The difference between epidemics and pandemics lies in the spread of the disease.

3.1.1. Epidemic

Epidemic is the occurrence in a community or region of cases of an illness, specified health behavior, or other health-related events clearly in excess of normal expectancy [4].



Source: Author

Figure 1. Research methodology

3.1.2. Pandemic

Pandemic is an epidemic occurring worldwide, or over an exact wide area, crossing international boundaries and usually affecting a large number of people [4].

3.2. History of Pandemic

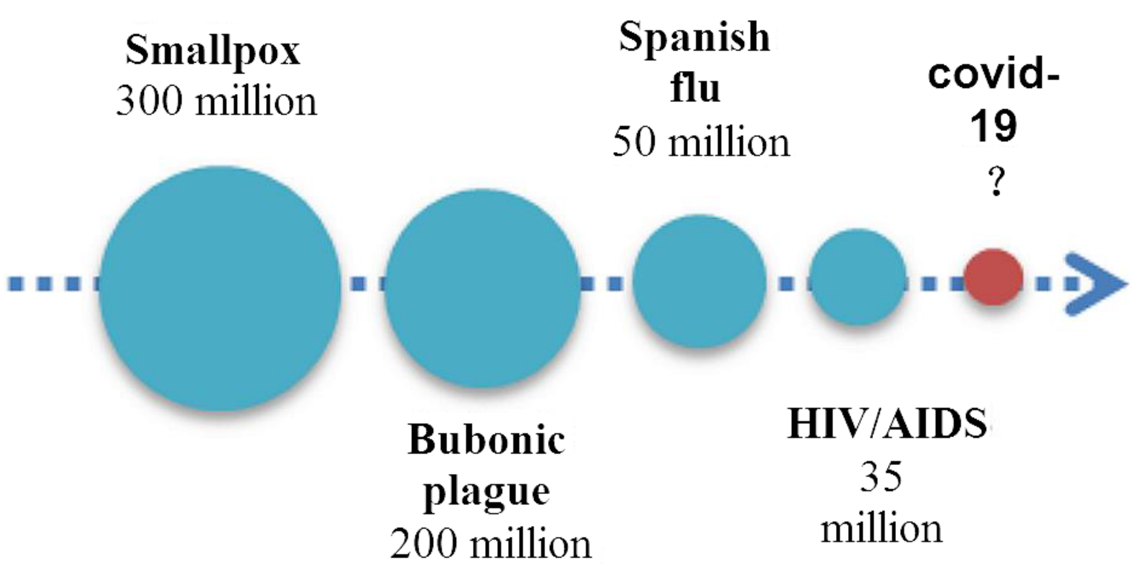
Over the ages, epidemics and pandemics have killed a large number of people and caused major crises that took a long time to overcome. The deadliest epidemic in history, the bubonic plague, also called the “Black Death,” spread between 1347 -1351 and caused nearly 200 million deaths around the world. In addition, one of the deadliest diseases in history is the “smallpox” which claimed 56 million lives when it emerged in 1520. Since 1900, it is believed to have killed over 300 million people. The “Spanish flu” from 1918-1919 caused nearly 40-50 million deaths in just one year and infected a quarter of the world's population. Between 541–542 AD, the “plague of Justinian” struck the world and killed more than 30-50 million people. Another one of the deadliest diseases in history is “HIV/AIDS” that has spread and caused 25-35 million deaths since its emergence in 1981. In 1855, a well-developed species of the plague, known as the "third plague," spread to all the inhabited continents of the world and caused 12 million deaths [5, 6, 7]. The world health organization represents the total number of Covid-19 cases infected, 465.93 million, and the total number of deaths 6.06 million [8]. Figure 2 shows the total mortality of major epidemics.

3.3. Causes and Classification of Pandemics

Population expansion, behavior, and sociodemographic features are some of the causes of lethal outbreaks that can spread over the world more effectively and quickly than in the past. World Wide Fund for Nature (WWF) confirmed that about 70% of infectious diseases in humans started with animals. However, there are four main reasons for the spread of viruses and epidemics around the world [9].

3.3.1. Frequent travel, trade and communication

The spread of sailing in the 14th century helped spread a deadly plague around the world. Then, the slave trade in the 16th and 17th centuries led to the transfer of the Egyptian nuisance (a highly domesticated urban mosquito, which prefers to live with humans at home, feed on humans and lay eggs in artificial containers made by humans) to the Americas from West Africa. This mosquito was responsible for the spread of viruses such as Zika. Consequently, globalization has facilitated the transport of goods and humans around the world causing the spread of various pandemics [10].



Source: Author based on [5,6,7]

Figure 2. Total mortality of major epidemics

3.3.2. Urbanization an emerging humanitarian catastrophe

Presently humans tend to live in densely populated urban environments. More than half of the world's population lives in cities. Therefore, cities are fertile ground for diseases.

3.3.3. Poverty rate/worst spread

When new viruses attack poor or weak health systems, they are more likely to multiply and kill people. The Ebola epidemic of 2014 and 2015 is an example. Every American who contracted the deadly virus during that period survived. However, it was not the case with those who contracted the virus in West Africa. An additional 97 million people live on less than $1.90 a day due to the pandemic, raising the world poverty rate from 7.8% to 9.1%; 163 million people living on less than $5.50 a day [11].

3.3.4. Global Warming Fuels the outbreak of disease

Environmental factors such as global warming, which are equally or sometimes more important than our behavior, for example, Zika and dengue fever spread through mosquitoes. One of the reasons these mosquitoes have reached new places and people is climate change. In addition, one of the environmental factors affecting the transmission and spread of infectious diseases that can cause epidemics is water and sanitation. There's a list of diseases classified according to the ministry of health Blood diseases, nervous system diseases, etc. The present research will focus on chest diseases (Corona virus) [12].

4. Methods for Dealing with Pandemics

4.1. Traditional Methods

Traditional methods for combating both epidemics and pandemics worldwide are limited to non-pharmaceutical interventions such as isolation, quarantine policy, and use of disinfectants, reduction of public gatherings, closure of workplaces, schools, and universities, in addition to the suspension of many activities and travels control.

This audit showed that simulation systems for quarantine scenarios revealed that it played a vital role in controlling the spread of Covid-19, as opposed to any other preventative measures, resulting in a 44-81% reduction in infection rate and a 31-63% mortality rate. Quarantine has both advantages and disadvantages, as listed below [13]:

4.1.1. Quarantine Advantages

It must be noted that the most important advantage of quarantine is the reduction in the number of infected patients, as well as the reduction in mortality rate for the most vulnerable, primarily the elderly.

Global quarantine brought about positive results for the whole planet, leading to a reduction in environmental pollution, bearing in mind the low rate of global warming, one of the most important problems facing the planet.

4.1.2. Quarantine Disadvantages

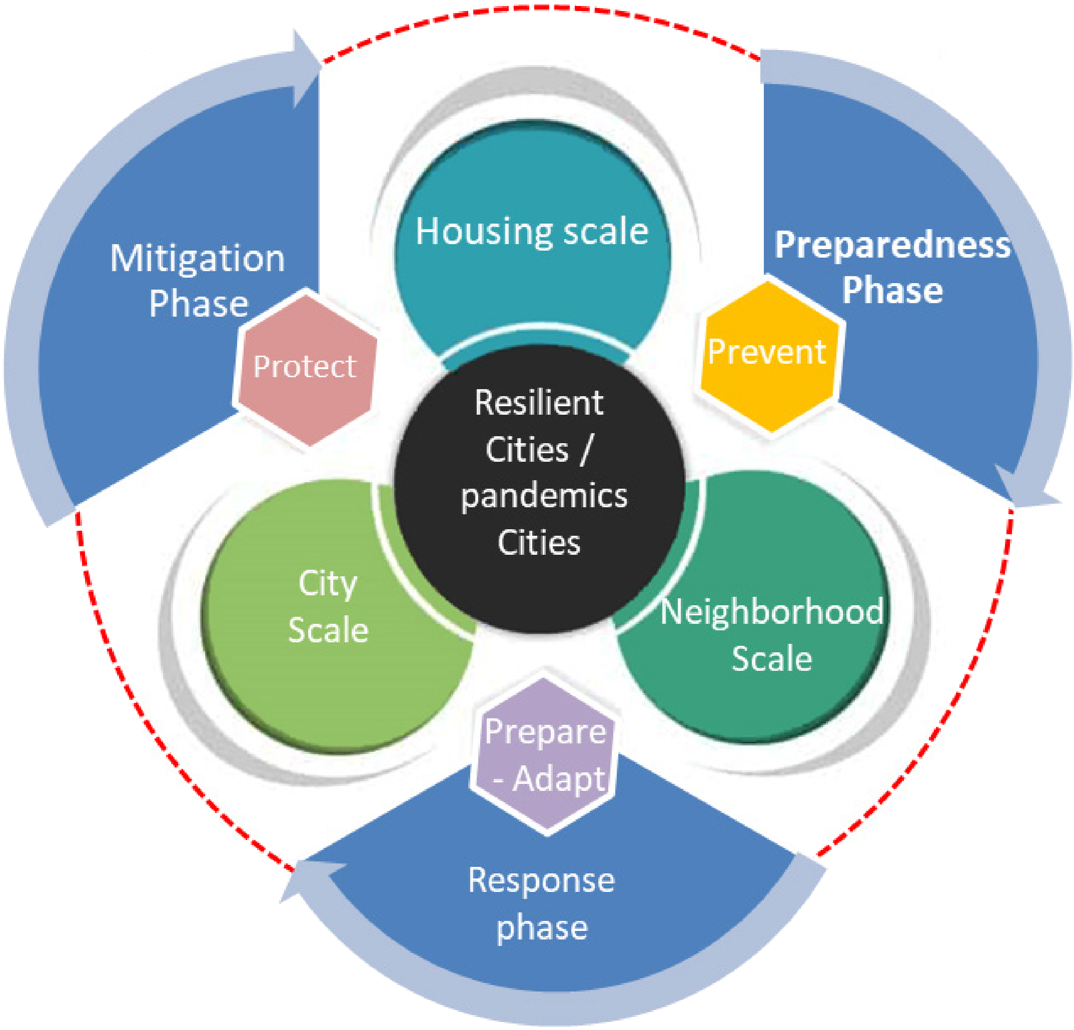
A major quarantine has disrupted the economic wheel, resulting in fast deterioration of the economic condition that the globe has not witnessed before, even at the end of the world wars, as well as the devastating impact of historical large number of deaths. The huge number of deaths, particularly among the poor, who are in desperate need of basic commodities, is one of the epidemic's most serious repercussions [13].

4.2. Innovative Urban Planning Models (Pandemic Cities / Resilient Cities)

The concept of a 'resilient' city' is one of the most important contemporary trends in sustainable planning, due to the environmental, economic, urban and health changes that cities are subjected to. It represents a concept to achieve sustainable development goals to face current and future crises.

Pandemic city planning perspectives in order to tackle the health crises can be separated into three steps: prevention, protection, and adaptation on city-scale and neighborhood scale as shown in Figure 3 [14, 15].

Innovative urban planning and design approaches such as (The 20-Minute Neighborhood, A car-free city, and Compact City) provide resilient methods for dealing with health crises. The following section presents further information and analysis of the approaches.



Source: Author based on [14,15]

Figure 3. Framework for a pandemic Cities and Resilient Cities

4.2.1. The 20-Minute Neighborhood

The concept of a 20-minute neighborhood (also known as 15-minute city) has gained popularity around the world, particularly since the COVID-19 pandemic highlighted the importance of the city urban context.

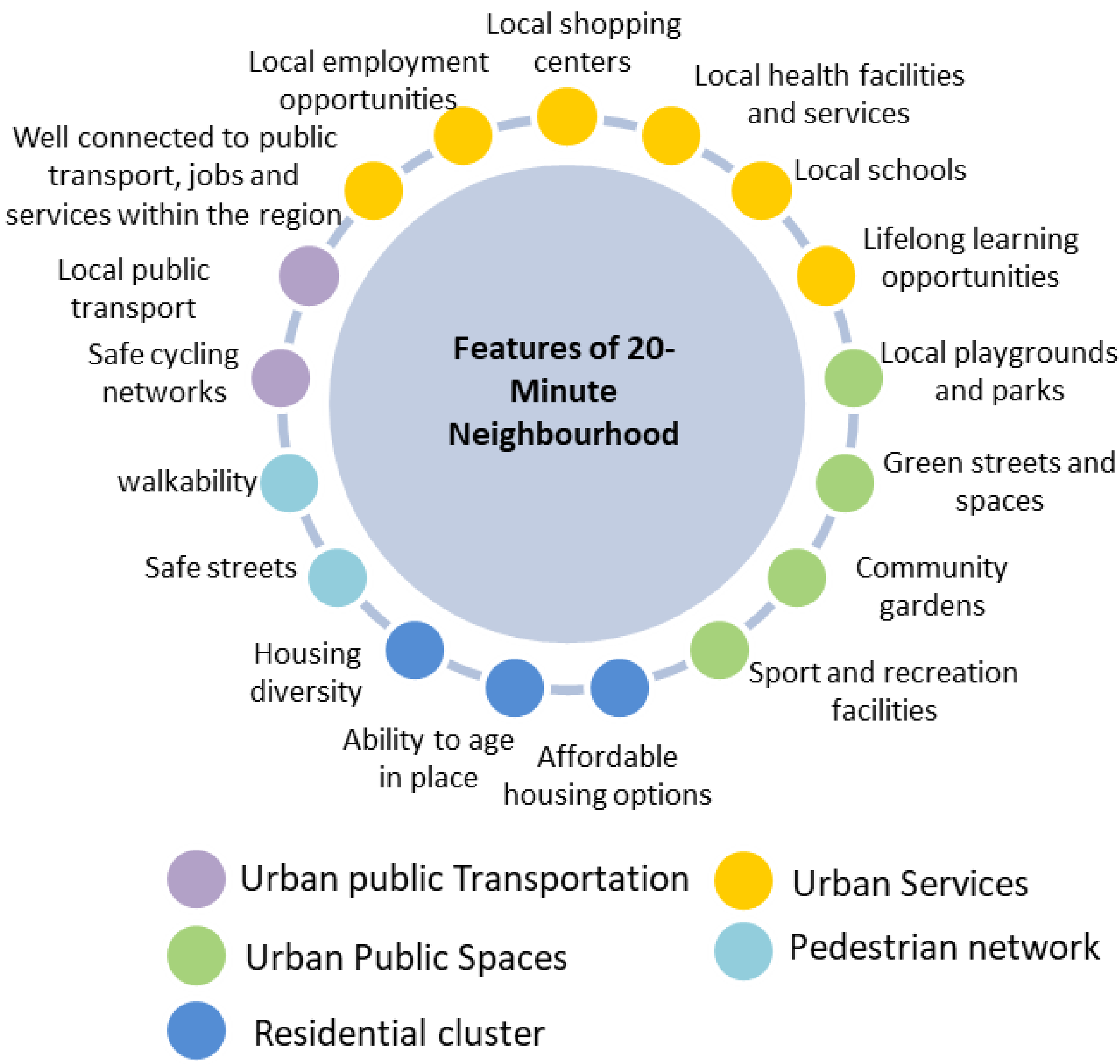
This 20-minute trip entails walking 800 meters from home to a particular destination and back. Alternatively, a ten-minute walk to your destination and a ten-minute walk back home, access to local health facilities and services, schools, and shopping malls are examples of daily necessities destination [16, 17, 18].

Advantages of 20-Minute Neighborhood against health crisis:

- Increase urban mobility, be safe, and well-connected for pedestrians and cyclists
- Provide high-quality public places and public realm
- Provide services and destinations for the benefit of the local community
- Enable people to access high-quality public transportation that connects them to higher-level services [18]. Figure 4 illustrates the five basic components of 20-Minute Neighborhood as a sustainable urban approach for dealing with pandemic crises.

4.2.2. A car-free city

A car-free city is a city where citizens travel within the city using public transportation, walking, or biking. The term "car-free zone" refers to places that do not allow motorized vehicles. Car-free city designs have gained popularity as a result of current traffic and infrastructural issues, as well as projected environmental and quality-of-life benefits. [19, 20].



Source: Author based on [18]

Figure 4. The Features of a 20-minute city

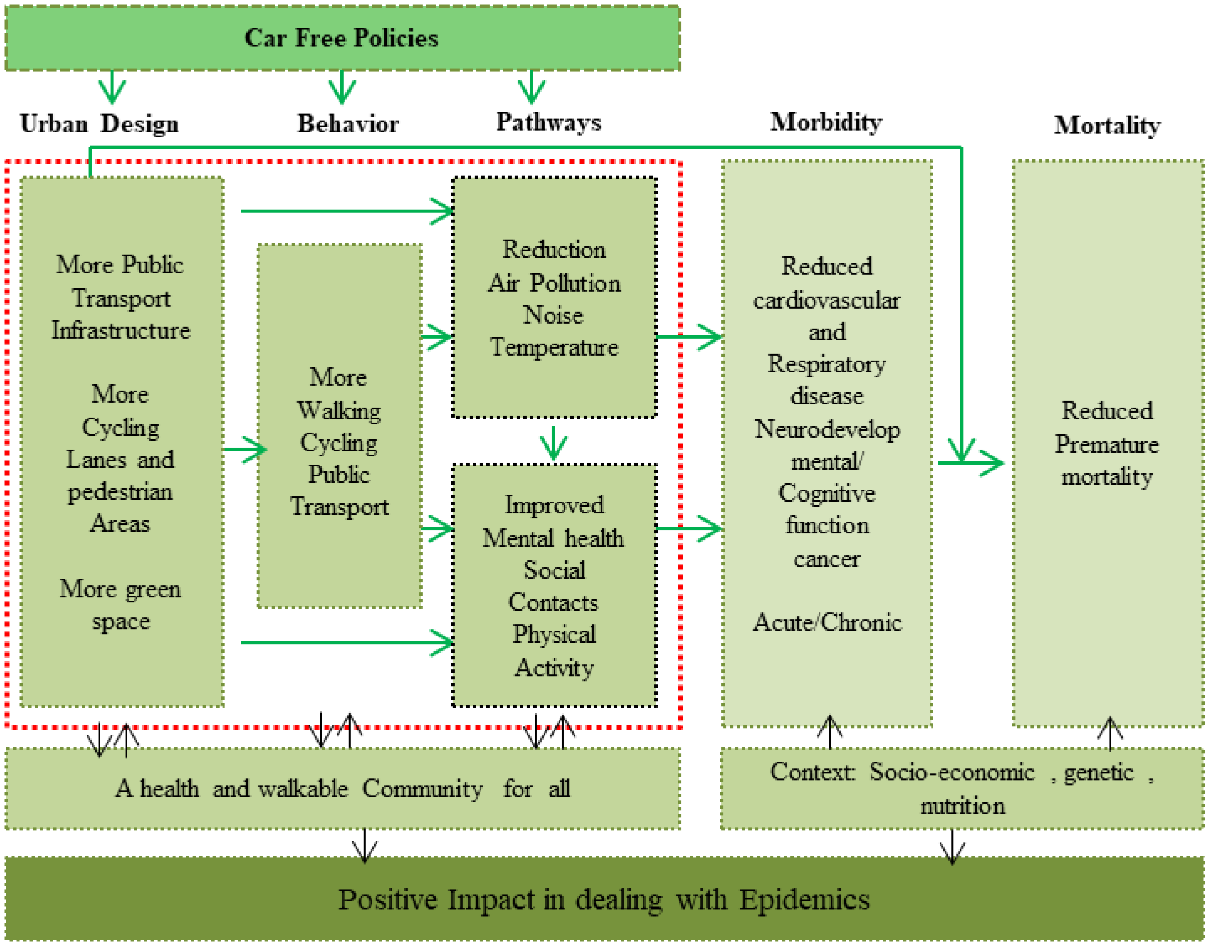
- Advantages of car-free city against health crisis:

Environmental: One of the environmental benefits is the reduction in greenhouse gas emissions. Car-free zones can also reduce levels of ambient noise [21, 22].

Economical: residents of car-free zones can benefit from more green space, a stronger economy, and higher real estate values [23].

Social: The space's restoration has a social benefit as it encourages individuals to be physically healthier for reasons like commuting, exercise [23].

Figure 5 shows the essential components of a car-free city. The approach is regarded as a sustainable urban approach for dealing with city pandemic health crises. The most critical components are urban design, behavior, pathways, morbidity, and mortality. Aiming to create a community that is healthy, social, and walkable.



Source: Author based on [22]

Figure 5. Car-free cities Concept

4.2.3. Compact City

The compact city concept is credited to Dantzing and Saaty [24] as its founders. They identified three characteristics of compact cities: (i) high-density residential areas, reduced reliance on motor vehicles, and clear boundaries with neighboring regions in terms of urban morphology; (ii) mixed land use and a high diversity of lifestyles in terms of spatial characteristics; and (iii) social equality, self-sufficiency of daily life, and independent habitation in terms of social functions.

A compact city, also known as a city of short distances, is built on well-functioning public transportation infrastructure and an urban design that, according to its proponents, fosters cycling and walking [25, 26].

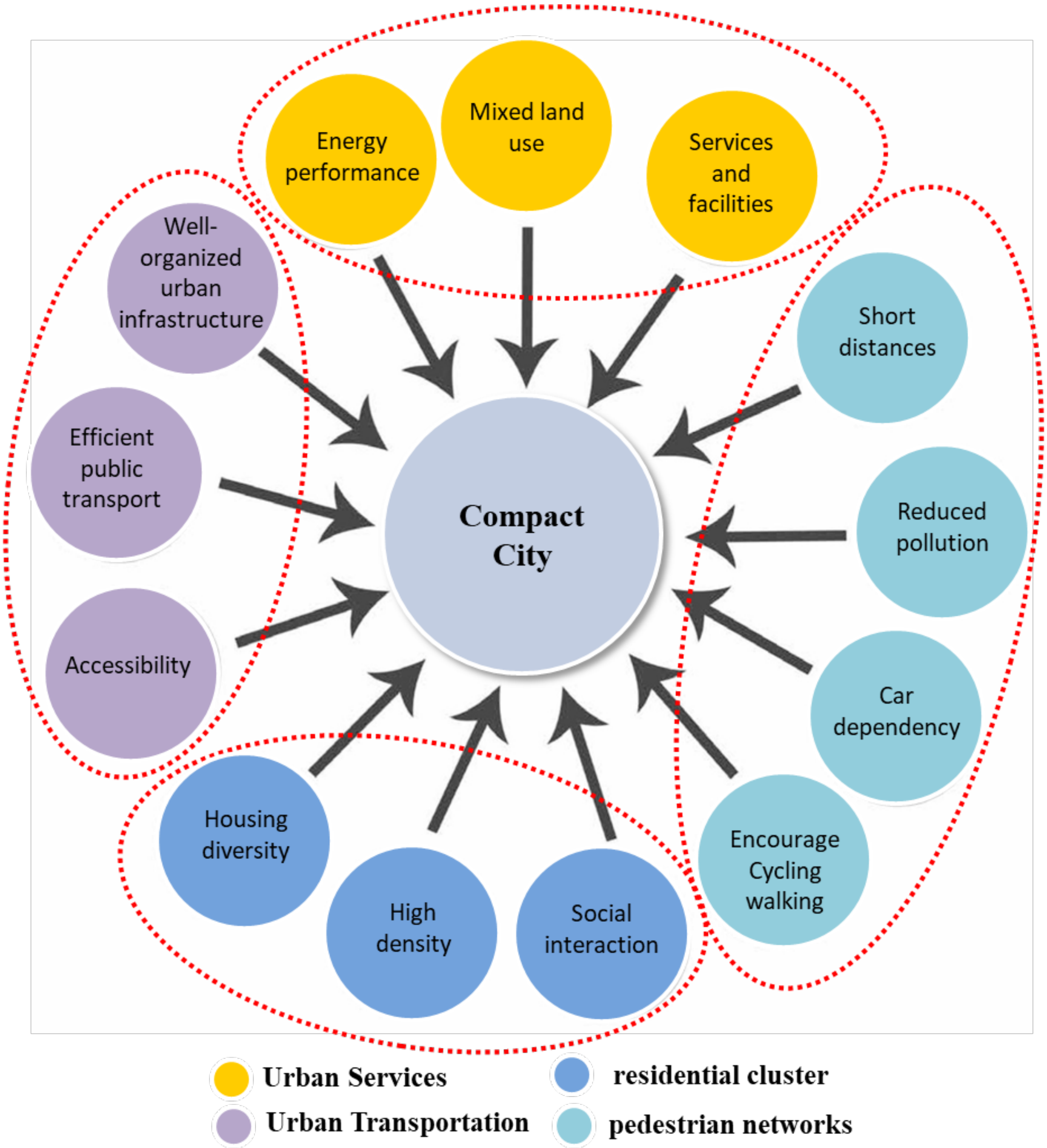
The fundamental components of the compact city approach are urban services, urban transportation, residential cluster and pedestrian networks, as presented in Figure 6.

- Advantages of compact city against health crisis:

Environmental: Compact cities affect the environment by reducing automobile pollution, reducing energy use per capita, and reducing carbon dioxide emissions [27, 28, 29].

Economical: The economic impact is increased productivity due to reducing worker travel time and technologies, rural economic development (renewable energy, urban agriculture, etc.), lower infrastructure investment [28, 30].

Social: compact cities affected the society by being more accessible, increased mobility for those who do not have access to a car, and improved human health as a result of cycling and walking [28, 31].



Source: Author based on [26]

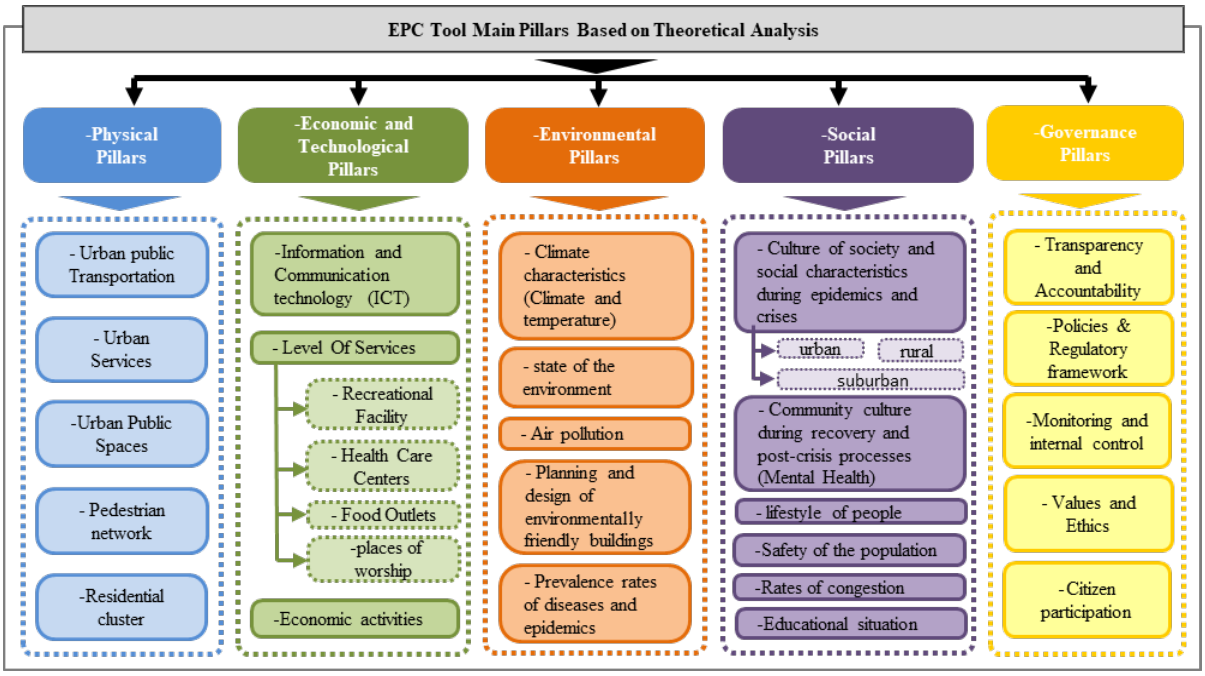
Figure 6. Urban components of a compact city

5. Theoretical Composition of EPC Tool

Based on previous theoretical studies, a core model has been deducted. Multiple urban components can work together, creating an integrated framework for assessing the ability of urban settlements to deal with epidemics and transform cities into healthy environments in the context of global epidemics. Utilizing of appropriate indicators can guide designers to make the built-in environment more resilient against epidemics.

The framework components can be classified into five main pillars: First: Physical Indicators, II: Economic and Technological Indicators, III: Environmental Indicators, IV: Social indicators, V: Institutional indicators. Each pillar is to be covered by a proposed list of indictors, composing the initial deducted theoretical list for measuring the extent to which cities urbanism is able to deal with epidemics according to theoretical studies, [32-38].

The pandemic city (EPC) main pillars have been deducted based on the findings of the theoretical studies and analysis as shown in (Figure 7).



Source: Author based on [32, 33, 34,35,36,37,38]

Figure 7. EPC Tool Main Pillars based on Theoretical studies

Individual researches are required for each of the main pillars to compose a final comprehensive tool. However, due to the aim of the paper and the authors' fields of expertise, aiming to innovate a tool that can regulate the urban context of city to increase its resilience against health crises, the paper is to target the physical pillar (urban dimension) for the purpose of this research. Table 1 defines the main components of the physical pillar covering the urban issues of the city component as the core of the EPC Tool. Further studies, for the defined components are to be covered in the next section, aiming to deduct and define the initial list of indicators for composing the EPC Tool

Table 1. Main Urban Components of the EPC Tool

physical indicators	
1	Urban Public Transportation
2	Urban Services
3	Urban Public Spaces
4	Pedestrian network
5	Residential cluster

Source: Author based on theoretical studies

6. Testing EPC Model based on Analysis of International Case Studies

The paper aims to increase the reliability of the findings of the selected international case studies, select the most similar cases that could match the developing, urban, environmental, and regional conditions for the Egyptian Cites. Accordingly, the case studies of Barcelona and Milan were selected:

Barcelona, as one of the most important cities in Europe, was affected by previous epidemics in Spain, such as the black plague, in addition to its urban fabric that is comparable to that of Egypt.

Milan, is one of the most impacted by the Corona virus, but in recent years, the city has transformed to become more resilient and healthy city. Additionally, it has geographical and cultural similarities with Egypt.

In addition to the former verifications, the availability of required data concerning the urban context and the documented reports concerning the late Covid-19 epidemic has confirmed the final selection of the two cities. The analysis of Barcelona city will be included within the paper; however, the Milan case will be reported on its findings only due to the paper limitations.

6.1. The Superblocks Model, Barcelona

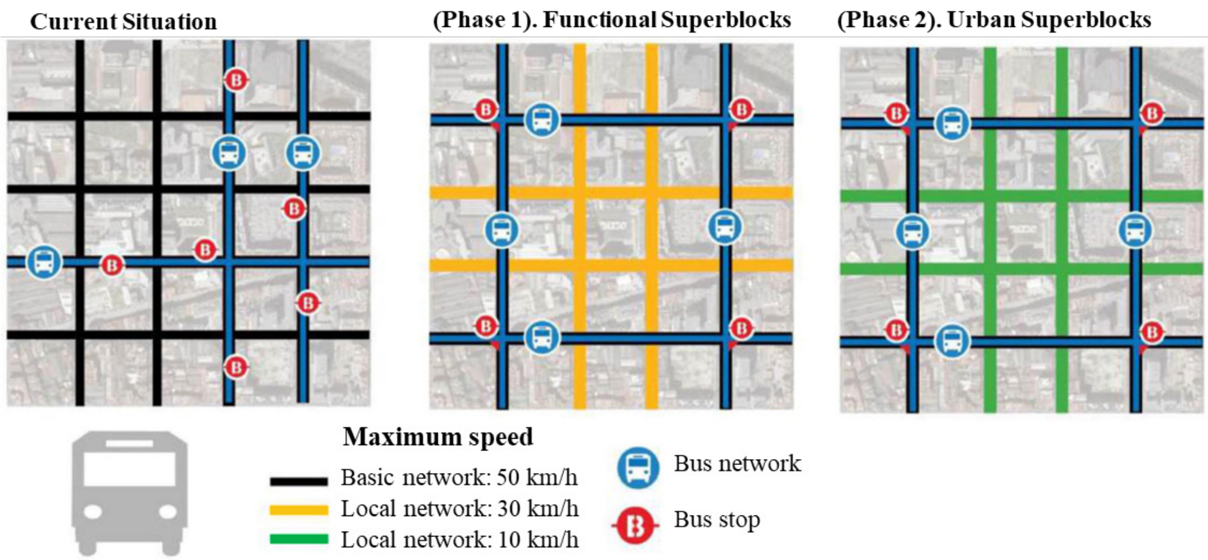
Barcelona is considered as the capital of the Spanish province of Catalonia. Barcelona, Spain's second-largest city, is situated on the northeastern coast of the Iberian Peninsula, fronting the Mediterranean, on a plain about 5 km, bordered to the southwest by the Collserola mountain range, and to the north by the Bess river. The plan covers 170 square kilometers (66 square miles) [39].

Barcelona is one of the most densely populated cities in Europe. The population is 1.62 million for 2018 (Instituto Nacional de Estadística) INE. The city is 102.2 km^2, giving the city an average population density of 15,926 inhabitants per square kilometer. The total number of covid-19 cases in Barcelona is 2.22 million, with 17,446 deaths) (Global Health Observatory data, 2022) [40,41].

6.2. Urban Transport

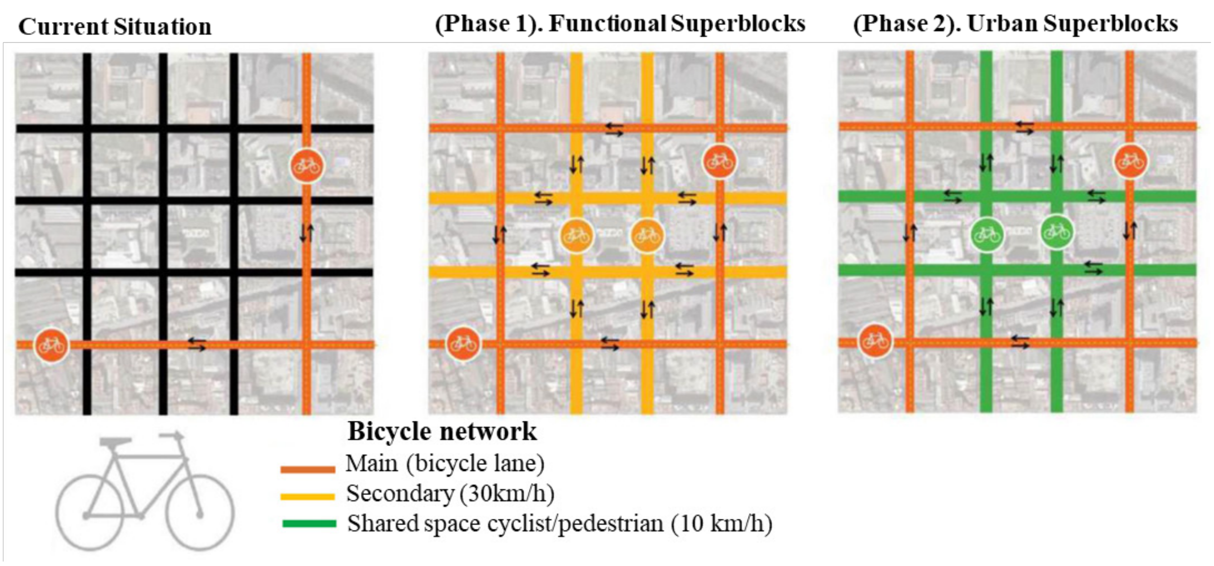
According to S. Rueda, [42] the Superblock is "a unique model of mobility, which restructures the conventional urban road network." Superblocks consist of a grid with basic roads that form a 400 by a 400-meter polygon and a population of 5000–6000 people per Superblock. The inside is blocked to motorized vehicles and parking, where pedestrians are given priority, the city has been adapted to the point where 75 percent of its roads have 30 km/h speed restrictions [43], Figure 8 shows urban transport in Superblock.

Although cyclists are free to ride within the superblock, they also contain bike lanes that run alongside the streets. Figure 9 shows Bike lanes in Superblock models [44].



Source: Reproduced from [44]

Figure 8 . Urban Transport in Superblock models



Source: Reproduced from [44]

Figure 9. Bike lanes in Superblock models

6.3. Urban Services

The ‘superblock' of Barcelona has been proven to be a 5-minute urban experience. 'Barcelonans' can carry out daily activities within 300 m of their homes. On-street and off-street parking are regulated by parking policies. They address shared-vehicle mobility and parking and motorcycles, on-street electric car charging stations, and, finally, on-street parking for bicycles and micro-mobility users (e.g., e-scooters), by classifying assembly gathering points to each of them to intermodal node, Services node and Neighbor Node [45]. Figure 10 shows the legibility and functionality of Barcelona Superblock.

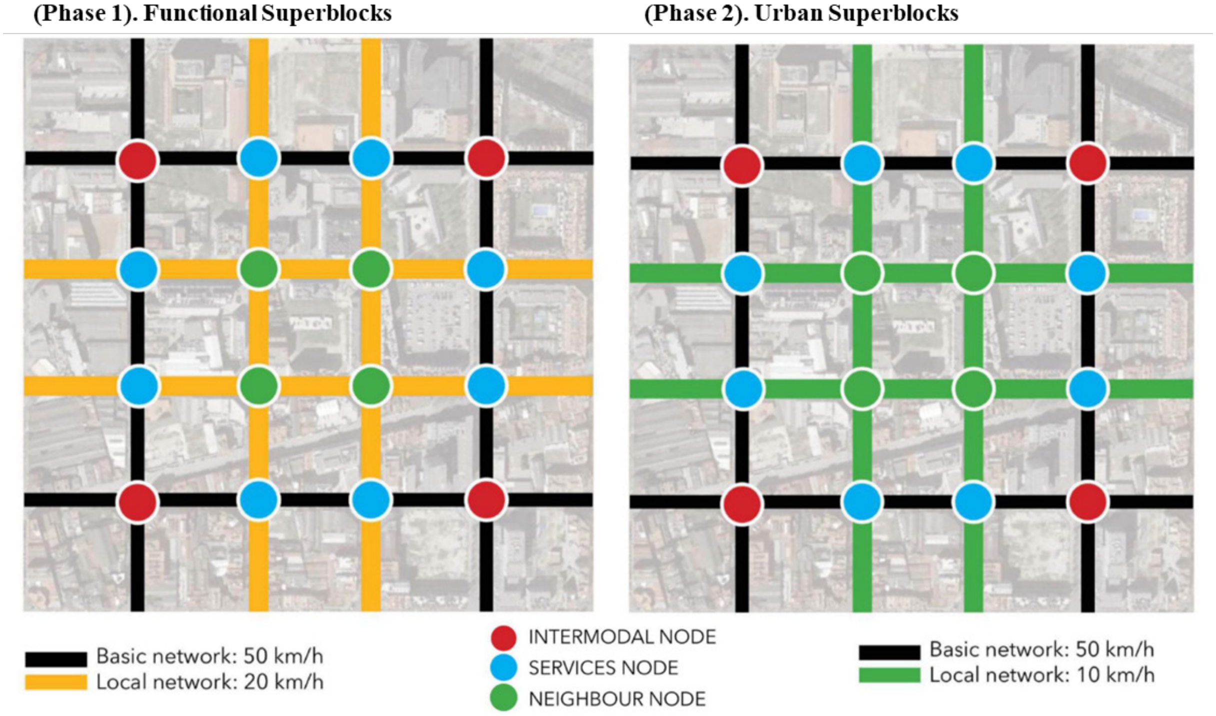


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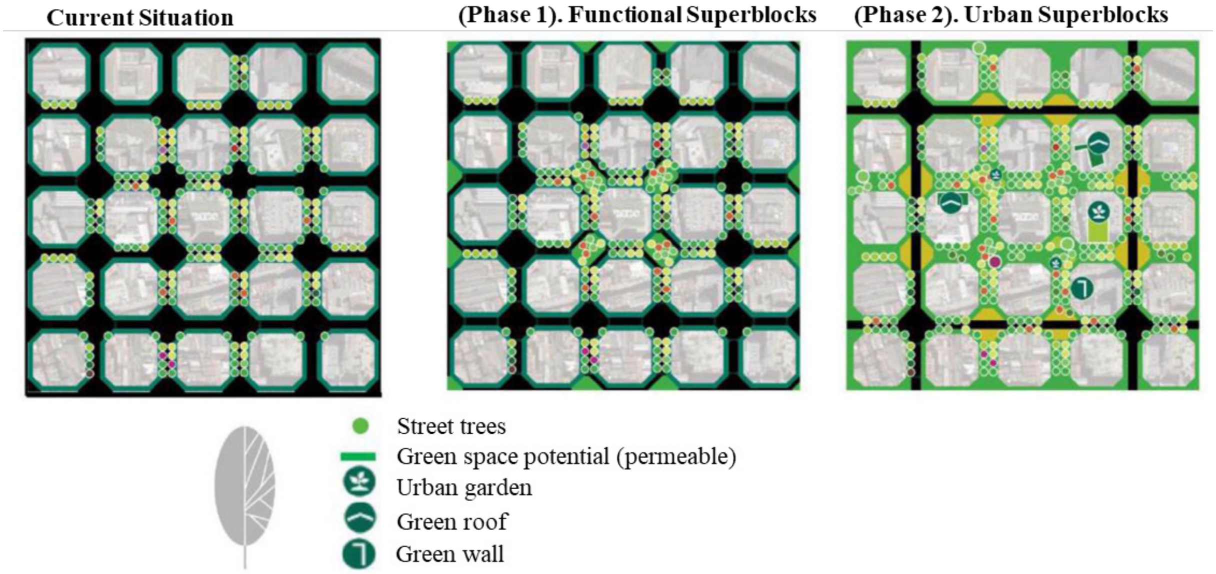
Figure 10. Urban Services in Barcelona Superblock



Source: Reproduced from [44]

Figure 11. Urban Spaces in Superblocks in Barcelona

6.4. Urban Space

Barcelona has built 21 new green streets, a total of 6.6 hectares of increased greenery, the region will be transformed so that one out of every three streets will be greened, urban public space within 200 meters of their homes [46].

It plans to build 21 urban public spaces at street intersections with a total area of 2,000 m^2 for people to walk, and spend their time. With container trees, street furniture and temporary activities, in order to promote public spaces within residential neighborhoods, improve public health, and limit the spread of diseases [47]. Figure 11 shows Urban Spaces in Superblocks in Barcelona.

6.5. Pedestrian Networks

On Barcelona's sidewalks, planters and trees replace the dull gray of the street. Car traffic is allowed only at 10 to 20 km/h on the remaining one-way streets. In addition to the noise of cars, you can hear the laughter of children, get some fresh air instead of polluting smog. Additional measures are required for this purpose: Increasing the number of bus lanes, as well as bike and scooter paths [48, 49].

Maximizing pedestrian networks will lead to lower emissions and alleviate the impact of heat islands. Furthermore, it prevents about 300 premature deaths each year. According to the analysis, weekly private car trips could drop from 1.19 million to 230,000. This fact would cut nitrogen dioxide emissions from 47 to 36 micrograms per cubic meter, falling below the World Health Organization (WHO) recommended limit of 40 micrograms [44]. Figure 12 shows pedestrian space (Sidewalks, pedestrian priority streets, boulevards and promenades).

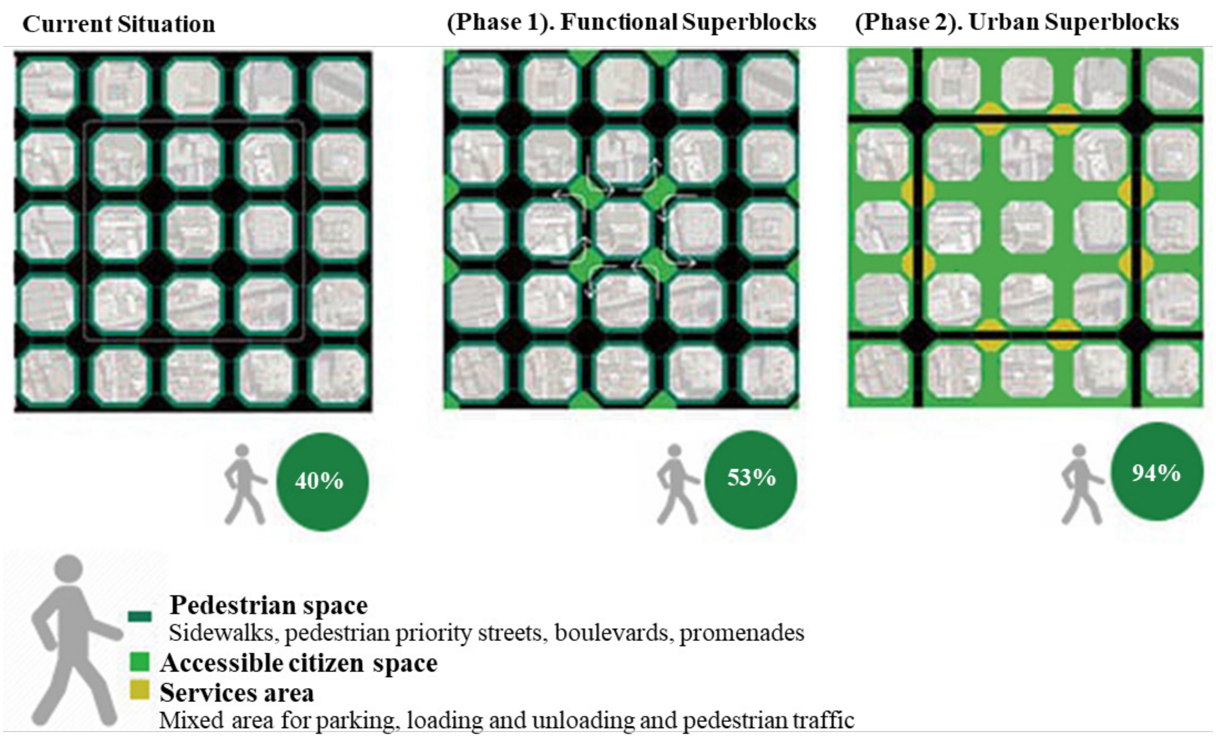
6.6. Residential Cluster

The bulk of Barcelona is controlled by a regular grid plan consisting of big square blocks with chamfered corners and broad radial boulevards that connect the city's center to its outskirts. The steam tram's journey along each street was made easier by the beveled street corners.

The proposal specifically expects a garden city with access to small parks and green spaces on both sides of each low-rise block. Most of the blocks were raised to a uniform height of eight floors [49].

A set of urban indicators has been identified based on theoretical studies and Case studies (Barcelona and Milan) in dealing with pandemics, to test the proposed instrument and determine the mechanism for implementing and activating it in the Egyptian urban context.

Table 2 presents the initial urban indicators to compose the proposed EPC Tool deducted from the findings of the theoretical studies and the analysis of the case studies [50, 51].



Source: Reproduced from [44]

Figure 12. The New Pedestrian-Friendly Superblocks in Barcelona

Table 2. The initial deducted list of urban indicators

Indicators		theoretical studies	case studies: 1. Barcelona (Spain)	case studies: 2. Milan (Italy)	Final Proposed indicators
A. The suitability of (urban transportation) in providing health requirements based on (bicycle paths) during epidemics.	1-Responding to the needs of cycling in cities during the epidemic and beyond and giving priority to cyclists, where people can find a safer alternative to private cars and public transportation to get around.	✓	✓	✓	✓
	2-Active transportation to provide a healthy lifestyle during epidemics	×	✓	×	
	3-Bike mobility during epidemics	✓	✓	×	
	4-Private vehicle mobility	×	✓	×	
	5-Urban public transportation Safety, to provide a healthy lifestyle	×	✓	×	
	6-Separation of (motor and pedestrian tracks) with (bicycle paths) through an increase and provision of a bicycle track (one direction at a width of 1.5 m), (two directions at a width of 3 m)	✓	✓	✓	✓
	7-Air/Noise pollution from Urban public transportation	✓	✓	×	
	8-Creating comfortable and safe environments to encourage cycling to provide a healthy lifestyle during epidemics	✓	✓	✓	✓
	9-Speed and Volume of vehicular traffic	×	×	✓	
	10-Optimize the urban public transport network to promote a healthy lifestyle	✓	✓	×	
	11-Use of bicycles to go to (work, school, shopping) to a maximum of 5 km, to reduce congestion in public transport to prevent epidemics and to improve physical fitness	✓	✓	✓	✓
	12-Greening of vehicles linked to public services	✓	×	×	
	13-Reduce the presence of the private vehicle	✓	×	×	
	14- Providing (bicycle stations) every 500m	✓	✓	✓	✓
B. Accessibility (Urban services): educational, health, commercial, administrative, religious, recreational, through the use of pedestrian and bicycle paths to achieve health dimensions	1-Providing services within 5 minutes (walking distance of 400m) as it contains (public garden, children's garden, elderly care centers, children's nursery, markets, small stores), to reduce the use of public transportation during the epidemic	✓	✓	✓	✓
	2-Enable creative services through the pandemic	✓	×	×	
	3- Providing services within 10 minutes (walking distance of 800m), as it contains (primary school, cultural centers "libraries", sports stadiums), to reduce the use of public transportation.	✓	✓	✓	✓
	4-Providing the infrastructure needed to provide electronic services	✓	×	×	
	5- Providing services within 15 minutes (walking distance of 1200m), as it contains (major stores, middle schools, health care centers at the district level), to reduce the use of public transportation during the epidemic	✓	✓	×	✓
	6- Availability of places for services designated for crises and emergencies (health centers and temporary housing) to provide the advantages of living in healthy cities	✓	✓	✓	✓
	7-Providing urban services to promote a healthy environment	✓	×	×	
	8- Providing job opportunities through electronic systems to reduce the spread of diseases	✓	✓	✓	✓
	9-Appropriate spatial allocation of services based on necessity (daily - weekly - monthly)	✓	✓	×	
	10- Availability of smart electronic services such as (education, health, government services, shopping) during epidemics	✓	✓	✓	✓

Table 2 Continued

C. Providing health requirements in the design of (Urban Space)	1-Providing ways for eradicating depression in public settings during epidemics	✓	✓	×	
	2- The design of the space consists of a set of spaces that meet the needs of different age groups and take into account health requirements	✓	✓	✓	✓
	3-Recreational Spaces	×	✓	×	
	4- Maintaining social distancing within the spaces (1.5 m) to reduce the spread of epidemics and maintain the public health	✓	✓	✓	✓
	5-Implement green roofs and facades with a positive impact on health	✓	×	×	
	6- Increasing open public spaces within residential areas to increase residents' interactions with green spaces to improve public health and reduce the spread of epidemics	✓	✓	✓	✓
	7-Include water surfaces in squares and gardens	✓	×	✓	
	8- Equitable distribution of spaces to reduce stress levels and maintain public health by accessing an open area with a distance of no more than (400 meters)	✓	✓	✓	✓
	9-Getting fresh air in Urban Space to promote a healthy lifestyle	✓	×	×	
	10- Providing health safety by providing sterilization and disinfection systems in Urban Space	✓	✓	✓	✓
	11-Achieving the best use of artificial intelligence technology in designing various elements in urban space	✓	✓	✓	✓
	12-Creating green spaces and riverbank areas	×	×	✓	
	13- Consideration of the use of plants with a positive impact on health	✓	✓	✓	✓
D. Consideration of (pedestrian networks) within neighborhoods and residential areas to Health requirements	1-Pedestrian mobility, Legibility, Comfort and Directness	✓	✓		
	2- Reducing walking distances to a maximum of 800 m to access various services: (clothing stores, educational facilities, gardens and open green spaces, restaurants, health units, sports services such as gym) to achieve the goals of healthy cities	✓	✓	✓	✓
	3-Reduce motorized roads, prioritizing pedestrian Roads, where people can find a safer alternative to private cars and public transport	✓	×	×	
	4-Integrating pedestrian paths with bicycle paths to improve the physical and psychological health of the population during epidemics	✓	✓	✓	✓
	5-Ensure that pedestrian access is clear and continuous	✓	×	×	
	6- Availability of pedestrian paths (at least 1.5 m wide) to encourage all people to exercise walking to achieve the health objectives of the pedestrian	✓	✓	✓	✓
	7-The appearance of banners related to health to enhance individual awareness	✓	×	×	
	8- Availability of sterilization, cleaning, hygiene and handwashing in pedestrians to reduce the spread and transmission of the epidemic	✓	✓	✓	✓
	9- Availability of service elements for pedestrians: such as (road furniture elements such as seats and pergolas, fitness equipment, garbage bins, periodic maintenance of paths) to encourage walking to enhance the level of public health during the epidemic period	✓	✓	✓	✓

Table 2 Continued

E. Providing health requirements in (residential cluster)	1-Provide a safe distance between buildings and achieve ventilation and exposure to sunlight to reduce the spread of epidemics and maintain the health of the population.	✓	✓	✓	✓
	2-Housing affordability during pandemics	×	✓	×	
	3-The Diversity of uses within the residential area (mixed use) for easy access to services during epidemics without the use of public transportation	✓	✓	✓	✓
	4-Determining the Housing value	✓	✓	×	
	5- The extent of the ability of the urban pattern (linear, organic, compact, radial, irregular, and grid) is capable of shifting to non-traditional means of movement such as (pedestrian, cycle paths)	✓	✓	✓	✓
	6-Social Neighborhood networks during epidemics	✓	×	×	
	7- Population density and its reflection on the quality of the residential cluster environment to reduce overcrowding to prevent the spread of epidemics	✓	✓	✓	✓
	8- Determining building heights (no more than 5 floors) to decrease congestion, improve the quality of life, and protect public health during the epidemic	✓	✓	✓	✓
	9-In the event that a curfew is imposed during a pandemic, the residence's flexibility is taken into mind	✓	×	×	

The initial list ✓

The refined list ✓

Source: Author based on theoretical studies and case studies

The first column of the table included the initial deducted list composed of 55 indicators. However, after correlating the results of both the theoretical studies and analytical studies as presented in the third, fourth and fifth columns, the final proposed 28 indicators were concluded as presented in the final column of the table. The aim of the study was to conclude and to deduct the most effective indicators, since a large number of indicators would not serve the aim of the research in developing and innovating a practical tool.

The indicators were chosen based on a variety of reasons, the most important of which is their applicability to the Egyptian context, measurable indicators, and frequency.

Out of 55 indicators, 28 were selected as the most important urban indicators. However, aiming to define the most appropriate indicators having the ability to address the situation of the Egyptian cities' urban context, an empirical study was conducted and reported on in the following section.

7. Examining the Efficiency of the proposed EPC Tool

In accordance with Egyptian reality, an empirical study was conducted to re-evaluate the proposed indicators of the suggested EPC Tool. A questionnaire was designed utilizing google form targeting the Egyptian urban planners, urban designers and city planners. The questionnaire objectives were set as follows:

- First, researching and tracking the most important urban Indicator's characteristics, as well as gathering data and expert feedback on the proposed EPC Tool for the Egyptian cities urban design process.
- Second, during the design phase, test the suggested EPC Tool for dealing with health disasters that approach the pandemic limit, examine expert perspectives on the tool's usefulness and efficiency, and develop recommendations that might be added.

7.1. Determine the Study Sample

Aiming to increase the reliability and the validity of the study a comprehensive sampling strategy was adopted. The study sample community was clustered into five groups comprising architects, urban designers, executive authorities, academics, and engineering consultancy. A questionnaire is administered using a closed and open question system.

The questionnaire is designed to take no more than ten minutes.

7.2. Sample Size

Survey was conducted from March 1st, 2022 to March 10th, 2022. The cases were randomly selected based on the sampling strategy to represent the research community and the researcher's capabilities, resources, and time available to collect data. 120 forms were distributed, utilizing Google Forms Survey.

7.3. Designing a Questionnaire Form

The questionnaire is designed using a set of questions formulated according to the research vision. The following categories are used to specify the contents of the questionnaire:

First: preliminary data to accumulate general information about the expert, such as years of experience and expertise field.

Second: researching the effects of the major factors that influence how cities should prepare for health crises.

Third: a survey of experts' opinions on the indicators that can be used to assess the tool's ability to deal with health disasters, which is made up of five main aspects.

7.3.1. Explanation of the form

It was taken into account that the answers should be in specific points for the ease of analysis. In addition, it determines the effects of each of the elements through the "Likert scale" of five scales (Very Low, Low, Moderate, High, Very High).

7.4. Pilot Study

A pilot study was conducted to test the efficiency of the questions, the clarity of the language, and finally the appropriateness of the utilized types of questions. Accordingly, the required adjustments were carried out to the questionnaire.

8. Results and Discussion

8.1. Data Analysis

Table 3. Classification of Experts

Classification of Experts	N	%
Architect	26	22%
Urban Designer	32	27%
Executive Bodies	4	3%
Teaching	28	23%
Engineering Consulting	30	25%
Total	120	100%

Source: Author based on Survey Study

Of the 120 questionnaires, 29 respondents (24%) have more than 20 years of experience, 37 respondents (31%) have between 10 to 20 years of working experience and 54 respondents (45%) have less than 10 years. Furthermore, the sample's target groups had the highest percentage of Urban Designer 27% followed by Engineering Consulting 25% As shown in Table 3.

8.2. Relative Importance Index Analysis

Responses were analyzed using SPSS package where data were imported from the questionnaires.

In this study, Relative Importance Index analysis was used to rank the criteria according to their relative importance. The relative index is calculated using the formula "(1)", (Table 4)

$$RII{=}{,}\sum (w/\text{-}AxN).\ (0 \leq \text{RII} \geq 1) \quad (1)$$

Where:

W= the respondent's weighting of each element

A= Highest Weightage

N= Total number of people who responded

The weighted average will be derived based on the ranking (R) of relative indices (RI) [52].

Table 4. Evaluation Criteria for Likert Scale Questions

Score Interval (Mean) RII Values	Importance Level Evaluation Criteria	
0 ≤ RII ≤ 0.2	Very low	V-L
0.2 ≤ RII ≤ 0.4	Low	L
0.4 ≤ RII ≤ 0.6	Medium	M
0.6 ≤ RII ≤ 0.8	High	H
0.8 ≤ RII ≤ 1	Very High	V-H

Source: Author based on [52]

8.3. RII Analysis for Physical Main Indicators

The five urban indicators are identified as the most influential indicators of the ability of urban settlements to face the pandemic crisis. The RII is obtained to summarize the importance of each indicator. The study clearly shows that indicator (E) residential cluster has the highest score, where its RII value = 0.802, followed by indicators (C), (B) with scores 0.752 and 0.742, respectively, followed by indicators (D), (A) with scores 0.665 and 0.660, respectively. (Table 5)

The Relative Importance Index scale was then applied to each major indicator sub-indicators, as illustrated in the next section.

Table 5. The ranking results (RII) Main Physical Indicators in Proposed EPC Tool

ID	Main Physical Indicators	RII (Mean)	Ranking by category	Importance level
A	The suitability of (urban transportation) in providing health requirements based on (bicycle paths) during epidemics.	0.660	5	H
B	Accessibility (Urban services): educational, health, commercial, administrative, religious, recreational, through the use of pedestrian and bicycle paths to achieve health dimensions	0.742	3	H
C	Providing health requirements in the design of (Urban Space)	0.752	2	H
D	Consideration of (pedestrian networks) within neighborhoods and residential areas to Health requirements	0.665	4	H
E	Providing health requirements in (residential cluster)	0.802	1	V-H

Source: Author

Table 6. The ranking results (RII) Sub Indicators for Urban Transportation

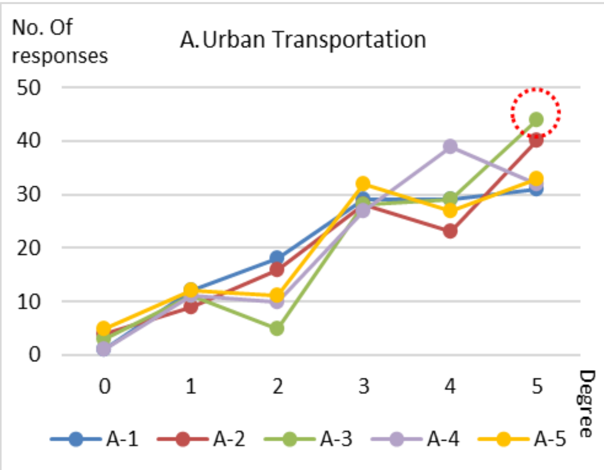
ID	Sub Indicators	RII (Mean)	Ranking by category	Importance level
A- The suitability of (Urban Transportation) in providing health requirements based on (bicycle paths) during epidemics.				
A-1	Responding to the needs of cycling in cities during the epidemic and beyond and giving priority to cyclists, where people can find a safer alternative to private cars and public transportation to get around	0.678	5	H
A-2	Separation of (motor and pedestrian tracks) with (bicycle paths) through an increase and provision of a bicycle track (one direction at a width of 1.5 m), (two directions at a width of 3 m)	0.702	3	H
A-3	Creating comfortable and safe environments to encourage cycling to provide a healthy lifestyle during epidemics	0.740	1	H
A-4	Use of bicycles to go (work, school, shopping) to a maximum of 5 km, to reduce congestion in public transport to prevent epidemics and to improve physical fitness	0.715	2	H
A-5	Providing (bicycle stations) every 500m	0.680	4	H

Source: Author

8.3.1. Urban transportation

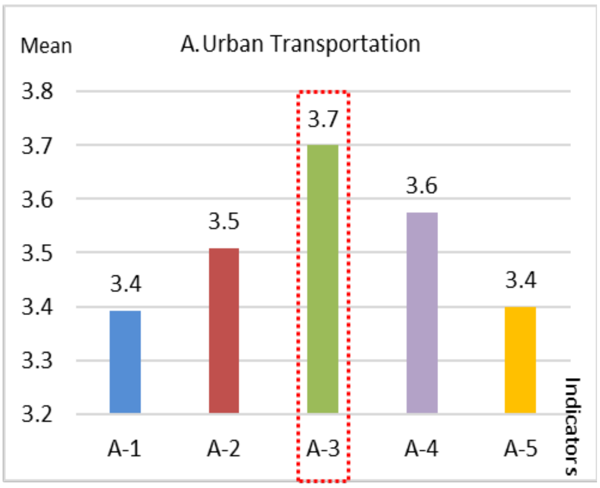
The relative importance index was applied to (Indicator A): (The suitability of (Urban Transportation) in providing health requirements based on (bicycle paths) during epidemics). The analysis shows that the most important urban variable was (A-3) with a score of 0.740 because the importance of these elements for users is explained by the variable connected to providing safety and comfort. It is followed by the indicators (A-4), (A-2) with scores 0.715 and 0.702 respectively" (Table 6).

Figure 13 shows the indicator (A-3) that received the most responses (up to 44 respondents), with a total rate of up to 37% of the total responses. Also, record the highest mean (with 3.7) as shown in figure 14.



Source: Author

Figure 13. The percent of expert evaluation from 0-5 in Urban Transportation

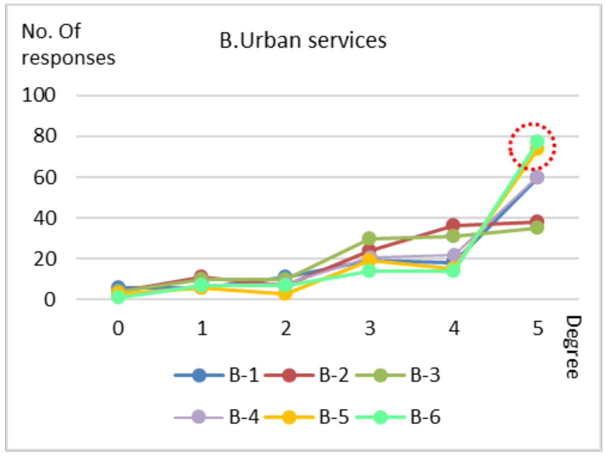


Source: Author

Figure 14. The mean Result of Indicators for Urban Transportation

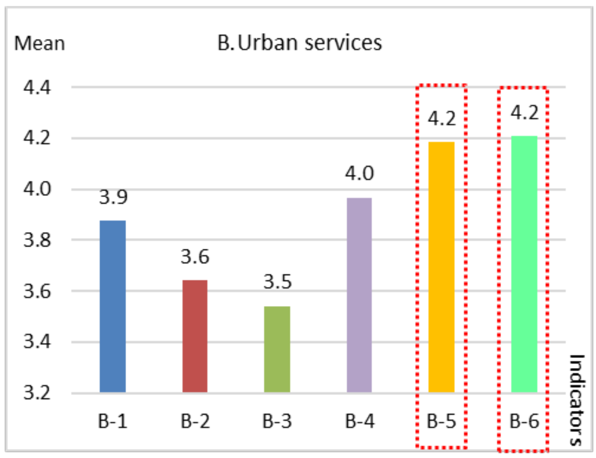
8.3.2. Urban Services

The relative importance index is applied (Indicator B): (Accessibility (Urban services): educational, health, commercial, administrative, religious, recreational, through the use of pedestrian and bicycle paths to achieve health dimensions), the most important urban variable was (B-6), (B-5) Very High with Score 0.842, 0.837 respectively, the main reason for this is the use of smart electronic services. Then, all the Indicators subscribed to the category High (B-4), (B-1), (B-2), (B-3) with scores 0.793, 0.775, 0.728, 0.708 respectively Table 7. Figure 15 shows the indicators (B-6) (B-5) that received the highest responses, with a rate of 64%, 61%. Also, record the highest mean (with 4.2) as shown in figure 16.



Source: Author

Figure 15. The percent of expert evaluation from 0-5 in Urban services



Source: Author

Figure 16. The mean Result of Indicators for Urban services

Table 7. The ranking results (RII) Sub Indicators for Urban services

ID	Sub Indicators	RII (Mean)	Ranking by category	Importance level
B- Accessibility (Urban Services): educational, health, commercial, administrative, religious, recreational, through the use of pedestrian and bicycle paths to achieve health dimensions				
B-1	Providing services within 5 minutes (walking distance of 400m), as it contains (public garden, children's garden, elderly care centers, children's nursery, markets, small stores), to reduce the use of public transportation during the epidemic	0.775	4	H
B-2	Providing services within 10 minutes (walking distance of 800m), as it contains (primary school, cultural centers "libraries", sports stadiums), to reduce the use of public transportation during the epidemic	0.728	5	H
B-3	Providing services within 15 minutes (walking distance of 1200m), as it contains (major stores, middle schools, health care centers at the district level), to reduce the use of public transportation	0.708	6	H
B-4	Availability of places for services designated for crises and emergencies (health centers and temporary housing) to provide the advantages of living in healthy cities	0.793	3	H
B-5	8- Providing job opportunities through electronic systems to reduce the spread of diseases	0.837	2	V-H
B-6	Availability of smart electronic services such as (education, health, government services, shopping) during epidemics	0.842	1	V-H

Source: Author

Table 8. The ranking results (RII) Sub Indicators for Urban Space

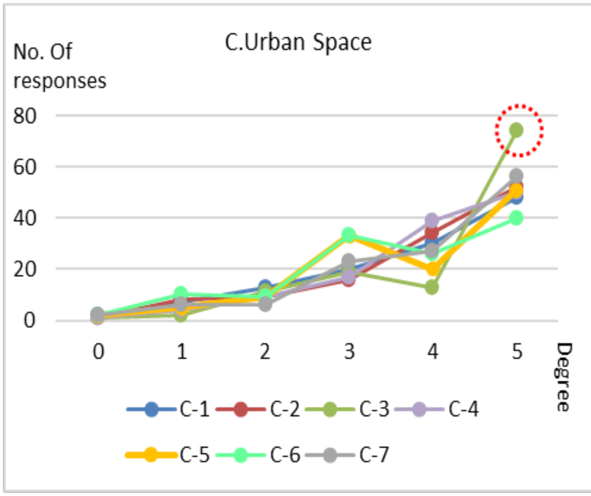
ID	Sub Indicators	RII (Mean)	Ranking by category	Importance level
C- Providing health requirements in the design of (Urban Space)				
C-1	The design of the space consists of a set of spaces that meet the needs of different age groups and take into account health requirements	0.758	6	H
C-2	Maintaining social distancing within the spaces (1.5 m) to reduce the spread of epidemics and maintain public health	0.785	4	H
C-3	Increasing open public spaces within residential areas to increase residents' interactions with green spaces to improve public health and reduce the spread of epidemics	0.840	1	V-H
C-4	Equitable distribution of spaces to reduce stress levels and maintain public health by accessing an open area with a distance of no more than (400 meters)	0.800	3	V-H
C-5	Providing health safety by providing sterilization and disinfection systems in Urban Space	0.765	5	H
C-6	Achieving the best use of artificial intelligence technology in designing various elements in urban space	0.728	7	H
C-7	Consideration of the use of plants with a positive impact on health	0.802	2	V-H

Source: Author

8.3.3. Urban Space

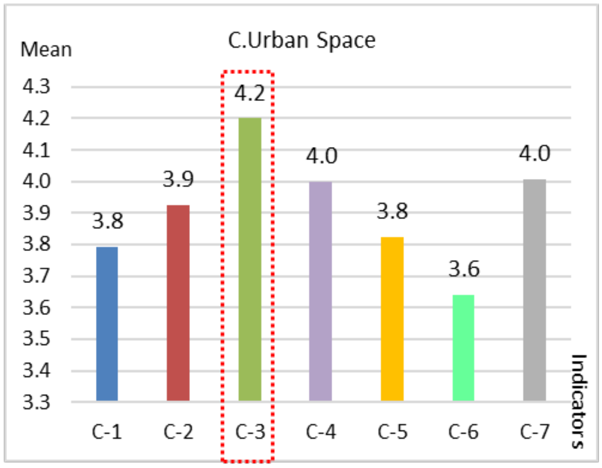
The result of analysis by RII for (Indicator C) shows that it is divided into two main categories. There are three Indicators in the same category; "Very High" (C-3), (C-7), (C-4) with scores 0.840, 0.802, 0.800 respectively. This is due to the importance of increasing open public spaces to improve public health and reduce stress levels and improve mood in Urban Spaces. These are followed by four Indicators that belong to the same category; "High" (C-2), (C-5), (C-1), (C-6) with Score 0.785, 0.765, 0.758, 0.728, respectively. (Table 8)

The indicator (C-3) that received the most responses (up to 74 respondents), With a total rate of 62% as shown in Figure 17, with the highest mean (4.2) as shown in figure 18.



Source: Author

Figure 17. The percent of expert evaluation from 0-5 in Urban Space



Source: Author

Figure 18. The mean Result of Indicators for Urban Space

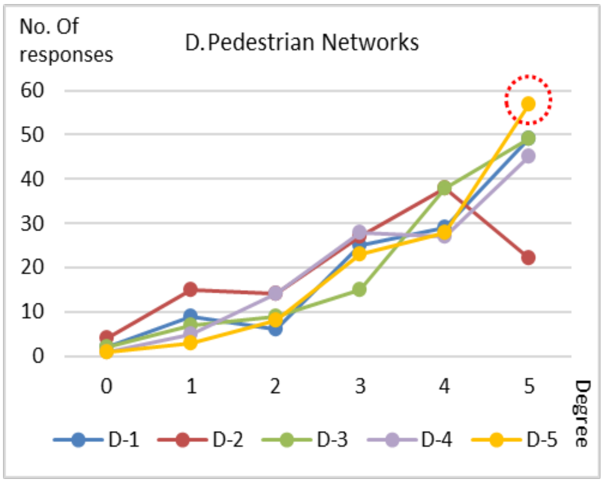
8.3.4. Pedestrian Networks

As stated in Table 9 (Indicator D): the highest ranking for pedestrian networks is sub-criteria (D-5) with a score of 0.810 "Very High". This is because it is critical to provide service elements for pedestrians. Also, received the most responses (up to 57 respondents), With a total rate of up to 47.5% of the total responses as shown in figure 19. The other sub- Indicators fell into the same category "High". Figure 20 shows the highest mean (with 4.1).

Table 9. The ranking results (RII) Sub Indicators for Pedestrian Networks

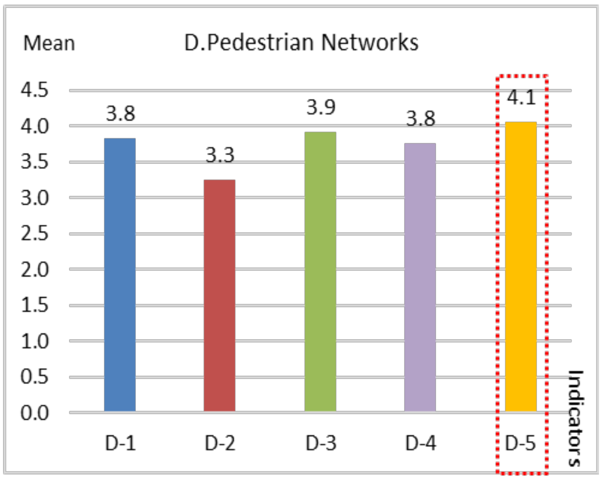
ID	Sub Indicators	RII (Mean)	Ranking by category	Importance level
D- Consideration of (Pedestrian Networks) within neighborhoods and residential areas to Health requirements				
D-1	Reducing walking distances to a maximum of 800 m to access various services: (clothing stores, educational facilities, gardens and open green spaces, restaurants, health units, sports services such as gym) to achieve the goals of healthy cities	0.765	3	H
D-2	Integrating pedestrian paths with bicycle paths to improve the physical and psychological health of the population during epidemics	0.650	5	H
D-3	Availability of pedestrian paths (at least 1.5 m wide) to encourage all people to exercise walking to achieve the health objectives of the pedestrian	0.782	2	H
D-4	Availability of sterilization, cleaning, hygiene and handwashing in pedestrians to reduce the spread and transmission of the epidemic	0.752	4	H
D-5	Availability of service elements for pedestrians: such as (road furniture elements such as seats and pergolas, fitness equipment, garbage bins, periodic maintenance of paths) to encourage walking to enhance the level of public health during the epidemic period	0.810	1	V-H

Source: Author



Source: Author

Figure 19. The percent of expert evaluation from 0-5 in Pedestrian Networks



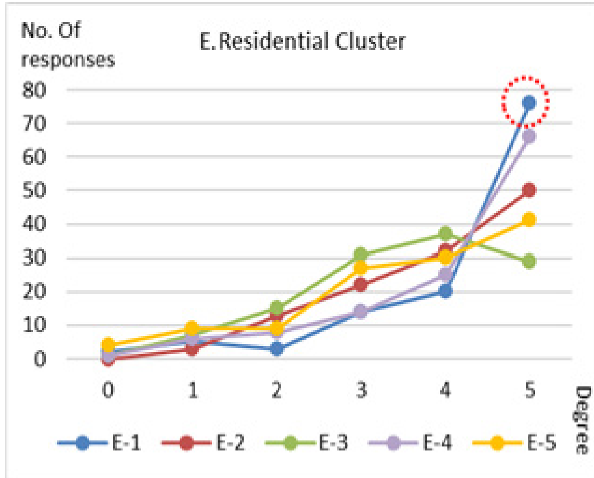
Source: Author

Figure 20. The mean Result of Indicators for Pedestrian Networks

8.3.5. Residential Cluster

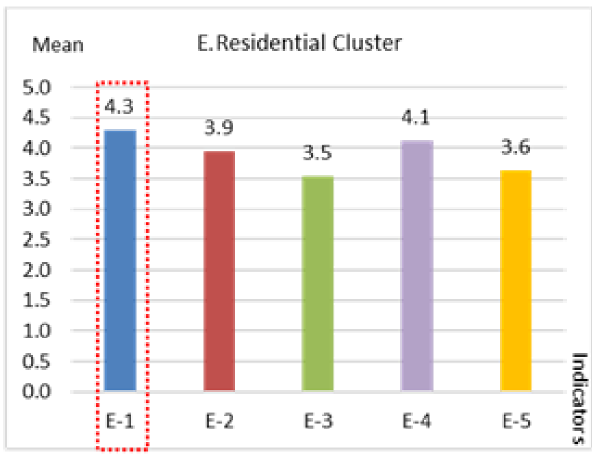
Due to assessing the Relative importance index analysis (Indicator E): the highest ranking for Residential Cluster is sub-criteria "Very High" (E-1), (E-4) with scores 0.858, 0.825 respectively, it returns to achieve safe distance between buildings and reduce overcrowding, followed by the other sub- Indicators fell into the same category "High" (Table 10).

Figure 21 shows the indicator (E-1) that received the most responses (up to 76 respondents), With 63%. Also, record the highest mean (with 4.3) followed by (E-4) (with 4.1) as shown in figure 22.



Source: Author

Figure 21. The percent of expert evaluation from 0-5 in Residential Cluster



Source: Author

Figure 22. The mean Result of Indicators for Residential Cluster

Table 10. The ranking results (RII) Sub Indicators for Residential Cluster

ID	Sub Indicators	Relative Index (Mean)	Ranking by category	Importance level
E- Providing health requirements in (Residential Cluster)				
E-1	Provide a safe distance between buildings and achieve ventilation and exposure to sunlight to reduce the spread of epidemics and maintain public health	0.858	1	V-H
E-2	The Diversity of uses within the residential area (mixed-use) for easy access to services during epidemics without the use of public transport	0.788	3	H
E-3	The extent of the ability of the urban pattern (linear, organic, compact, radial, irregular, and grid) is capable of shifting to non-traditional means of movement such as (pedestrian, cycle paths)	0.707	4	H
E-4	Population density and its reflection on the quality of the residential cluster environment to reduce overcrowding to prevent the spread of epidemics	0.825	2	V-H
E-5	Determining building heights (no more than 5 floors) to decrease congestion, improve the quality of life, and protect public health during the epidemic	0.728	5	H

Source: Author

8.4. The Final Effective Physical Urban Indicators for the EPC Tool

Based on the research findings and results a final Egyptian Pandemic Cities Tool (EPC Tool) was concluded, which can measure the ability of urban settlements to face pandemic crises as presented in Table 11.

Table 11. The Final Effective Physical Urban Indicators for the EPC Tool

ID	Physical Indicators	%
A	The suitability of (Urban Transportation) in providing health requirements based on (bicycle paths) during epidemics	18
B	Accessibility (Urban Services): educational, health, commercial, administrative, religious, recreational, through the use of pedestrian and bicycle paths to achieve health dimensions	21
C	Providing health requirements in the design of (Urban Space)	21
D	Consideration of (pedestrian Networks) within neighborhoods and residential areas to Health requirements	18
E	Providing health requirements in (Residential Cluster)	22
TOTAL (Main Physical Indicators)		**100**
A. The suitability of (urban transportation) in providing health requirements based on (bicycle paths) during epidemics		
A-1	Responding to the needs of cycling in cities during the epidemic and beyond and giving priority to cyclists, where people can find a safer alternative to private cars and public transportation to get around	19
A-2	Separation of (motor and pedestrian tracks) with (bicycle paths) through an increase and provision of a bicycle track (one direction at a width of 1.5 m), (two directions at a width of 3 m)	20
A-3	Creating comfortable and safe environments to encourage cycling to provide a healthy lifestyle during epidemics	21
A-4	Use of bicycles to go (work, school, shopping) to a maximum of 5 km, to reduce congestion in public transportation to prevent epidemics and to improve physical fitness	21
A-5	Providing (bicycle stations) every 500m	19
TOTAL (A)		(A)100

Table 11. Continued

B. Accessibility (Urban services): educational, health, commercial, administrative, religious, recreational, through the use of pedestrian and bicycle paths to achieve health dimensions		
B-1	Providing services within 5 minutes (walking distance of 400m), as it contains (public garden, children's garden, elderly care centers, children's nursery, markets, small stores), to reduce the use of public transportation during the epidemic	16
B-2	Providing services within 10 minutes (walking distance of 800m), as it contains (primary school, cultural centers "libraries", sports stadiums), to reduce the use of public transportation during the epidemic.	16
B-3	Providing services within 15 minutes (walking distance of 1200m), as it contains (major stores, middle schools, health care centers at the district level), to reduce the use of public transportation.	15
B-4	Availability of places for services designated for crises and emergencies (health centers and temporary housing) to provide the advantages of living in healthy cities	17
B-5	8- Providing job opportunities through electronic systems to reduce the spread of diseases	18
B-6	Availability of smart electronic services such as (education, health, government services, shopping) during epidemics	18
TOTAL (B)		(B)100
C. Providing health requirements in the design of (Urban Space)		
C-1	The design of the space consists of a set of spaces that meet the needs of different age groups and take into account health requirements	14
C-2	Maintaining social distancing within the spaces (1.5 m) to reduce the spread of epidemics and maintain public health	**14**
C-3	Increasing open public spaces within residential areas to increase residents' interactions with green spaces to improve public health and reduce the spread of epidemics	**15**
C-4	Equitable distribution of spaces to reduce stress levels and maintain public health by accessing an open area with a distance of no more than (400 meters)	**15**
C-5	Providing health safety by providing sterilization and disinfection systems in Urban Space	**14**
C-6	Achieving the best use of artificial intelligence technology in designing various elements in urban space	**13**
C-7	Consideration of the use of plants with a positive impact on health	**15**
TOTAL (C)		(C)**100**
D. Consideration of (pedestrian networks) within neighborhoods and residential areas to Health requirements		
D-1	Reducing walking distances to a maximum of 800 m to access various services: (clothing stores, educational facilities, gardens and open green spaces, restaurants, health units, sports services such as gym) to achieve the goals of healthy cities	**20**
D-2	Integrating pedestrian paths with bicycle paths to improve the physical and psychological public health during epidemics	**17**
D-3	Availability of pedestrian paths (at least 1.5 m wide) to encourage all to exercise walking to achieve the health objectives of the pedestrian	**21**
D-4	Availability of sterilization, cleansing, hygiene and hand washing in pedestrians to reduce the spread and transmission of the epidemic	**20**
D-5	Availability of service elements for pedestrians: such as (road furniture elements such as seats and pergolas, fitness equipment, garbage bins, periodic maintenance of paths) to encourage walking to enhance the level of public health during the epidemic period	**22**
TOTAL (D)		(D)**100**
E. Providing health requirements in (Residential Cluster)		
E-1	Provide a safe distance between buildings and achieve ventilation and exposure to sunlight to reduce the spread of epidemics and maintain public health	22
E-2	The Diversity of uses within the residential area (mixed use) for easy access to services during epidemics without the use of public transportation	20
E-3	The extent of the ability of the urban pattern (linear, organic, compact, radial, irregular, and grid) is capable of shifting to non-traditional means of movement such as (pedestrian, cycle paths)	18
E-4	Population density and its reflection on the quality of the residential cluster environment to reduce overcrowding to prevent the spread of epidemics	21
E-5	Determining building heights (no more than 5 floors) to decrease congestion, improve the quality of life, and protect public health during the epidemic	19
TOTAL(E)		(E)100

* The Total Value from A to E Should be 100%.
Source: Author

9. Conclusion & Recommendations

9.1. Conclusion

The research developed and innovated a practical tool that has the ability to measure the resilience of the Egyptian cities against health crises ECP Tool. The proposed tool could be applied as a proactive tool if considered during the planning and design process of cities. Also, the tool can be applied on existing Egyptian cities to define and report on elements that can increase the resilience of the cities to mitigate health crises, within the urban context.

The research manage to deduct an initial list of physical urban indicators that can be used to regulate the impact of health crises on the urban context of cities, through controlling the urban product of cities. The initial list was further refined based on analytical case studies concluding the most effective indicators. The EPC Tool can be applied on Egyptian cities urbanism, both new and existing to measure, monitor and guide their abilities to face the pandemic crisis.

9.2. Points for Further Research

The paper focused on the urban pillar of the proposed EPC framework. Consequently, further research is needed to identify and test the indicators of the other 4 pillars (social, economic, environmental, Governance), aiming to formulate a comprehensive measurable framework that could help planners and decision-makers develop cities and urban areas that are more resilient against pandemics crises. In addition, practical studies aim to apply and test the model, using geographic information system (GIS), on real urban settlements case studies are required and surely recommended as points for further research.

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