



A Review of Strategies for Resilience and Healthy Urban Living Environment under the Background of COVID-19 Pandemic

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Abstract: Since the COVID-19 pandemic strikes the global world, our cities are facing severe damage that affects all sectors of human life and their living environment, and it brings severe harm to humans physical and damaging impact on the urban economy and the operation of the urban system. With higher population density, dense space, and polluted urban areas as the main battlefield for pandemics and becoming the epidemic epicenter, a greater risk of virus transmission is more significant, especially person-to-person infection. A living environment is an essential place for people to devour and change nature and entails the physical attributes and the reconciliation of human exercise, which has essential roles in preventing and controlling pandemics. Thus, this study proposes pandemic resilience and a healthy urban living environment as the suitable future urban living environment concept. Reviewing available published literature related to resilient and healthy urban living environment studies during COVID-19 pandemic becomes the only method applied in this study. Starts by reviewing the concept of the healthy and resilient urban living environment, presenting the experience of Chinese cities facing the pandemic, and providing the urban living environment's potential strategies reflecting healthy and resilience comprehensively through evaluating recent ideas and trends. It aims to answer the research question to find the potential strategies to create pandemic resilience and a healthy urban living environment.

Keywords: COVID-19 pandemic; healthy; resilience; strategies; urban living environment

Introduction

Recently the COVID-19 pandemic phenomenon has become a heated topic. COVID-19 pandemic struck more than 200 countries worldwide, with over 33 million confirmed cases and 1 million deaths, as WHO reported on October 1st, 2020. Recent studies indicate

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that the pandemic affects urban and rural inhabitants' living and environment, regardless of endangering human health. A hugely damaging impact struck the economy, built environment, and society's way of life (Li et al., 2020). Cities, as the main battlefield for epidemic epicenters with a large population, high density, and mobility, make them vulnerable to respiratory infectious diseases. Higher population density, dense space, and polluted urban areas make it ideal for the virus to live and transmit infectious diseases such as Severe acute respiratory syndrome, influenza, tuberculosis, and other chronic diseases. Facing the COVID-19 pandemic, the risk of virus transmission is more significant, especially person-to-person infection. These human-populated areas also have living environment issues before and during the pandemic, especially in rapidly growing cities. China carried out several measures to reduce the transmission of COVID-19 and protect public health, such as the lockdown policy, social distancing, and other acts to limit people's mobility. During the pandemic, offices are empty, shops and business centers are closed or struggling to survive, the life of social events is put on hold, physical interaction between people is narrow, empty streets, and public spaces are closed.

Moreover, there is a cessation of public transit, and the city lockdown make people's mobility is limited, city construction terminated, the flow of goods, services, and people between urban and rural were influenced. The widespread impacts highlight the urban vulnerability and failure of self-sustaining against the sudden pandemic threat. During the pandemic, the urban living environment is affected by urban land use, buildings and surroundings, public places' functions, transportation modes and systems, and others (Ahsan, 2020). Suppose the physicians are responsible for discovering vaccines and treating the disease. In that case, we are urban planners and architects responsible for maintaining public health by creating living space that decreases the probability of infection, protects vulnerable urban inhabitants and provide a healthy and resilient living environment through planning and design.

During the COVID-19 outbreak, urban faced challenges since the current urban living environment cannot deal with a contagious disease. The pandemic requires an urban system to prevent, control, provide isolation sources and cut off the transmission of the disease to protect urban inhabitants and keep generally running during and after the pandemic. The living environment is the principal place for people to devour and change nature and become the significant factor of sustainable socio-economic development (Wang et al., 2017). Along with the rise of the COVID-19 pandemic, the living environment is expected to adapt and transform to anticipate the spread of the virus by averting and adapting to the recent crisis and preparing for the upcoming pandemics.

Previously, researchers and professionals have discussed how the cities impact the pandemic and deliver potential measures in planning and designing the urban settlement. As far as scientific studies on finding measures to anticipate COVID-19 in the urban planning and design context are concerned, they are primarily relevant to making a resilient and healthy city responding to the pandemic threat. Debate continues about the best strategies to update our urban living environment post-pandemic and prepare for the future pandemic. This paper aims to review the concept of a healthy and resilient urban living environment, the experience of Chinese cities facing the pandemic, and provide the urban living environment's potential strategies reflecting healthy and resilience comprehensively. This study will review available published literature related to resilient and healthy urban living environment studies during the COVID-19 pandemic. The value of this review paper is to find broader potential strategies to create an urban resilient and healthy urban living environment, compile and filter the primary research in a particular area of study by evaluating recent ideas and trends.

Research Method

The research question posed by this research study is "What are the potential strategies to create pandemic resilience and healthy urban living environment?" Our paper encourages searching for suitable strategies by reviewing published literature on resilient and healthy urban living environment studies under the COVID-19 pandemic. To fight the COVID-19 pandemic, many researchers conduct studies in the architecture, environmental, and urban planning sectors by finding future urban design and development. Some of them are limited to the general concept and provide no visualization. Thus, to address this gap, this study aims to find broader potential strategies to create an urban resilient and healthy urban living environment by compiling and filtering the primary research in a particular area of study through evaluating recent ideas and trends. The strategies may be chosen based on reflecting urban resilience and improving urban health and well-being under COVID-19 circumstances. They should reflect the pre, during, and post-pandemic qualities such as sufficient preparation for prevention and facing the pandemic, addressing the problem and quickly returning to the normal state during a pandemic, and adaptation and transformation capability post-pandemic. The primary purpose is to avoid spreading and further contamination, solve a medical emergency and normalize the urban function by improving the spatial configuration, providing more blue and green space, and improving the transportation system; the review framework can be found in Figure 1. Subsequently, this study is also equipped by the discussion of why we need to improve the Urban Living Environment, the theory review of healthy and resilient cities to provide a better understanding of the concept, and The Chinese cities experience and living environment issues facing the pandemic.

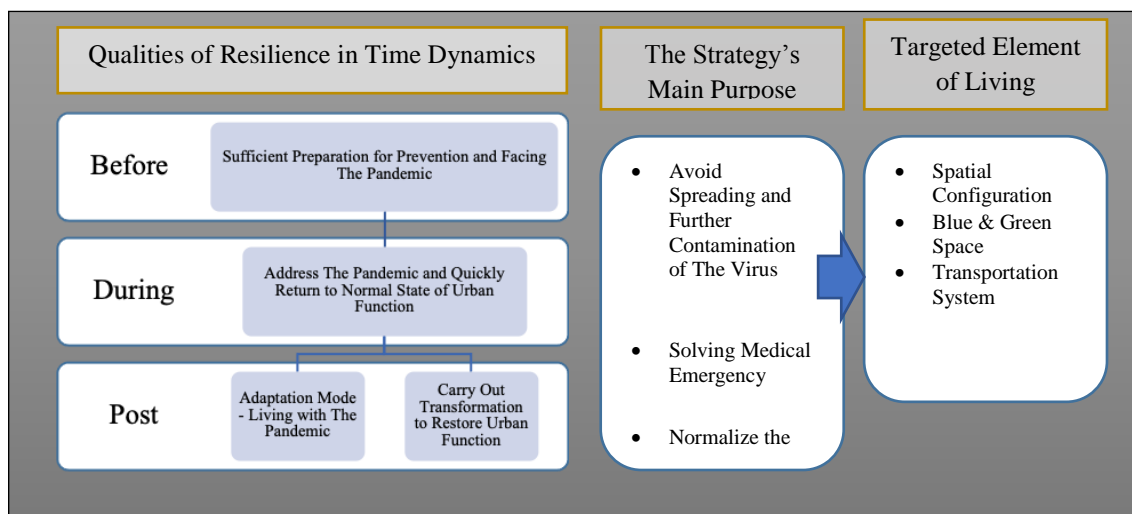


Figure 1. The Prospects Strategies for Resilience and Healthy Urban Living Environment Review Framework

Rethinking Urban Living Environment and the Concept of Resilient and Healthy City

The Needs to Improve Urban Living Environment

The living environment is the principal place for people to devour and change nature and become a significant factor in sustainable socio-economic development (Wang et al., 2017). Living environment entails not only the physical attributes of any housing, urban, and rural but also the reconciliation of human exercises, including living arrangement,

work, education, well-being, culture, and leisure, thus in the process of urban vertical pushing to create an environment (Li et al., 2020). The urban living environment research primarily focuses on exploring human-made living spaces, providing a livable place to people and facilities in consort with the surrounding environment. Along with the urbanization and modernization process, the living environment becomes a primary concern, especially in the urban planning area, to ensure a sustainable and resilient living environment under rapid urban development and natural threats. The living environment contains the built environment and the ecological environment. The built environment consists of residential and supporting facilities building, spaces between buildings such as parks and plazas, and the infrastructure that assist human activities such as transportation system and utilities. The ecological environment includes blue and green networks such as green spaces and water bodies.

Pandemics affect the urban living environment because of the risk of spreading and infection of the disease. The living environment also transforms how the urban inhabitants live, behave, value during, after, and prepare for the upcoming pandemics. Taking China experience during the pandemics, with inadequate medical facilities supply in number, resources, and distribution became the main problem. To avoid virus transmission because of people density, the Chinese government implemented the lockdown policy; most urban inhabitants are isolated, mobility is limited, while urban residential has an inadequate quality of building and neighbourhood environment endured. Building density, less quality, and public and green space also become a challenge for human health and well-being. We acknowledge how the quality of the urban space environment impacts public health. If the living environment lacks quality, it will accelerate the spread of the virus and endanger human health and well-being. Instead, the connection between nature and the urban built environment is essential for urban metabolism and buffer urban threats. Therefore, improving security layers and the living environment's quality is a daunting task for urban planners and architects. Together with the urban planner, architect, economist, and socialist, the government should continue to formulate and implement the best strategies for creating a better living environment even after the "New Normal" of the pandemic.

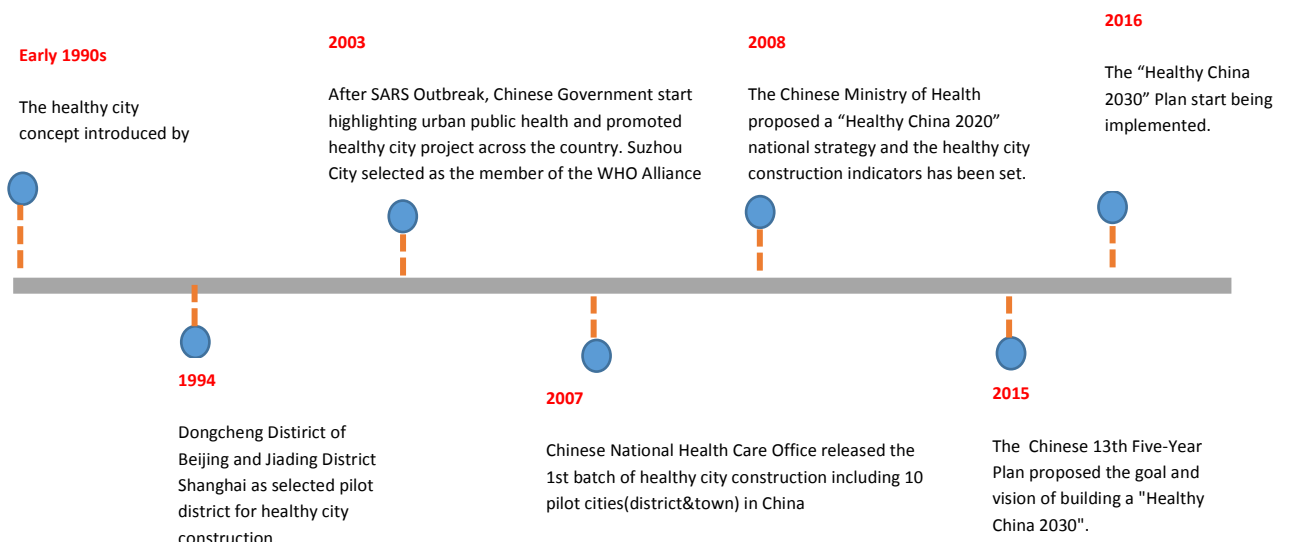
Resilient Cities Concept

The term resilience was first introduced by Holling (1973) as the system's efficiency, stability, and predictability focusing on bounce-back to equilibrium, recovery rate, and intrusion tolerance. Meanwhile, the Rockefeller foundation defined resilience as a capacity of urban to bounce back to the normal function after facing various shocks and stresses (Index, 2014). In urban space and residential as general, resilience, also known as adaptability, refers to adapting and growing when facing long-term stress and disaster. In the case of public health emergencies, a sound and resilient urban built environment system may use its adaptive mechanism to decrease the harm done to the city and its citizens by planning and integrating multi-level aspects such as society, environment, and space. Design plays a significant role in increasing city people' quality of life and health. Meanwhile, under COVID-19 outbreaks, scholars are primarily concerned with the interaction between land use and urban settlement spatial layout, road traffic and slow-moving systems, green landscapes and recreational spaces, sports facilities and health facilities, as well as the establishment of healthy settlements as measures to improve the urban resilience (ARUP, 2020; Liu & Liu, 2020; Mouratidis, 2021; Shelter COVID-19 Support Team, 2020; C. Wang, 2020).

Healthy Cities Concept

The WHO initiated the concept of healthy cities to respond to world health issues that emerge from urbanization. A healthy city aims to provide an equitable and inclusive

healthy society by creating a healthy built environment that protects from harmful environmental exposure, connect people to the resources for a healthy life, focus on equity in accessing health service, provide support for healthy behaviour when doing activity outdoors, applying cross-sector collaboration to address chronic disease. A healthy city is persistently making and improving those physical and social conditions, and growing those network assets that empower individuals to uphold each other commonly is playing out all the elements of life and creating to their most significant potential. Duhl & Hancock (1988) also described 11 features of a Healthy City such as clean and secure high quality built environment; long-last sustainable ecosystem; stable, jointly community, and equal community; public-oriented to decide lives, health, and well-being; sufficient basic needs for all city's inhabitant; admittance to a wide assortment of encounters and assets, with the chance of various contacts, interactions, and connection; a various, vigour, and advance city economy; connection with previous cultural and biological heritage, and with other groups or person; a suitable urban form that supports above criterion and actions; equitable access of public health and health services for all; and finally, having high health status and standard disease status.



Source: Li et al. (2018)

Figure 2. The concept introduction and development of Healthy Cities in China

"Urban diseases" such as excessive population density, environmental pollution, increased traffic and accidents, increased chronic and mental disorders, and faster spread of infectious diseases caused by rapid urbanization have progressively become significant hazards to human health. Realizing the importance of social health and well-being, the concept of a healthy city had been introduced to China since the early 1990s. Several piloting cities projects were constructed after that until 2015, the Chinese Government took it seriously and released the "Healthy China 2030" plan that started to implemented in the year 2016. The Central Committee of the Communist Party of China and the State Council's "Healthy China 2030" Planning Outline see the building of healthy cities as an essential starting point for promoting the construction of a healthy China. The building of healthy towns is an essential carrier of the patriotic health movement in the new era, as it promotes a new form of municipality oriented on people. Globalization is a vital aspect of furthering the creation of a healthy China and establishing a prosperous society in general.

The concept introduction and development of healthy city construction in China can be seen in Figure 2. Furthermore, the healthy cities dimension and indicators used in China nationally and locally can be seen in Table 1.

Designing and planning healthy cities of tomorrow might ensure that urban and its living environment remain safe and livable, having quality of prevention and control, isolating and cutting off the transmission; and adapting and protecting the vulnerable urban inhabitants. Some measures can be implemented to make the outdoors not a horror zone as a virus-transmission epicentre but as a habitable space to connect people and nature, support human activity, and maximize their potential. The suitable urban built environment for healthy cities to cope with pandemics can focus on three aspects.

Table 1. China's Healthy City National and Local Dimension and Indicators

Dimension	Healthy City Indicator	Dimension	Healthy City Indicator
Healthy environment	Proportion of days with good ambient air quality	Health service	Maternal system management rate
	Harmless treatment rate of household garbage		Proportion of primary-level medical and health institutions providing TCM services
	park and green area per capita		Child health management rate
	Centralized drinking water sources meet the safety standards		Number of general practitioners per ten thousand population
	Domestic drinking water quality standards		Number of public health personnel per ten thousand population
	Prevalence rate of sanitary-free sanitary toilets (rural areas)	Healthy people	Average life expectancy
	Animals led disease and virus transmission control level		Maternal mortality rate
	National health county (township) proportion		Infant mortality rate
	Days with heavy pollution or above		Under-5 mortality rate
	Density of Public Toilets (built-up area)		Urban and rural residents meet the National Physical standards
Healthy society	Beds for every thousand elderly people	Proportion of people above qualified	
	sports area in the city per capita	Incidence of category A and B infectious diseases	
	Coverage of occupational health examination	Premature mortality from major chronic diseases	
	Healthy community coverage	Prevalence of hypertension in 18-50 year olds	
	Healthy school coverage	The range of age-normalized incidence of tumors	
	Ratio of social sports instructors per thousand people	Healthy culture	Proportion of the population who regularly take part in physical exercise
	Actual reimbursement ratio of hospitalization expenses under basic medical insurance		Residents' health literacy level
	Excellent and good rate of students' physique monitoring		Smoking rate among people aged 15 and over
	Coverage of healthy enterprises		Media Health Promotion Level
	Food sampling inspection 3 batches per thousand people		Registered volunteers ratio
Health service	Number of beds in health institutions per thousand population		
	Standardized management rate of patients with severe mental disorders		
	Proportion of health expenditure in fiscal expenditure		

Source: Shen et al., 2019

Chinese Cities Experience and Living Environment Issues Facing the Pandemic

COVID-19's geographically spread is impacted by various spatial factors, including population density, vehicle traffic, and the spatial distribution of various public areas, and follows a particular spread pattern. Researchers were done the investigation and showed that the spatial distribution of urban nodes such as hospitals, transit hubs, and other public indoor spaces might directly impact the transmission of acute respiratory diseases (Ren et al., 2003). Urban development influenced the geographical distribution of these public spaces. In order to reach their maximum resource usage, they tend to converge in densely populated regions, in which simultaneously the urban flows (such as people and logistics flow, etc.) cause the urban space to transform from static to dynamic, which increases the chance of pandemic spreading.

Besides, based on the analysis of the evolution characteristics of time and space scales by Wang et al. (2020), the spatial spreading mode of the COVID-19 pandemic in China is primarily characterized in four forms: neighbouring spread, migratory spread, hierarchical spread, and corridor spread as illustrated in Figure 3. The neighbouring spread happened following the rules of proximity which are cities closer to Wuhan are more likely to have pandemic first and more severe; the migratory spread happened due to the cross-regional population mobility, especially with the advancement of transportation technology to ease the mobility to reach distant areas in a short period; hierarchical spread mode is the pandemic development follows a similar geographical diffusion pattern, according to a national scale investigation, the pandemic spreads primarily through regional core cities and provincial capital cities; corridor spread is happened due to traffic corridors which often connect places with a high density of social and economic activity as well as regular population flows.

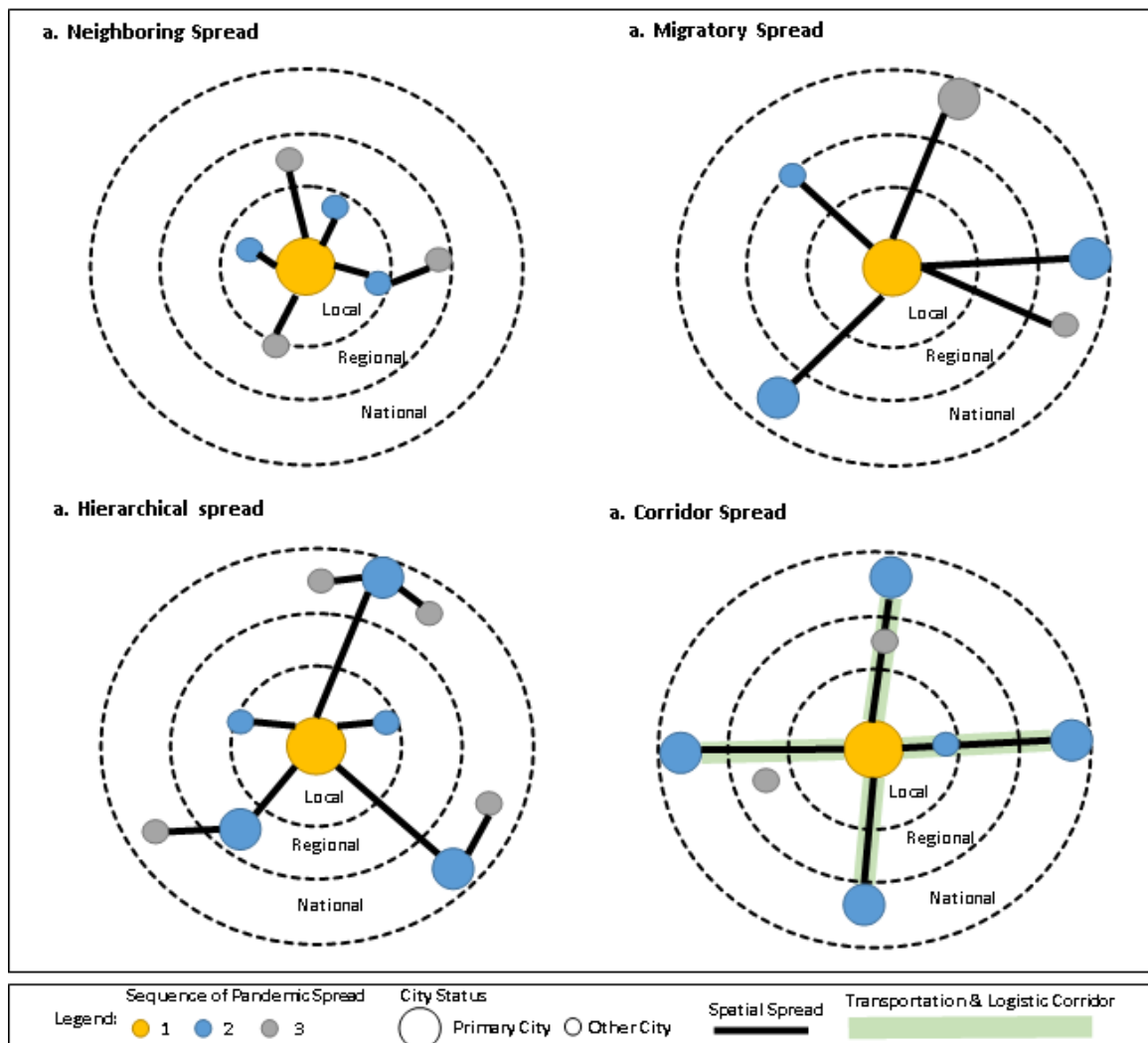
Furthermore, Li et al. (2021) researched the spatial risk factors of urban form using floor area ratio and road density as indicators. Urban facilities include hospital density, commercial density and subway station density, and urban function utilize the mixing degree of land use for investigating the impact of potential urban risk factors on the COVID-19 situation in Wuhan. The studies found the public unawareness of the virus during the early stages of the pandemic, causing cross-infection in the medical environment. Thus surrounding areas of large hospitals become the potential high-risk area of pandemic spreads; the developed subway-railway network and commercial facilities also contributed to the pandemic to spread to the inner and outer city; and the high-density areas, particularly high-rise residential areas, are more vulnerable to the epidemic's devastating impact. Chinese cities nowadays intensively develop a vertical city, in order to achieve land intensification, the mixed-used area of residential, commercial, and office are commonly found. The typical Chinese city residential floor area ratio is about 0.8 to 4.5, and the high-rise residential area building is spread across the city. Each building unit is connected to dozens or even hundreds of residents, highly dependent on elevators for travel. Wuhan's floor area ratio itself exceeded 2.0; as a consequence, it is hard to control the spread of the pandemic. Thus, the floor area ratio should be maintained at a reasonable level in the future to effectively avoid and control the pandemic's spread (Li et al., 2021).

With the fast growth of high-speed transportation such as high-speed railways and subway, the temporal and spatial convergence effect caused by them would minimize geographical space limits to some extent and promote connectivity and interconnection between cities. Previous research prevails that urban rail transit like the subway may become the fast channel for the pandemic to spread (Figure 4). The communities located nearby while enjoying the convenience of travel may also face a greater risk of pandemic exposure. Thus, the additional buffer spaces such as gardens, parks, green belts, and greenways. Promoting green travel can lower and distribute some subway users and

staggered peak transit periods, and this method may aid in the prevention of virus transmission.

Meanwhile, Tan (2020) explained some issues found concerning urban spatial during the outbreak: (1) the provision of medical facilities, even though the number of beds of medical facilities rapidly growing after 2005, the proportion of medical and health care spending in the GDP, number of doctors, nurses, and beds that indicate social-medical level still lack behind the developed countries; (2) the original master plan of urban disaster prevention and reduction plans did not include the mechanism and contents related to responding to public health emergencies; (3) the distribution of the high-level service of medical facilities is mainly concentrated in the city centre. Thus, the pandemic spreads more quickly in the city centre than in the urban fringe and rural areas.

Besides those issues mentioned before, the government's quick response to construct temporary wards like Huo Shen Shan and Lei Shen Shan temporary hospital in the unoccupied urban space in Wuhan during the emergency period to deal with medical issues is a good example.



Source: Wang et al., 2020

Figure 3. China's Spatial Spreading Mode of COVID-19



Source: Ah, S., 2021

Figure 4. Wuhan City Density Appearance & Chinese High-Speed Rail

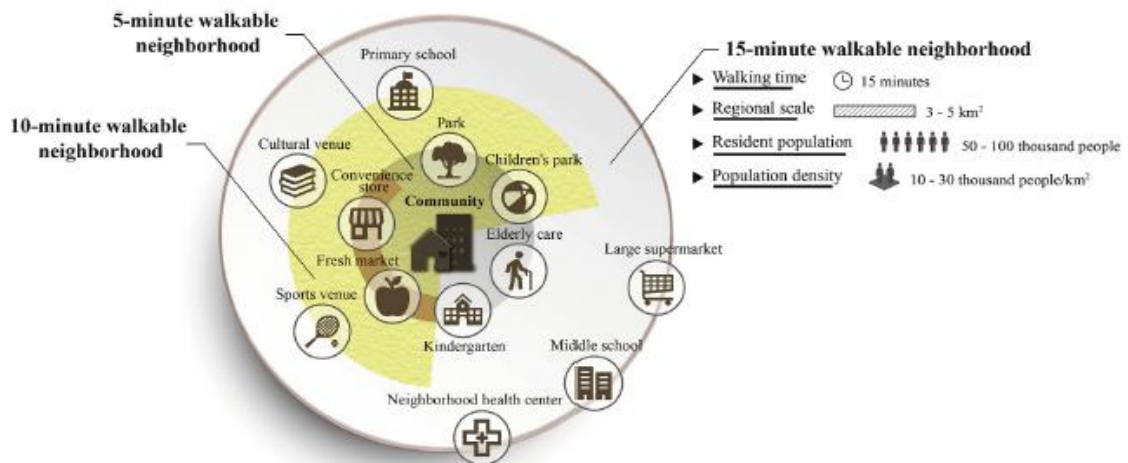
The Prospect Strategies for Creating Healthy and Resilience Urban Living Environment

Urban Spatial Configuration

15 Minutes City Concept

The city needs to transform to be more resilient and healthier in facing the pandemic and climate change challenge. Shelter Foundation released the book *Healthy Pandemic Resilient Cities Strategies for COVID-19 Pandemic*; one of their strategies is adopting "The 15 Minutes City", thus concept transforms car-centric suburban-style zoning into walkable with more excellent proximity, this may allow urban to implement lockdown policy during pandemic without interfering with self-sufficiency and proximity to health care (Shelter COVID-19 Support Team, 2020). The 15 minutes city is the strategy to reorganized urban space to improve living conditions and the environment. First initiated by Professor Carlos Moreno in Paris, this city concept aims to create urban life within proximity by walking or biking. It represents the vibrant and efficient urban spatial function, increasing the possibility of limiting mobility since their community facilities, park, education, social housing, workplaces, and commercial area are closer to their home. Chinese cities also have related standards for urban residential planning and design which started being implemented in December 2018. The standard book listed what kind of residential service and facilities should exist within the proximity of 15 minutes, 10 minutes, and 5 minutes walking, namely 15-minutes walkable neighbourhoods (Figure 5). It promotes healthy living with fewer cars, more cycling and walking, and provides safe and accessible urban facilities for all community groups. During the pandemic, our mobility is limited; the government encourages us to do less activity outside and reduces our commuting time for pandemic prevention and control and cutting off the transmission route. However, since many cities have just started the following program, most are not ready to face the pandemic. Thus, this city concept should be vastly promoted and adopted to create more resilience and a healthy urban living environment. Meanwhile for some cities who adopted this concept there are some lack and needs to improve. Weng et al. (2019) for example, they studied the 15 minutes life circle built in Chengxian Street Community in Nanjing, China, performing pre, during, and post-pandemic. Through the questionnaire survey and the GIS analysis the increasing demand is detected for public service facilities of community residents during

and after the pandemic, such as in 10-15 minutes life circle, the indoor and outdoor sports centre facilities and the cultural centre facilities and in 5 minutes life circle, the express delivery collection point and the medical and elderly care facilities. Moreover, the study proposed the flexibility of the facility functions and demanded the construction of two vitality centres to fulfil such demand and the needs to change the function if the pandemic strikes again. Figure 6 shows the community vitality center 1 will be mainly used for isolation and material distribution: the community center square is temporarily used as a distribution center for epidemic prevention materials; the community health service center is temporarily used as a community fever clinic, and the original activity square is used as a community quarantine checkpoint. the community vitality center 2 will focus on material storage to ensure that the community has sufficient self-sufficiency during the epidemic. Thus, this study showed a community life circle that switches in time, responds quickly, and builds a high-quality space that considers both pandemic emergencies and prevention to achieve a healthy, resilient community.



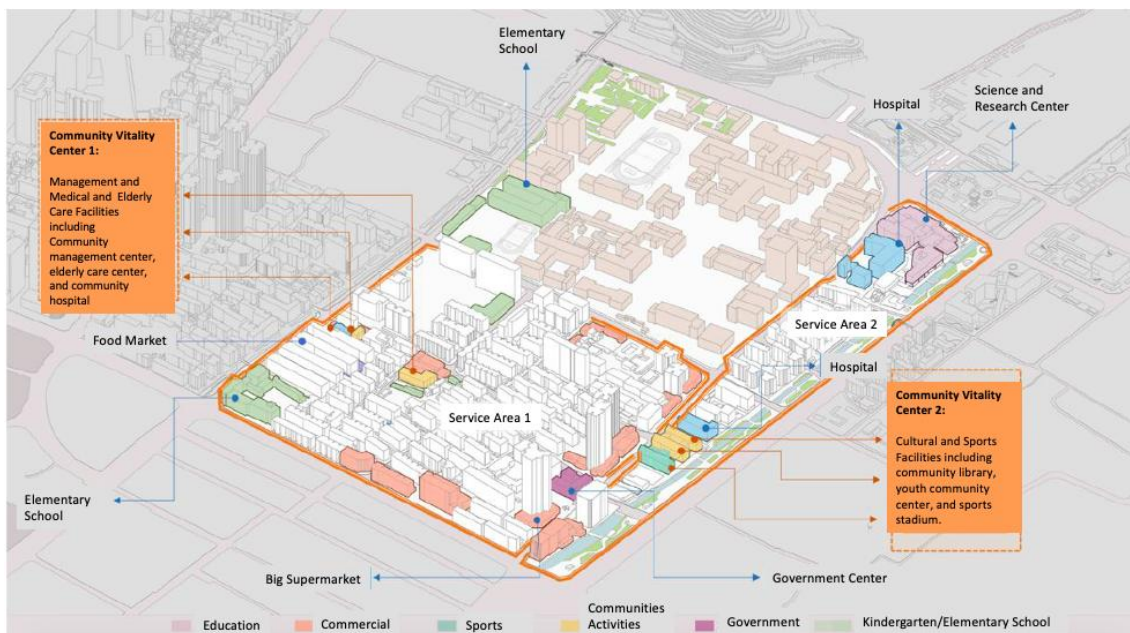
Source: Weng et al., 2019

Figure 5. Diagram of Chinese 15-min Walkable Neighbourhoods

Multiple Center Urban Structure

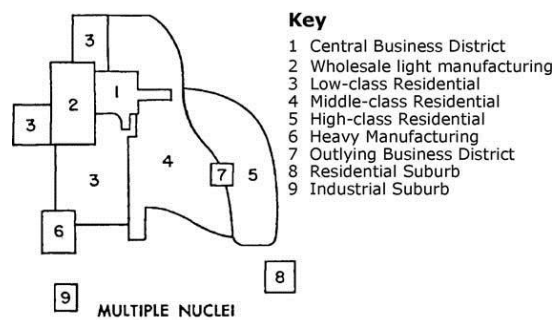
The spread of pandemics is related to the urban density; the disease transmission may vary depending on the city size and densities. The concentration of urban population and resources may bring significant advantages for scaling up the urban economy; however, to face the pandemic, it increases the disease spreading intensity. As a result of urban spatial structure, the population distribution gathers in one city centre. Moreover, during the pandemic, public transportation is suspended and brought difficulties for medical workers to commute, and it also reflects the unreasonable urban functional zoning, which hinders the urban operation. Post pandemic, we need to consider adopting more resilient urban spatial structures such as "Multiple Nuclei Spatial Structure" that allows cities to grow from several independent points rather than depending on one CBD (Figure 7). The decentralization approach in multiple nuclei spatial structures may result in horizontal urban expansion, requiring strict adequate city planning and development. This kind of structure allows the decentralization of urban function and splits the population;

thus, the pandemic transmission can be controlled under reasonable spatial allocation of health care in particular and other urban functional elements (Liu & Liu, 2020).



Source: Weng et al., 2019

Figure 6. Renovation Strategy of Post-Epidemic Healthy Living Circle in Chengxian Street Community



Source: Harris & Ullman, 1945

Figure 7. Multiple Nuclei Spatial Structure

Increasing Urban Space Natural Light and Ventilation

The first severe acute respiratory syndrome (SARS) pandemic began in China in 2003, and the COVID-19 pandemic will hit cities again towards the end of 2019. Many questions are raised about the urban built environment roles in spreading and controlling the spread of the disease. The compact and dense urban form may create unsustainable and unhealthy living environments, always related to air and ecological pollution and high urban air temperature. The role of urban natural light and ventilation is to alleviate the risk

of disease transmission. A living environment with sufficient natural light and good air circulation quality may result in healthier cities. In a dense city, the breezeway along the primary prevailing wind direction is a significant factor to improve air circulation in an urban area. Specific research has been conducted on designing and enhancing the air circulation in the city, and the measures such as street orientation and pattern, continuous open space, building height and disposition become the guideline for future urban development or urban renewal, as illustrated in Figure 8 (Lau et al., 2018). Meanwhile, in China, these management and control strategies for urban ventilation corridors are popular:

1. The direction of ventilation corridors

The direction of corridors at all levels should match the local light, and mild wind and the angle between the prevailing wind direction should be between 30° and 60° due to the regional variety of urban wind conditions (Liang et al., 2014).

2. Control over the air inlet

Based on maintaining the status quo without destroying natural water bodies, mountains, and forests, combined with topography, main highways, green corridors, etc., air inlets are designed in a balanced manner through numerical simulation assessment, and the degree of contact between the construction area and open space is raised.

3. The width and length of the air duct

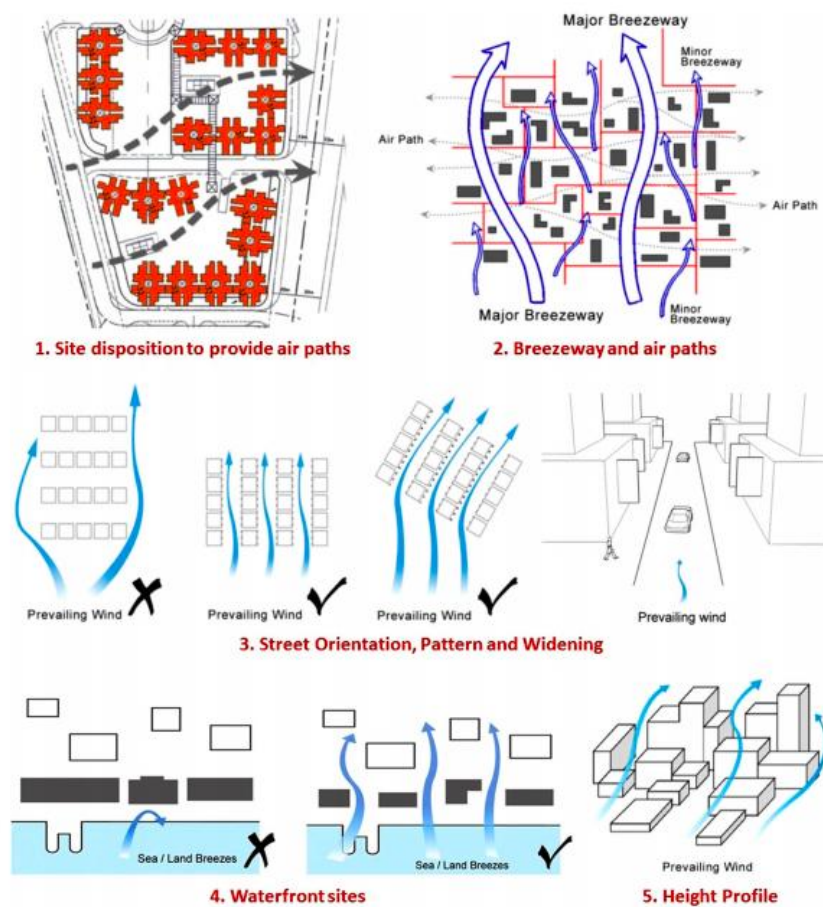
The air duct control conditions at different levels are different. The primary urban ventilation corridor measures more than 150 meters in width and more than 2000 meters in length, while the secondary ventilation corridor measures more than 80 meters in width and more than 500 meters in length.

4. The configuration in the air duct.

Generally, the type of land utilized inside the corridor should be a green space, water body, or open space, with a minimum of 30% of the area being covered by greenery. High-density construction and development are forbidden, the construction size should be rigorously regulated, and the buildings should be perpendicular to the corridor whether it has already been created or are being built. Building surface width should not exceed 60% of site width, the breadth in the direction should be less than 10% of the corridor's width, and the ratio of building height to building spacing should not be more significant than 3:1 (Yin & Zhan, 2019).

5. The adjacent interface of the air duct.

Building height-width ratios on either side of the main ventilation corridor must be kept within 0.5, and opening degrees cannot be less than 40% (Chen, 2019). Building height-width ratios on either side of the secondary ventilation corridor must be kept within 1.0, and opening degrees cannot be less than 30%. Buildings should be positioned in height increments, diagonal increments, or following the direction of the oncoming wind. Forming a closed, contained area is inappropriate; instead, staggered, oblique, and free patterns should be used.



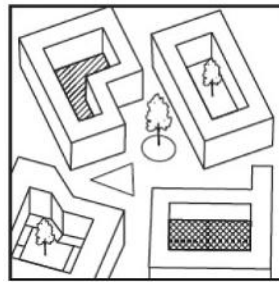
Source: Lau et al., 2018

Figure 8. Qualitative guidelines in Hong Kong Planning Standard and Guidelines for Safeguarding Urban Air Ventilation and Microclimate

Provide Diversity of Outdoor Spaces

The outdoor space is essential in providing the recreational space, balancing ecological and built elements, enabling mobility, and increasing social relations. It is usually accessible, open for the public, and accommodates outdoor life that urban inhabitants can enjoy anytime. Streets, squares, and parks offer a different experience than the private space one—people spending the time outdoors to get fresh air and maintain physical and mental health. However, during the pandemic, many outdoor public spaces are closed to cut off the disease transmission resulting in even greater demand for the plan and design of the future urban outdoor public space. In his book "The Soft City", David Sim (2019) promotes that the existence of the outdoor public and private space should complement each other by proximity, so the people have broader choices and prevent densely populated space. Urban primarily promotes leisure well-being by making amenities, green areas, and open public places available (Carmona, 2019; Mouratidis, 2019). Although many facilities were shuttered during the COVID-19 in numerous places throughout the world, some remained open in some situations. Due to the risks of transmission when commuting, especially by public transportation, the existence of and closeness to local facilities that

could be used for leisure activities was significant for leisure well-being during COVID-19. Subsequently, the need to provide space for performing leisure activities with a lower risk of infection becomes a significant challenge. Pinheiro & Luís (2020) reassured the future public outdoor space during and post-pandemic with more natural ventilation, and sufficient sun exposure may slow the rate of contagion. Thus, the semi-public and semi-private outdoor public space may be a good practice. The concept of semi-public and semi-private outdoor public spaces such as colonnades, arcades, decks, verandas, terraces, and roof gardens reconnect the outdoor public and private space. These spaces can be used for specific activities such as sports, games, and performances. To create a more resilient and healthy urban space, the future urban space should reconsider accommodating different kinds of outdoor spaces located nearly each other to fulfil the demand of people outdoor life (Figure 9). For example, Miyashita Park in Tokyo is a semi-public space built as a complex facility that comprises a park on top of a public parking lot alongside a busy rail line (Figure 10). It becomes the iconic urban canopy that integrates the park with retail facilities. The rooftop park is accessible the natural circulation routes with two pedestrian bridge connections have been well integrated into the city's urban infrastructure. This kind of semi-public space becomes a new icon of the cityscape, fulfilling the demand of emerging trends towards accessible and inclusive open public spaces during and post-pandemic, which Mouratidis (2021) mentioned.



Source: Sim, (2019)

Figure 9. Diversity of Outdoor Space



Source: Archdaily, 2021


Figure 10. Semi Public Space: Miyashita Park, Shibuya Japan

Increasing Blue and Green Space Construction


Under the pandemic threats, urban spaces should be transformed and adopted with more green and blue spaces to promote a healthy and resilient living environment. It is crucial to ensure the connection between ecological space and urban built space by constructing and maintaining urban blue and green space. The blue and green spaces improve biodiversity, water storage and draining, improve air quality, and mitigate urban greenhouse effect caused by climate change. They support communities with greater physical and mental resilience by providing natural space for their outdoor activities.

The blue space refers to a water body such as an ocean, river, lake, pond, artificial pool. Meanwhile, green space refers to natural edge buffers, urban green belts, urban gardens, wetlands, parks, and other green spaces. They are created natural corridors in urban environments to create a cool urban micro-climate, ensure food securities, and provide sustainable drainage and waterways infrastructure to reduce natural hazards. Nowadays, several design concepts for developing urban green and blue space are introduced, such as urban forest, agriculture, sponge city, water sensitive urban design, biophilic city (Table 2). offering various feasible solutions to address urban green space and water challenges. By formulating the plan and construction of urban green and blue space to lighten spatial burdens experienced during and post the pandemic, the utilization of urban green and blue space may vary from accommodating vigorous outdoor activities, community-driven health, and achieving ecological results (Shelter COVID-19 Support Team, 2020).


Table 2. The Concept, Definition, and Best Practices of Blue and Green Spaces Construction

Concept	Definition	Best Practices
Urban Forest	Forests, street trees, trees in parks and gardens, and trees in abandoned corners are all part of networks or systems that comprise all woodlands, groups of trees, and individual trees situated in urban and peri-urban regions (Salbitano et al., 2016)	<p>Ootemachi Tower Forest, Tokyo Japan</p> 
Urban Agriculture	a rising movement aimed at addressing different urban sustainability goals such as food security, food fairness, efficient food supply chains, stormwater management, urban heat island abatement, and waste management utilizing biodegradable trash (Harada & Whitlow, 2020)	The green roof growing drought-tolerant Javits Center, The Klyde Warren Park, and The Brooklyn Grange USA

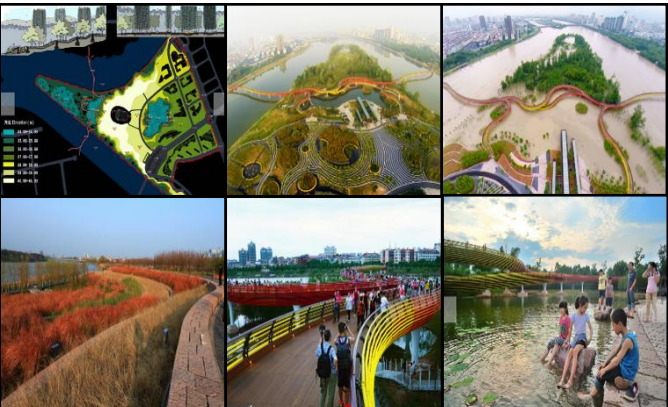
Source: Tokyo Tatemono, 2021

Concept	Definition	Best Practices
		 <p>Aerial views of urban green spaces and rooftop gardens. Image A shows a large green field in an urban setting. Image B shows a modern building with a green roof. Image C shows a rooftop garden with people walking on it.</p>


Source: Harada & Whitlow (2020)

<p>Biophilic City</p>	<p>A Biophilic City is defined as a city with an abundance of nature; it is a city that cares about, seeks to maintain, repair, and expand its natural environment, and strives to promote deep relationships and everyday touch with the natural world. (Beatley & Newman, 2013)</p>	<p>Singapore Biophilic City</p>  <p>A collage of images showing biophilic city designs in Singapore, including green buildings, parks, and urban landscapes.</p>
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Source: Biophilicities, 2021

<p>Sponge City</p>	<p>Cities structured and designed to be more permeable in facing urban stormwater challenge (Hermaputi and Hua, 2017)</p>	<p>The Yanwei Island Park China</p>  <p>A collage of images showing the Yanwei Island Park in China, including a map, aerial views, and ground-level photos of the park's water features and green spaces.</p>
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Source: Hermaputi & Hua, 2017

Concept	Definition	Best Practices
Water Sensitive Urban Design	a land planning and engineering design method that incorporates the urban water cycle, including stormwater, groundwater, and wastewater management, as well as water supply, into urban design in order to reduce environmental degradation while improving aesthetic and recreational appeal (BMT WBM, 2009).	The Nantong Eco Corridor China 

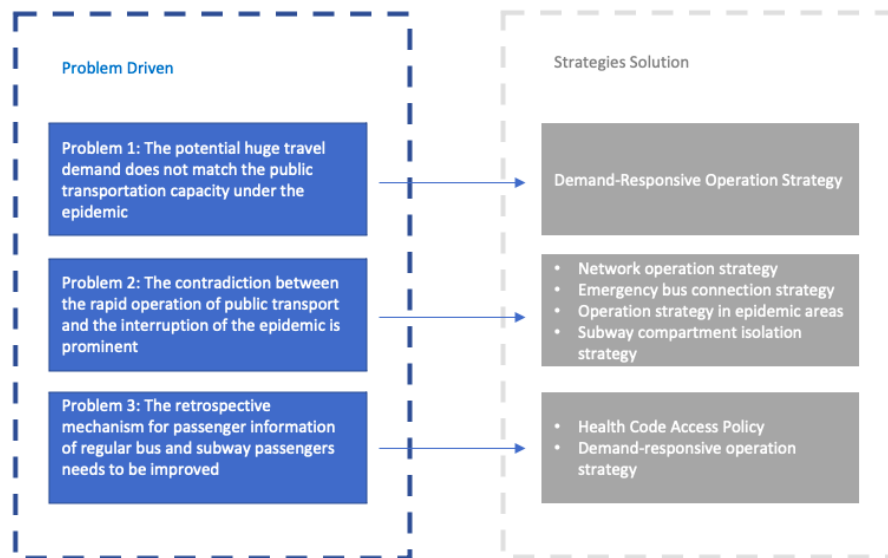
Source: (AECOM, 2018)

Transforming the Transportation System

The economic and social activities were suspended during the pandemics. In different nations, social separation, distance working, and stay-at-home mandates have decreased the spread of COVID-19. These restrictions have a significant impact on global mobility and transportation. Generally crowded with commuters, public transportation networks worldwide have been nearly vacant. This unique circumstance necessitates significant modifications to the conventional urban mobility concept. Urban public transportation must simultaneously provide travel and contain the pandemic during big national catastrophes. Urban public transportation must provide efficient movement and lower the danger of the epidemic's spread in the face of the new coronavirus-infected pneumonia (also known as COVID-19) pandemic. Regular buses and the subway are essential components of the metropolitan public transportation system and play a significant role. Based on the problem-driven approaches, Ningbo city, China, adopted several techniques that have since become the nation's best practices for managing urban public transportation. In order to achieve differentiated and precise prevention and control, zoning, classification, and grading are required to ensure the efficient operation of public transportation and to stop the spread of the virus. Examples of such strategies include the Grid operation strategy, which refers to the gridization of the bus operation area within the city, taking the township (street) as the unit, determining the risk level of different towns; demand-responsive operation strategies include using specialized public transportation apps to upload and count actual passenger flow demand and generate customized operation routes. Emergency bus connection strategies concentrate on implementing the reservation system for emergency connection lines, while the demand-response bus is used to address long-distance travel needs, which are met by the emergency shuttle bus. These inspiration strategies can be seen in Figure 11 (Zhou et al., 2020).

Besides, improving personal health and sustainable mobility options transition encourages people to walk or cycle to commute during the pandemic may also feasible and efficeient to implement. People now choose to reduce their mobility since working and schooling from home are encouraged by the government as disease prevention and control measures. Thus, transforming and investing in a resilient and healthy urban transportation system provides a solution to promote active travel facing pandemic pressure. ARUP (2020) has done specific research in the area of transportation system during the COVID-19

Outbreak and found that there was a reduction in public transport usage even after the end of urban lockdown, most people feel uncomfortable being in dense and populated space, public transportation, in particular, they tend to use private cars, cycling or walking while commuting. Instead of remote working or schooling, they also detect micro-mobility as an opportunity to encourage safer and energy-saving mobility for people and their environment. The increase in remote working or schooling reduces urban traffic and makes movements safer. Strategies mentioned by ARUP (2020) such as Building Transit Oriented Development Cities, Promoting Active Travel Through Sustainable Transportation Modal Shift and Promoting Urban Slow Streets had been implemented in some Chinese cities and support the urban pandemic control.

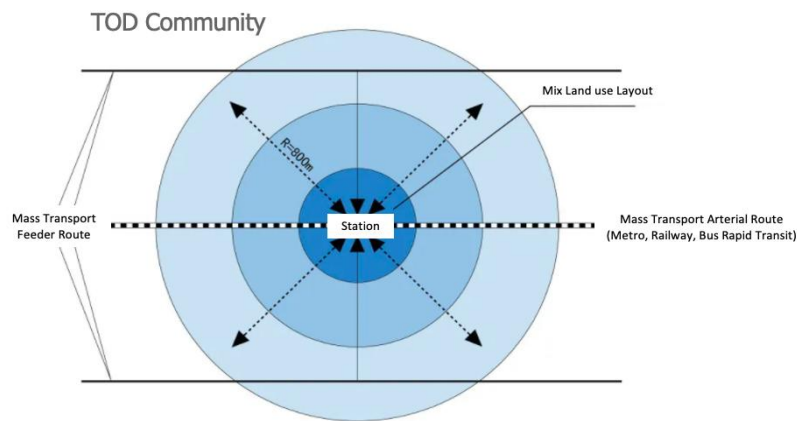


Source: Zhou et al., 2020

Figure 11. Ningbo Problem Driven Public Transport Strategies in Pandemic Control

Building Transit-Oriented Development Cities

Providing public transport integration and promoting various connected transportation modes increased transit ridership, provided transportation network connectivity, and promoted pedestrian and cycling activity while improving physical health by active travels and improving urban air quality. It is also essential that urban areas have the specific authority responsible for managing and integrating all modes, providing an interactive platform for scheduling, smart ticketing, and a broader choice of travel mode and distance.



Source: Nie, 2015

Figure 12. TOD Community Design Concept

Promoting Active Travel Through Sustainable Transportation Modal Shift

To encourage people to shift towards active travel, we need to make cycling and walking-friendly cities. It can be realised by providing high-quality infrastructure such as a broader pedestrian lane; providing shaded and green pedestrian lane; reallocating road space for cars, segregating the lanes for cars, pedestrians, and cyclists; investing in other active travel infrastructure, and promoting bike-sharing options instead of owning a bike. As a key element of shared micro-mobility, bike sharing is recognized as an eco-friendly form of transportation. It lessens the need for individuals to drive, which lowers carbon emissions. It also helps to advance the sharing economy by offering a solution to the "last mile" problem in urban travel. Chinese bike-sharing companies got their start on college campuses. Four Peking University grads who wanted to share bikes anytime and anyplace brought "ofo" dockless shared bikes to campus in September 2015. There were over 70 bike-sharing businesses as of July 2017. During pandemic, in contrast to public transportation and taxis, bike sharing operates in public areas and has less security risks. The most popular means of transportation in Chinese cities during the COVID-19 shutdown was bike sharing, which gave healthcare workers vital mobility services (Figure 13).

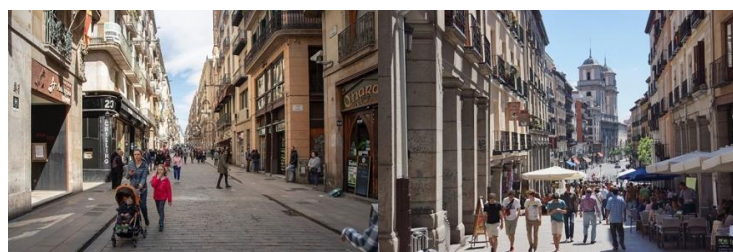


Source: Yangtse News, 2020

Figure 13. Public and Private Sharing Bikes

Promoting Urban Slow Streets

The slow streets ' movement should be implemented to support social distancing without compromising the increasing needs of sustainable transportation modes. The idea is to create pedestrian and cyclists' shared space by restricting local traffic use and creating urban superblocks. The piloting cities of this movement are Madrid and Barcelona (Figure 14). It allows safer mobility for pedestrians and cyclists inside the neighbourhoods, and it also provides bigger outdoor space that can be used for outdoor café, dining restaurants, relaxation benches which promote healthier and resilient neighbourhoods.



Source: Heritier, 2021

Figure 14. Urban Slow Streets in Madrid

The momentum of urban slow street popularity in china starts when the Shanghai Street Design Guidelines, were published in 2016 and were the country of China's entire street design's first significant study publication. Four levels of transitions are raised by the Guidelines: from motorized vehicle orientation to human orientation; from engineering design to comprehensive environmental design; from road red line control to street space control; and from focusing on transportation efficiency to focusing on the integrated development of streets and street blocks. The "Guidelines" outline four objectives: "safety," "green," "vigor," and "intelligence." Six objectives fall under the umbrella of "safety," including "orderly traffic," "pedestrians and bicycles first," "ample sidewalks and crosswalks," "safe street crossing," "smooth riding experience," and "dependable facilities." The four sub-goals of the green street aim are resource recycling, eco-friendly transportation, ecological planting, and eco-friendly technology. Six sub-goals make up the aim of vitality: a variety of uses, cozy activities, pleasant spaces, multi-layered views, distinctive styles and characteristics, and historical legacy. The five sub-goals of intelligence are facility integration, aid with travel, intelligent monitoring, convenient interaction, and environmental intelligence. Jiang (2019) is given the example of street renovation design which become significant on pandemic control measure for future Shanghai, namely, Caoyang New Village Old Community Street, Xuhui Hengfu Historical and Cultural District Street, and Lingang New Town Street.

Discussions

In the case of public health emergencies, a sound and resilient urban built environment system may use its adaptive mechanism to decrease the harm done to the city and its citizens by planning and integrating multi-level aspects such as society, environment, and space. Urban design has a critical role in improving city dwellers' quality of life and health under the COVID-19 outbreak. Designing and planning healthy and resilient cities of tomorrow might address how to ensure urban and its living environment

remains safe and livable, make the outdoors not become the horror zone as virus-transmission epicentre but as habitable space to connect people and nature, support human activity, and maximize their potential. The primary goal of this study is to give ideas to redesign our cities that reflect resilience and a healthier living environment to improve the city's emergency response to unanticipated public health catastrophes. This study also reviews the strategies for redesigning urban spatial configuration mainly connected to avoiding and controlling the pandemic through several published literature and policy document. The research gap between this article, the previous studies and published policy document mainly at the given praxis, especially on the strategies implementation in Chinese Cities.

The pandemic has changed the way we utilize urban space; it calls into question and confronts the city and the neighbourhood, urban block, and residence. It also causes individuals to reconsider the accessibility and functioning of public and private worlds and locations. In order to ensure public safety and normalize the urban function during and post-pandemic, the future urban space design should consider living within proximity, the diversity of space function, and the importance of urban natural light and urban micro-climate. Shelter COVID-19 Support Team (2020) in Healthy Pandemic Resilient Cities Document states the prospect design strategies for post-pandemic cities such as 15 minutes walkable cities, increasing urban space natural light and ventilation, and increasing blue and green space construction. The document had given a brief introduction of strategies definition but failed to provide the design detail and the current praxis to use as reference. Therefore, this article tries to fill those gaps by elaborating the strategies concept and giving praxis, primarily which has already been implemented in China.

The pandemic calls into question and confronts the city and the neighbourhood, urban block, and residence. It causes individuals to reconsider the accessibility and functioning of public and private worlds and locations. Many residential neighbourhoods no longer provide economic life or recreational activities within walking distance. This status necessitates a reconsideration of how communities might become more mixed-use and how core neighbourhood streets can be strengthened as subcentres of everyday life. To improve urban vibrancy and resilience, it is necessary to promote the mix of land use and building space functions. A mixed land use development is an urban design that mixes residential, economic, cultural, and institutional functions into a single location. Until we fully comprehend the virus's influence on our society, the pandemic-driven accelerant of market trends provides vital insights into the future of mixed-use. When it comes to encouraging low-carbon mobility, cities have natural leverage. Because of its compactness and varied usage, many places are easily accessible by foot, bike, or public transportation. As a result, mixed-use neighbourhoods intertwine various urban activities within walking distance, therefore in spatial proximity. Under the COVID-19 outbreak, the provision of urban facilities and services may help to improve people's quality of well-being. Healthcare facilities and services supplied healthcare to inhabitants, while other amenities, when available, allowed people to participate in everyday activities such as education, social contact, culture, recreation, and physical activity. To preserve these roles, communities must guarantee that residents have easy access to quality healthcare facilities and services, as well as a range of local attractions. Thus, the mixed land use development and the application of 15 minutes may help improve urban resilience and well-being.

Moreover, reviewing the strategies for redesigning the public space, it is known that public space accommodates people's behaviours when constructing a series of social relations in the public sphere. In modern society, with the gradual expansion of the lifeworld, the scope and level of public space are constantly expanding, and its internal mechanisms are undergoing continuous changes. Open public spaces, such as public squares, pedestrian zones, and streets, were critical during COVID-19 because they offered

a safe environment for physical, social, and cultural activity. The need for open public places was emphasized, particularly in cities and areas that lack such spaces. There is an urgency to create a resilient urban area by planning subterranean spaces, green corridors, and healthful walks from all across the city, both as public places during the day and as isolated transfer channels during an emergency. When a public safety problem happens, this space is allocated for wartime, and a war readiness hospital can be temporarily constructed up here. Besides, there is also a necessity to accommodate the emerging trend of outdoor social activities. Therefore, providing diverse outdoor spaces and increasing urban space natural light and ventilation may bring leverage in cutting and controlling the virus transmission.

The COVID-19 pandemic resulting from the lockdown brought significant changes to the urban daily lives. The "limited" activity space, healthy, ecological and green lifestyle become people concerns. The implementation of physical distancing and lockdowns is likely responsible for saving millions of lives. However, Pouso et al. (2021) found that contact with nature gives numerous intangible advantages and can shield us from the harmful impacts of mental health confinement measures. This epidemic has taught us to investigate the relationship between green open space and public health, to investigate the processes and mechanisms underlying green open space's health effects, and to comprehend the utility and significance of green open space for public health in terms of physical, psychological, and social health. Several design concepts for developing urban green and blue space are introduced, such as urban forest, urban agriculture, sponge city, water sensitive urban design, a biophilic city offering various feasible solutions to address urban green space and water challenges during and post COVID-19, the combination of nature and leisure space offering a safe environment for activities as well as emotional and mental health advantages, urban blue-green space and neighbouring nature were critical for minimizing the harmful effects of COVID-19 on quality of life. Cities would need to create or retain urban green space, trees, and other sorts of plants and preserve neighbouring nature. Access to blue-green space and environment is also essential so that inhabitants may reap the health and well-being advantages.

Concerning the urban traffic, during the pandemic, traffic may play two roles: first, it can produce transmission hazards, and traffic is dense and enormous, increasing the danger of the pandemic; second, there is a more prominent need for traffic to fulfil during the pandemic, such as physicians, nurses, rescue personnel, and the movement of materials, as well as regular people's transit requirements. Pandemic prevention awareness on urban transportation development when safety becomes one of the most important considerations affecting travel decisions, communities should react to the pandemic's problems and better balance public transit and vehicle travel. The pandemic has demonstrated that much effort can change travel behaviours and reduce long-distance travel. Individual travel across small distances and for short periods is critical for safety. This option may give prospects for positive interaction between urban space and urban transportation and the development of work-leisure-housing balance commuting. If short-distance transit becomes more prevalent, additional demands will be imposed on urban space; building a more acceptable space environment for walking and cycling is also critical and essential. The potential strategies ARUP (2020) offered, such as building TOD, promoting active travel through sustainable transportation modal shift, and promoting urban slow streets has been implemented in Chinese cities even before the pandemic, by giving the praxis from chinese previous studies, we may conclude those strategies are proven to be reasonable and efficient options fulfilling the demand for resilient and healthy urban transportation system post-pandemic.

Conclusion

Public safety issues have always been the main focus of planning and designing an urban space, especially natural disaster prevention and mitigation. However, there is insufficient attention towards public health emergencies. The COVID-19 outbreak encourages us to pay more attention to predicting public health emergencies and their prevention. With a lack of experience and preparation facing the outbreak, our urban overwhelmed and government failed to undertake timely urban physical examinations for "urban diseases," and therefore uncovered the pre-disaster early warning system and society. The outbreak poses a significant threat to human life, the urban economy, and productivity. Thus, in the future, an urban system is required to prevent, control, provide isolation sources, and cut off the transmission of the disease to protect urban inhabitants and keep run generally during and after the pandemic and maintain public health in general.

The Chinese experience in fighting the COVID-19 pandemic can be a lesson learned for other countries worldwide, their fast and targeted response to cut the virus transmission and restrict people mobility to protect them from the contagious disease even being praised by the UN World Health Organization. The popular measures they take are the lockdown policy, constructing temporary hospitals in short duration, applying social distancing, and wearing mask regulation, all contributed to their recent success in controlling the pandemic. However, there are also deficiencies behind those strength emergency responses. There are still several lacks in the quality of the urban living environment. Thus, this study reviewed the potential strategies and visualization strategies for creating a healthy and resilient urban living environment to address those lacks. The strategies listed in each element of the urban living environment are as follows: (1) redesign urban spatial configuration by creating 15 minutes city, applying multiple centre urban structures, increasing urban space natural light and air ventilation, and providing a diversity of outdoor spaces that reflect the living environment resilient capacity and are connected to the realization of the healthy living environment; (2) the construction of blue and green space promotes a healthy and resilient living environment by connecting ecological space and urban built space; and (3) the transformation of the transportation system focuses on building transit-oriented development cities, promoting active travel and slow urban streets that contribute to the improvement of urban inhabitant health, pollution reduction, and promoting sustainable mobility.

This study has identified comprehensive strategies that pose the urban living environment needs to adapt, transform, and readiness facing current outbreaks and prevent the upcoming outbreak. However, which strategies are suitable and how to measure the level of efficiency through implementation under different urban space characteristic and planning background still need further research in order to give a clearer and broader understanding.

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