

Study on Design Methods of Urban TOD Area Based on Resilient Cities Theory

Taking Sichuan Normal University Subway Station Area in Chengdu, China as an example

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Abstract

The outbreak of the novel coronavirus (COVID-19) from 2019 to the present has caused great disaster to the whole human society. This paper is based on the "Resilient Cities" theory and "Transit-Oriented-Development, TOD" as the carrier to explore urban design strategies to deal with sudden public health events in urban areas. Firstly, the concept, development and theoretical connotation of resilient cities are reviewed. Secondly, to solve the three problems in the current city's response to public health emergencies, based on the theory of "resilient cities" and "health plus", the "TOD Healthy living mode" is proposed as the design guide of urban TOD area. Thirdly, the Sichuan Normal University subway station area is selected as the design site, and the site conditions and users are analysed. Finally, the design result of urban TOD area based on "TOD Healthy living mode" is proposed. And the life trajectory of four types of users, included students, office workers, retirees and purpose visitors, is simulated.

Keywords

Resilient cities, Urban design, TOD healthy living mode, Sichuan Normal University subway station area

During the novel coronavirus (COVID-19) outbreak from 2019 to now, China has adopted community isolation for urban residents, most of them in nearby hotels or at home. During the pandemic, a series of adverse problems emerged, such as high hotel costs, inconvenient home quarantine, shortage of medical supplies, and inadequate epidemic prevention facilities in temporary hospitals, prompting cities to establish and improve urban resilience mechanisms that can withstand sudden catastrophic events and recover quickly.

The concept of resilient cities was first proposed by "Local Governments for Sustainability (ICLEI)" at the U.N. Sustainable Development Summit in 2002. It emphasizes the integration of engineering improvement, facility improvement, public participation and institutional innovation to enhance the resilience of the urban system. Based on resilient city theory and taking the TOD model as a carrier, this paper proposes the "TOD healthy living model" as the urban community design strategy for resilient cities to deal with unexpected public health events.

1. Interpretation of resilient cities theory

1.1. Concept and development of resilient cities

The word "resilience" comes from the Latin word "resilio". It was first a physical concept, meaning "resilience; elasticity", which refers to the ability of an object to return to its original condition after being subjected to external forces. Resilience is considered one of the basic features of natural and human systems (Holling C. S., 1978). Holling C. S. (1973) introduced the concept of resilience into ecology, defining it as "the ability of ecosystems to return to a stable state after disturbance". After the Resilience theory was applied to the Urban system, concepts such as "Resilient Cities" or "Urban Resilience" emerged (Fishwick, M. W., 2005). The emergence of such concepts benefits from the efforts of ecologists, sociologists and urban planners to actively promote multidisciplinary and interdisciplinary studies based on the perspective of urban complex systems (Meerow S., Newell J. P., 2016). Alberti M., Marzluff J. M. Shulenberg E, et al (2003) first clearly proposed the concept of "Resilient cities". Subsequently, Resilience Alliance (2007) defined the resilient city as the ability of a city or urban system to digest and absorb external disturbances while maintaining its original main features, structure and critical functions. Due to the high complexity of the urban system and the diversity of external disturbance factors, the concept of resilient cities has been discussed for nearly 15 years since it was proposed at the Conference of Ecological Society of America in 2002. There is still no broad consensus on the detailed scientific definition of resilient cities (Meerow S., Newell J. P., Stults M., 2016). Since then, resilience has undergone the evolution of three phases of engineering resilience, ecological resilience and evolutionary resilience (Folke C., 2006). It has gradually become one of the characteristics of sustainable urban development.

From 2001 to 2007, scholars in urban planning, ecology and environmental science in the United States began to pay attention to the resilience of urban systems in dealing with disasters, and the research object of resilience theory gradually expanded from ecosystem to "social-ecological" system. It was redefined as the ability of a system to absorb disturbances, reorganise, and remain essentially the same in structure, identification, and feedback as it changes. (Li T. Y., 2017). Since then, the theory of resilience has been applied to urban system research. In March 2010, the United Nations Office for Disaster Risk Reduction (UNDRR) launched the "Making Cities Resilient Campaign", which aims to encourage local governments to build resilient cities that respond to disaster risks in the process of sustainable urbanisation and to provide a model for global disaster prevention and mitigation. In 2011, the second World Urban Science Development Forum and the First Mayors' Summit on Disaster Prevention and Mitigation formally proposed the concept of resilient cities. At the meeting, ten cities including Chengdu joined the "Making Cities Resilient Campaign" and jointly signed the "Chengdu Action Declaration", and rated Chengdu as the "Model City of Post-disaster Reconstruction and Development" (Chengdu Government Research Office research group, 2011; 2020). In 2012, the UNDRR launched a network of Asian cities' resilience to climate change. In 2013, The Rockefeller Foundation launched the Global 100 Resilient Cities Programme (Johnson, C., Blackburn, S, 2014). In 2015, UNDRR made it clear in the research consensus of the Third U.N. World Conference on Disaster Risk Reduction for Sendai Framework for Disaster Risk Reduction 2015–2030 that "Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020", "Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030" (UNDRR, 2015). In 2016, the third United Nations Conference on Housing and Sustainable Urban Development made it clear that "ecology and resilience of cities" would be one of the core elements of the new urban agenda (Yang F., 2019).

According to the above review, resilient cities theory originated in the United States, gradually developed in Britain, Japan and other countries, and achieved many practice results. At present, the resilient cities theory has gained great attention in China, and the stability, recoverability and wisdom advocated by it

have great reference significance for the prevention and control of COVID-19. In the future, the study of resilient city theory will be a continuous and deepening research focus.

1.2 The interpretation of connotation of resilient cities

According to the overall framework of the "100 Resilient Cities Programme", which focuses on the complexity and diversity of urban systems (Spaans M. & Waterhout B., 2017), According to different stages of resilience city, resilience shows additional secondary attributes, such as reflective, resourceful, inclusive, integrated, robust, redundant and flexibility (Xu Y. Y., Li G. & Cui S. H., et al., 2018).

At the Third U.N. World Conference on Disaster Risk Reduction in 2015, UNDRR proposed "10 essentials for making cities resilient (Johnson C. & Blackburn S., 2014). " The ten essentials are: 1. Organise for Disaster Resilience. 2. Identify, Understand and Use Current and Future Risk Scenarios. 3. Strengthen Financial Capacity for Resilience. 4. Pursue Resilient Urban Development and Design. 5. Safeguard Natural Buffers to Enhance Ecosystems' Protective Functions. 6. Strengthen Institutional Capacity for Resilience. 7. Understand and Strengthen Societal Capacity for Resilience. 8. Increase Infrastructure Resilience. 9. Ensure Effective Disaster Response. 10. Expedite Recovery and Build Back Better (UNDRR, 2015).

The above two types of urban resilience characteristics are defined primarily in terms of resilience types rather than urban components. It is considered that "resilience" includes resistance, coping capacity, recovery and adaptive capacity, and it covers individual, family, community and city scales (Figure 1).

Essential 4 and 6 are closely related to urban planning and architectural design in 10 essentials.

Essential 4 is "Pursue Resilient Urban Development and Design". With the city's product, the transportation network is increasingly perfect, which is conducive to the flow of people and logistics in the city, and provides conditions for the spread of diseases. Problems such as high concentration of population, uneven distribution of resources and lack of sound property management in old residential areas in big cities add to the difficulty of epidemic prevention and control. In future urban development, the urban design thinking of resilience should be fully implemented in reconstructing old communities and constructing new urban areas.

Essential 6 is "Strengthen Institutional Capacity for Resilience." Engel GL (1977) proposed the Bio-Psycho-Social Model, which focuses on both biological, psychological and social dimensions in the treatment process (Figure 2). In the event of a public health incident, the medical institution system is the core of the prevention and control of the epidemic. Urban design needs to improve the essential functions of medical institutions at the same time to create high-composite urban parts to ensure the stable operation of medical institutions in daily situations and public health emergencies.

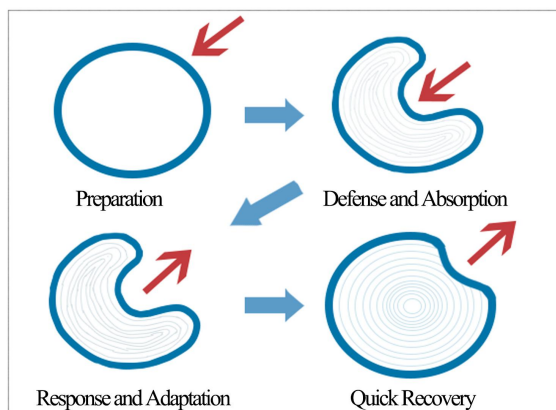


Figure 1. The adaptive process of complex system subjected to external forces

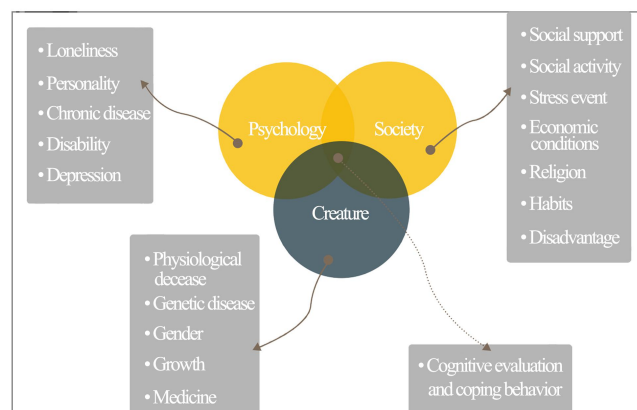


Figure 2. Schematic diagram of the Bio-Psycho-Social model

2. Expansion of the problem-oriented resilient cities theory

The outbreak of COVID-19 has brought people a profound reflection, and it is urgent to explore a series of urban strategies to deal with similar public health events. By interpreting the interpretation of the concept and connotation of resilient cities, this paper takes the following three questions as the entry point for applying the resilient cities theory to urban design.

- (1) How to improve the healthy life quality of residents in urban design?
- (2) How to improve urban resilience in urban design to deal with sudden public health events?
- (3) How to consider the traffic characteristics, management-prevention system, and residents' healthy life needs in urban design?

2.1 Extension I : take "health plus" as the design concept to improve the healthy life quality of residents

According to Essential 6 of resilient cities, "Strengthen Institutional Capacity for Resilience", this paper intends to improve the humanistic care of the community from both physical and psychological levels to enhance the well-being of the residents. The "health +" design concept is taken as the urban design method of resilient cities. By improving the medical system in urban areas, users' health is concerned from the two scenarios of daily life and epidemic outbreak.

The great health industry is an industrial integration led by the concept of healthy life (Hai Q. S. & Jin Y. J., 2017). According to the characteristics of the design site and the activities of the young, middle and old people, this paper further puts forward the design concept of "health plus", with urban areas as the carrier to flexibly arrange the industry, to build a healthy and resilient community living environment. It integrates medical care facilities with residential apartments, kindergartens and commercial leisure Spaces on the ground and underground, creating healthy, convenient and diversified lives for people of different ages (Figure 3).



Figure 3. "Health plus" design concept

2.2 Expansion II : establish a management and prevention system to improve the medical resilience of urban areas

The critical point for cities to respond to public health emergencies in the future is to establish effective prevention and feedback mechanisms. Resilience urban design should propose a prevention-feedback

mechanism from planning design to urban management strategy. After a disaster occurs, feedback data can be received in promptly and quickly start processing. By analysing disaster data after a disaster, preventive measures are upgraded and improved. In this paper, effective urban area management and prevention mechanisms are established according to the logic of "problem-factor-solution" (Figure 4).

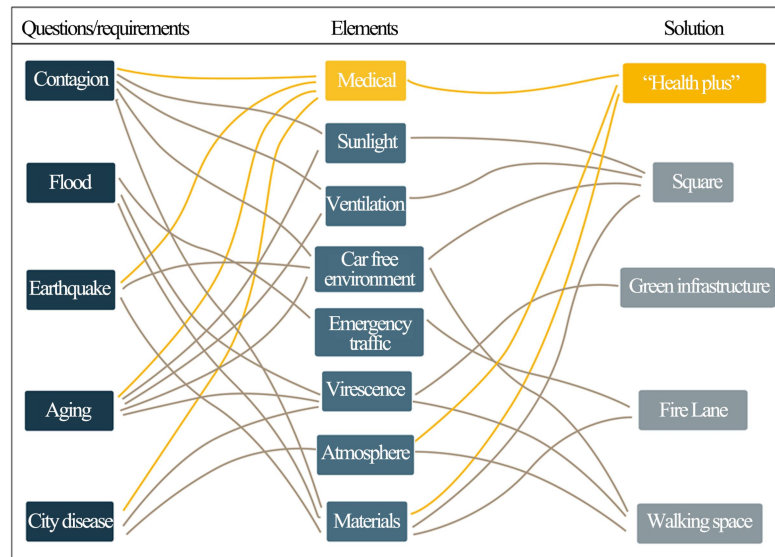


Figure 4. The logic of building prevention mechanisms in areas of resilient cities

The design site proposed in this paper is located in the northwest of Sichuan Normal University subway station area at Subway Line 7 and Line 13 in Jinjiang District, Chengdu. The site covers an area of approximately 56,500m² (Figure 5). Based on the concept of "health plus", this design closely integrates medical care with commercial, cultural and residential functions, and sets up three types of thematic health stations on the site.

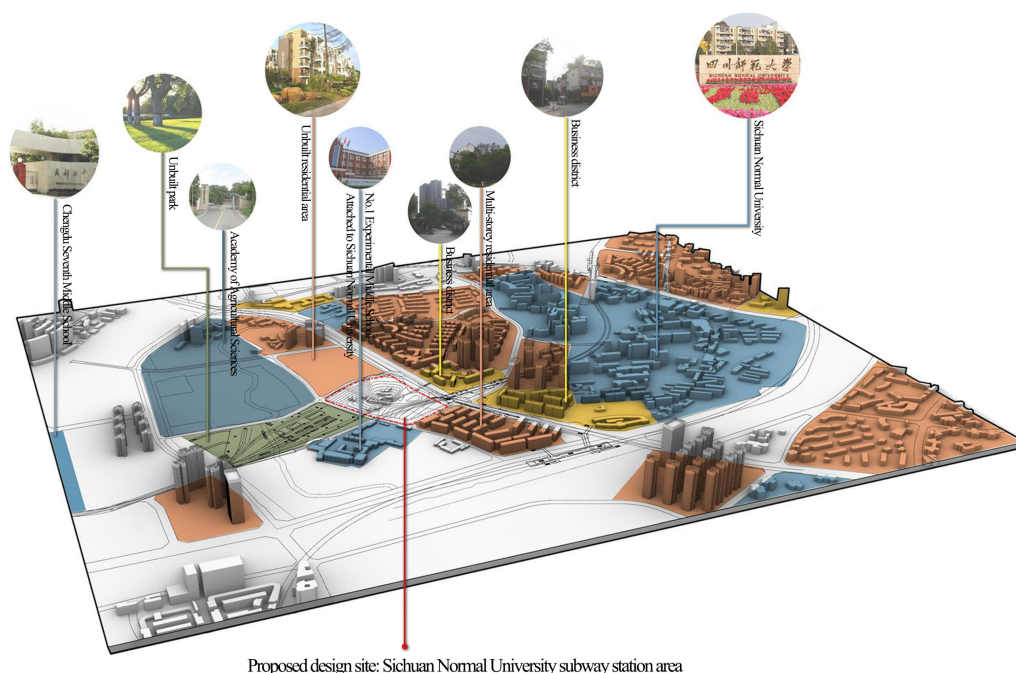


Figure 5. Overview of the Site

- (1) Apartment thematic health station: Regular physical examination, data tracking and timely conditioning of the elderly in the pension apartment.
- (2) Commercial thematic health station: provide cosmetic, dental, skin management and other medical services.
- (3) Cultural thematic health Station: provides psychological counseling services to residents

The health management centre manages three types of thematic health stations and receives real-time feedback. In an outbreak, thematic health stations can be converted to temporary community isolation points, and the movement of people and materials through closed passages. The urban area takes the health management centre as a control point to schedule and manages a medical system of the whole region (Figure 6).

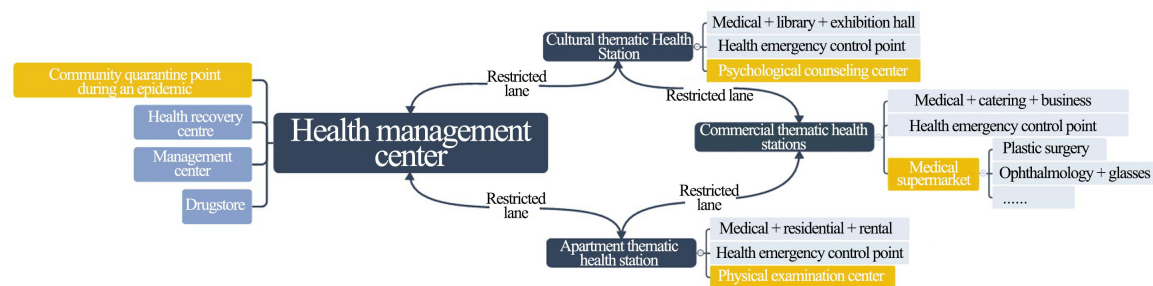


Figure 6. The logic of "Health Plus" mode

2.3 Extension III: take "TOD Healthy Living Mode" as the design guide for urban TOD area

In view of the third problem, this paper intends to combine the TOD characteristics of a specific area with exploring urban design strategies to meet two needs of use scenarios of "daily" and "epidemic". Based on the conclusions of Extension I and Extension II, this paper puts forward "TOD Healthy Living Mode" as design guideline of urban TOD area (Figure 7).

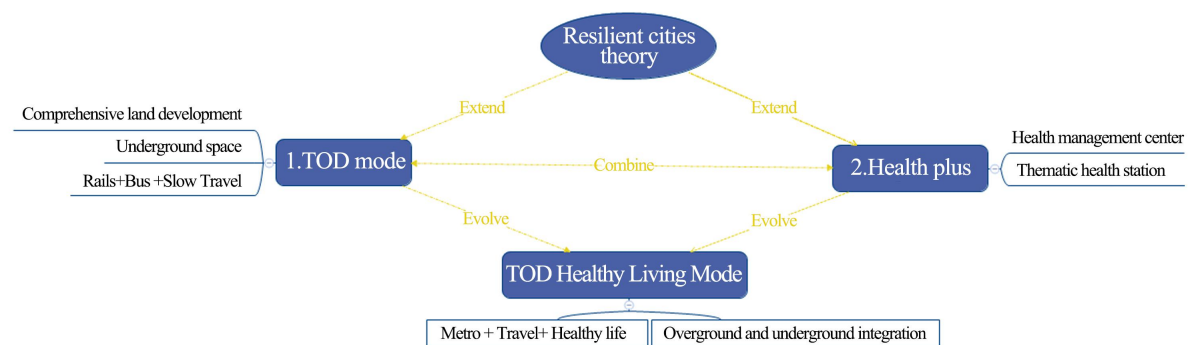


Figure 7. Logical association between "resilient cities", "health plus" and "TOD Healthy Living Mode"

In 1992, Peter Calthorpe came up with the concept of TOD in an attempt to solve the problem of disorderly urban sprawl (Shi X. D., Zhao Y. T. & Wu K. J., 2020). In recent years, Chengdu has divided the integrated development site into four levels: city-level, district-level, group-level and general-level sites. Sichuan Normal University subway station belongs to the general level site, but it also listed as a demonstration TOD project in Chengdu.

The core content of TOD mode is "Rails, Bus and Slow Travel", the primary purpose of preventing the unchecked growth of cities. In light of this outbreak, epidemic prevention problems are highly likely to occur in high-density urban areas. This paper integrates the concept of resilient cities and "health plus", and expands its content to "tracks, travel, and healthy living". The functional axis of "transportation station -- big health industry -- residential area" was established in this design, and commercial, office

and cultural functions were selectively added. Its medical resilience is enhanced by closely integrating the high-density TOD area the surrounding commercial, residential, and health systems.

The health management centre is taken as the core point. The overall layout is made according to intensity and correlation of the medical needs of users for each building, and the "Health +" design layout with TOD as the centre is constructed (Figure 8). The ground and underground space on-site are integrated with the commercial complex through the sunken square, presenting a coupling relationship of "rail station + underground passage + supporting commercial and medical facilities" with the subway station.

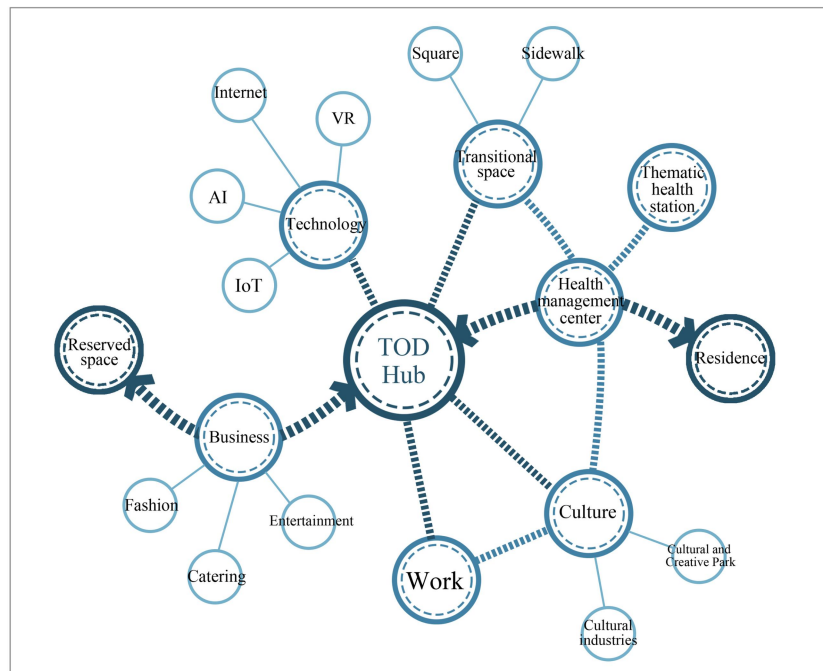


Figure 8. The functional connection of TOD Healthy Living Mode

3. Urban design application of Sichuan Shida subway station area

3.1 Site analysis and site plan design

TOD mode encourages comprehensive utilization and compact development of land, reduces travel costs and stimulates community vitality, which is an effective solution to the current disorderly spread from city to suburb. However, the mode is unfavorable for epidemic prevention and control, and similar public security emergencies, so it is urgent to find complementary design strategies.

In this paper, the metro station area of Sichuan Normal University with the characteristics of TOD mode is selected, and the resilient urban design method of TOD area with universal significance is proposed. The site is close to Sichuan Normal University subway station, and its underground space construction of the subway station is relatively perfect. The industrial form, building type, building function and users in the site are diversified. There are also schools, residential areas, research institutes and other crowded areas around the site, which have good public transportation conditions and essential characteristics of TOD. The analysis of plot nature, road width and entrance and exit around the area is shown in Figure 9.

Based on the above site analysis results, the site plan, site section and aerial view are shown in Figure 10 to Figure 12. Building functions on the site include: The apartment for the aged is about 30,000 m², the vegetable market is about 5,000 m², the kindergarten is about 4,000 m², the community service centre is about 5,000 m², the office building is approximately 70,000 m², the hotel is about 40,000 m², the

centralised commercial is about 60,000 m², the underground connection commercial is about 6,000 m², the health centre is about 4,000 m². The cultural and creative neighborhood is about 12,000 m².

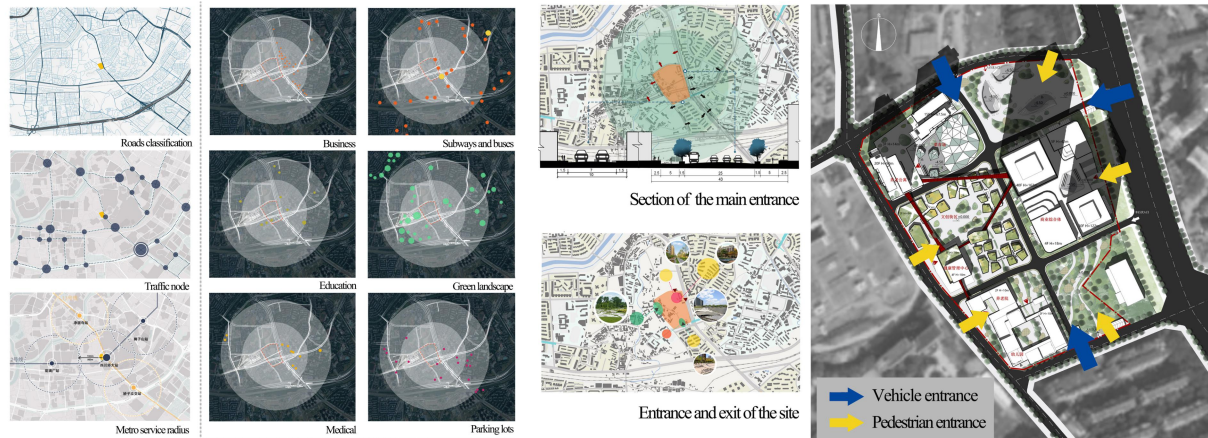


Figure 9. Design site analysis



Figure 10. The site plan of Sichuan Normal University subway station area



Figure 11. The bird-eye views of Sichuan Normal University subway station area

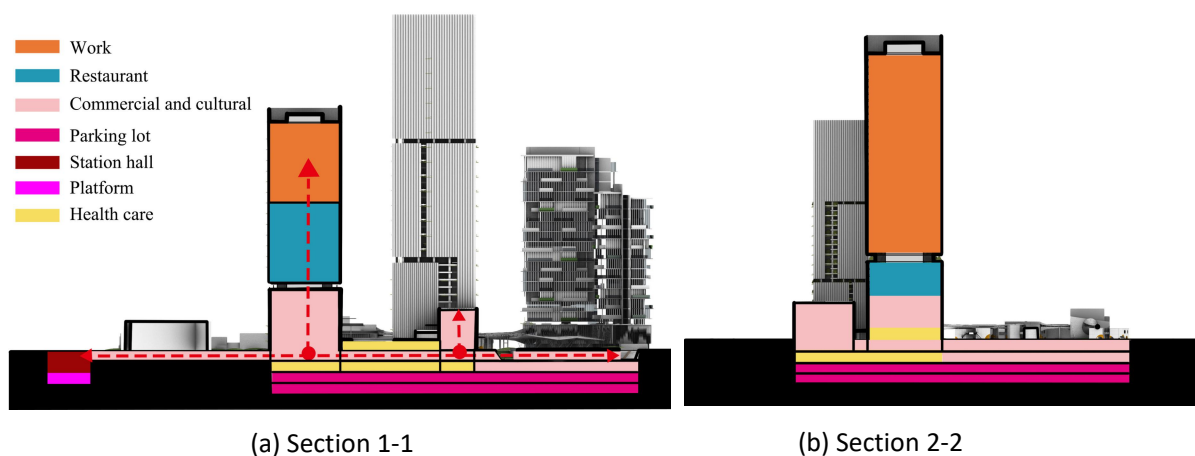


Figure 12. The sections of Sichuan Normal University subway station area

3.2 The design application of TOD Healthy Living Mode

3.2.1 The design application of "Health Plus"

The design integrates the commercial, entertainment, office, residential and medical functions in the site, and builds a new urban residential medical system that meets the two types of use in daily life and epidemic period, so as to strengthen the ability of urban areas to cope with public health emergencies. Four different themed health stations are set up on the site, under the unified control of the Health management Centre and directly connected by dedicated medical access (Figure 13).

In the event of an outbreak, the health management centre and the four thematic health stations are cut off from other daily functions and quickly join medical facilities and patient beds as temporary isolation points. Epidemic prevention support and quick control were carried out for surrounding communities in the mode of "one centre and four stations", so that the situation of people could be checked and controlled (Figure 14).

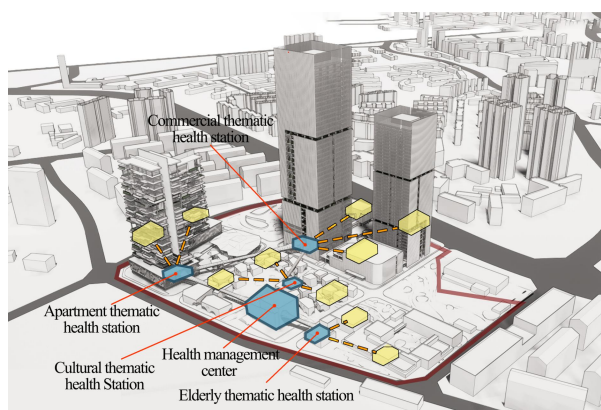


Figure 13. "Health plus" mode in daily life

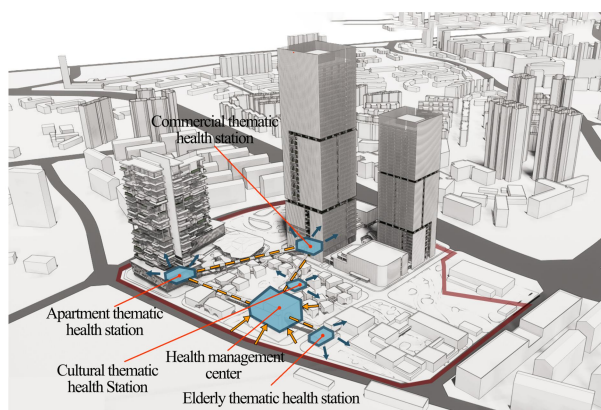


Figure 14. "Health plus" in epidemic period

The air medical channels were set up between four thematic health stations and a health management centre (Figure 15). The medical corridor is designed with two floors: the upper one is a pedestrian corridor, and the lower one uses intelligent robots to store and transport medical supplies in daily life and during the epidemic period, so as to isolate the virus contamination. Through the installation of closed doors, medical access can be connected to the roof platform when needed. The entire roof terrace is landscaped with views towards the park on the west side. During the epidemic period, the quarantined people can go out for air ventilation and outdoor activities to circulate the air, reduce the risk of virus transmission and relieve the psychological pressure of the quarantined people.

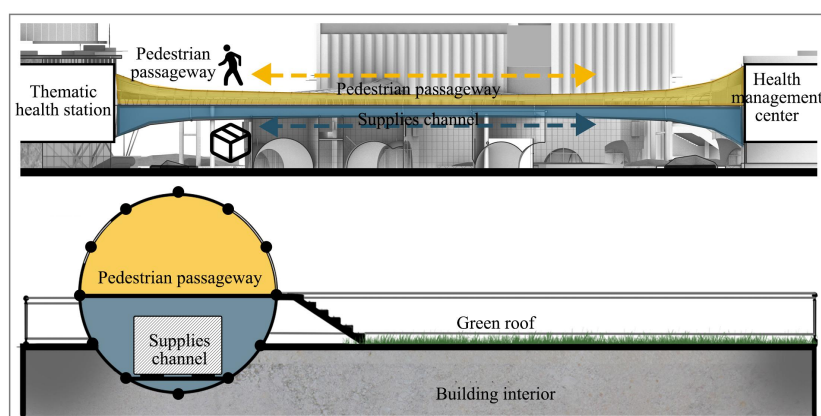


Figure 15. The air medical channel of the site

3.2.2 Integration of "Health Plus" with TOD mode

Based on the design concept of "health plus", the design logic of "underground space + public service + rail transit" is proposed to carry out a comprehensive design of the ground and underground space of the site. "Public service" refers to the aggregation function of commerce, medical care and public transportation.

(1) The above-ground part takes the health management centre as the central point, connecting the vertical and horizontal axes. The vertical axis is associated with apartment and pension institution in the site, the suitable for aging and ordinary residences outside the area. The horizontal axis connects cultural industries, commercial functions and office functions, and users can reach the Sichuan Normal University subway station through overground and underground passages (Figure 16).

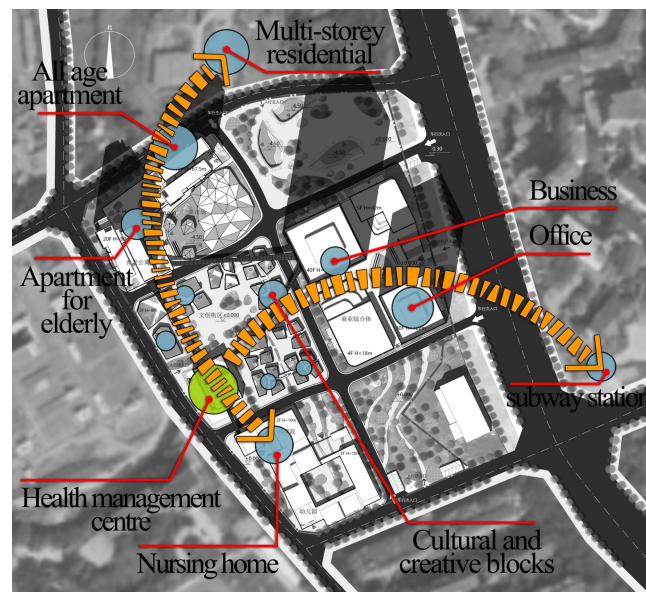


Figure 16. Analysis of the axis of "underground space + public service + rail transit"

(2) The sunken square and underground walking space on the first floor form a convenient connection with the buildings on the ground. Supporting commercial facilities are arranged along the underground passage from the subway station to the site, and medical stations are set up at crowded places. The second underground floor is mainly for commercial functions, while the third and fourth underground floors are parking lots (Figure 17).

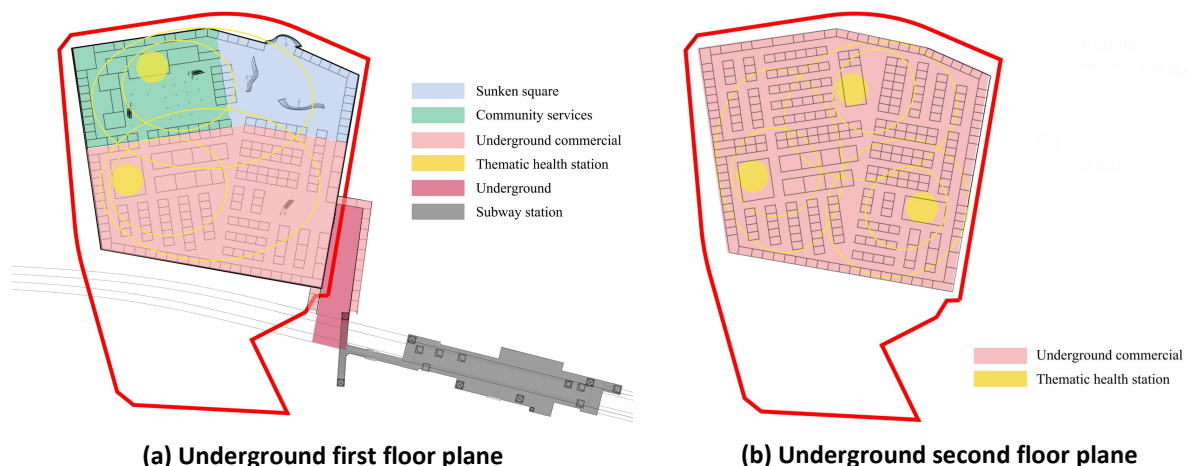


Figure 17. The underground space plane of Sichuan Normal University subway station area

3.3 The simulation of activity trajectory of users

3.3.1 Population analysis

The analysis of the nature, age structure, use time and needs of the population living in the site is shown in Figure 18. Through the analysis, it can be seen that the purpose visitors, family residents and business customers all have high demand for commerce, and hope to have high-quality rest space. Therefore, corresponding functions should be comprehensively arranged in site layout to meet the needs of different people in different periods. This paper simulates the activity trajectories of students, office workers, the elderly and purpose visitors.

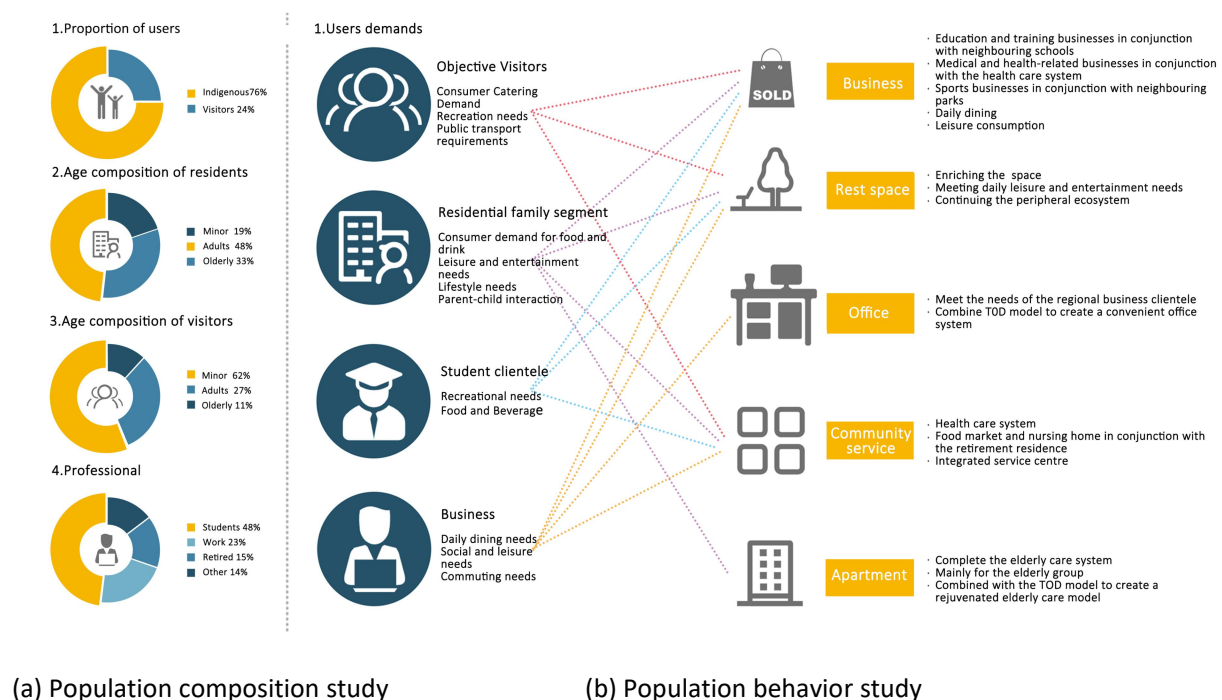


Figure 18. Analysis of site users

3.3.2 Analysis of student population

Cultural and creative blocks and business districts are the most frequently visited areas for students, so a direct passage is set between two functions and a subway station. In the design, the nursing home and the kindergarten are arranged next to each other. Both of them can serve as service points for student volunteers, and provide an excellent mental health environment for the elderly living alone (Figure 19).

3.3.3 Analysis of working people

As the site is adjacent to Sichuan Normal University Station, workers mainly arrive at the site by subway, and quickly reach office buildings, commercial streets and cultural and creative blocks through above-ground and underground passages. Workers' needs for full-time work, such as food, rest and medical services can be met in the site (Figure 20).

3.3.4 Analysis of elderly population

The elderly living alone in the pension apartment can go to the nearby park for morning exercise with their dogs, buy food in the supermarket, socialize and exercise in sunken square and health care stations, and make regular appointments for regular appointments health check-ups at various health care stations. To facilitate the daily life of the elderly, the above functions are adjacent to pension apartments (Figure 21).

3.3.5 Analysis of purposeful visitors

Visually, visitors mainly use the site for an artistic and creative experience, dining, entertainment, visiting relatives, and friends. They can easily reach the site through indoor and outdoor access (Figure 22).

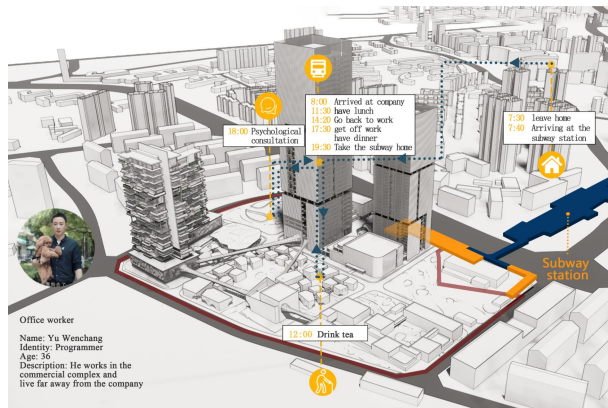
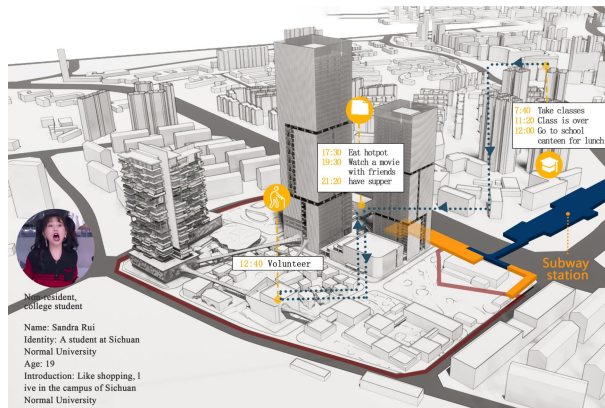


Figure 19. Simulation of the movement trajectory of college students

Figure 20. Simulation of the movement trajectory of office workers

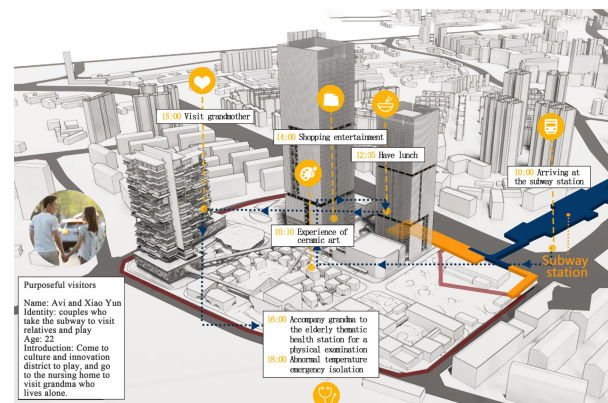
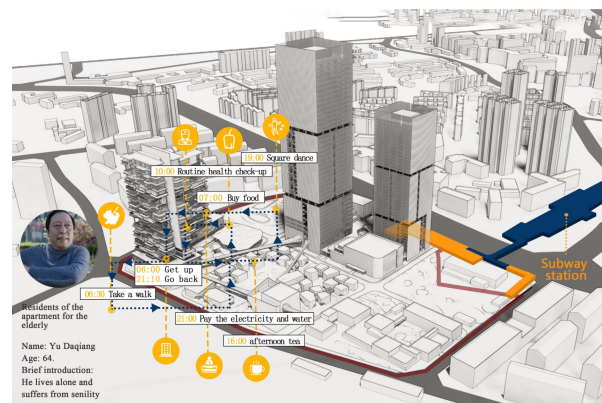


Figure 21. Simulation of the movement trajectory of the elderly

Figure 22. Simulation of the movement trajectory of purposeful visitors

4. Conclusions and prospects

The outbreak of the COVID-19 pandemic from 2019 to the present has caused great disaster to the whole human society, and has also brought much new thinking to all walks of life. In order to effectively respond to the same kind of sudden public health events, this paper takes Sichuan Normal University station in Chengdu as the design site, and puts forward three urban design strategies of "TOD Healthy living mode" based on ten essentials of resilient cities and the TOD characteristics of the site.

- (1) Improve residents' healthy life quality with the design concept of "health plus". Organically integrate the medical system with residents' apartments, kindergartens, businesses, restaurants and supermarket to improve the convenience of residents' lives and weaken the sense of medical care.
- (2) Improve the health resilience of urban areas by establishing of effective management and prevention systems. The medical system of "one centre, multiple stations" was proposed to care for the physical health of site users in daily life and epidemic outbreak scenarios. Multiple medical control points are set up according to the flow lines of different users, which the health management centre centrally manages, so that the whole site's epidemic prevention and control situation can be monitored.

(3) In urban design, "Health plus" and TOD mode are integrated to form "TOD Healthy Life Mode", which is used as the design guide of urban TOD areas. By comprehensively considering the characteristics of overground and underground space, public service demand and rail transit function of urban TOD area, the healthy and convenient life of different age groups can be met.

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