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Urban Transportation System Planning under the COVID-19 Pandemic in Beijing

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Abstract: The COVID-2019 outbreak severely affected the operation of cities and caused huge losses to national economy. As the pandemic situation stabilizes, cities gradually return to normal operation, which presents great challenges to urban transportation system. As a megacity with a huge travel demand, Beijing's transportation characteristics under public health emergency are different from the past. Based on the travel demand changes in Beijing under the pandemic, this paper proposes the traffic management strategies for the city's transition from the abnormal to normal status. By summarizing the lessons learned during the pandemic, this paper proposes the new ideas in transportation planning to improve urban system resilience in several aspects: network development, transportation resource allocation, application of information technology, etc. **DOI:** 10.13813/j.cn11-5141/u.2020.0021-en

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1 Characteristics of the traffic operation in Beijing during the special time of COVID-19

Urban transportation is an important carrier for city functions. Its core is human activity and its travel demand characteristics are determined by the positioning of urban development. As the capital of China, Beijing is also an important transportation hub with huge travel demand in the world. Beijing's intercity transportation system is composed of air, railways, highways and other transportation modes. To perform urban functions as a megacity, Beijing built its intracity transportation system composed of urban rail transit, buses, cars, bicycles, walking, etc. At present, Beijing's transportation system is serving 1.71 million intercity trips and 62.07 million intracity trips each day. Affected by Coronavirus Disease (hereinafter referred to as "COVID-19") and under the travel control requirements and the public's psychological effect about pandemic prevention, the intercity travel volume has decreased, such as the travel volume for air, railways and highways. In the meantime, the intracity discretionary travel demand, such as the travel demand for leisure, tourism, and social activities, has been minimized, and the urban transportation system has shown the characteristics of decreased total volume while increased shares of personalized transportation modes.

1) The total intercity travel volume is small, and the passenger volume for air, railways and highways has reduced significantly

Statistics released by Beijing Municipal Bureau of Statistics

show that the total intercity passenger volume for Beijing was 10.152 million in February 2020, including 8.177 million highway passengers, 650,000 railway passengers, and 1.325 million air passengers. However, these numbers were 52.063 million, 34.437 million, 10.158 million, and 7.468 million^[1] respectively for February 2019. It is evident that the total intercity travel volume has dropped sharply due to the COVID-19 pandemic.

The number of airline destinations during the COVID-19 pandemic decreased from 114 to 62 for the domestic network and from 71 to 34 for the international network at the Beijing Capital International Airport. It dropped significantly for the domestic network and was almost zero for the international network at Beijing Daxing International Airport^[2].

2) Within Beijing, the travel volume decreased and more people are traveling by personalized transportation modes

Under normal circumstances, the travel volume within Beijing is about 62.07 million trips per day, and the average trip rate for each traveler is about 2.6 trips per day. The resident population makes 92% of the total trips, and the floating population makes 8%. Commute trips takes the largest share of the trips made by the resident population; business and work trips account for 75% of the trips made by the floating population^[3] (Fig. 1). Due to the COVID-19 pandemic, the Beijing government requires that the proportion of employees who work on site for densely-populated companies shall not exceed 50% by taking measures such as flexible work schedules, working from home, taking turns to be on site, and staggered rush hour. According to the data released by Beijing Municipal Commission of Transport, it is estimated that

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the travel intensity of Beijing residents in March, 2020 had recovered to about 60% of the level over the same period of 2019. The traffic indexes on working days during peak hours in the central area of Beijing were 2.08 and 3.84 in February and March (as of March 23), 2020, decreased by 42% and 36% from the same period of 2019. On March 23, 2020, there were 2.68 million cars running on the road, which is 68% of the normal value.

Before the COVID-19 pandemic, Beijing has formed an urban transportation structure that is mainly composed of public transportation, walking and cycling (Fig. 2). After the

outbreak of the pandemic, the concerns about the travel risks have affected residents' choices of transportation modes. An Internet survey conducted in early March 2020 by Institute for Transportation and Development Policy (ITDP) in the US showed that the mode share of public transportation had declined significantly due to the COVID-19 pandemic. For example, the share of subways had declined by more than 50%, from 29.2% to 13.5%, and the share of buses had also declined with similar magnitude. On the other hand, the share of cars had increased from 36.8% to 40.1%, and the share of walking and cycling had also increased slightly^[5].

Fig. 1 Aggregated daily travel in Beijing by trip purposes

Source: Reference [3].

Fig. 2 Travel mode share on working days within the central district of Beijing in 2018

Source: Reference [4].

Beijing's data showed similar changes. Under normal circumstances, the average weekday passenger volume of Beijing's subway network was about 10 million passengers per day. However, it was only about 0.7 million in the first week after February 10, 2020, on which day people returned to work officially, and this number was less than 10% of the number for the same period of 2019. The total passenger volume for April 1, 2020 on the 16 lines managed by Beijing Subway was 3.047 million, whereas it was 10.090 9 million for the same day in 2019. Currently, the load factor of public transportation is still strictly controlled, and the passenger volume is only 30% of that for the same period of the last year. In contrast, bicycle-sharing is favored. According to the data of the bicycle-sharing companies, after the resumption of work in Beijing, the bicycle usage of Meituan is 1.87 times of the normal value, and it is 1.37 times for Hellobike and 1.20 times for Qingju.

2 Traffic management during recovery from COVID-19 outbreak

The COVID-19 situation is now stabilized in China but is not over yet. As an international and domestic hub city, Beijing may face more risks. COVID-19 broke out in China during the Spring Festival, when many people left Beijing for home. According to the data released in 2017 by Beijing Municipal Commission of Transport, the number of people in Beijing decreased by 8.48 million during the Spring Festival, which accounted for 39% of the resident population. Therefore, a large number of people need to return to Beijing after the Spring Festival, which presents great challenges to the prevention and control of the pandemic. Furthermore, as the core of the Beijing-Tianjin-Hebei region, Beijing has an average exchange volume of more than 860,000 persons per day with the Tianjin-Hebei region, which accounts for half of Beijing's daily exchange volume. On the other hand, COVID-19 is now breaking out in many overseas countries, and Beijing, as an international hub city, is facing greater risk of COVID-19 cases from abroad. Special management measures must be taken so that the spread of COVID-19 can be prevented and the transportation system can be restored gradually as a carrier for people to travel.

2.1 Strictly control major transportation hubs such as airports and railway stations

The international communication function of Beijing determines that Beijing has close contact with other overseas cities, and airports are transportation hubs to connect with the world. Beijing's railway hubs are undertaking the task to serve the departure, arrival and transfer of numerous domestic passengers. Since airports, railway stations and other transportation hubs have become the first line of defense to block viruses from entering the city, the management of passengers who arrive at the city through transportation hubs

should be strengthened. For the purpose of reducing the potential risk of virus transmission, airport-dedicated transit lines can be operated according to flight schedules and their load factors should be controlled strictly to provide point-to-point connection service. In addition, due to the changes in transportation modes, the management of vehicles, such as taxis and ride-hailing vehicles, should be strengthened to ensure adequate supply. More parking facilities should be added and temporary parking areas should be installed around major transportation hubs to meet the short-term parking needs of drop-off and pick-up vehicles. At the same time, the organization of transportation around the hubs should be optimized and traffic order should be maintained.

2.2 Take advantage of highway checkpoints

According to *Beijing Highway Checkpoint Construction Plan (2019–2035)*, the highway checkpoint integrates the law enforcement function of several government departments, such as security inspection of Public Security Bureau, counterterrorism of Armed Police Force, licensing and inspection of Traffic Management Bureau, exhaust inspection of Environmental Protection Agency, oversize and overload control of Department of Transportation, animal quarantine of Quarantine Bureau, and timber transportation inspection of Forestry Administration. The highway checkpoint is the front line and an important carrier for integrated management of the capital of China. At present, Beijing has 44 highway checkpoints on 10 national freeways, 15 ordinary national highways, and 20 municipal roads to secure important political, economic, and cultural activities. In the past, highway checkpoints have also played an irreplaceable role in the prevention and control of the American white moth and African swine fever. During the COVID-19 pandemic, highway checkpoints should continue to play the role of firewalls and strictly check people and vehicles that are going to enter Beijing. At the same time, it is recommended to use intelligent means to share highway traffic data and mobile phone signaling data, so that the driving routes of vehicles can be monitored dynamically and people and vehicles from pandemic hotspots can be found.

2.3 Provide diversified public transportation services

Public transportation, such as subways and buses, is the transportation mode that car-free travelers must choose for long-distance travel. Giving priority to public transportation is also one of the fundamental methods to solve traffic congestion problems in large cities. In the current special period, public transportation has certain risks due to its closed and crowded space, so few people are taking it. However, the transportation demand in a special period cannot become the normal. As a megacity, Beijing has always taken public transportation priority as its urban transportation strategy, but the way that public transportation provides service should be

adjusted appropriately due to the changes in travel demand during a special period. The Mobility as a Service (MaaS) platform established in Beijing should be used to provide services to travelers over their entire trips. This platform can integrate indicators such as the degree of congestion on buses and subways, which can display the travel time and cost of various transportation modes. Therefore, it can provide travelers with intelligent one-stop door-to-door travel guidance over the entire travel process, e.g., intelligent decision-making before the trip, full-course guidance during the trip, and incentives to go green after the trip. It can also provide the trip planning service for the entire process of intercity travel. In addition, it is suggested to provide customized shuttle service for companies to meet their demand for resumption of work.

2.4 Take special measures to manage the travel demand of private transportation during the special period

During the pandemic, private transportation such as cars plays an important role in ensuring urban mobility. Before lifting the pandemic travel restrictions, the Beijing government relaxed regulations to meet the travel demand during the special period. For example, the Beijing government suspended the regulation that restricts cars from traveling on certain days of the week based upon the last digit of the license plate number. In addition to providing convenience to car travel, appropriate policies have also been provided to parking. For companies that can accommodate the parking demand of commute trips during the special period, they should allow their staff to drive into and park on the corporate campus, or temporary parking spaces can be designated at the entrance for short-term parking to avoid interference with the traffic on the public road. For companies or residential areas with tight parking resources, temporary parking spaces can be installed on roadways during the special period.

3 Enlightenment of public health emergency on transportation planning in megacities

3.1 Construct a comprehensive three-dimensional transportation network to improve resilience of the network

The *Program of Building National Strength in Transportation* proposes to build a three-dimensional transportation network with a fine infrastructure layout and strong interconnection, which would support the goal of building national strength in transportation. Beijing has preliminarily built a comprehensive three-dimensional transportation network that serves at three levels. In the global network, Beijing is an important node with a three-dimensional transportation network that is finely laid out and interconnected. This three-dimensional transportation network

consists of air, railways, highways, pipelines and other transportation modes, which enables Beijing to function as an international transportation hub. At the regional level, Beijing is the core of the Beijing-Tianjin-Hebei region and has built an intercity network that primarily consists of high-speed railways, intercity railways and highways. This intercity network enables Beijing to access the major cities of the Beijing-Tianjin-Hebei urban agglomeration in less than 1.5 h. Within the Beijing urban area, a one-hour metropolitan area has been built based upon regional rail express, rail transit and high-level highways. In the future, Beijing should continue the goal of modernizing infrastructure, intelligently managing traffic and integrating transportation services. Important transportation infrastructure corridors and nodes should continue to be optimized at three levels: the international hub, the core city of the Beijing-Tianjin-Hebei region and the megacity. It is also suggested to strengthen the connection of networks for different transportation modes, make full use of the three-dimensional transportation network, and find the alternative for each transportation mode to enhance the anti-risk ability and increase the resilience of the transportation network.

3.2 Give priority to public transportation while providing space to other transportation modes

The individualized and diversified needs of travelers determine the diversity of urban transportation modes. Each transportation mode, such as walking, cycling, public transportation, cars and taxis, has its own advantages and disadvantages, and all modes are rational choices in certain circumstances. During the COVID-19 pandemic, private transportation modes, such as cars, bicycles, walking and even motorcycles, have all played an important role. Although giving priority to public transportation is a strategy that big cities should unswervingly stick to, other transportation modes should not be suppressed and development space should be provided to them by fully considering the compatibility of various transportation modes in the supply of road resources. For the purpose of ensuring the healthy development of urban transportation, space resources should be allocated by taking various management measures, such as designating bus only lanes and implementing congestion pricing on cars over certain periods. In addition, urban development plans should include some land exclusively reserved for transportation facilities, which should have certain flexibility to deal with the uncertainty of urban development in the future. The possibility of sharing the land for transportation facilities by multiple transportation modes should also be considered. For example, urban public parking lots can meet the parking need of buses and bicycles, and they could as well be converted into places for the parking and maintenance of driverless cars in the future.

3.3 Pay more attention to walking and cycling

Walking and cycling are essential components of a city's

comprehensive transportation system. They can ensure social justice, which are convenient, flexible to use, and environment friendly. Walking is also a basic travel mode for human. Impacted by motorization, the urban bicycle traffic volume has shrunken year by year, and the walking and cycling space has also been reduced. However, walking and cycling have received more attention gradually due to the goal of building a livable city, and the changes in travel behaviors caused by the COVID-19 pandemic urge megacities to pay more attention to the role of walking and cycling in urban transportation. The 15-min community life circle, which is built by taking walking and cycling as the transportation modes, can not only provide convenience for people's daily life but offer a reliable transportation network to provide residents with supplies in public safety emergencies. It is recommended to guarantee enough passage space for walking and cycling, provide the shortest path that is exclusively for pedestrians and bicycles within street blocks, and improve the efficiency of walking and cycling. It is also recommended to build a complete citywide walking and cycling network that is composed of municipal roads, dedicated roads, urban greenways, etc. and strengthen the construction of bicycle parking facilities and regulate the bicycle parking order. Besides, it is also advised to accept legal electric bicycles and provide them with parking and passage space as well as optimize the operation of bicycle sharing and regulate its parking order.

3.4 Strengthen urban logistics system

Logistics is an essential safeguard to maintain the normal operation of a city, serve the daily life of urban residents, and support urban development. In the past, more attention was paid to urban passenger transportation, and the space control of logistics facilities was neglected to some degree since logistics facilities had been mainly driven by the market and constructed and operated by enterprises for a long time. With the rapid development of Internet Plus, logistics demand is reflected in efficient "door-to-door" delivery, and many residents use the Internet to obtain basic living necessities, especially during the COVID-19 pandemic. It is recommended to scientifically formulate a special plan for the urban logistics system by considering various factors comprehensively, such as urban positioning and development, spatial distribution of population and industries, land use, road network planning, and public facility layout. It should plan the layout of infrastructures and public resources that are related to the urban logistics network and various transportation modes, such as railways, highways, waterways, air, and pipelines, so that the integration and optimal allocation of urban logistics resources can be maximized. It is recommended to strengthen the last mile delivery of urban logistics, integrate the last-mile-delivery facilities and resources for communities, office buildings, schools, enterprises and institutions, support

the construction of various forms of last-mile-delivery distribution centers and outlets, and achieve the goal to cover the entire urban area with last-mile-delivery distribution centers and outlets. The last-mile-delivery distribution centers and outlets should be included in the planning and construction of newly built communities to provide users with convenient last-mile express delivery^[6]. It is also recommended to strengthen the management of logistics distribution vehicles and consider the passage space of the vehicles that comply with the regulations in relative plans. The application of 5G technology, vehicle-road collaboration technology, and autonomous driving technology should be realized in the field of logistics. The intelligent logistics system that integrates the networks of passengers, freight and information should be built, and the unmanned distribution business should be promoted gradually.

3.5 Pay attention to the Internet, big data, the Internet of Things, artificial intelligence and other information technologies

A city is a complex huge system, but it is now possible to map and virtually reconstruct real cities in computers since new technologies, such as cloud computing, big data, the Internet of Things, and artificial intelligence, are becoming more mature. All the elements that constitute an urban system are digitized, modeled, and defined by software to build a parallel city. The parallel city can not only describe the real urban system accurately but be used to construct virtual scenarios to evaluate the urban system's control plan, predict the urban system's operating status, and warn of the urban system's future health status. The travel demand under normal circumstances follows certain rules, which can be obtained traditionally through surveys, and urban transportation planning and management can be determined and adjusted based on historical data. However, there is no historical data for the characteristics of abnormal travel demand or people's activity patterns during some public health emergencies. The parallel city that has been constructed can then be used to simulate and infer the state, characteristics, and development situations of the urban system under different environments, backgrounds and assumptions, which can be employed to analyze and predict the real urban system and provide intelligent analysis and support for various decisions^[7] (Fig. 3).

4 Conclusion

The urban transportation system is an essential support for the normal operation of a city. The COVID-19 pandemic has caused a huge impact on normal life, and the changes in travel demand have triggered thinking on the supply and management of urban transportation facilities. The impact of public health emergencies should be considered at the

Fig. 3 Functional characteristics of parallel cities

Source: Reference [7].

beginning of urban transportation planning, and a comprehensive three-dimensional urban transportation network that can carry various transportation modes and ensure efficient flow of people and goods should be built. Thus the capacity for the urban transportation system against risks can be improved.

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