Citation: ZHANG Xiaochun, SHAO Yuan, SUN Chao, LONG Junren, AN Jian, LIN Yulong. Data-Driven Pandemic Response and Delicacy Governance of Shenzhen Transportation [J]. Urban Transport of China, 2020 (4): 93–100.

Data-Driven Pandemic Response and Delicacy Governance of Shenzhen Transportation

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Abstract: In the early rapid response to the Coronavirus Disease 2019 (COVID-19), urban operations encountered a series of emergency problems. To build a credible, controllable, and reliable transportation system, this paper discusses the overall situation of pandemic prevention and control, travel demand between Shenzhen and outside groups, urban traffic operation, activities in key areas, and enterprises resuming normal functions based on big data. Focusing on the key issues such as how to dynamically and accurately identify the changes of citizens' travel demand and travel chain characteristics of the whole population, the paper puts forward the measures for the transformation of urban transportation system from the conventional pursuit of "large passenger flow and high efficiency" to "safe, reliable and accurate control." Finally, the paper points out that developing a resilient transportation system should be included in the long-term transportation strategy to ensure urban operation.
DOI: 10.13813/j.cn11-5141/u.2020.0406-en

Keywords: pandemic prevention and control; reliable bus; delicacy governance; resilient city; Shenzhen

0 Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic broke out in China during the Spring Festival of 2020, which has imposed a great impact on people's production and daily activities. At the meeting to coordinate and promote the prevention and control of COVID-19 and the deployment of economic and social development, General Secretary Xi Jinping emphasized that the key for enterprises to resuming work and production is to break the bottlenecks of people and freight flow. Along with the return of people after the Spring Festival and the gradual resumption of production by various enterprises and institutions in Shenzhen, the goal of urban transportation service has changed from the pursuit of large capacity and high efficiency to more reliable and credible control of pandemic risks.

The traffic operation in Shenzhen is facing severe challenges, which are mainly reflected in three aspects: 1) There is a lack of special traffic control and service methods to deal with the COVID-19 pandemic. There is also a lack of retrospective investigation methods to trace people at risk who have taken public transportation with confirmed COVID-19 patients. Therefore, residents may have a sense of distrust in taking public transportation, which is relatively crowded. 2) There are differences in the arrangements for the resumption of work in enterprises and institutions throughout the city. Due to the lack of sufficient and timely information of commuting trips, such as the scale, the temporal and spatial characteristics, and the mode structure, it is difficult to accurately predict and formulate plans to avoid the mass gathering of passengers. 3) The passenger flow of rail transit and buses has dropped sharply because the departure intervals have increased and some lines have been suspended. Therefore, a large number of trips have been shifted to cars, which puts great pressure on road traffic and brings new challenges to the measures and the timing of policy control.

Pandemic prevention and control can be divided into three stages: the early rapid response, the middle protection and recovery, and the late optimization and construction. In response to the emergent problems in urban operations encountered in the early rapid response to the COVID-19 pandemic, Shenzhen quickly developed efficient response capability in city governance and employed traffic big data to continuously track the trend of the pandemic. This data-driven approach supported the formulation of a series of pandemic prevention measures and traffic management regulations in Shenzhen. Shenzhen's experience can be beneficial to other megacities with a large number of migrants for traffic delicacy governance in the context of pandemic prevention and control combined with Spring Festival travel rush.

Received: 2020-03-06
Supported by: National Key Research and Development Program of China (2018YFB1601100)
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1 Use big-data-based tracking to support the government's decision-making

1.1 Overall situation of COVID-19 in Shenzhen

In response to the COVID-19 pandemic, Shenzhen quickly established the coordination and command mechanism for pandemic prevention and control and concentrated its technical forces to grasp the pandemic changes in a comprehensive, dynamic and timely manner. These measures provided the big-data foundation for delicacy governance. The declaration methods, such as i-Shenzhen and the "Pandemic Prevention Pass (Fangyi Tong in Chinese)" Platform, were used to collect the travel and health information of residents during the COVID-19 pandemic. These methods provided the basis for the fine pandemic prevention and control at the level of communities, enterprises, and transportation hubs. Due to the return of the migrants after the Spring Festival, most of the COVID-19 cases in Shenzhen were imported ones. According to the statistics from Shenzhen Municipal Health Commission, Shenzhen reported 417 confirmed COVID-19 cases and 308 discharged cases as of February 29, 2020. Most cases were confirmed between January 19, 2020 and February 10, 2020. Due to the implementation of a series of pandemic prevention and control measures across the country and Shenzhen City, the number of daily cases has dropped significantly since February 8, 2020 (Fig. 1), and the COVID-19 pandemic has been preliminarily controlled in China. The pandemic trends before and after the implementation of pandemic prevention measures nationwide and in Shenzhen were analyzed and compared, which can help master the overall situation of the pandemic and support the formulation of subsequent measures to ensure smooth transportation operations.

1.2 Intercity travel

Passenger flow data (including passengers traveling by sea, land, air and railway), Tencent location data, i-Shenzhen data and others were adopted to assess the passenger flow in Shenzhen during the Spring Festival. They were also used to study the trend of returning passenger flow and support the prevention and control of traffic safety risks at key transportation hubs. Multisource big data were collected to conduct comprehensive and accurate studies on the scale, structure and distribution of the people returning to Shenzhen. These studies can help concentrate pandemic prevention and control efforts on key population groups and intercity transportation hubs, which can support to determine how to appropriately extend the period for people to return to Shenzhen after the Spring Festival. According to Shenzhen Spring Festival Transport Office, within the 40-day period of the Spring Festival travel rush from January 10 to February 18, 2020, the numbers of passengers arriving in and departing from Shenzhen by sea, land, air and railway (not including people traveling by car) were 7.534 million and 10.194 million respectively, with a year-on-year decrease of 51.3% and 40.9%. Within the 25 days of the COVID-19 outbreak from January 25 to February 18, 2020, the numbers were 2.806 million and 1.739 million respectively, with a year-on-year decrease of 73.9% and 80% (Fig. 2). During the Spring Festival travel rush, about 60% of the passengers arriving in Shenzhen came from Guangdong Province (60.5%), followed by Hunan (7.3%), Jiangxi (3.8%) and Guangxi (3.3%). Due to the lockdown of Hubei Province, the period of returning to Shenzhen from Hubei Province has been extended. The passengers traveling from Hubei to Shenzhen accounted for 2.1% of the total passenger flow arriving in Shenzhen, and nearly 1.9 million Shenzhen permanent residents who migrated from Hubei are still waiting to return to Shenzhen. In addition, the number of intercity trips made by Shenzhen residents during the Spring Festival dropped significantly due to the impact of the COVID-19 pandemic. The intercity passenger volume of Shenzhen was less than 50% of the volume for the same period of 2019.

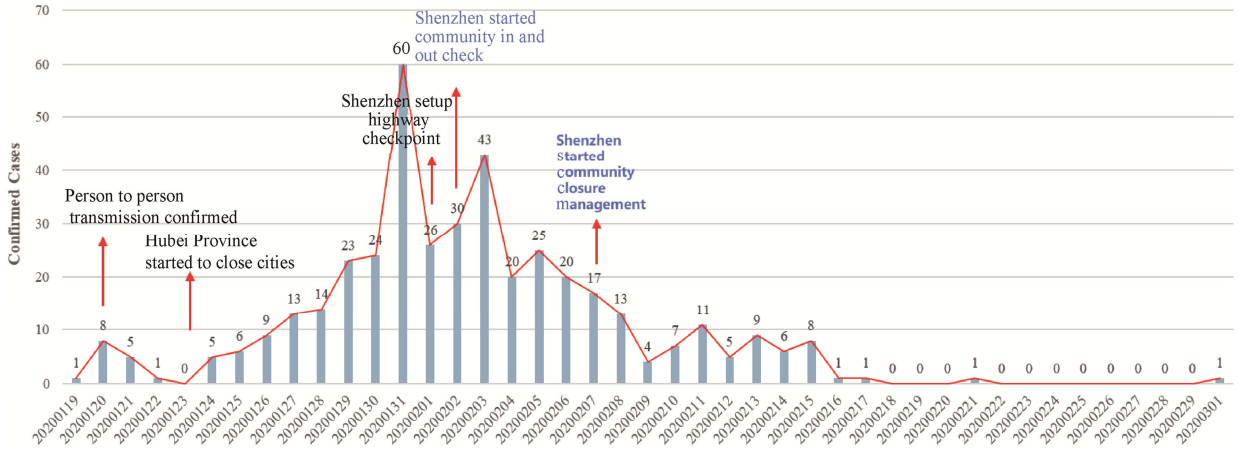

Fig. 1 Daily confirmed new COVID-19 cases in Shenzhen

Source: Shenzhen Municipal Health Commission.

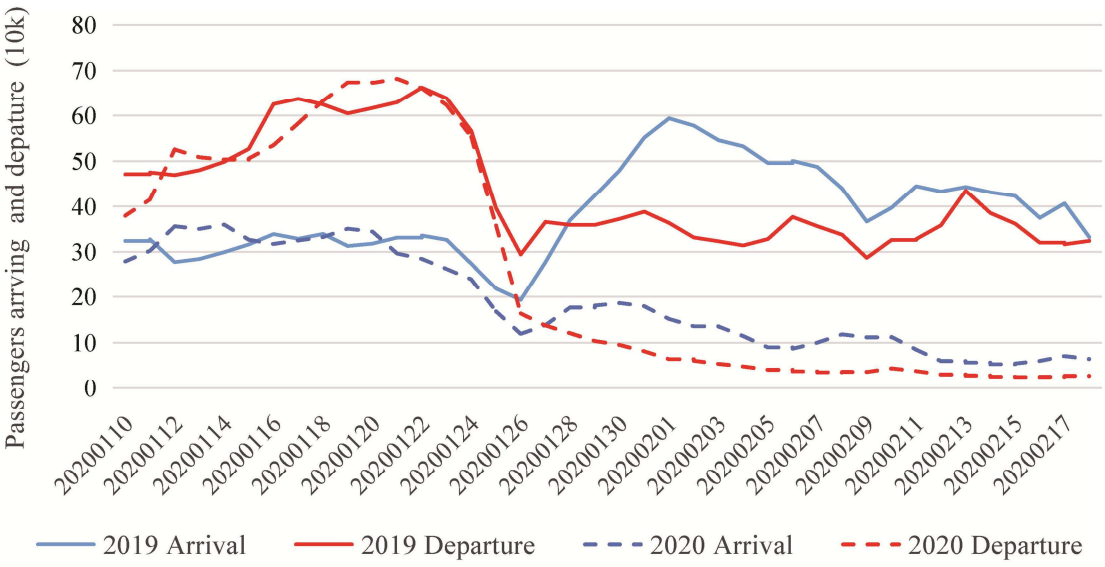

Fig. 2 Comparison of departure and arrival passenger volume of urban external traffic in 2020 and 2019

Note: Passenger volumes do not include people traveling by car. The 2019 dates have been aligned to match the Lunar New Year dates of 2020. Source: Spring Festival Transport Office of Shenzhen Municipal Transportation Bureau.

1.3 Intracity travel

Shenzhen Tong smartcard data, traffic operation index data and other data were adopted to analyze the trend of public transportation and car trips, which laid a strong base for urban traffic safety management and pandemic prevention and control. Dynamically tracking the changes in the passenger flows of rail transit, bus, and taxi ensured the dynamic adjustment of urban transportation capacity. During the 40-day period of the Spring Festival travel rush in 2020, Shenzhen's bus and rail transit passenger volumes were 48.23 million and 80.114 million respectively, presenting a year-on-year decrease of 60.9% and 53.1% (Fig. 3). The bus and rail transit passenger volumes between the 15th and 40th day of the Spring Festival travel rush dropped by 91.8% and 89.9% respectively, compared with those in the same period last year. After February 18, 2020, public transportation capacity gradually recovered along with the resumption of work. Compared with that in the same period last year, the rail transit passenger volume recovered to 30% as of February 28, 2020; the bus passenger volume recovered to approximately 13% as of February 20, 2020. Affected by the COVID-19 pandemic, the travel mode has changed with residents preferring private cars when making trips, and the traffic operation index was less than 50% of the last year. Along with the resumption of production and work, travel demand will be released gradually, and it is predicted that roadways will face great pressure.

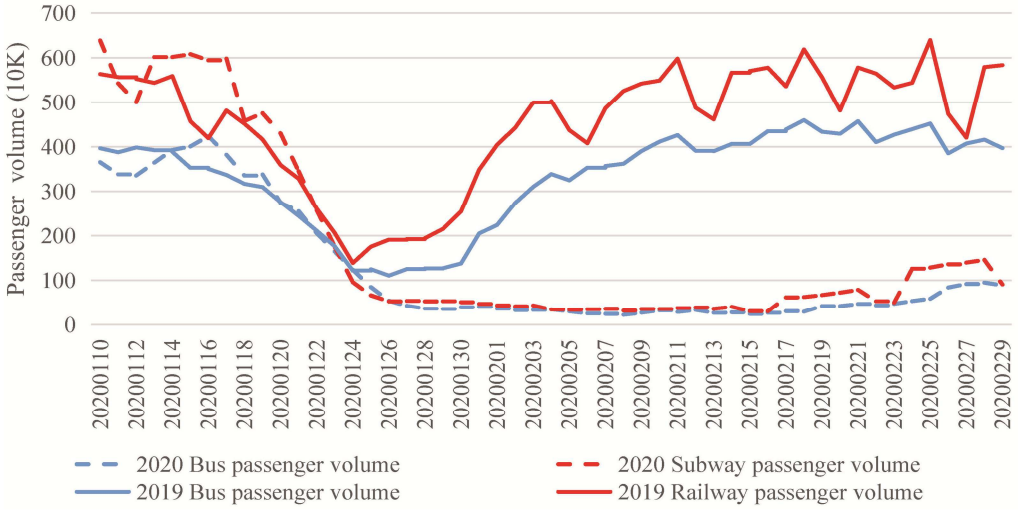

Fig. 3 Comparison of urban public transportation passenger volume in 2020 and 2019

Note: The 2019 date have been aligned to match the Lunar New Year dates of 2020. Source: Shenzhen Municipal Transportation Bureau.

1.4 Regional activities

WeChat location data was adopted to analyze the activity intensity of 61 key areas to ensure transportation capacity for potential travel demand. These key areas included transportation hubs, business districts, employment centers, and scenic spots. Affected by the COVID-19 pandemic, the activity intensity in Shenzhen's key areas, such as intercity transportation hubs, large business districts, employment centers, and scenic spots, dropped significantly (Fig. 4). The average daily intensity of passenger flow between February 3, 2020 and February 18, 2020 was 20% to 30% of the normal values (namely the average intensity of passenger flow of weekdays in 2019). The activity intensity of the airport and railway hubs was 30% to 40% of the normal values, and the scale and density of the people flow at Donghu, Yinhu, Yantian and other intercity bus terminals were about 50% of the normal values. Affected by telecommuting and the delay in the resumption of work, the activity intensity of business and office areas, such as Futian CBD, Baoan Central District, Longgang Central City, and Shenzhen Bay Science and Technology Ecological Park, was only 20% to 40% of the normal values. Along with the gradual resumption of work after February 18, 2020, the activity intensity of the main office areas has reached 50% to 60% of the normal values. At the same time, under the influence of the COVID-19 pandemic, residents' activity radius has shrunk to a travel requiring 15 minutes, and their demand for safer transportation modes, such as walking and cycling, has increased significantly.

1.5 Resumption of work and production

Electricity consumption data, Baidu map migration data, and official government data were adopted to analyze the business activity level and work resumption rate. This can support the decision-making to ensure reliable urban traffic operation and service after the large-scale resumption of work in the future.

Shenzhen used smart-city big data from state-owned enterprises to conduct timely analysis to scientifically organize and ensure orderly resumption of production and work. Since then, the city's electricity consumption has maintained a steady growth. Between February 9, 2020 and February 12, 2020, the maximum daily electricity consumption was approximately 700 000 kWh, which was only 14% of the value over the same period in 2019 (5 million kWh); the business activity level was 10% to 20% of the value over the same period last year. About 95% of micro, small and medium enterprises had a severe cash flow, and it was difficult for them to maintain operations. To respond to this situation, Shenzhen Municipal Government has issued a series of policies to support the resumption of work in a timely manner, which ensured the recovery of production effectively.

2 Develop a resilient transportation system by data-driven delicacy governance

Shenzhen conducted in-depth traffic operation analysis under the COVID-19 pandemic based on comprehensive multisource data, such as mobile signaling data and the data from Shenzhen Traffic Monitoring Platform, Shenzhen Spring Festival Transport Office Daily Report, Tencent Wechat Migration, "Pandemic Prevention Pass" Platform and i-Shenzhen app. To dynamically and accurately identify the changes in residents' travel demand and the whole population's travel chains, Shenzhen took a series of measures, such as proactive prevention and control at key transportation

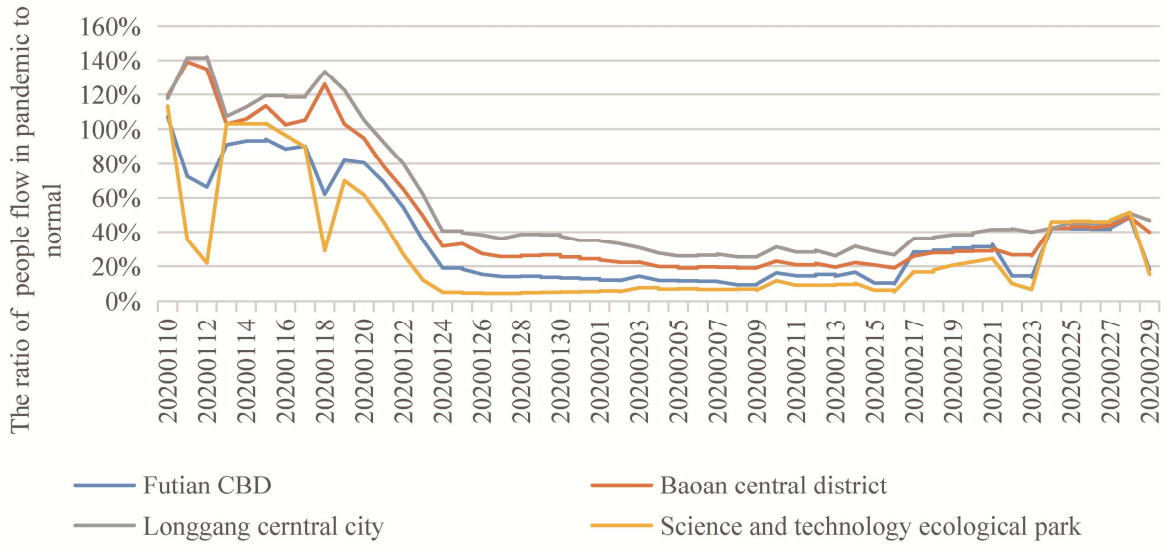

Fig. 4 Comparison of weekday passenger flow intensity in urban major commercial districts in 2020 and 2019

Source: Tencent location data.

hubs, dynamic operation scheduling of railway transportation, development of "credible" public transportation, dynamic control of urban traffic, and construction of 15-minute daily life circle. The establishment of the "credible, controllable and reliable" resilient transportation system accurately supported the transportation capacity and the control of traffic safety in Shenzhen during the Spring Festival travel rush under the impact of the COVID-19 pandemic.

2.1 Proactive prevention and control system to accurately track people returning to Shenzhen at key transportation hubs

As of February 15, 2020, the passenger volume of main transportation hubs in Shenzhen has recovered to 20% to 40% of the values over the same period last year (Fig. 5). As nearly ten million passengers returned to Shenzhen in the next stage, the joint prevention and control of the city's transportation hubs was strengthened to strictly prevent imported COVID-19 cases. First, all passengers arriving in Shenzhen were required to use the "Shen i Nin" applet to fill in basic personal information, recent itinerary and fever information. Second, the connection demand at transportation hubs during the peak return-to-Shenzhen period was studied in advance based on multisource data to formulate connection plans for important transportation hubs, such as airports and high-speed railway stations. The multisource data included data from Shenzhen Traffic Monitoring Platform, i-Shenzhen app and Wechat location. Public transportation resources were allocated reasonably and it was ensured that all first-line transportation hubs had adequate connection capacity of public transportation to achieve the goal of fast and safe distribution of passengers. Third, passenger density in airports, high-speed railway stations and other hubs was monitored dynamically to avoid a mass gathering at transportation hubs. In addition, the precise quarantine mode was first implemented in the airport. This quarantine mode involved customs, border inspection and airlines. By matching data in the database, it precisely quarantined high-risk passengers from key areas, classified suspected passengers with COVID-19, tracked close contacts and improved the efficiency of pandemic inspection.

2.2 Management and control system to organize, operate and dynamically dispatch rail transit based on the accurate prediction of passenger flow

With the gradual alleviation of the COVID-19 pandemic and the gradual resumption of production, the rail transit passenger volume increased gradually and the average passenger volume has reached 20% to 30% of the level over the same period of 2019. The operation and scheduling of rail transit is challenged by uncertain passenger flow and pandemic prevention and control. It is therefore urgent to analyze the data of work resumption to make suggestions on the allocation of transportation capacity.

1) Daily operation of rail transit should be based on the multi-scenario forecasting of the passenger travel demand for the next week according to the data of work resumption. For example, two scenarios were studied by assuming 50% and 80% of employees resuming their work. In each scenario, the passenger volume of each rail transit line, the peak load and the top 20 stations with the highest passenger entries and exits were forecasted for the next week (February 24 to February 28, 2020). Since the rail transit passenger density was under control due to pandemic prevention measures, the results from the scenario where 80% of employees resumed their work were taken as a reference to organize the rail

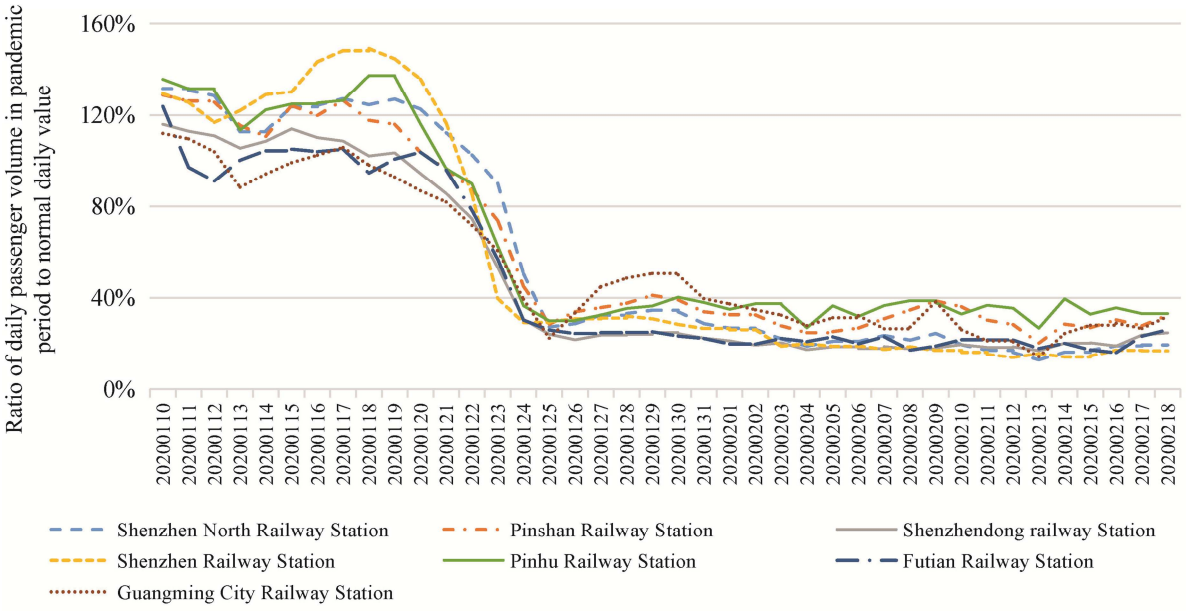

Fig. 5 Comparison of passenger flow in urban areas within the main railway terminals in 2020 and 2019

transit operation. The forecast results indicated that the passengers entering and exiting rail transit stations in the morning peak (7:00 am to 9:30 am) accounted for 25% of the daily passenger volume with apparent tidal characteristics due to the plunge of the non-commuting travel demand. It was forecasted that the load factors of Line 3 and Line 4 were approaching 30%, and the passenger flow pressure was mainly concentrated on railway carriages over peak hours and peak sections and rail transit stations with high passenger volumes. According to the "Guidelines for Region-specific and Hierarchical Prevention and Control of COVID-19 Pandemic at Passenger Terminals and on Transportation Vehicles" issued by Ministry of Transport of the People's Republic of China, the transportation capacity of rail transit should be allocated appropriately so that the load factors are less than 50%. In addition to ensuring the conformity to this requirement, the passenger flow forecasting results provided accurate decision-making support to rail transit companies on various measures. These measures were used to allocate transportation capacity during the peak to accommodate high passenger volume and to reduce the risk of cross infection, including controlling the passenger density of railway carriages, dispatching standby vehicles and implementing the alternative operating plan for the peak period. The continuous monitoring of the actual rail transit operation showed that the load factor of the entire rail transit network was 41%, which ensured the smooth operation of the urban rail transit.

As more employees resumed their work gradually, rail transit stations around employment centers, such as Luohu, Futian, and Nanshan, significantly improved their rankings among the top 20 stations with the highest passenger entries and exits (Fig. 7); Chegongmiao Station, Grand Theater Station, Shenzhen University Station, and High-tech Park Station were all ranked in the top 10. Therefore, flexible work schedules were recommended. Government agencies, institutions, and state-owned enterprises should start work 30 minutes earlier or later, and private enterprises were encouraged to take the same measures.

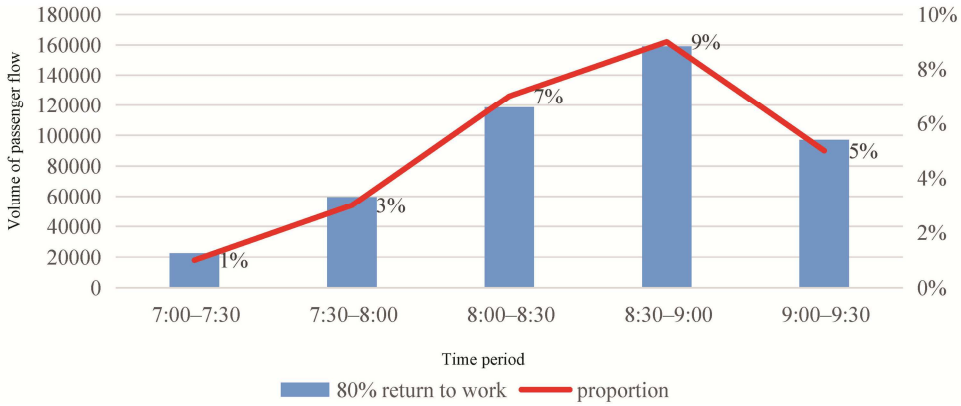

Fig. 6 Passenger volume of entering/departing rail transit stations in the whole network during peak hours

Source: Shenzhen Metro Construction Command Office.

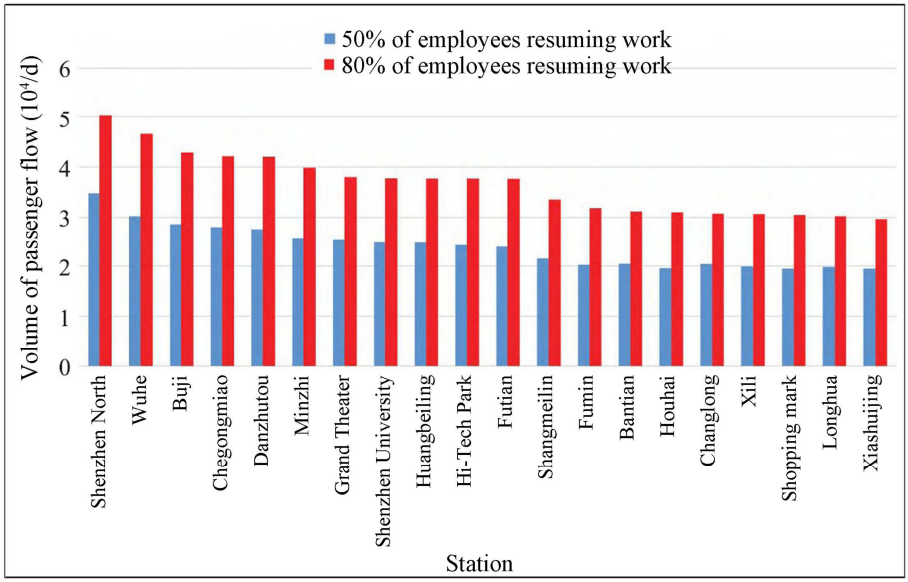

Fig. 7 Forecast on passenger volume of entering/departing stations

2) The real-time monitoring and early warning system for rail transit should warn of high passenger-flow events in time by dynamically monitoring the congestion in railway carriages. An intelligent display system has been built for Line 11 to report the congestion of each railway carriage every 10 seconds, which can be obtained in real time through a WeChat applet, to avoid the gathering of passengers. In the future, smartcard data from the Automatic Fare Collection (AFC) system would be used to derive the passenger volume of the entire rail transit network, which would enable the distribution of congestion for the entire network to guide residents in avoiding congestion.

2.3 Credible, controllable and traceable public transportation system

As the gradual increase in travel volume due to the resumption of work, the passenger volume of intensive public transportation modes (such as rail transit and buses) is expected to grow rapidly to 4–5 million passengers per day. Transportation capacity should recover accordingly based on different travel demand in different areas. The passenger density of buses and platforms should be safe and controllable, and essential public transportation service should be secured during the COVID-19 pandemic. At the same time, the operational mode of the public transportation system over the abnormal period should be explored. For example, customized and demand-responsive bus services should be promoted to provide safe and reliable service to commuters.

1) Real-name registration is fully implemented for bus passengers so that bus-riding activities of comfirmed cases could be traced and the close contacts could be screened and alerted. All rail transit, buses, taxis and trams operated in Shenzhen have a unique code on each vehicle (or each railway carriage). Once the code is scanned, the passenger information is linked with the numbers of license plates and lines, and passengers would be notified in time if they are close contacts of suspected or confirmed cases of COVID-19. The next step is to promote the registration of the passenger's trip chain, which will be implemented on all public transportation modes and even in major public spaces.

2) Shenzhen initiated special bus lines dedicated for enterprises that had resumed production and promoted customized and demand-responsive bus services which were safer. Idle transportation capacity was utilized to provide point-to-point service, which lowered the risk of infection from travel activities. Based on the trip information reported by 230 000 employees on the state-owned "Pandemic Prevention Pass" platform, the demand of the commuters was accurately matched with the supply to provide customized bus services for enterprises. The first batch of 20 bus lines has been put into operation, providing more than 370 state-owned enterprises in Huaqiangbei, Grand Theater and other areas with safe and comfortable door-to-door bus service.

3) Three lines of defense in pandemic prevention were established based on big data: ① The first line is to verify passenger information. A special bus line platform for pandemic prevention and work resumption is currently connected with the "Pandemic Prevention Pass" platform. It can obtain the health status of the employees who work in state-owned enterprises in real time. Passengers who do not meet the safety requirements are not allowed to purchase tickets. All passengers in a bus on a special work-resumption bus line have passed the strict identity and health verification of the "Pandemic Prevention Pass" platform, making such buses safer and more reliable. ② The second line is to trace passengers. The travel chain of an employee can be restored to deduce this employee's true situation so that concealed or missing report can be identified. The restoration of travel chain depends on the key technology from the National Key Research and Development Project of "Big Data Intelligent Computing Platform for Urban Transportation" led by Shenzhen Urban Transport Planning Center (SUTPC). It is based on transportation big data such as data from airports and high-speed railways, as well as city-level data from mobile operators. ③ The third line is to control the load factor. Real-time monitoring of dynamic employee demand and flexible vehicle deployment can ensure that the vehicle load factor would not exceed 50%. For example, the number of passengers on a 50-seat bus is strictly controlled to be below 25 to reduce the risk of cross infection.

2.4 Urban transportation system under dynamic control regarding travel restrictions, parking, etc.

Based on the changes in residents' living habits and travel demand during the COVID-19 pandemic, Shenzhen fully evaluated the traffic and parking pressure induced by the shift from public transportation to private transportation after the resumption of production (February 10, 2020, which is the 31st day of Spring Festival travel rush). The evaluation results supported the decision-marking of the government in pandemic prevention and deployment, which improved the government's capacity for pandemic prevention and risk control.

1) Enterprises and institutions are encouraged to adopt flexible modes of work resumption and commuting. Since January 30, 2020, Shenzhen's traffic operation index during peak hours has reached 54% of the same period last year. The road traffic continued to recover under the influence of the gradual resumption of work, the restrictions applied to public transportation and the promotion of private cars. As of February 24 to 28, 2020, the traffic operation index during peak hours has reached 72% of the same period last year (Fig. 8). Various modes were adopted to minimize the spread of COVID-19 caused by the close contact of commuters during the COVID-19 pandemic, such as resuming work at different times, staggered commuting hours, flexible work schedules and working from home.

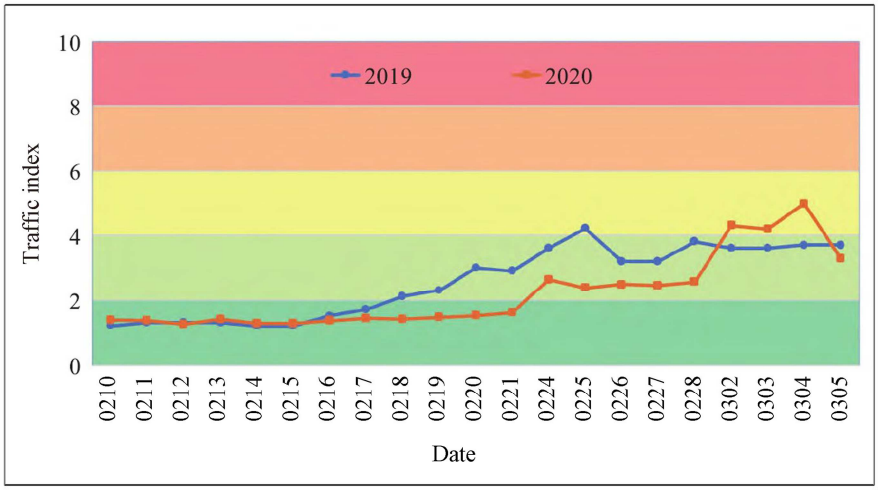

Fig. 8 Comparison of traffic operation index after the Spring Festival in 2020 and 2019

2) The restrictions on nonnative cars were lifted and traveling by car was encouraged to reduce the risk of infection. At the same time, parking rates erre reduced. The parking rates on working days were reduced to the level of non-working days, with a reduction of more than 50%.

3) The traffic carrying capacity in employment areas is considered to meet the potential commuting travel demand in key areas. At present, less than 20% of production is resumed in Futian CBD, while less than 7% in High-tech Park. Since the gradual resumption of work in such dense areas could lead to temporary large-scale gathering and centralized commuting, the monitoring of the trips in such areas is emphasized. In addition, early warnings on potential travel risks are disseminated and preparations are made in advance.

2.5 15-minute living circles for communities

Affected by the COVID-19 pandemic, the departure intervals of subways and buses have been extended, and some bus lines have been suspended. Alternatively, safer transportation modes, such as walking and bicycles, are encouraged to meet the essential travel needs of residents. The intensive and high-density land development model in Shenzhen is more conducive to building street blocks with mixed functions, which ensures that residents can obtain more living supplies and services in the 15-minute circle that are accessible by walking or biking. 1) The construction of a 15-minute living circle for communities is accelerated by boosting green transportation. 2) A healthy, mutual-assistance and comfortable travel environment is created by improving services for 15-minute living circles such as public bicycles and contact-free delivery of basic necessities of life, which would ensure residents' daily needs within a short distance during the pandemic. 3) The mechanism of "disinfecting all shared bikes" is established and enhanced by bike-sharing companies, such as Meituan and Haluo, to enhance the management of shared bikes in cities. Maintenance staff disinfects shared bikes continuously with an emphasis on those in key areas. At the same time, discount rates are offered to encourage residents to use shared bikes and expand the range of walking and bicycles.

3 Continue to ensure the recovery of urban operations and incorporate resilient transportation into a long-term strategy

3.1 Recovery of urban transportation in the middle stage of the pandemic

As the COVID-19 pandemic is brought under control in China, production and work have gradually resumed and the commuting demand of residents has gradually increased. Affected by the pandemic, urban transportation structure has changed in consideration of pandemic prevention and safety. Public transportation capacity has declined, and the proportion of car trips has increased significantly. Such changes led to some phenomena in the middle recovery stage of the pandemic, such as queues outside the rail transit stations with large passenger volumes and increased congestion on the road. In this stage, the focus is to assess the travel demand for public transportation, accurately match transportation capacity to demand, strengthen the guidance and control of passenger flow at rail transit stations with large passenger volumes, ensure the daily commuting of residents, and reduce the risk of the secondary outbreak of the COVID-19 pandemic in Shenzhen.

Due to the global COVID-19 pandemic situation, most new confirmed cases in Shenzhen in the late stage are imported from abroad. A travel chain tracking system for passengers from overseas countries is established at international comprehensive transportation hubs to implement measures such as information registration and nucleic acid testing and sampling. Through association of multivariate data, the travel chain of confirmed cases can be backtracked to locate close

contacts and reduce the risk of the secondary outbreak of the COVID-19 pandemic caused by imported cases.

3.2 Construction of comprehensive emergency system for resilient transportation in the late stage of the pandemic

The concept of resilience was first proposed in 1973 [1] and introduced into urban planning after 2001. London implemented the "Manage Risks and Enhance Resilience" strategic plan in 2011. In 2013, New York issued the Adaptation Planning [2] and the Rockefeller Foundation launched the Global 100 Resilient Cities Project [3]. At present, the construction of resilient cities focuses on the cities' resistance and resilience in scenarios of natural disasters and terrorist attacks, while there are few strategies for outbreaks of infectious diseases. In this COVID-19 pandemic, Shenzhen adopted strict control measures, and the city operations were almost suspended. However, from the perspective of a resilient city, a city should have resilience in structure, process, and system [4]. Process resilience refers to a city's capability to maintain normal operations during a disaster and the city's capability to set up safe and controlled space in urban space to effectively defend against the impact from the disaster. Credible transportation space is the core of safe space. It is a growing process in which massive data sharing, cross-department collaboration and business process reengineering are continuously promoted. Therefore, developing resilient urban transportation should be incorporated into the long-term transportation strategy, and comprehensive transportation emergency response capability should be built eventually.

Ministry of Land, Infrastructure, Transport and Tourism of Japan compiled and issued the *Action Plan for Measures Against Pandemic Influenza* in 2015 [5], which established a mature disaster relief system including measures before the pandemic, during the pandemic, and after the pandemic (Table 1). 1) A departmental structure with vertical management should be established to formulate prevention measures in terms of transportation and spreading at a macro level. 2) The routes for transporting relief supplies should be developed, and system information should be updated by the government. The Coast Guard should work closely with relevant organizations, and the Tourism Administration should inform foreign tourists in advance where to live in Japan. 3) The situation of patients should be mastered, and data should be collected actively. The data should be shared publicly, and pandemic prevention plans should be developed.

3.3 Building of urban transportation emergency system oriented to future public emergencies

The operation of urban transportation system has entered a non-normal state under the influence of the COVID-19 pandemic. To improve the emergency response and management of the urban transportation system to public emergencies, Shenzhen is advancing the construction of an integrated management and control platform that involves the urban transportation modes of sea, land, air and railway. This platform includes data about airports, ports, railways, public transportation, road operations, and infrastructure, as well as that about emergencies, incidents, and major events. It collects data from multiple departments, such as Public Security Bureau and Urban Management Bureau, which can be used for real-time monitoring and situation assessment of the city's intercity traffic, intracity traffic, and traffic conditions in key

Tab. 1 Main contents of Japan's Action Plan for Measures Against Pandemic Influenza

Stage	Pre-pandemic	Overseas outbreak	Early domestic outbreak	Domestic outbreak	Recovery
Objective	Establish emergency systems and confirm with international organizations	Ban the entry of infected relatives, and prevent spreading through family gatherings	Slow the spread, provide medical services for patients, and develop transmission models	Strictly implement the medical requirement, and reduce the impact on health and national economy	Restore socio-economic life activities
Internal institutional system	Establish emergency agencies, explore and confirm countermeasures, review the action plan, and establish a vaccination system	Establish influenza response headquarters, and vaccinate	Establish influenza response headquarters	Establish influenza response headquarters	
Border measures	Implement government action plans, determine inspection requirements, ensure the supply of masks, and isolate infected people	Perform strict testing and vaccination for travelers arriving in Japan, conduct centralized quarantine at transportation hubs, and restrict cross-border transportation	Perform strict testing for travelers arriving in Japan (including Japanese citizens)	Perform strict testing for travelers arriving in Japan (including Japanese citizens)	Evaluate countermeasures implemented during the pandemic, review the action plan, avoid the secondary wave of infections, and lift or reduce restrictions
Preventive and spread-preventing measures	Implement government action plans, avoid unnecessary travel, survey the operation of public transportation, and vaccinate	Improve cross-border transportation	Emphasize the necessity for masks to transportation companies and personnel, impose requirements for transportation during the non- operational period, and cancel gatherings	Emphasize the necessity for masks to transportation companies and personnel, impose requirements for transportation during the non- operational period, and cancel gatherings	
Ensure stability of life and national economy	Formulate production plans for essential companies, and establish the transportation system for emergency supplies	Formulate production plans for essential companies, and give vaccine priority to essential workers	Reduce transmission at the workplace, and secure the transportation of emergency supplies and daily necessities	Check the operation of enterprises that affect national economy and people's livelihood in addition to the foregoing measures	

Source: Reference [5].

areas. In order that the urban transportation system can operate normally in the a non-normal state, it is suggested to develop emergency plans for major public safety and health emergencies, build the rapid response, dynamic dispatch, and resilient recovery capabilities of the urban transportation system to respond to major public safety emergencies, and develop the capability to precisely control and proactively manage urban traffic in peace or war.

4 Conclusion

Under the COVID-19 pandemic, urban operations encountered new difficulties. The urban transportation system is transforming from the signal goal of "large passenger flow and high efficiency" to the new goal of "safety, reliability and accurate control." In the early rapid response to the COVID-19 pandemic, Shenzhen made full use of cross-industry and full-chain data to provide a safer and more reliable way to travel, focusing on how to dynamically and accurately identify changes in residents' travel demand and the whole population's travel chains. Shenzhen also strengthened its urban transportation system's capabilities in precise control and credible service to provide continuous support for the restoration of urban operations. Drawing on Japan's rich experience in building an urban disaster relief system, this paper proposes that developing a resilient transportation system should be included in the long-term urban transportation strategy, which provides the reference for data-driven pandemic response and delicacy governance of transportation in the non-norm state.

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