Citation: SU Yuejiang, ZHOU Lulu, WEI Qingbo, CUI Ang. Traffic Management Under Public Health Emergencies: A Case Study of Guangzhou [J]. Urban Transport of China, 2020 (03): 20–27.

Traffic Management Under Public Health Emergencies: A Case Study of Guangzhou

SU Yuejiang[1], ZHOU Lulu[1], WEI Qingbo[2], CUI Ang[1]

1. Guangzhou Transport Research Institute, Guangzhou Guangdong 510635, China;
2. Guangzhou Public Transport Data Management Center, Guangzhou Guangdong 510635, China

Abstract: Under public health emergencies, a transportation system should guarantee effective travel of people to support social and economic development and prevent the spread of the epidemic through public transport. This paper analyzes the impact of the COVID-19 on Guangzhou transportation system in several aspects: passenger flow, road performance, traffic structure, and social economy. Through the review of the emergency traffic management measures taken by the People's Government of Guangzhou City amid COVID-19, the paper concludes that these measures have played a positive role in epidemic control and the guarantee of citizens' basic travel. Finally, the paper suggests the improvement in traffic operation, management, and policies, including tracking and monitoring of people, vehicles, roads, and traffic environment with technologies such as big data and artificial intelligence, and integrating the above improvements into the general framework of urban management. It is necessary to establish a regional collaborative mechanism during epidemic control and prevention and an informatizationalized cooperation platform for external transportation and urban transport. **DOI:** 10.13813/j.cn11-5141/u.2020.0020-en

Keywords: abnormal traffic management; public health emergencies; COVID-19; management measures; Guangzhou

0 Introduction

According to management types, traffic management can be divided into traffic system management and traffic demand management. Traffic system management typically includes signal control adjustment and traffic organization optimization; traffic demand management includes public transit prioritization and parking demand management. Traffic management can also be classified based on normal or abnormal management situations. Traffic management should be conducted in such abnormal as follows: (1) traffic congestion occurs in the part of or the entire area as a result of the surge in traffic demand that exceeds traffic supply, such as mega sport events and important activities; (2) short-term traffic supply changes lead to bottleneck nodes or road sections, such as subway construction enclosure and road reconstruction and expansion; (3) travel behavior is influenced by extreme weather, such as heavy rain and snowstorm; (4) intervention or passive traffic choice should be made with respect to right of way under public health emergencies, such as regional traffic closure to isolate virus spread and roadway closure in response to earthquake disasters.

Public emergencies are emergent events that have resulted in or will lead to major casualties and property loss, damaged ecological environment, serious social harm, and endangered public safety. Public emergencies are characterized by suddenness, urgency, high uncertainty, social impact, and non-procedural decision-making. Public emergencies can be classified into five categories according to the occurrence process and nature, including natural disasters, accidental disasters, public health emergencies, social security emergencies, and economic crises. Major infectious diseases are public health emergencies [1,2], such as Severe Acute Respiratory Syndrome (SARS), influenza, cholera, and anthrax. During public health emergencies, transportation system operations should not only ensure regular traffic and efficient transport of travelers to support social and economic development but also reduce the larger gatherings at transportation sites and control the risk of pandemic spread in the transfer area. China has recently experienced a critical period of the Coronavirus Disease 2019 (COVID-19); this article discusses traffic management practices in Guangzhou, a metropolitan in south China, under this public health emergency.

1 Impact of COVID-19 on Guangzhou's transportation

Since the COVID-19 pandemic was interleaved with the

Received: 2020-03-10
Supported by: Guangzhou Science and Technology Foundation of China (201903010101)
First author: SU Yuejiang (1983–), male, master, senior engineer, from Liupanshui, Guizhou Province, China, mainly engaged in the research on public transportation and traffic information. E-mail: 250234329@qq.com

2020 Spring Festival, 2019 and 2020 Spring Festival travel rushes were chosen as the timeline, which was extended to the point when traffic went back to normal to perform comparative data analysis and ensure complete coverage. The data analysis covered several critical nodes, including the 40 days of Spring Festival travel rush (January 10 to February 18, 2020 and January 21 to March 1, 2019, with the Day 15 on Chinese New Year's Eve), first-level public health response mechanism in Guangdong Province launched on January 23, 2020, resumption of work on February 9, 2020 ①, and transportation returning to normal operation. It lasted 71 days in total (from January 21 to April 1, 2019 and January 10 to March 20, 2020).

1.1 Pattern of passenger flow: regular variation followed by a rapid decline

In terms of external transportation, the total volume of passengers in the four major transportation modes of railway, highway, air traffic, and water transport during the 2020 analysis period was 35.17 million, which decreased by 57.2% compared to that during the same period in 2019. Specifically, railway passenger volume was approximately 24.9 million, dropping by 55.9%. Highway passenger volume was about 4 million with 63.7% reduction. Airline passengers were about 6.23 million, which fell by 57.1%. Water transport passengers were about 30,000, a decrease of 61.1% [3]. The analysis period with milestones could be divided into three stages (Fig. 1). The first stage was 14 days before the Spring Festival with the peak of the holiday trips, when the passenger flow of the four major transportation modes increased by 5% in 2020 compared to that in 2019. Their passenger flows resemble, which remained high during the Spring Festival travel rush and then went down. In the second stage (Days 15–30 of the travel rush), the passenger flow of the four major transportation modes soared in 2019 due to the growing number of returning trips while the passenger flow just rose slightly in 2020 given the COVID-19. In the third stage (Day 32–71), the passenger flow of the four major transportation modes suggested a somewhat stable but up-and-down pattern in 2019. In 2020, influenced by the pandemic control and resumption of work, transportation management has switched from pandemic prevention to pandemic prevention plus resumption of work and production. However, the passenger flow associated with all major transportation modes remained sluggish.

In terms of urban public transit, including subway, bus transit, and taxi, the passenger volume during the 2020 analysis period was 396 million (5.57 million/day), decreasing by 61.6% compared to that in 2019. In the 2020 analysis period, subway passenger volume was 233 million (3.28 million/day) with a decrease of 59.9% from 2019. The number of bus transit passengers decreased by 64.1% to 129 million (1.81 million/day). Taxi passenger volume was 34 million (0.48 million/day), dropping by 62.2% from 2019. The analysis period can be divided into two stages in accordance with the critical node (Fig. 2). The first stage was 14 days before the Spring Festival, with similar trends of passenger flow in 2019 and 2020. After the peak of returning trips, the passenger flow took a dive near the Spring Festival. Day 14 of the Spring Festival seemed to be an inflection point for the passenger volume of public transportation. The second stage was the Days 15–71 of the Spring Festival travel rush, with similar passenger flow characteristics between 2019 and 2020. The trend suggested a general growth of passenger flow with variations, but the 2020 passenger flow increased less. In addition, the impact of the COVID-19 pandemic in 2020 showed a clear downward trend on weekends, indicating that weekend travel demand plummeted by 28.7% compared with the weekday travel demand.

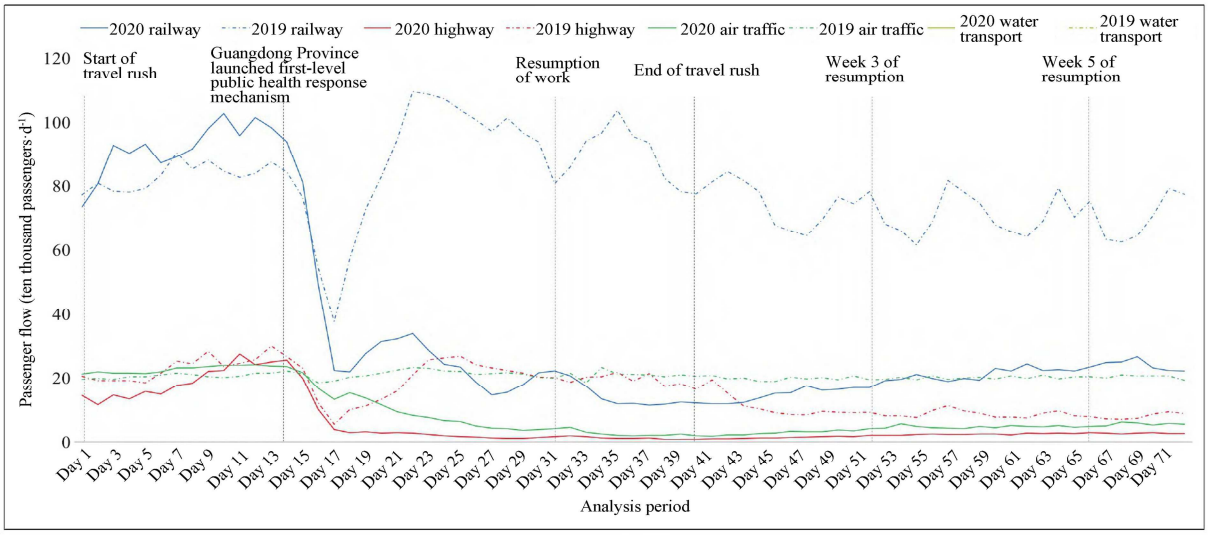


Fig. 1 Arrival and departure passenger flows of different travel modes in Guangzhou during Spring Festival travel rushes in 2019 and 2020

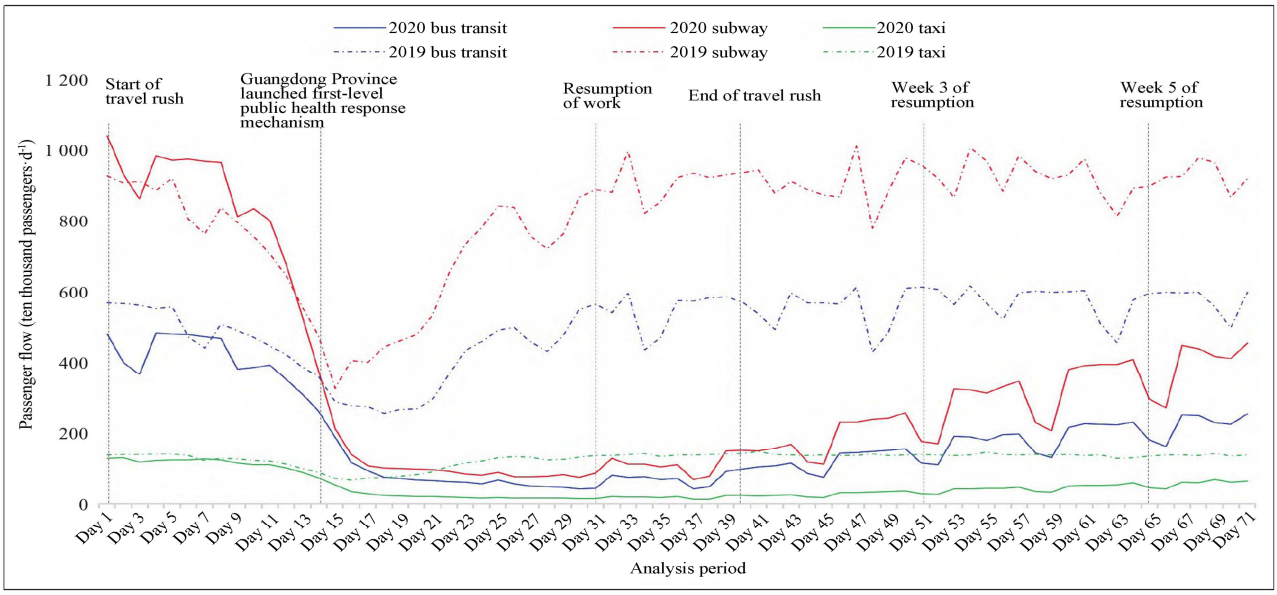


Fig. 2 Public transportation passenger flow during Spring Festival travel rushes in 2019 and 2020

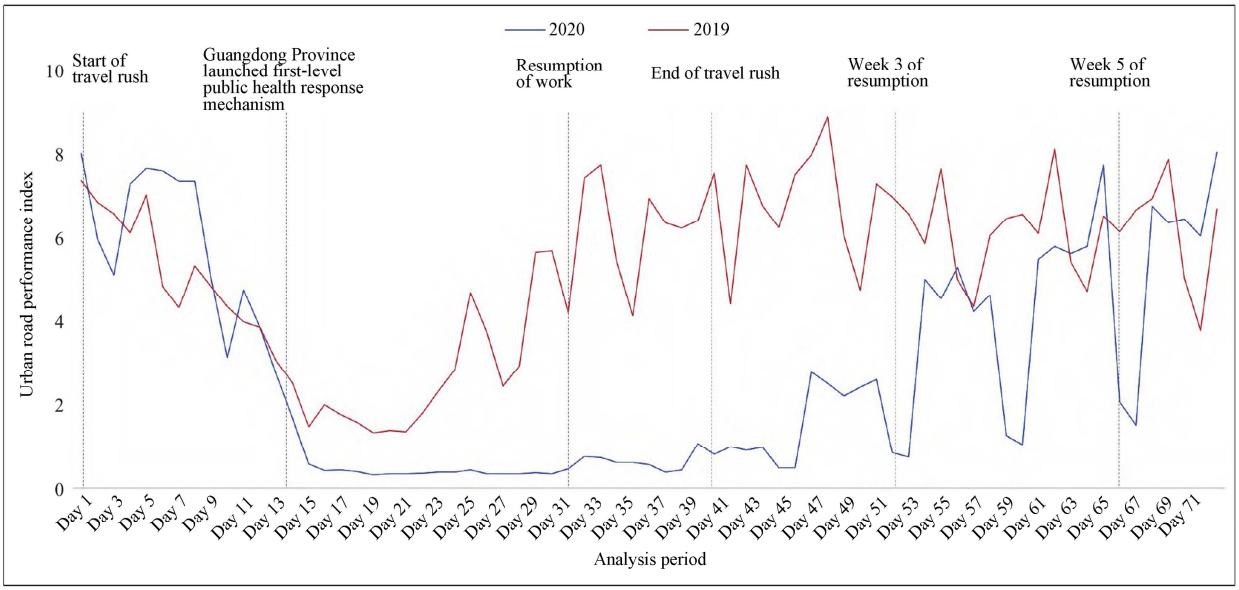


Fig. 3 Urban road operation index of the evening peak during Spring Festival travel rushes in 2019 and 2020

1.2 Pattern of urban road performance: reduced peak traffic followed by regular congestion with lower weekend traffic

The overall roadway performance was reasonably well during the 2020 analysis period; the average daily urban road performance index was 2.8 for the evening peak, a 41% decline compared with that in 2019. The analysis period can be divided into three stages based on critical nodes (Fig. 3). The first stage was 14 days before the Spring Festival. The overall urban road performance index declined, similar to the trend in 2019. The main reason is that a portion of the non-local population drove home for the Spring Festival holiday. The second stage was Days 15–40 of the analysis period. With the growing returning trips of the non-local population, the urban road performance index continued to and rose in fluctuation in 2019 while the index in 2020 kept limp. The third stage was the Days 41–71 of the analysis period. The urban road performance index showed up-and-down fluctuation and a slightly downward trend in 2019 while the index continued to rise in 2020 and was low in weekend. These data have suggested that a large amount of travel demand was suppressed in the early stage of the COVID-19 pandemic. Overall, the road ran well with the low travel demand. From the start to the Week 5 of the resumption of work, the road performance gradually restored to its regular level. However, the weekday operation index fell by 28.7% compared with that at the weekend due to reduction in rigid demand for weekend travel.

1.3 Changes of traffic structure: decreased proportion of public transit trips and increased use of private cars

Although it is difficult to assess traffic structure changes based on total travel amount under public health emergencies, it can be analyzed using three factors, namely public transit volume, private car travel, and urban road performance index.

(1) Public transit: The number of average daily trips by bus and subway in 2019 was 10.65 million/day according to 2019 Guangzhou Transportation Survey, while the average daily trips of public transit in the Week 6 after the resumption of work in 2020 were 6.73 million/day, which makes up 63% of daily transit trips. The results showed a sharp decline in the amount of travel. According to the analysis period, the passenger flow of the morning peak (7:00 AM–9:00 AM) accounted for 45% of the whole day, 10% higher than that in 2019, reflecting a higher portion of rigid passenger demand.

(2) Private cars and road performance: Due to the impact of the pandemic, Guangzhou lifted the ban on the use of small- and medium-sized private cars and allowed toll free of expressways ②. In 2019, 25.1% of the vehicles in Guangzhou traveled shorter than 10 km on expressway, with most short-distance travel occurring during the 7:00 AM–9:00 AM and 5:00 PM–7:00 PM; 13.8% of the vehicle passed through expressway for commuting [4]. According to data mining analysis of the HD bayonet system, urban road performance index rose from 0.8 on February 18, 2020 to 8.0 on March 20, 2020 (an increase of 900%). In week 5 (March 16 to 20) after the resumption of work, the number of private cars traveling in Guangzhou was 1.186 million/day, at a level similar to that in 2019. The number of private cars traveling in the evening peak was 498,000, 135% of that in 2019. The data analysis showed that most people, especially those with rigid demand, traveled by private cars. According to survey and analysis from Tongji University, Shanghai, 54.8% of subway trips and 56.2% of public transit trips shifted to private car trips during the pandemic [5]. These data suggested that, during the pandemic, residents' traffic modes have changed drastically.

Besides, based on an analysis of mobile phone tracking data, the minimum populations in Guangzhou during the Spring Festival travel rush were the Day 16 in 2019 and the Day 20 in 2020 and were 47% of the regular population. In other words, 53% of the population left Guangzhou during the Spring Festival travel rush. However, there was 91% of the population in Guangzhou on the last day of the Spring Festival travel rush in 2019 and the proportion fell to 66% in 2020. Specifically, 25% of the population did not return Guangzhou in time after the Spring Festival holiday in 2020, greatly affecting the resumption of work and urban economic development.

In summary, the COVID-19 pandemic had a substantial impact on passenger flow, road performance, and traffic structure of Guangzhou. The main way to contain the pandemic is to decrease the mobility and gathering through isolation or blockage, thereby reducing the risk of virus cross-infection. However, social operation depended on the flow of people and goods, which demanded high-quality management of transportation system. Therefore, traffic management needed to not only ensure the normal operation of transportation as much as possible but also minimize or even eliminate the pandemic in transportation. In addition to implementing normal traffic organization and control measures, traffic management should also focus on drawing up emergent traffic management plans.

2 Traffic management measures in Guangzhou amid COVID-19

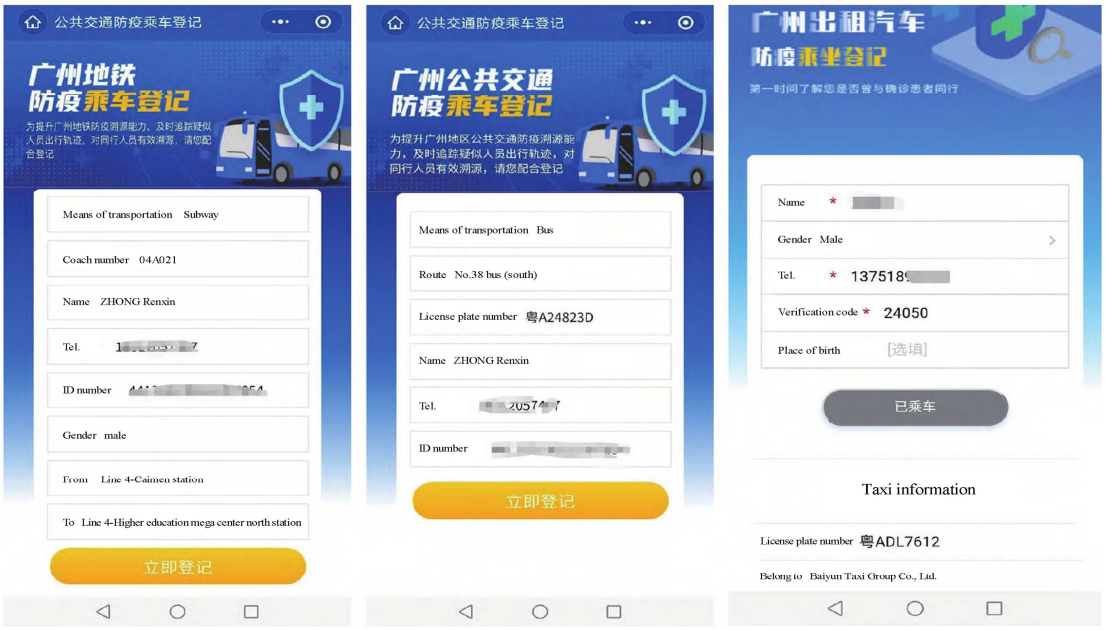
Relevant control measures have been adopted in various places with regards to COVID-19 to reduce citizens' flexible travel demand, and mainly to meet the basic living needs and rigid travel demand for resumption of work. As one of the three major comprehensive transportation hubs in China and the distributing center of people and goods in Pearl River Delta, Guangzhou is characterized by large-scale population mobility, a wide transport area, long traffic flow duration, and multiple transportation modes. Moreover, the overlap of the pandemic and the Spring Festival resulted in a grave challenge for pandemic prevention and control. "One blockage and three non-interruption" was proposed in Guangzhou as the prevention and control strategy. "One blockage" means firmly blocking virus transmission channels; "Three non-interruption" means ensuring the smooth operation of highway traffic network, emergency transportation channel, and the transportation channel of necessary goods and materials for live and production. The main purpose is to meet the basic living needs of residents and passengers, and to support and promote the demands of various enterprises for resumption of work and production.

Guangzhou's management measures can be classified into four categories. First, information on citizens' health status, place of birth, current residence, and recent travel trajectory has been fully recorded through the Suikang code on safety grounds. The temperature of passengers who travel by air, railway, highway, bus, subway, or taxi was measured to avoid further spread of the virus from suspected or confirmed COVID-19 patients. Second, the resumption of work and school was postponed according to the government's notice; additional measures such as flexible working schedules and online office were adopted to reduce citizens' travel demand. Third, primary transportation modes were controlled based on key indicators to limit the gathering of travelers, reducing the spreading of the virus (Table 1). Finally, personal travel information in subways, buses, taxis, and long-distance shuttles was registered, including means of transportation, route, coach number or license plate number, mobile phone number, and ID number. The purpose of information collection

Table 1 Management measures for different means of transportation

Means of transportation		Management indicators	Specific measures
External traffic	Highway	Load factor	The load factor of long-distance passenger vehicles should not exceed 50%
	Railway	Load factor	The load factor should be 60% or below, and about 60% of passenger trains are cancelled according to the situation
Urban transport	Bus	Load rate	Passengers are not allowed to seat near each other; the load factor is monitored in real time; the operation scheduling plan is dynamically adjusted according to the passenger flow of each line and each shift, including extra short-term buses and interzonal buses and timely adjustment of capacity and departure intervals; customized bus routes are organized
	Subway	Congestion rate	The operational organization plans; the changes in the passenger flows of temperature measuring points, station platforms, and coaches are monitored continuously. The passenger flow will be diverted timely by staff or transport resources to avoid gathering of passenger flow
	Private car		The car control measures are suspended and citizens are encouraged to travel by private car
	Shared bike		"Free riding week" are introduced by shared bike firms to propel resumption of work and production

Source: the official website [6,7].



a Subway b Bus c Taxi

Fig. 4 Information collection form for public transit passengers in Guangzhou

Source: Reference [7].

was to track the travel trajectory of suspected patients in time and to improve the anti-pandemic traceability of public passenger transport (Fig. 4).

3 Insights and suggestions

3.1 Operation management: accurate traceability and control

With gradual improvement of the pandemic recently, management measures have shifted its focus from simple blockage to follow-up monitoring management. Travel trajectories of citizens were tracked and monitored through various big data analyses. These analyses aimed to achieve precise traceability and control of relevant population, which can greatly reduce the risk of virus transmission and spread. On the one hand, the inflows, outflows, and distribution of origins and destinations of the population can be dynamically monitored via mobile phone and internet big data. In particular, the trajectories of those who returned Guangzhou from areas seriously hit by the COVID-19 must be precisely analyzed with relevant measures introduced to accurately manage related population. For example, the population movement in the early stage of the pandemic was monitored and pro-judged. In the middle stage, those who returned Guangzhou from affected areas should be recognized and the health care resources should be assessed. In the later stage, the resumption of work and production were evaluated. Moreover, the distribution and trajectories of those who came back from Hubei Province, the city seriously striken by the COVID-19, should be tracked and monitored, as a strong data

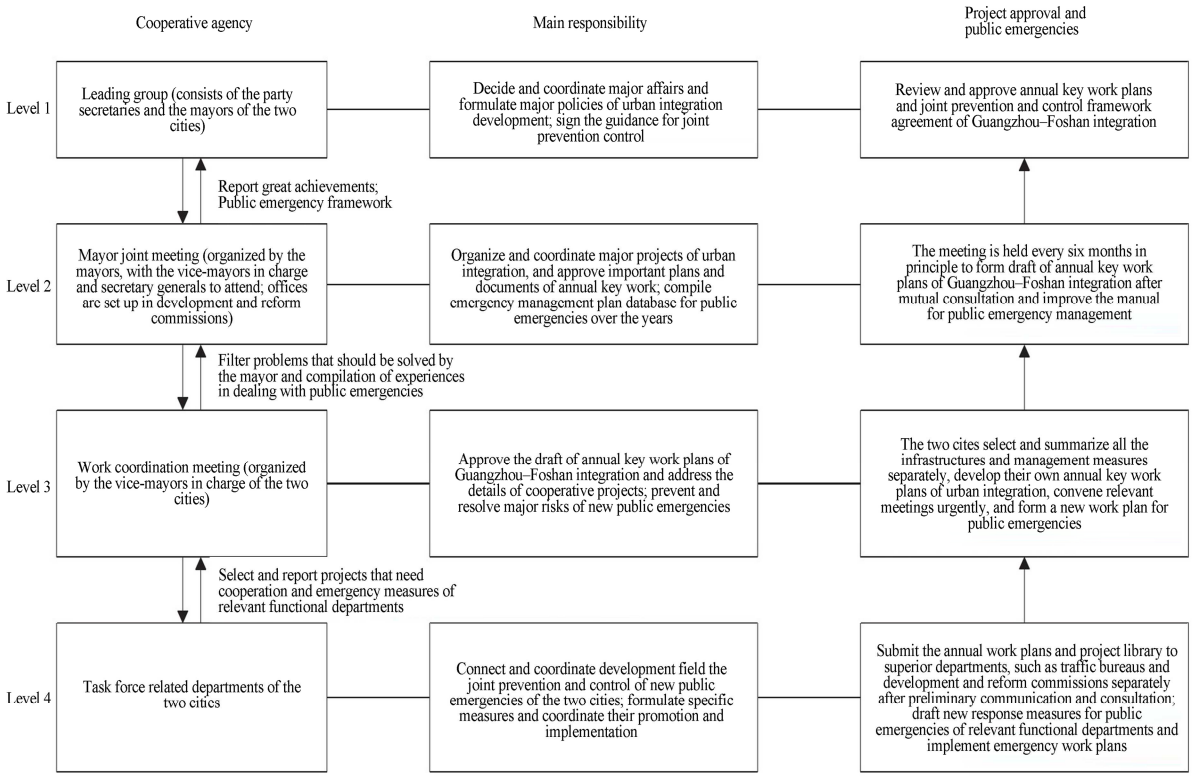


Fig. 5 Regional collaborative management and epidemic control and prevention mechanism in Guangzhou–Foshan integration

support for the government in accurate traceability and control [8]. On the other hand, the passenger reservation and registration system of buses, subways, taxis, and long-distance shuttles has been adopted to track the trajectories of suspected patients in a timely manner and to improve the anti-pandemic traceability of public transportation. In summary, people, vehicles, road, and environment can be tracked and monitored by advanced technologies such as big data and artificial intelligence. The application of these technologies can be integrated into the general framework of urban management to achieve precise traceability and control, which should be a management strategy of public health emergencies.

3.2 Policy mechanism: coordinated management and refined governance

The pandemic information was released through relevant platforms, with statistics and indicators of global, national, and provincial COVID-19 cases, such as confirmed and suspected cases and those who have died or recovered, as well as the distribution of communities with confirmed cases. The purpose is to timely provide citizens with relevant information, avoid other social problems out of panic, and strengthen pandemic prevention and control. Transparent information has played an active role in improving the efficiency of the organization and management of pandemic prevention and control.

In areas with strong inter-city connections, regional collaborative governance should be adopted to form a joint pandemic prevention and control mechanism. For example, the Guangzhou–Foshan integration is the most urbanized in the country's city cluster, which has an average daily inter-city passenger flows of 1.65 million/day, 300,000 commuters, and a bus–subway transfer volume of 320,000/d [9]. In the framework of the joint meeting mechanism of Guangzhou–Foshan integration [10], it is recommended to include a consultation mechanism for the response to public health emergencies (see red text in Fig. 5). We also recommended establishing a regional collaborative prevention and control mechanism of external and urban transport and an informationalized collaboration platform. In these ways, we can set up a prevention and control mechanism of data analysis that combined trajectory collection, refined management support, and intelligent pandemic prevention and early warning via big data. Based on this mechanism, we can precisely and timely obtain the spatial distribution and of inter-city population, its health status, OD (origin and destination) distribution, and travel trajectory, improving pandemic prevention and control plan for large transportation hubs and important stations, and ensuring the resilience and safety of inter-city mobility by timely addition of human resources.

Guangzhou had permanent residents of 15.36 million and private cars of 2 million in 2019. Only one out of eight people (excluding floating population) owned cars. Assume that each private small and medium private car serves two people, the remaining six people will travel via non-motorized

transportation or public transit. Given the current urban planning level, it is impossible to ensure that everyone works and goes to a doctor on foot or by bike in the place of residence. Basic public transportation services should be provided to ensure stable operation of the city. However, public transport and the sites are usually the areas where the virus spreads. In addition to blocking or lockdown of external traffic during the pandemic, some cities also suspend public transport or reduce capacity and frequency of transit service to avoid virus infection and spread ③. The above measures can meet the basic living needs of the public, but it is difficult for those who have to commute (e.g., medical staff, supermarket employees, and courier) or patients who need to see a doctor to rely solely on private cars. Therefore, it is necessary and urgent to formulate a refined management strategy based on public transport issues amid the pandemic. Customized bus lines can be planned through mobile phone-based big data ④. Commuter-dedicated transit lines and bus routes with flexible reservation can be planned based on the analysis of bus lines, frequency, and passenger flow at stations via smart card data. Flexible plans such as large station expresses and interzonal buses can be adopted based on the control of load factors. The plan to implement public transport subsidies to individuals can be considered during the emergency period (Fig. 6). These strategies can not only serve the basic travel needs of citizens but also achieve reasonable utilization of public transport resources.

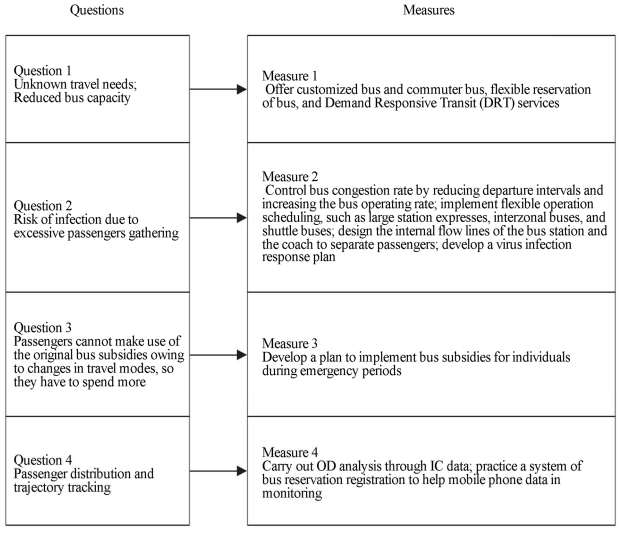


Fig. 6 Refined management strategies for public transport during epidemic control and prevention

In summary, while bus services were shut down successively in 413 cities of 27 provinces during the pandemic, Guangzhou has implemented policies with no lockdown or blockage of transportation. This implementation ensured basic transportation supply and has played an active role in providing transportation services to support the prevention and control of Guangzhou pandemic, as well as the resumption of work. Guangzhou has explored various solutions. The distribution of population, travel trajectories, and passenger OD in public transport were monitored and tracked by big data. The load factor of buses was monitored and analyzed timely by the dynamic adjustment of bus capacity and departure intervals. Customized bus lines were organized and body temperature of bus passengers was measured through face recognition. Subway capacity and departure intervals were adjusted dynamically according to passenger flow changes. The above measures have enhanced Guangzhou's traffic management capabilities under public health emergencies, and its experience was worthy of reference.

4 Conclusion

Transportation system is not only the skeleton and veins that support the operation of cities, but also the basic assurance for maintaining daily production and life in cities, emergency rescue, and pandemic prevention and control. Special traffic management measures under public health emergencies have been taken, which have a positive effect on pandemic prevention and control as well as certain impacts on people's life, urban production, and social and economic development. In this paper, the impact of the pandemic on Guangzhou's sector of transportation is analyzed macroscopically in terms of passenger flow, road performance, and traffic structure. The further impact of the pandemic is substantial on social and economic development, which raises higher requirements on transportation management. Therefore, in addition to regular traffic organization and control measures, transportation management should also involve an emergency plan. Transportation system cannot only maintain the basic operational conditions under special circumstances but also guarantee transportation during emergencies. In the future, resilience management measures for transportation modes, citizens' travel behavior (peak shifting travel, use of private cars, and changes in traffic structure) and lifestyle (online office, shopping, learning, and leisure), and urban planning (15-minute life circle [5] with public buildings such as hospitals and supermarkets around) should be further studied.

Anotation

① According to the notice from the People's Government of Guangdong province, all the enterprises in its authority area should not reopen until February 9; middle and primary schools, and kindergartens are not allowed to open until February 17; junior colleges, secondary vocational schools, and technical institutes are not allowed to open until February 24.

② From February 17 to the end of the pandemic control, toll roads can be access free of charge throughout the country until further notice.

③ Airport and railway stations of Wuhan, Hubei Province were the first to have been closed on January 23, 2020, followed by the suspension of buses, subways, ferries, and long-distance passenger transport. Subsequently, the corresponding traffic control measures in 17 cities in Hubei Province were implemented and all public transport was suspended. As of February 12, except for Beijing, Tianjin, Shanghai, Guangdong, and Tibet that continued to offer bus services, there were still 413 cities in 27

provinces where bus services were suspended.

④ Guangzhou Public Transport Group Co., Ltd. opened a dedicated transit line during the pandemic for 196 enterprises, which served a total of 373,000 passengers from February 10 to March 9.

⑤ *Standard for UrbanResidential Area Planning and Design* (GB 50180-2018) provides assessment indicators in terms of walking distance, residential population, and the number of residences for 5-minute, 10-minute, and 15-minute life circles. *Urban Master Planning of Beijing* (2016–2035) has set a goal to achieve full coverage of the 15-minute community service by 2035. *The Guideline for 15-Minute Community Life Circle Planning in Shanghai* proposed the development of 15-minute community life circle, in which basic living functions and public activity spaces can be available within a 15-minute walking distance and a safe, friendly, and comfortable social life platform can be formed. According to *Guangzhou Master Planning of Land and Space* (2018–2035), creating a 15-minute community life circle aims to provide basic living functions and public activity space needed within a 15-minute walking distance and to reshape the old Guangdong-style community. In *Urban Master Planning of Chengdu* (2016–2035), it is proposed to create a life circle of a 15-minute walk based on public transport and green space networks, accurately plan and ensure the coordination between allocation of public service facilities and population structure, and implement distinguishable construction guidance of public service facilities. According to the *Melbourne Plan* (2017–2050), a pedestrian-friendly community and a local bike network should be developed; schools and other regional facilities should be located around the existing public transport infrastructure; routes for bikes and pedestrians and areas for getting on and off should be safe. In these ways, a 20-minute life circle can be created.

References

[1] Xue Lan, Zhong Kaibin. Classification of Types, Levels and Stages for Emergencies: Managerial Foundation of Government Emergency Response System [J]. China Administration, 2005, 236 (2): 102–107 (in Chinese).

[2] Cao Jie, Yang Xiaoguang, Wang Shouyang. Key Scientific Problems in Public Emergency Management [J]. Journal of Public Management, 2007, 4 (2): 84–93 + 127 (in Chinese).

[3] Guangzhou Transport Research Institute. Analysis of the passenger flow of Guangzhou during the Spring Festival Travel Rush in 2020 [R]. Guangzhou: Guangzhou Transport Research Institute, 2020 (in Chinese).

[4] Guangzhou Transport Research Institute. Big data overall planning of the transport in Guangzhou and the mining analysis of road traffic information data [R]. Guangzhou: Guangzhou Transport Research Institute, 2019 (in Chinese).

[5] Urban Mobility Institute, Tongji University. Advice and suggestions for the prevention and control of COVID-19: Report on the prevention and control of COVID-19, Urban Mobility Institute, Tongji University [EB/OL]. 2020 [2020-03-05]. https://mp.weixin.qq.com/s/ 9h61kc Hi1om7Of0yd0zAbA (in Chinese).

[6] Guangzhou Transport. Guangzhou's multiple measures for guaranteeing the implementation of epidemic prevention and control in transport and offering a "Guangzhou Sample" [EB/OL]. 2020 [2020-03-05]. https://mp.weixin.qq.com/s/zvfn7MND6Yrwd8Bl7-k7KQ (in Chinese).

[7] South Plus. Automatic warning for over high load factors: smart "cloud brain" monitors buses in Guangzhou [EB/OL]. 2020 [2020-03-05]. https://static.nfapp.southcn.com/content/202002/23/c3162861.html?colID=0&code=200&msg=%E7%99%BB%E5%BD%95%E6%88%90%E5%8A%9F&evidence=31a01459-fb18-41b0-a436-0ac7e3e265f4&firstColID=38&appversion=6310&from=timeline&layer=2&share_token=&date=bnVsbA%3D%3D (in Chinese).

[8] Chian City Planning. Practice and reflection on the application of mobile phone signaling in the prevention and control of public health risks in Guangzhou [EB/OL]. 2020 [2020-03-05]. https://mp.weixin.qq.com/s/5U9A5ZTkKAU3dAcAOnOn8g (in Chinese).

[9] Guangzhou Transport Research Institute. A new round of comprehensive survey of Guangzhou transport [R]. Guangzhou: Guangzhou Transport Research Institute, 2019 (in Chinese).

[10] Su Yuejiang, Meng Juan, Cui Ang, et al. Public Transportation Development Under Urban Integration: A Case Study of Guangfo City [J]. Urban Transport of China, 2018, 16 (1): 23–30 (in Chinese).

