

Analysis on the Development of Subway in a Pandemic City

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Abstract. The outbreak of COVID-19 poses a severe challenge to the epidemic prevention and control of urban public transport system. As the backbone of urban public transport, urban rail transit is one of the important links in the epidemic prevention and control of urban public transport system. It faces the challenge of heavy tasks and great pressure. Using the methods of questionnaire survey, field investigation and case analysis, this paper aims to find out how to improve the operation of the subway under the epidemic situation, and finally comes to a conclusion that there is need to further strengthen the control measures to deal with peak passenger flow concentration, and improve the emergency plan. Besides, a traceable and reliable epidemic prevention cooperation system should be created and a real-time dynamic interaction system should be built to open up the information barrier between passengers and operating units. Moreover, it is also important to improve the normalized and refined monitoring and early warning system for high-risk areas, as well as simplifying the display of passengers' personal information and realize automation, intelligence, and integration.

1 Introduction

COVID-19 is named "coronavirus disease 2019" by the World Health Organization [1-2], which refers to the pneumonia caused by novel coronavirus infection in 2019. Since December 2019, some hospitals in Wuhan City, Hubei Province have successively found multiple cases of pneumonia of unknown cause with a history of exposure to the seafood market in South China, which is confirmed to be an acute respiratory infectious disease caused by 2019 novel coronavirus infection [3-5]. At present, in the public transport system of large and medium-sized cities in China, the subway is an extremely important part [6]. Therefore, the prevention, control and response measures taken by the Metro department under the COVID-19 epidemic are of great significance to ensure its safe and stable operation and social and economic recovery. Due to the universality of novel coronavirus transmission and the particularity of asymptomatic patients, and the mobility, complexity, and diversity of the subway as a public transport system, the subway operation has its own difficulties in epidemic prevention and control.

This paper is composed of a set of questionnaires created by the author and some examples of urban subway epidemic prevention and control measures. Through the statistics and analysis of these data and examples, the author puts forward some suggestions and opinions on how modern urban subway should operate under the epidemic situation, and provided some ideas on how subway and other urban underground spaces should develop in the future if they encounter similar conditions to COVID-19.

2 Methodology

2.1 Locations and Ages of Participants

As shown in the Figure 1, The participants in this survey come from many provinces in China, including Jiangxi, Anhui, Guangdong, Guangxi, Hunan, Zhejiang, Sichuan, Shaanxi, Hebei, Shandong and Heilongjiang. People in northwest, northeast, North China, Southeast, central and southwest China participated in the survey. A total of 236 people participated in this survey. Therefore, the information collected in this questionnaire is the data from different living environments and climatic environments in various regions of China.

As shown in the Figure 2, most of the people surveyed are aged 18-50, which is the main part of Chinese workers. Among them, people aged 31-50 account for the largest proportion. This kind of people usually have obtained stable jobs and can live completely independently. Meanwhile, people aged 18-30 account for the second place. Most of these people are still exploring the society. They are usually students or new recruits. Finally, minors and the elderly account for the smallest proportion. They are the people who need protection and care in society. So this survey mainly reflects the views of social workers.



Fig. 1. Regional distribution of the survey population.

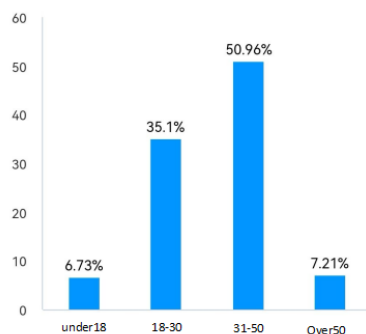


Fig. 2. Age distribution of the participants.

2.2 Questions in the Questionnaire

Question 1: How old are you?

Question 2: How long do you think the epidemic will last?

Question 3: What is the main way you travel?

Question 4: Do you think the epidemic has a great impact on the subway operation?

Question 5: Do you think the epidemic has reduced the connection between the subway and the ground space?

Question 6: What inconvenience do you think you have when taking the subway because of the epidemic? Choose the one that disturbs you most.

Question 7: Do you think the ventilation system of the subway is good?

Question 8: Describe the real subway operating environment with 2-3 adjectives.

Question 9: Describe your ideal subway operating environment with 2-3 adjectives.

3 Result and Analysis of the Investigation

As shown in Figure 3, it can be seen that most people are optimistic and hold the opinion that the epidemic will end in the short term, but a considerable number of people believe that people will coexist with the epidemic all the time. Therefore, it can be seen from this result that the Chinese people are very convinced of the control measures introduced by the government.

As shown in Figure 4, the main travel modes of contemporary people are driving private cars or taking subways, and the transportation modes used by people of

different ages are completely different. People aged 31-50 mainly drive private cars, while people aged 18-30 mainly take subways. This may due to the fact that most people aged 18-30 do not have a stable income. The money they have can only maintain their normal life at most. While most people aged 31-50 have a certain amount of savings, so they will choose to buy a car for convenience and comfort (as shown in Figure 5 and 6)

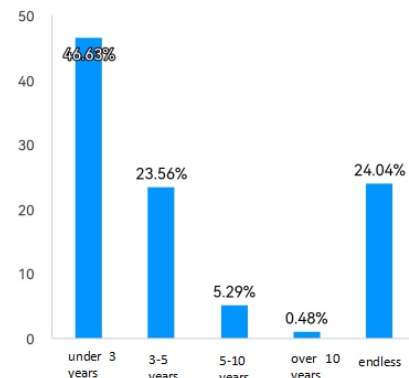


Fig. 3. Results of the participants' opinions on how long they believe the epidemic will last.

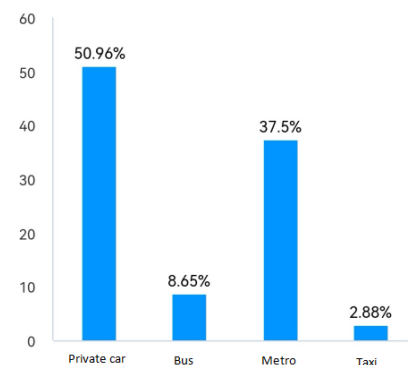


Fig. 4. Proportions of the main travel transportation of the participants.

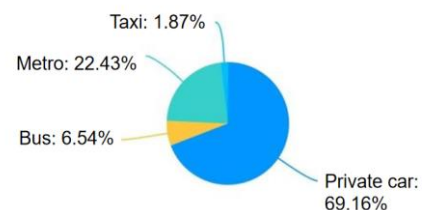


Fig. 5. The main travel transportation of people aged 31-50.

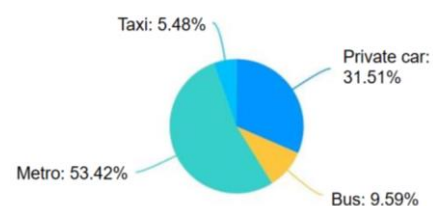


Fig. 6. The main travel transportation of people aged 18-30.

As shown in Figure 7, 37.5% of participants think that the impact of the epidemic on subway operation is medium, and 54.8% think the impact is large or very large. The fact is the same. Due to the COVID-19 epidemic, the passenger flow of the subway has been greatly reduced [7]. Many cities have to reduce the subway scheduling to reduce the operating cost. However, this has caused great inconvenience to many people, especially office workers.

As shown in Figure 8, over half of the participants believe that the epidemic has not reduced the connection between the subway and the ground space. Because now there is a relatively mature underground pedestrian street between the subway and the ground.

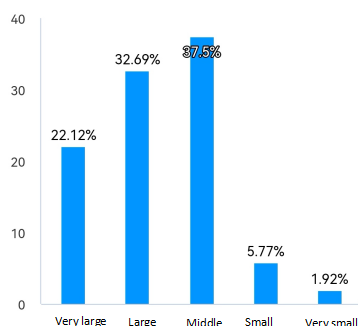


Fig. 7. Voting distribution on the impact of the epidemic on subway operation.

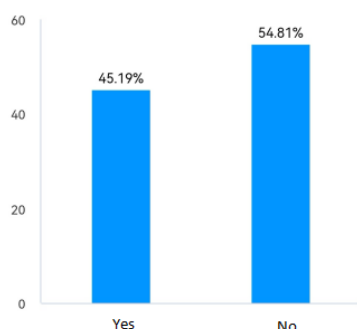


Fig. 8. Voting distribution on whether the epidemic has reduced the connection between the subway and the ground space.

As shown in Figure 9, the most annoying thing for people is that COVID-19 makes security inspection very cumbersome. Before the epidemic, the subway security inspection was to pass the bag through the detector, but because of the epidemic, people need to show their health codes and accept temperature measurement one by one. This brings a lot of inconvenience to people and increases the workload of the staff. Besides, because of the epidemic, a large number of subway stations and even the whole line can be shut down, which not only brings inconvenience to people, but also brings greater pressure to urban traffic. In addition, the discomfort of wearing a mask and limits on the flow of passengers also make people miserable. Moreover, people of different ages worry about different things since they have different social identities. As shown in Figure 11 and 12, people aged 18-30 are relatively more free, so things that restrict their freedom such as wearing masks and restricting the flow of people are more likely to cause their discomfort. However, for people aged 31-50, cumbersome security checks and the shutdown of stations

or lines will directly affect their going to work and cause their dissatisfaction.

As shown in Figure 10, obviously, the ventilation of the subway is very poor, so how to prevent the epidemic on the subway is particularly important.

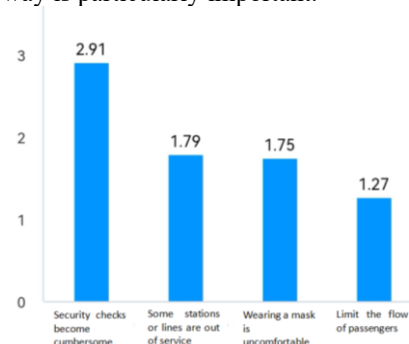


Fig. 9. Voting distribution on the things people find inconvenient in the subway station because of the epidemic.

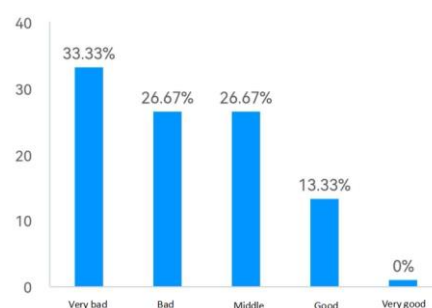


Fig. 10. Voting distribution on the ventilation of the subway.

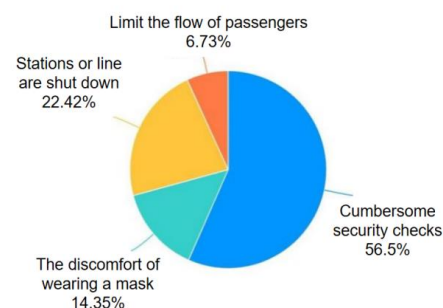


Fig. 11. Measures that have the greatest impact on people aged 31-50.

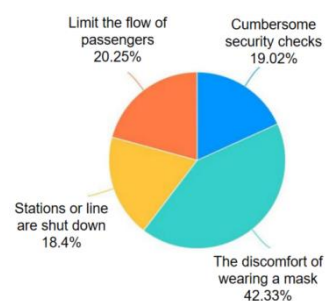


Fig. 12. Measures that have the greatest impact on people aged 18-30.

According to the result of describing real subway operating environment today with 2-3 adjectives, the adjectives that occur the most are cumbersome, troublesome, repression, and tidy. From people's

descriptions, it is not difficult to see that although most people still abide by the subway epidemic prevention and control measures, these measures inevitably bring lots of inconveniences to people.

According to the result of describing their ideal subway operating environment with 2-3 adjectives, the adjectives that occur the most are comfortable, clean, rapid, and convenient. It can be seen that people's expectation for the subway lies in its comfortable, efficient and convenient operating environment. Therefore, the future subway epidemic prevention measures should be more convenient and humanized.

4 Anti-epidemic Measures of Urban Subways in Some Cities

4.1 Measures of Xi'an

All employees, security guards, security inspectors, cleaners and outsourced construction personnel at all stations of the subway shall wear masks and gloves throughout their work. Passengers entering the station must wear masks before taking the train. The disinfection and sterilization work should be strictly implemented.

A temperature measuring point shall be set in front of the security inspection entrance of each station to measure the temperature of each passenger entering the station in real time. The temperature shall be measured with a hand-held thermometer and a temperature measuring thermal camera. If the temperature is 37.3 degrees or above, the passenger shall cooperate with registration and isolation [8]. The passenger flow in the station was organized in an orderly manner, and the special one stop one plan for epidemic prevention and control was revised in real time. Key passenger flow stations shall arrange personnel to the temperature measuring points in advance to ensure the peak passenger flow in the morning and evening, guide passengers to queue outside the temperature measuring points in an orderly manner, and avoid the accumulation of passenger flow.

Implement the combination of passenger real name verification and Xi'an "one code pass" card control. The passenger can accurately locate the vehicle number, car number, and door number of the subway line by scanning the code, inputting the mobile phone number, and obtaining the verification code, so as to provide convenient and accurate travel trajectory services for passengers as well as accurate data for epidemic prevention and control.

The epidemic prevention and control measures for 21 feeder stations, transfer stations and large passenger flow stations in the line network are more stringent [9]. Compared with other stations, the epidemic prevention work is more difficult, and each link of the station is carefully controlled.

4.2 Measures of Wuhan

Personnel Protection. For employees, all of them need to complete the application for "Health Code", sign the letter

of commitment for integrity of returning employees, and carry out the temperature monitoring of employees. Meanwhile, pre job epidemic prevention training and meetings should be carried out online, the operation shift system needs to be adjusted to fix team members and reduce staff contact. Besides, it is necessary to provide employees with masks and protective gloves according to the requirements of the guide. Finally, the psychological counseling is carried out to relieve the psychological pressure of employees. For passengers, first, they must be screened for body temperature before entering the station for security check. Second, they must guide the passengers to wear masks throughout the journey. For the passengers who violate the rules, the police will persuade them to leave. Last but not least, they need to remind passengers to avoid piling up and ride in an orderly manner.

Cleaning and Disinfection. To refine the zoning and grading disinfection standards of Wuhan Metro station, five-level disinfection measures are adopted for facilities and equipment frequently and easily touched by passengers, passenger contact areas, disposable tickets and cards, and work areas. In addition, a "special recycling box for masks" shall be set to ensure the sealed storage and timely cleaning of garbage [10]. Domestic garbage is cleared daily, and garbage containers are disinfection and sterilization daily. After the collected waste masks are sprayed with disinfection water, they shall be treated as other garbage. Moreover, during the operation time, the ventilation system of the station shall implement the fresh air mode to ensure the air circulation of the station.

Passenger Transport Organization. The passenger flow is monitored in real time and controlled according to different levels to control the full load rate of the train and the passenger density of the station [10]. The system of real name scanning code boarding registration shall be implemented. Before passengers travel, they shall conduct real name registration and obtain the "green code" of Hubei Province health code. After entering the station, they shall scan the "entry code". During security inspection, they shall check the entry information and passenger health status. When arriving at the station, they shall scan the corresponding two-dimensional code of the carriage and automatically upload the boarding information to ensure that the passenger travel information can be queried and traced.

5 Solutions

In view of the above results, combined with the development trend of cutting-edge technologies in smart rail, smart city and other industries, the following countermeasures are put forward.

First is to further strengthen the control measures to deal with peak passenger flow concentration and improve the emergency plan. In view of the challenges of continuous return of frequent passengers and greater concentration of passenger flow during peak hours under the background of full resumption of work, there is a need to continue to strengthen the management and control of high-risk areas of passenger flow concentration, and focus on monitoring the passenger flow density of peak sections

and hot stations of each line, so as to match the transportation capacity and ensure the basic operation safety.

Second is to create a traceable and reliable epidemic prevention cooperation system. Continue to implement the real name system of boarding measures to ensure that boarding behavior can be traced, abnormal conditions can be investigated, and infection risks can be warned, create a mutually trusted epidemic prevention cooperation system between passengers and operating enterprises, so as to achieve mass prevention and control, consolidate the achievements of epidemic prevention and control, and strictly control the rebound risk. In the future, the formation of a normalized cooperation mechanism can be promoted for universal emergency management, and the intelligent management level of rail transit daily operation can be further improved.

Third is to build a real-time dynamic interaction system to open up the information barrier between passengers and operating units. Through station broadcast, social media, navigation software and other media, specific forms of expression can be innovated and the real-time and accuracy of passenger flow information push can be strengthened. This will also break the information barrier between passengers and operating units, and guide passengers to optimize travel choices.

Fourth is to improve the normalized and refined monitoring and early warning system for high-risk areas. There is a need to promote the establishment of an integration and sharing mechanism with multi-source social big data (crowd flow monitoring data of large business districts, office buildings, residences, etc., and shared bicycle and conventional bus operation data, etc.), and form a regional and urban passenger flow trend monitoring and early warning linkage. Through the passenger flow deduction method combining real-time monitoring data and historical data, the short-term prediction and early warning of real-time passenger flow can be realized. Subsequently, travel trajectory tracking can be carried out based on ticket data with identifiable personal attributes, and the data of the whole travel chain can be deeply integrated to predict travel behavior on the basis of long-term data accumulation, so as to realize the active prediction of passenger flow.

Finally is to simplify the display of passengers' personal information and realize automation, intelligence and integration. Nowadays, the health code system is too cumbersome for tourists. The important data such as tourists' personal health information and nucleic acid detection result information need to be connected with tourists' biometric information (such as face, fingerprint, etc.) to realize fully automated detection and improve detection efficiency and realize dynamic, intelligent, and integrated management and control.

6 Conclusion

To conclude, metro's prevention and control measures against COVID-19 are a strong guarantee for urban safety and sustainable social and economic development. There is a need to timely sum up experience to provide reference

for winning the normalized prevention and control campaign of the epidemic. Through strict management and organization, key measures such as personnel protection, environmental disinfection and sterilization, passenger flow control and screening and isolation are implemented. Besides, with the help of science and technology, important measures such as automatic temperature detection, big data monitoring, and efficient information transmission will be implemented, and the application of new technologies will be attached importance to. Finally, in view of the normalization trend of the epidemic situation and the changing characteristics of the virus, the prevention and control measures also need to be adjusted in time and keep pace with the times. Within the operation department, it is also necessary to establish and continuously improve the public health emergency plan for the subway to cope with the COVID-19 epidemic according to the new changes in epidemic prevention and control, and improve the crisis response ability of the subway department, so as to ensure the safe and stable recovery and development of the subway operation economy and the sustainable development of the subway system and social economy.

However, due to the difficulty of obtaining accurate data of all ages when collecting the data of the questionnaire, there is still space for improvement of this paper. Moreover, the scope of the survey is mostly about affluent areas, without considering the needs of all consumption levels. Therefore, future studies can focus on collecting more domestic data and cases to learn more.

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