Analysis of the influence of traffic control measures on the prevention and control of COVID-19

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Abstract: Transportation plays an important medium role in the COVID-19 epidemic spread, and correctly understanding this role will help to prevent and control the epidemic spread among different areas. This paper analyzed the process of the COVID-19 epidemic spread through transportation channels at home and abroad, and made a comparative analysis of the epidemic development before and after taking traffic control measures in different countries around the world. After clarifying the role of transportation channels in the epidemic spread, we simulated the epidemic development under different traffic control measures based on the SEIR disease dynamics model. The results show that, without traffic control measures, the peak value of infected people will appear earlier. If strict traffic control measures are taken, the simulated lines of the latent and infected people will almost disappear, and the epidemic will soon stop. Our research results provide a theoretical basis for formulating reasonable traffic control measures.

1. COVID-19 epidemic spread characteristics and process

1.1. Epidemic spread characteristics
COVID-19 is an epidemic disease that spreads very quickly. According to the research of health and anti-epidemic experts, the virus is mainly spread by direct transmission, aerosol transmission and contact transmission. In the early stage of the infectious disease outbreak, as people need a certain period to know the epidemic, we failed to take the necessary measures to prevent and control it in time, resulting in the spread of the virus, and further spread through human contact and transportation. This virus is similar to the transmission of atypical pneumonia (SARS) in 2003, but as patients in the incubation period of COVID-19 are also infectious, making it spread faster. The first infector contacts potential contactors through the transportation channel in public areas such as airports, railway stations, long-distance passenger stations, buses, shopping malls, supermarkets, etc., and spreads the virus to these contactors, who then communicates with other people and spreads the virus to more people. As shown in Figure 1, the virus spreads as an exponential function increases, and the spread speed is extremely fast.

1.2 Global spread process
COVID-19 virus was discovered in late January 2020 in Wuhan, China, and many cases occurred in many countries around the world. This sequence is basically similar, which shows that the spread of the COVID-19 virus takes traveler as carriers and spreads to all parts of the world through various transportation methods.
2. Comparison of measures for prevention and control of COVID-19 between China and foreign countries

2.1 Comparison of current situation
The project team statistically analyzed the current status of the global outbreak, and selected several key countries in China, South Korea, Japan, Italy, France, Germany, and Iran for comparison according to the degree of the outbreak. China's epidemic data comes from the official website of the National Health and Health Commission of the People's Republic of China, and the world's epidemic data comes from the official website of the World Health Organization. The results are obtained after normalizing the number of people diagnosed according to the population base of each country. As can be seen from Figure 2, the global epidemic situation is basically divided into three situations. One is Italy, France, and Germany, and the outbreak is growing very fast; the second is South Korea and China, which grew rapidly in the early stages of the outbreak, but after a certain period of time, the growth rate slowed down significantly; the third is Iran, where the growth rate is between the two kinds mentioned before.

![Figure 1. COVID-19 transmission characteristics](image1)

![Figure 2. Infection rate of 10,000 people in key countries](image2)

2.2 Comparison of transport measures for COVID-19 control in priority countries
In order to know the reasons for the different distribution of the growth rates of confirmed cases in these priority countries, and the important role of transport, this study analysed the transportation policy measures in the early stage of epidemic outbreak in the above-mentioned countries (the number of diagnosed people exceeded 100). Through the research, it was found that the priority countries in the outbreak have made the personnel flow control as the focus of the epidemic prevention and control. Different countries have successively made decisions on traffic control to slowdown the spread speed of the epidemic. The difference is that the time and space for traffic control measures in different countries are different. The Korean government announced the strictest anti-epidemic measures in Daegu and Gyeongsangbuk-do after one week of the outbreak in Daegu; Although the Italian
government declared a partial "lockdown" at the time 79 cases confirmed, it was limited to 11 small towns around Milan. By the time the Italian government realized that the situation was so serious that 11 provinces had been quarantined and public facilities, including schools, had been closed, the cumulative number of cases in Italy had reached 6,012; France government’s actions have been relatively rapid. Two weeks after the outbreak, President Macron announced that it will close schools and kindergartens across the country. At that time, there were 2,876 cases in France. Germany closely followed France, and 12 days after the outbreak, the German government announced the suspension of classes in all 16 states and banned activities of up to 50 people. Table 1 summarizes the traffic control measures of various countries.

| Time of traffic control | China | Korea | Italy | Germany | France | Iran |
|------------------------|-------|-------|-------|---------|--------|------|
| Within one week after epidemic outbreak | √ | √ | √ | √ | √ | √ |
| One to two weeks after epidemic outbreak | √ | √ | √ | √ | √ | √ |
| Two weeks later after epidemic outbreak | √ | √ | √ | √ | √ | √ |

3. Simulation analysis based on SEIR model

3.1 SEIR model

The SEIR model selected in this article is based on the traditional SIR infectious disease model, and adds a new element of Exposed, which is more in line with the actual situation of the COVID-19 virus. People who are susceptible to infection will experience an incubation period at the beginning of the virus infection, and specific symptoms will only appear after a period of time. Patients in the incubation period may also be infectious, and the latent person will become an infected person according to a certain probability. Based on the above theory, the differential equation of the SEIR model are:

\[
\begin{align*}
\frac{dS}{dt} &= -\tau \beta IS / N \\
\frac{dE}{dt} &= \tau \beta IS / N - \alpha E \\
\frac{dI}{dt} &= \alpha E - \gamma I \\
\frac{dR}{dt} &= \gamma I
\end{align*}
\]

In the equation:
- \( \alpha \) is the probability of infection.
- \( \beta \) is the probability of latent carrier converting to infected.
- \( \tau \) is the number of contactors.
- \( \gamma \) is the probability of cure.

In this model, the number of susceptible persons \( S \), latent persons \( E \), infected persons \( I \), and rehabilitated persons varies with the change of time \( t \) per unit time, and they will affect each other. The following is an iterative form:
\[ S_t = S_{t-1} - \tau \beta I_{t-1} S_{t-1} / N \]
\[ E_t = E_{t-1} + \tau \beta I_{t-1} S_{t-1} / N - \alpha E_{t-1} \]
\[ I_t = I_{t-1} + \alpha E_{t-1} - \gamma I_{t-1} \]
\[ R_t = R_{t-1} + \gamma I_{t-1} \]

(2)

3.2 Model operation
The parameters in this model include population, hospital-patient-segregation-area, human-flow-range, infection-rate, transform-rate, recovery-rate, initial-infectious-num, latent-time, receive-cure-response-time and receive-rate. In this study, the "traffic control situation" is an important adjustment parameter to run the model.

Assuming three situations:
① No traffic control, and people move at will;
② Close the external passage of the city (region), and the flow of people within the city (region);
③ Cut off all modes of transportation, and people only stay at the place of residence or walk around the place of residence.

These three situations are simulated by the human-flow-range parameter. Human-flow-range is the range of activity relative to each person’s location, ① ② ③ corresponds to the values of human-flow-range of 50, 10, and 2. Figure 3 shows the changes in the number of subjects.
3.3 Summary
By comparing the simulation diagrams, it is found that if traffic control measures are not taken, the peak number of infected people will be larger and earlier appeared. If strict traffic control measures are adopted to reduce the range of activities of the residents and even stay at home, the simulation lines of the latent and infected people almost disappear, which prove that self-isolation is one of the most effective measures to control the epidemic when the virus spreads.

4. Conclusion
Based on the above analysis, we can know that transportation plays an important role in the spread of infectious epidemics. When no traffic control measures are taken, the epidemic can quickly spread between different areas by transportation channels. Therefore, strict traffic control is the most effective way to control the epidemic situation. It is hoped that the results of this study can provide references and ideas for the prevention and control of epidemic in countries around the world.

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