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Research on the transmission trend and mechanism of novel coronavirus pneumonia based on data analysis

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Abstract: The outbreak of COVID-19 has caused tremendous changes in human life in the whole country and even the world. Based on the epidemic data of Omicron variant in January 2022, this paper improved the traditional Sir infectious disease model, established the sgir model of adding isolators, and predicted the changing trend of the ratio of healthy people, isolators, infected people and rehabilitated people. By comparing with the actual data, It shows that the improved model is basically consistent with the change of epidemic situation in Tianjin. The study provides a theoretical basis for the rational prevention and control of the epidemic, and shows that a series of measures taken by the Tianjin municipal government for the prevention and control of the epidemic are effective, and puts forward suggestions for the government to further formulate prevention and control measures.

Keywords: Novel coronavirus, SIR infectious disease model, prediction, government prevention and Control measures

I. INTRODUCTION

The emergence of COVID-19, at present, has a major impact on the world, mainly on the harm caused to mankind. At the beginning of 2020, there were more and more cases of novel coronavirus disease 2019 (covid-19) infectious pneumonia in Wuhan City, Hubei Province, and the epidemic quickly spread to all provinces and cities and even the world. On March 12, 2020, the World Health Organization announced that the viral pneumonia caused by the coronavirus that is raging around the world is a pandemic.

Over time, viruses have evolved. The newly discovered Omicron virus has ravaged the world and become the main epidemic strain in the United States, India and other countries. On January 4, 2022, the number of new confirmed cases in a single day in the United States reached a record 1.02 million, and has remained high ever since. According to the associated press, Omicron has replaced Delta as the main epidemic strain in the United States. The mutant spreads quickly, conceals disease and is highly infectious. As of March 20, 2022, the world has reported more than 468 million confirmed cases and 6 million deaths [1]. In the early morning of January 8, 2022, two positive cases of novel coronavirus nucleic acid were detected in Tianjin city, all belonging to the Omicron variant [2]. Tianjin is struggling with the Omicron variant that has swept the world, which is the largest local infection case caused by Omicron in China so far.

Literature [3] uses Runge Kutta method to program, and simulates and predicts the spread trend of COVID-19 by changing parameters such as daily cure rate and daily contact rate; Document [4] is based on SIR model, considering the factors of inter city traffic flow; Literature [5] established a system dynamics model to simulate the changing trend of the epidemic and the basic regeneration coefficient.

Based on the research on the outbreak of the epidemic in Tianjin, this paper established an sgir model to increase the number of quarantiners, analyzed the epidemic transmission data caused by the Omicron variant in Tianjin, predicted the trend of the number of infections in Tianjin, objectively evaluated the intervention measures taken by the government according to the results, and discussed the impact of prevention and control isolation and centralized treatment on the development of the epidemic.

II. MODEL CONSTRUCTION

A. Classical infectious disease model

Infectious diseases have always been the enemy of human health. In history, the epidemic of infectious diseases has had a great impact on human health and even survival. At present, there are four main research methods on infectious diseases, including descriptive research, analytical research, experimental research and theoretical research [6]. Infectious disease dynamics is an important method of infectious disease theory and quantitative research. It establishes a mathematical model that can reflect the dynamic characteristics of infectious diseases according to the characteristics of population growth, the laws of disease generation, transmission and development, and the social factors related to infectious diseases. Through the qualitative and quantitative analysis and numerical simulation of the dynamic characteristics of the model, the disease development process is displayed, the epidemic law of the disease is revealed, the development trend is

predicted, the optimal prevention and control strategy of infectious diseases is sought, and the theoretical and quantitative basis for the government's prevention and control decision is provided.

In the past 30 years, the research of infectious disease dynamics has developed rapidly. Scholars at home and abroad have established a large number of mathematical models to analyze the dynamic properties of various infectious diseases and the impact of various preventive measures on the epidemic law of diseases. SIR model is a classical dynamic model in infectious disease research, which was first proposed by Kermack and McKendrick in 1927 [7]. The model can give clear logical relationship and accurate trend prediction, and its prediction results are also mutually confirmed with the actual data of many infectious diseases in history. Therefore, it is still widely used and developed until now.

Common infectious disease models include Si, SIS, sir and SEIR models. Si model refers to that a patient has certain infectious power after contacting with susceptible persons, which is mainly applicable to the modeling of AIDS; SIS model refers to the transformation of the emigrant into the susceptible population, that is, the convalescent will be infected with the disease again, which is often used in influenza infectious diseases; A remover is added to the SIR model, that is, the patient who recovers and moves out will not be infected with the infectious disease again, which is often used in acute infectious diseases; The seer model has newly added the latent person, which is often used for infectious diseases with latent period, such as smallpox and measles. According to the data analysis and transmission of COVID-19, this paper establishes an improved SIR model for data analysis. Assumptions are as follows:

(a). The total population has always remained stable, that is, the birth rate and mortality rate of the population have not been considered;
(b). The infectious ability of the patients to the susceptible population is certain;
(c). After the patient is infected and recovers after treatment, he will acquire the immune capacity of the virus, that is, he will not be infected again;
(d). The birth rate and mortality rate are not considered, that is, the dynamic balance of the total population..

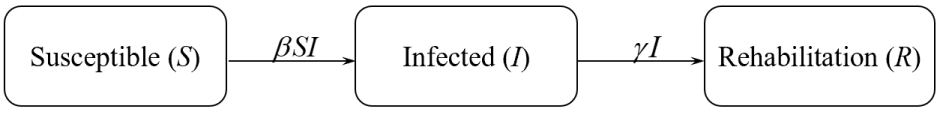

Figure 1.Flow chart of SIR model

The traditional Sir is established as follows. It is assumed that the number of new patients infected by the patient is βSI (β is an infection coefficient) and the number of dislodgers is γI in the unit time of time t. obviously, γ is the proportion of the dislodgers in the patients per unit time, which is called the removal rate coefficient. When the dislodgers include only the rehabilitated, it is also called the recovery rate coefficient. The flow chart is shown in Fig. 1. The classical model equation is as follows:,

$$\begin{cases} \dfrac{dS}{dt} = -\beta SI \\ \dfrac{dI}{dt} = \beta SI - \gamma I \\ \dfrac{dR}{dt} = \gamma I \end{cases} \quad (1)$$

B. SGIR model

Due to the particularity of the COVID-19 epidemic, which spreads widely and takes a long time, the government has implemented complete prevention and control measures. The government has vigorously screened and isolated close contacts and sub close contacts of the patients. Therefore, we consider establishing an sgir model with isolators, adding isolators variables to make the model closer to reality and easier to analyze the trend of the number of infections. Based on the sgir model, we add the following assumptions:

(1) All close contacts who came into contact with the infected person were isolated;
(2) The quarantinee will no longer contact with others after being quarantined;
(3) Infected people will not infect susceptible people after entering the hospital for treatment;

(4) The reason why susceptible people are directly infected and become infected is due to other channels such as overseas import.

The flow chart of establishing sgir model is shown in Fig. 2,

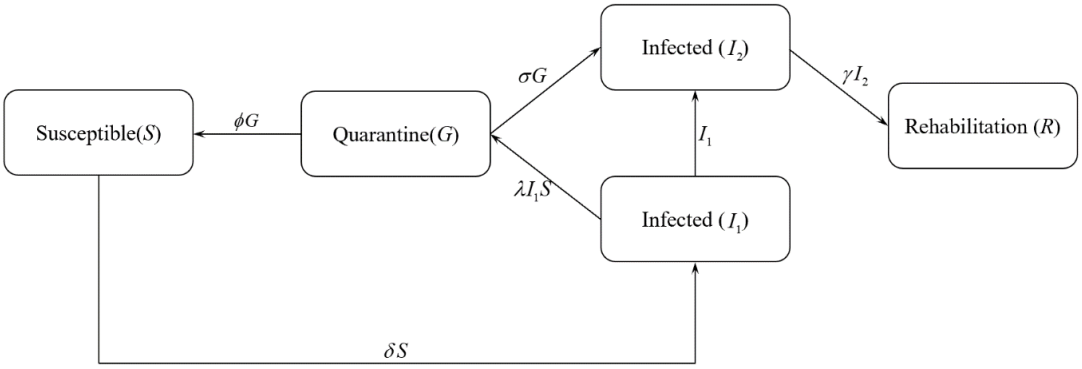

Figure 2. SGIR model flow chart

In Fig. 2, S represents the susceptible, G represents the isolated, I_1 represents the infected who did not receive treatment in time after being infected, I_2 represents the infected who received treatment in the hospital, and R represents the recovered. ϕ represents the rate of quarantiners moving out when they are not infected every day, δ represents the rate of susceptible people being directly infected, λ is the proportion coefficient of the daily contact population of infected people, σ is the rate of quarantiners being diagnosed with infection every day, and γ is the rate of the number of infected people moving out every day.

The SGIR model is established as shown in equation 2,

$$\begin{cases} \dfrac{dS}{dt} = \phi G - (\lambda S + 1) I_1 \\ \dfrac{dI_1}{dt} = \delta S \\ \dfrac{dG}{dt} = \lambda S I_1 - \sigma G - \phi G \\ \dfrac{dI_2}{dt} = \sigma G + I_1 - \gamma I_2 \\ \dfrac{dR}{dt} = \gamma I_2 \end{cases} \qquad (2)$$

C. Model solution

(a)Parameter fitting

(1) Daily removal rate of ϕ isolators

ϕ =Number of people removed from quarantine on that day/Total number of people quarantined on that day. Collect complete and real data in China through the official website of the Chinese Center for Disease Control and prevention [12], and get the number of close contacts who have removed their medical views and are still under medical observation within 30 days from January 8 to February 6, 2022. Curve fitting the removal rate is performed by MATLAB, as shown in Figure 3.

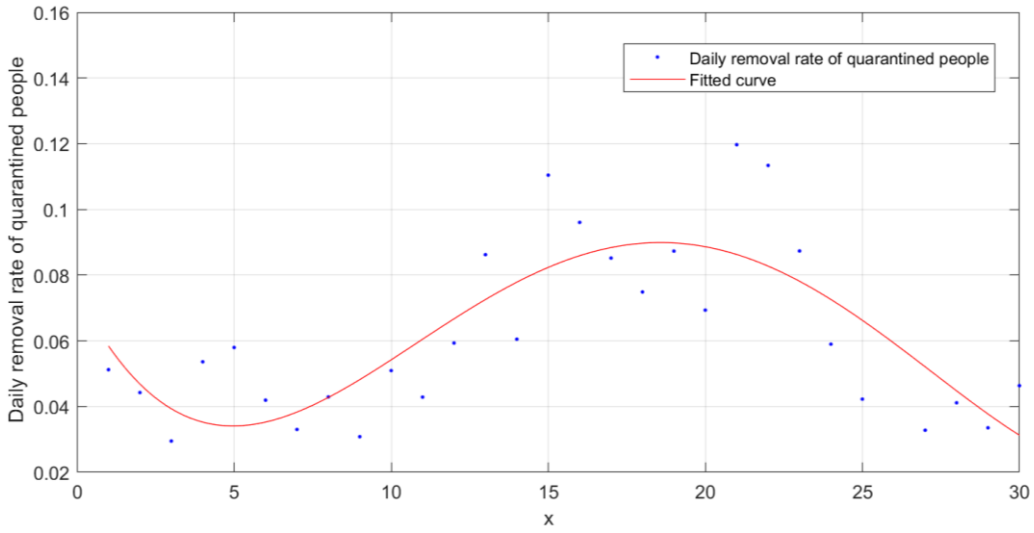

Figure 3.Fitting diagram of daily removal rate of isolators

It was observed that the daily removal rate of isolators fluctuated between 3% and 9%, and there was a certain volatility. Omicron initially broke out in Tianjin within 0-5 days, with a large increase in close contacts, and all close contacts were isolated for medical observation, resulting in a decrease in the daily removal rate of isolators; Within 5-20 days, the Tianjin municipal government took a series of effective measures, such as home isolation, non essential non going out, nucleic acid for all employees, etc., which increased the daily removal rate of quarantiners; Within 20-30 days, the daily removal rate of quarantiners will decrease again, which may be caused by overseas import, inadequate isolation measures, and a new round of small outbreaks of the epidemic. We found that ϕ basically fluctuated within a certain range, which indicates that the virus may not be completely eliminated in the short term. After being exposed to medical observation, the quarantiner may still become a close contact again and be isolated for medical observation. By calculating the expectation of ϕ, we determine that ϕ = 6.4%.

(2) δ susceptibility daily diagnostic rate

δ =Number of susceptible persons infected/Total number of susceptible persons.That is, the number of people who are susceptible to δS who are infected directly due to overseas import and other reasons, and who do not enter the hospital for treatment in time. By adjusting the parameters δ for data processing, we found that the δ between 0.1% - 1% was more similar to the actual.

(3) Proportion coefficient of infected persons in contact with the population

The number of susceptible persons contacted by a patient in t time is directly proportional to the total number of susceptible persons in the environment, and the proportionality coefficient is λ, that is, the number of close contacts caused by I_1 infected person in t time is λSI_1. The parameter λ is closely related to the local population density, the measures taken to prevent and control the epidemic, and everyone's life trajectory. By consulting relevant literature [13].

It was determined that the daily contact rate of each patient was 45%.

(4) Daily diagnosis rate of σ quarantiners

σ =The number of quarantinees diagnosed as infected on that day/Total number of quarantiners on that day. Collect complete and real data in China through the official website of the Chinese Center for Disease Control and prevention [8], and get the number of people who were confirmed to be infected by the quarantiners under medical observation and the total number of quarantiners under medical observation in the 30 days from January 8 to February 6, 2022. Curve fitting is performed on the confirmation rate by MATLAB, as shown in Figure 4.

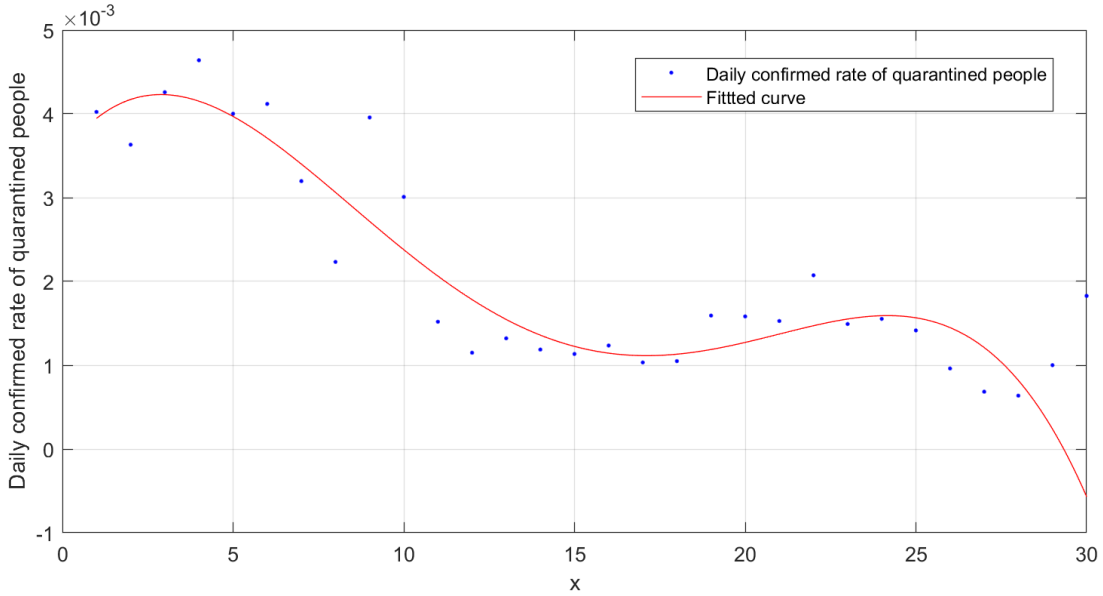

Figure 4.Fitting diagram of daily diagnosis rate of quarantiners

The diagnostic rate of quarantiners in 30 days generally showed a downward trend, and the diagnostic rate rose slightly from 0 to 3 days, and then reached the highest point. At this time, the Omicron epidemic in Tianjin initially broke out, and the number of confirmed cases was large; On March 18, the diagnosis rate dropped significantly, which showed that the government had taken effective measures to prevent and control the epidemic in time, medical facilities were perfect, people consciously carried out nucleic acid tests, and cooperated with the work of the government and the community, greatly reducing the diagnosis rate; The diagnosis rate rebounded from May 18 to 25, but the increase was slow. Finally, σ tended to 0.05%, and there may still be a few confirmed cases. Through the analysis of σ fitting curve, we set σ = 0.15%.

(5) Daily removal rate of γ infected persons

γ =Number of persons recovered on that day/Total number of infections on that day. Collect complete and real data of China through the official website of the Chinese Center for Disease Control and prevention, and get the number of cured and discharged patients in Tianjin every day and the total number of infected people on that day within 30 days from January 8 to February 6, 2022. Use matlab to curve fit the removal rate, as shown in Figure 5.

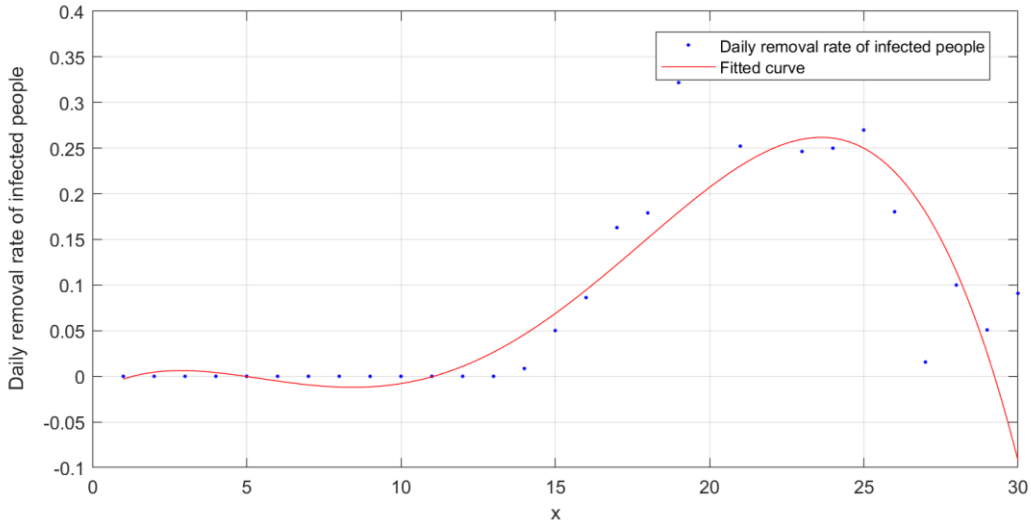

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Figure 5.Fitting diagram of daily removal rate of infected persons

We found that γ was 0 within 0-13 days, which indicates that the Omicron epidemic has initially broken out, the medical pressure is great, the effective treatment of infected people has not been started in time, and the medical progress is slow; γ increased significantly from 13 to 23 days, and reached its peak on 23 days, which indicates that medical assistance has been carried out, infected people have been effectively treated, and most infected people have been cured and discharged, and medical care has been carried out smoothly; After 23 days, the removal rate began to decrease, indicating that most patients had been discharged, which led to a decrease in the removal rate. On 30 days, 87% of the infected patients were discharged. Excluding the case that the removal rate is 0 in the first ten days, the rest of the data are expected, and the daily removal rate of infected people γ = 17.42%.

(b) SGIR model solution

The above five parameters are fitted and solved, and the parameter values are shown in Table 1,

Parameter	ϕ	δ	λ	σ	γ
Value range	3%-9%	0.1%-1%	45%	0.05%-0.4%	5%-30%
Selected value	6.4%	0.5%	45%	0.15%	17.42%

Use this parameter and substitute it into equation 2. Use matlab to solve the ordinary differential equation. Based on this model, predict and plot the ratio of healthy people, quarantiners, infected people and rehabilitated people, as shown in Figure 6.

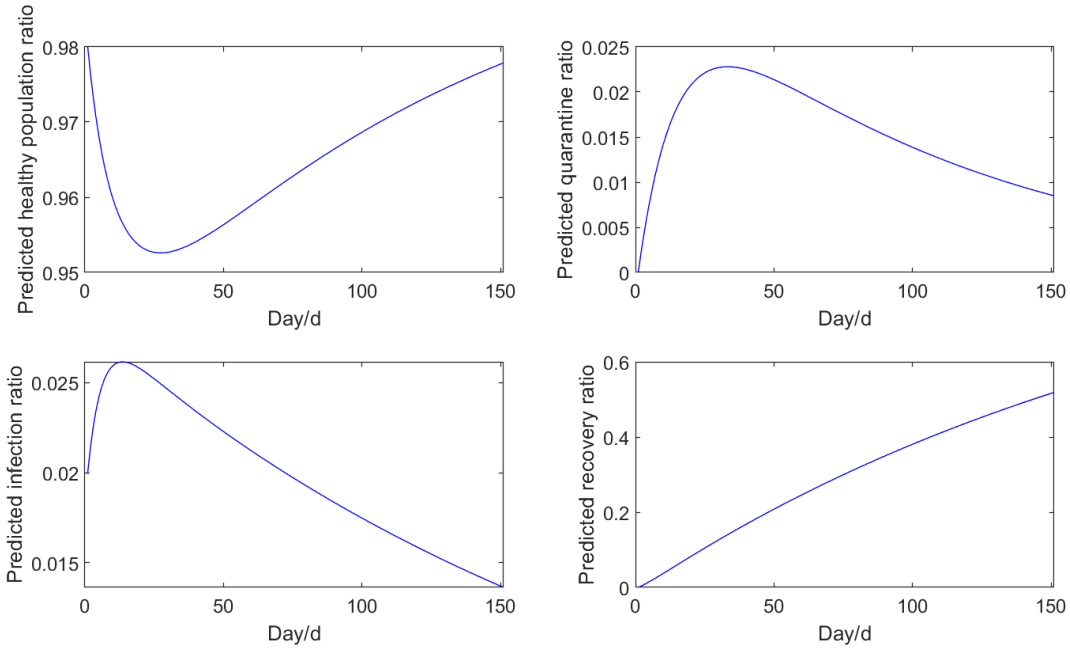

Figure 6. SGIR model result prediction diagram

The figure of the ratio of healthy people shows that at the beginning of the outbreak of Omicron variant, the number of healthy people decreased, and some people became infected, reaching the lowest on the 20th. Later, due to the smooth development of medical work, the infected people were successfully cured and recovered, and became healthy people again. Therefore, the ratio of healthy people gradually increased after the 20th, and recovered to the initial state after a period of time.

The ratio chart of quarantiners shows that at the beginning of the outbreak of the epidemic from January 8 to February 6 in Tianjin, due to people's low awareness of vigilance, the number of close contacts increased, resulting in a substantial increase in the number and ratio of quarantiners under medical observation; Through the overall regulation and control by human means, and the improvement of the consciousness of the people in Tianjin, and the active cooperation with the government's prevention and control actions, the number of close contacts has been reduced, and the proportion of quarantiners has been gradually reduced. It was observed that the ratio of quarantiners did not reach 0, indicating that the COVID-19 epidemic had not been completely eliminated, and there were still a small number of residues.

The infected person ratio chart shows that at the beginning of the epidemic, a large number of infected people were detected, mainly through nucleic acid screening, close contact tracking and observation, self-help medical treatment and medical observation of high-risk people, resulting in a significant increase in the infected person ratio, which reached its highest point on the 18th day; After that, through prevention and control measures, the diagnosis rate was reduced, so that the rate of infected people was gradually reduced and the number of infected people was reduced. Through observation, we found that the rate of infected people has not been reduced to 0, which indicates that the epidemic has not been completely eliminated, and there are still new infected people found and screened, which may be caused by overseas imports and other reasons.

It can be seen from the analysis of the ratio chart of rehabilitated persons that the ratio of the number of rehabilitated persons is gradually rising. Once the infected persons are found, they are treated in time, successfully cured and become rehabilitated persons. This shows that Tianjin has perfect medical equipment and developed medical level.

III. CONCLUSION

A. Analysis of prevention and Control Countermeasures

After the outbreak of the Omicron mutant in Tianjin, the government quickly adopted effective prevention and control measures, and encouraged the public to actively cooperate, strive to achieve early detection, early report, early isolation and early treatment, and strengthen the prevention and control strategy of "external defense investment and internal defense rebound". For epidemic prevention and control, the most important thing is to reduce the ratio of quarantiners and infected people and improve the recovery rate. Therefore, the government should do the following:,

(1) We should identify the source of the epidemic as soon as possible, implement blockade and control measures, quickly investigate and manage key areas and industries, reduce people's travel activities, monitor places, isolate close contacts in time, and reduce secondary infections. Before the epidemic spreads or the infected have not yet acquired the ability to spread, close contacts and sub close contacts should be identified as soon as possible, potential infected people should be controlled in advance, and efforts should be made to control the spread of the epidemic within the incubation period.

(2) Expand the scope of nucleic acid testing, implement all tests that should be done, strengthen case detection and treatment, comprehensively improve the case detection ability through fever outpatient screening, concentrated isolation medical observation of close contacts, home observation of high-risk people, large-scale population nucleic acid testing, and so on, so as to reduce the number of virus infected people infecting susceptible people due to insufficient screening. At the same time, hospitals should adhere to the outpatient appointment registration system, strengthen the protection of medical personnel, and strictly prevent hospital infection.

(3) We will take measures to further strengthen the technical training of medical, disease control, laboratory testing and other professionals to ensure that there are enough mobile transfer teams and testing capabilities to respond to the epidemic at the first time. The government and other relevant departments should timely respond to social concerns, eliminate public panic, strengthen health education, guide the public to take healthy behaviors, wear masks, wash hands frequently, do not gather, maintain ventilation, and actively do a good job in personal protection.

To sum up, in order to understand the current development and research hotspots of China's adult education, taking China Adult Education as an example, through the analysis of the column distribution, topic distribution, author group distribution and other aspects of all the online papers of the journal from its inception in 1992 to 2017, it can be concluded that in terms of topic selection, "teaching theory and teaching method" account for a considerable proportion, accounting for 26% of the total, These research topics are also consistent with the purpose of the journal, and are also the research hotspots in this field. Therefore, we can focus on the consideration and construction of such topics, which is of guiding significance to the practical work of continuing education; There is no direct correlation between the fund support and the quality of the paper and the frequency of citation, and it is not necessary to have the fund project support as the necessary condition for the paper employment; Six authors, including Le Chuanyong, published 12 highly cited papers, with a citation frequency of 720 times, making a great contribution to the total citation frequency. For such high-yield and high-quality authors, we should actively establish a long-term cooperative relationship to form a high-level author team.

In addition, China Adult Education started to introduce the author's title and academic qualifications from the 23rd issue of 2011. Therefore, in the future, we can analyze the correlation between the author's

academic level and professional title level and the highly cited papers, and provide a basis for the selection of the author's identity. At the same time, we can also understand the current situation of Chinese adult education practitioners.

B. Conclusion

In this paper, the Sir infectious disease model is improved. The main conclusions are as follows:

(1) Based on the classical SIR model and the factors of close contacts being isolated, a sgir infectious disease model based on increasing isolation factors is proposed. According to the data of the new round of Omicron mutant outbreak in Tianjin in 2022, the epidemic development process is simulated by MATLAB to predict the trend of the ratio of healthy people, quarantiners, infected people and rehabilitated people. The calculation results of the model prove the effectiveness of the new model and support the effectiveness of the government and relevant departments in epidemic prevention and control measures.

(2) From the analysis of the model calculation results, it can be seen that reducing the infection rate is the main means to reduce the number of infected people. Therefore, in the absence of vaccines and targeted drugs, prevention and control, isolation and centralized treatment are still the most effective measures to control the epidemic, which proves that the government's intervention has played a very positive role. However, the recent epidemic has spread rapidly in Jilin, Shanghai and other places. According to the research results of this paper and in combination with the actual situation, it is suggested that the intervention strategy should shift from "large-scale prevention and control" to "precise prevention and control", rely on community forces to focus on key populations, and effectively prevent the secondary transmission caused by imported sexually transmitted diseases.

(3) The improved SIR model in this paper can provide appropriate reference for formulating epidemic prevention and control measures. However, because there are many changing factors in the actual epidemic spread process, the virus mutation speed is fast, and the number of asymptomatic infections is further increased, the model established in this paper is relatively ideal, and needs further improvement in the follow-up work.

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REFERENCES

[1] World Health Organization. COVID-19 Weekly Epidemiological Update[EB/OL]. [2022-03-22]. http://www.who.int/.

[2] Yaxin Chai, Xiaopu Guan. The struggle of heaven [n]. The struggle of China, 2022-01-10 (004). Doi: 10.28423/n.cnki.njjc.2022.000104.

[3] Yanxia Zhang, Jin Li. Prediction and analysis of our epidemic transmission based on SIR model. *Anhui Industrial News Natural Science Edition* 37 (01): 94-101.

[4] Yi Ying, Hui Huang, Kai Ren, Ding Liu. Analysis of early covid-19 transmission and Research on government prevention and control measures based on susceptibility infection recovery (SIR) model. *Science and technology for development*, 2020, 16 (10): 1213-1220.

[5] Jiarui Liu, Yanrong Hu, Hongjiu Liu. Simulation study of covid-19 virus transmission based on Sir. New technology, 2022 (03): 62-64 + 68. Doi: 10.15940; 13 / j.cnki.kjycx.2022.03.019.

[6] Zhi'en Ma, Mathematical modeling and research of infectious disease dynamics. Shaanxi Province, Xi'an Jiaotong University, 2004-12-01

[7] KERMACK W O, MCKENDRICK A G. A Contribution to the Mathematical Theory of Epidemics. *Proceedings of the royal society of London. Series A, Containing papers of a mathematical and physical character*, 1927, 115(772):700-721.

[8] China Center for Disease Control and prevention. Epidemic situation [EB / OL]. [2020-03-30] http:/ /www.Chinacdc.cn/jkzt/crb/zl/szkb_ 11803/

[9] Ruguo Fan, Yibo Wang, Ming Luo, Yingqing Zhang, Chaoping Zhu. Prediction and analysis of COVID-19 transmission model and inflection point based on SEIR. *Journal of University of Electronic Science and technology of China*, 2020,49 (03): 369-374