Design of public safety and health system in the context of epidemic

Xiao Wang[1*], Deyi Xu[1], Tianqi Liu[1], Guowei Zhang[2]

[1]School of Safety Engineering, Shenyang Aerospace University, Shenyang, China;
[2]Mechanical School, Shenyang Institute of Engineering, Shenyang, China

ABSTRACT: Designing the public safety and health system in the context of epidemic is critical to public safety. This paper conducts modeling and analysis on the basis of the SIR model, establishes the "big prevention" system and the "grassroots" grid system. The purpose is to improve the response speed of the public safety and health system respectively, and play a reverse detection role on the epidemic data reported by the grassroots and reduce the possibility of under-reporting. The big data and computer network are used in the public safety and health system, which is the main tool of information transmission and analysis of the public safety and health system. Finally, the feasibility of the design is demonstrated by a case study.

1. INTRODUCTION

Public health is a science that aims to improve public health, disease and medical and health service-related problems from a group perspective, and use group methods to solve health-related problems. Prevention of infectious diseases through sanitary measures is the only magic weapon to effectively deal with infectious diseases. The design of public safety and health system in the context of epidemic is of critical importance.

In 2003, the SARS emergency management team has made a detailed analysis of the emergency management measures in the outbreak of anthrax. It provides comprehensive experience and reference for the improvement of China's public safety and health system [1]. Tong Li makes a detailed analysis of the China's public health safety system. From 2008, combining with the experiences of emergency management, the China's public safety has not only been limited to theories, but also been improved from the practical ability [2]. Jun Xu uses agent modeling and simulation method to conduct simulation analysis on the transmission process of infectious diseases in complex network [3]. Xiaoquan Hu confirmes the correctness for the China's emergency management system of unified leadership, classified management, comprehensive coordination, hierarchical responsibility and local management [4]. Shili Qin analyzes the advantages of China's public safety and health system [5]. A public safety and health system is designed basing on the big data. The COVID-19 epidemic is modeled and simulated, and which provides new ideas for the management of public safety.

Scholars from all countries have studied this new global epidemic [6]. This paper designs a public safety and health system of the epidemic according to basic SIR model.

2. QUANTITATIVE ANALYSIS METHOD

2.1 MODEL SELECTION

The SIR model is adopted in the paper, The basic SIR model is described by three ordinary differential equations. Three ordinary differential equations are susceptible population S, close contacts I and recovers R.

Their relationship is shown below:

$$\begin{cases} S' = -\beta SI \\ I' = \beta SI - \gamma I \\ R' = \gamma I \end{cases} \tag{1}$$

Where, the parameter β is transmission rate; the parameter γ is recovery rate. The SIR model is presented in Figure 1:

*Corresponding author. Email: 761385745@qq.com

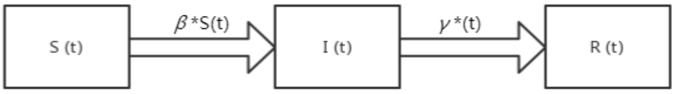

Figure 1 SIR Model

In addition, $N(t) = S(t) + I(t) + R(t)$, from which it can be deduced:

$$\frac{dN(t)}{d(t)} = \frac{d\left(S(t)+I(t)+R(t)\right)}{d(t)} = \frac{dS(t)}{dt} + \frac{dI(t)}{d(t)} + \frac{dR(t)}{d(t)} = 0 \quad (2)$$

3. NUMERICAL EXAMPLE

The COVID-19 data in a local scope during the initial stage of the epidemic are collected. At the same time the COVID-19 data within 9 days after the epidemic being basically controlled are collected. The data are listed in Table 1, and they are from the official website of Hubei Provincial Health Commission.

Table 1. Epidemic data of the epidemic

Date	Number of new cases	Cumulative number of confirmed cases
January 27	892	1590
January 28	315	1905
January 29	356	2261
January 30	378	2639
January 31	576	3215
February 1	894	4109
February 2	1033	5142
February 3	1242	6384
February 4	1967	8351
February 5	1766	10117
February 6	1501	11618
February 7	1985	13603
March 2	111	49426
March 3	114	49540
March 4	131	49671
March 5	126	49797
March 6	74	49871
March 7	41	49912
March 8	36	49948
March 9	17	49965
March 10	13	49978

https://doi.org/10.1051/shsconf/202214802016

3.1 MODELING AND ANALYSIS

After the initial epidemic data are entered into the Matlab system, the fitting results can be presented in Figure 2. The horizontal axis is time (days), and the vertical axis is the number of infected people. The blue curve I(t) represents the number of patients, the green curve S(t) represents the estimated number of susceptible people, and the red curve R(t) represents the estimated number of recoverers. The number of infected people shows a rising trend in the early stage of the epidemic, and the epidemic is still in a development stage. In addition, on the third day after the epidemic, there is an abrupt increase of the number of confirmed COVID-19 cases. This phenomenon is mainly due to lack of understanding of COVID-19 in the early stage of the epidemic. Many patients are not diagnosed with COVID-19 in the early stage of the epidemic.

It is necessary to calculate the coefficient and the confidence interval. In this paper, the more accurate DELTA method is selected to set the values of the confidence interval. The fitting value and confidence interval ranges of the model of S(t) and I(t) are shown in Figure 2. It can be seen from the calculation results of confidence interval that the number of COVID-19 infections reported is basically credible. According to the trend of data, the COVID-19 epidemic is still in the development stage and will be faced a more severe test. This analysis results are in line with the actual situation of epidemic development.

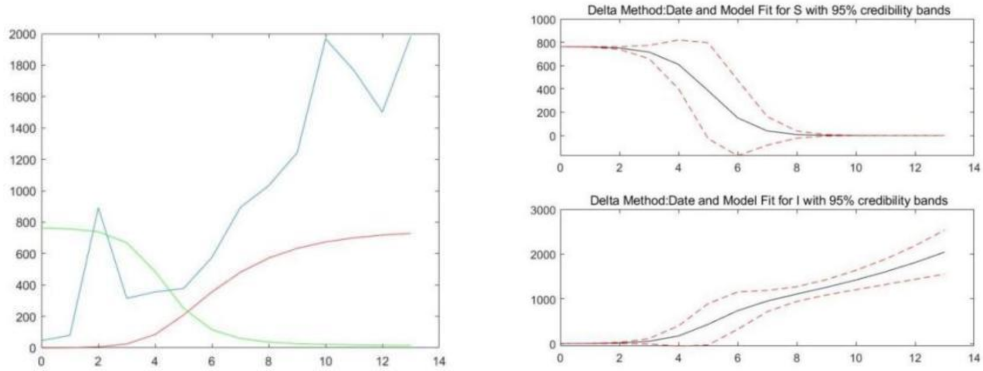

Figure 2 Data fitting and confidence interval of the first stage of the epidemic

According to Figure 3, the number of infections shows a downward trend in the latter stage of epidemic prevention. It indicates that the COVID-19 epidemic has been effectively controlled, and the risk level can be appropriately reduced. This prediction is consistent with the actual following epidemic prevention policy.

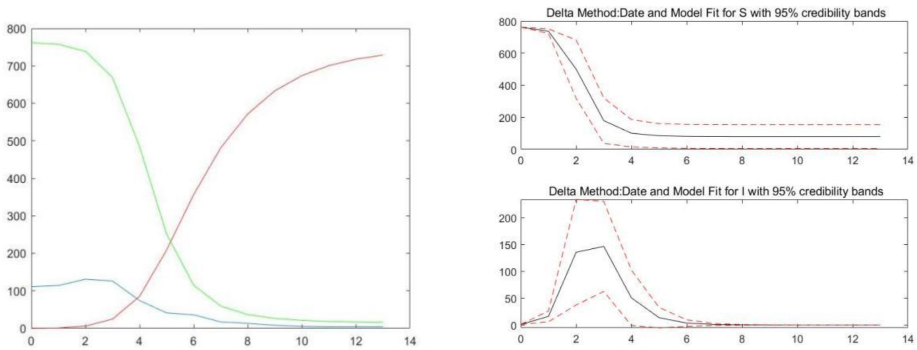

Figure 3 Data fitting and confidence interval of the second stage of the epidemic

4. CONCLUSION

Based on the analysis and evaluation in the epidemic outbreak, this paper has established a public safety and health system model based on SIR model. When an epidemic occurs, the grassroots epidemic prevention and control institutions are divided into hot nodes and common nodes. When the number of hot nodes reaches 50% of the total number, the infection rate of all nodes is acceptable under the condition of the value assumed in this paper. The design can improve the response rate of the epidemic, and reduce the possibility of under-reporting.

ACKNOWLEDGMENTS

This work has been supported by Social Science Planning Fund of Liaoning Province (Key Project) under Grant L21ATJ012, and National Natural Science Foundation of China under Grant 12102271.

REFERENCES

1 B. Wang, and X.Z. Song, (2020), "Research on the intelligence-led epidemic prevention and control model under the big data environment", Modern Intelligence, Vol. 40 No. 9, pp.15-19.

2 T. Li, (2008), "Risk Management of Urban Public Safety", Chinese Journal of Safety Science, Vol. 18 No. 3, pp.65-72.

3 J. Xu, (2013), "Study on emergency management of infectious disease emergencies based on complex network", Wuhan, Huazhong University of Science and Technology.

4 X.Q. Hu, (2020), "Rational reflection on improving public health emergency management system under COVID-19", China Medical Guide, Vol. 22 No. 7, pp.477-481.

5 S.L. Qin, (2020), "Advance with The Times and improve the public health safety system", Zhejiang Economy, Vol. 2, pp.36-37.

6 Q.M. Wang, Z. Zhang, "Based on the fact analysis of COVID-19 in the United States and the United Kingdom", Journal of Nankai University, Vol. 5, pp.106-117.