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Development of a Data Visualization-based Epidemic Transmission Chain Grooming Scheme

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Abstract

As the most serious major public health emergency in human history, an epidemic is rare in history in terms of its infectiousness, wide impact, large number of deaths, and difficulty in prevention and control. An epidemic is spreading rapidly to many countries and regions around the world, and the transmission mechanism is similar in different countries. In this paper, we take the historical data of an epidemic in a province in xxxx years as an example, estimate the disease transmission parameters, determine the influence of the number of infections Z on the disease, and establish a mathematical model of the epidemic transmission chain. Secondly, based on the mathematical model, a combing scheme of the transmission chain is derived, a blocking scheme is specified, and finally a recommendation report is written for the joint prevention and control department of the epidemic.

Keywords

Pneumonia in an Outbreak; Mathematical Model; Interruption Program; Referral Report.

1. Introduction

China was the first country to have an epidemic outbreak, and under the leadership of the Party with Comrade Xi Jinping as the core, China took stock of the situation and curbed the spread of the epidemic early[1]. Therefore, the combing and tracing of the transmission chain of new cases of pneumonia in an epidemic has become an indispensable basis for interrupting the spread of the epidemic, formulating prevention and control measures, and improving the efficiency of prevention and control. In this paper, a mathematical model for the chain of transmission of an epidemic will be established by analyzing the transmission mechanism of an epidemic; based on the mathematical model for the chain of transmission of an epidemic, a plan for the chain of transmission will be given; based on the plan for the chain of transmission, a plan for the interruption of the chain of transmission will be formulated.

2. Assumptions and Notations

2.1. Assumptions

We use the following assumptions.

1, the individual differences of the people conform to normal distribution.

2, When there are sufficient hospital beds, people automatically enter treatment.

3, Each hospital bed has a matching medical facility

4, After the first level of response to a major public health emergency was activated, people started to wear masks at home voluntarily.

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3. Model Construction and Solving

3.1. Model Building

The population can be divided into the following states.

Infected population Z, probability of infection G, number of cured people Y, uninfected population W, latent population Q, and dead population S.

We assume that the initial infected population is Z0, then after 1 day of infection.

$$Z_1=(G+1)\ Z_0 \tag{1}$$

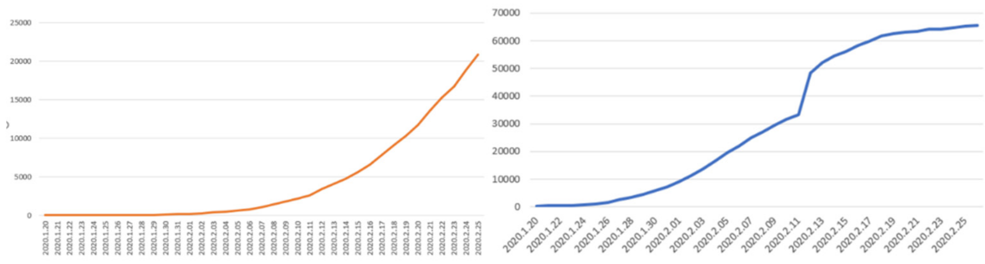
Then after N days of infection.

$$Z=(G+1)^N Z_0 \tag{2}$$

After adding the number of cures Y and the number of deaths S.

$$Z=(G+1)^N Z_0-Y-S \tag{3}$$

But the reality requires a correction of the parameters.



(a) (b)

Figure 1. Data on an outbreak in Hubei, China, a) The cumulative number of cured people in Hubei, China from January 20th to February 25th, 2020, b) The cumulative number of confirmed cases in Hubei, China from January 20th to February 25th, 2020

From this Figure 1, an exponential relationship exists between the number of cures Y and the number of infections Z, yielding a modified value for Y.

$$Y=Z^t \tag{4}$$

Find the average value of t.

$$t=(1.021)^T*0.562 \tag{5}$$

$$Y=Z^{(1.021)T*0.562} \tag{6}$$

Similarly, removing the unsuitable data from April 13-21 can be seen in a positive form to obtain the corrected value about S.

$$S=D*Q \tag{7}$$

The mean value of D was calculated IS 1.01675071538389.

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The equation obtained is.

$$Z=(G+1)^{T}Z_{0}-(G+1)^{T}Z_{0}^{(1.021)T*0.562}-(1.016)^{T}0.022*(G+1)^{T}Z_{0} \quad (8)$$

3.2. Validation Fitting of the Model Using Python Simulation

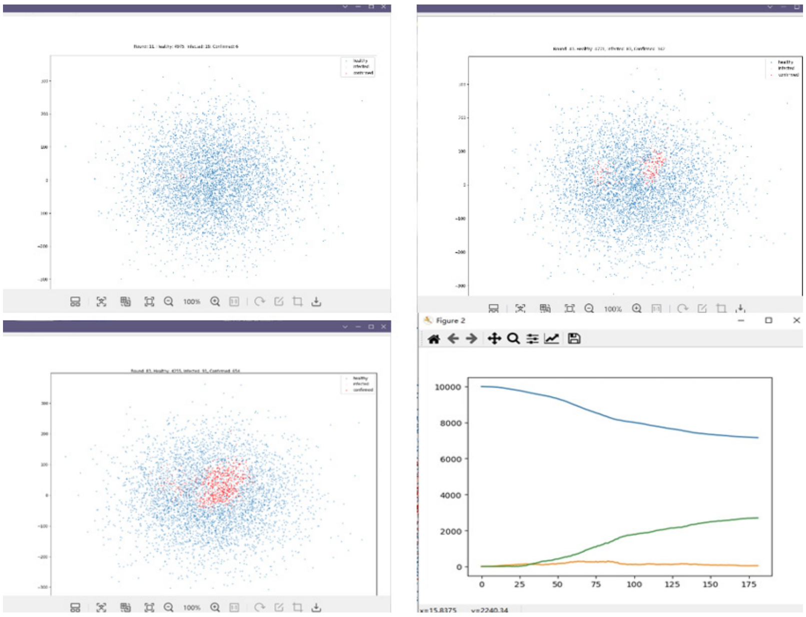

Figure 2. Python simulation data

Python Simulation
Total number of people:10000
Initial number of infections Z0=3
Infection probability G=0.5
As you can see as Figure 2.

$$S=(1.024)^{T}0.023*(G+1)^{T}Z \quad (9)$$

Similarly, we get Y.

$$Y=Z^{(1.128)T*0.687} \quad (10)$$

$$Z=(G+1)^{T}Z_{0}-(G+1)^{T}Z_{0}^{(1.021)T*0.562}-(1.016)^{T}0.022*(G+1)^{T}Z_{0} \quad (11)$$

With the original equation (11) match.

3.3. A Mathematical Model based on the Transmission Mechanism of an Epidemic

According to the analysis of the transmission mechanism of an epidemic, established a mathematical model for simulation research, and the research results showed that the activity range, contact distance, activity probability, protection rate, hospital response, and vaccine coverage have a great influence on the spread of the epidemic, and reducing travel, improving self-protection awareness, and active hospital response are important guarantees to stop the spread of the epidemic[2].

1.Activity range

The initial setting value of activity range is 2000 meters, when the epidemic has just appeared, everyone still keeps normal activities, that is, keep the initial value of activity range unchanged,

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through the simulation experiment, we can see that the virus spreads fast and covers a large area[3].

2. Contact distance

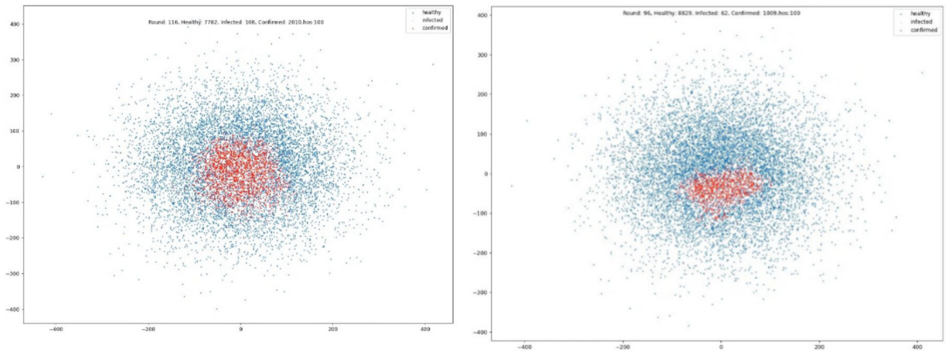

Figure 3. Original contact distance simulation data

The initial setting value of contact distance is 0.5 m, i.e. the distance when the residents are in normal contact. When the epidemic has just appeared, the residents still keep the normal intercourse distance, i.e. keep the contact distance unchanged. Through the simulation experiment, we can see that the epidemic spreads rapidly. Contact distance simulation data is shown in Figure 3.

Assuming that after the emergence of the epidemic, residents meet to consciously maintain a certain safe distance, the contact distance increases to 1.5 meters (assuming a safe distance of 2 meters for the spread of the epidemic), and simulation experiments are conducted to see that the spread of the epidemic slows down, and if the contact distance is greater than 2 meters, there are no new infections. Safety contact distance simulation data is shown in Figure 4.

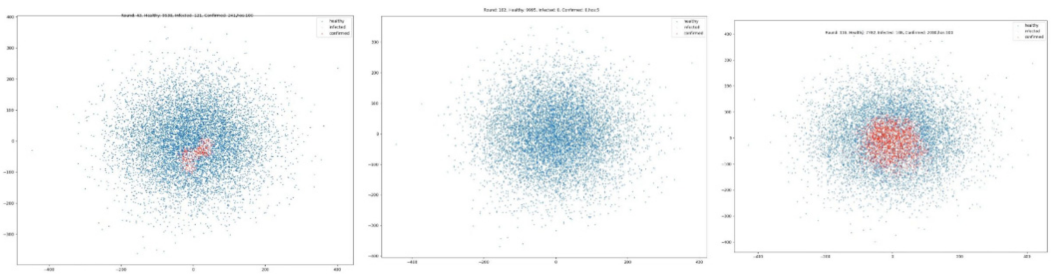

Figure 4. Safety contact distance simulation data

Conclusion: By comparison, the spread of the epidemic was significantly slowed by increasing the contact distance.

3. Activity probability

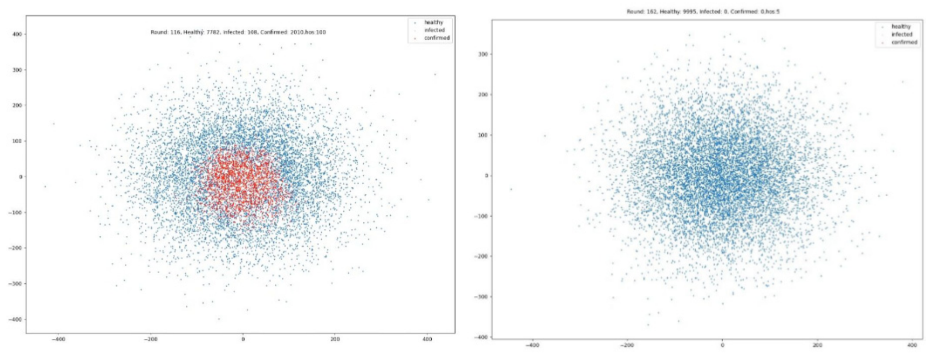

Figure 5. Simulation data to reduce the probability of activity

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Assuming that the probability of residents going out is 50%, the initial value of activity probability is 0.5. When the epidemic has just appeared, residents still keep going out normally, that is, the activity probability remains unchanged[4].

Assuming that after the emergence of the epidemic, residents do not go out in isolation at home, the activity probability decreases to 0%, and simulation experiments are conducted, it can be seen that there are no new infections except for the initial cases. Simulation data to reduce the probability of activity is shown in Figure 5.

4. Hospital response

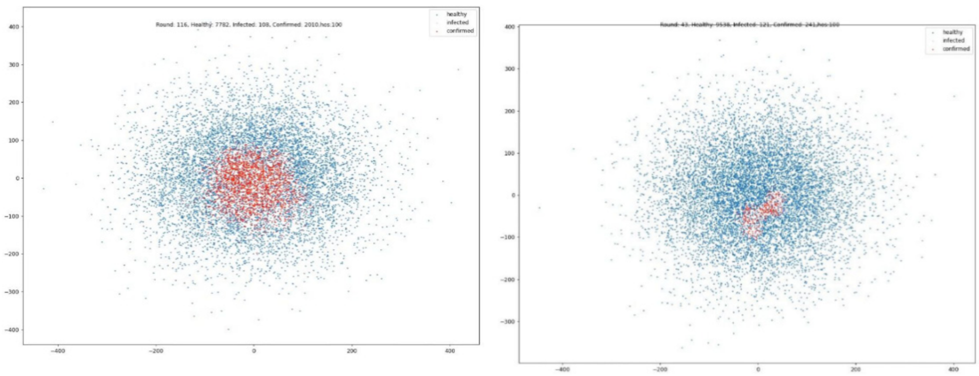

Figure 6. Simulation data during hospital response

Simulation data during hospital response is shown in Figure 6. When the epidemic first appears, the hospital has no response, i.e., it sets the number of isolation beds to 0, i.e., the patients cannot be isolated, and through simulation experiments, it can be seen that the infected patients will pass the virus to other residents if they are not isolated[5].

Suppose the hospital responds promptly after the epidemic emerges by setting 500 isolation beds, i.e., the first 500 patients with the disease can be isolated, and by conducting simulation experiments, it can be seen that patients are isolated after being diagnosed, and the spread of the epidemic can be stopped very effectively in the case of abundant hospital beds. In the absence of beds, infected patients can in turn pass on the virus they carry to other residents, but the cumulative number of confirmed cases decreases when the outbreak is over relative to when isolation beds are not set up.

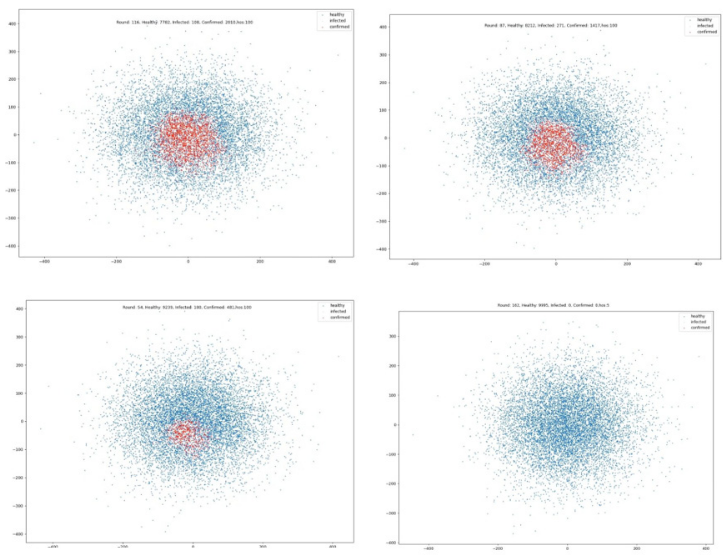

Figure 7. Simulation data during mask wearing and vaccination

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Conclusion: Strengthening the hospital response significantly slows down the spread of the epidemic and reduces the cumulative number of confirmed cases.

5. Protection rate and vaccine coverage

Assuming that residents do not take any protective measures and are not vaccinated, the chance of contracting the epidemic is 80%, the chance of infection is 0.8, and the epidemic breaks out quickly through simulation experiments.

Assuming that after the emergence of the epidemic, residents consciously do protective measures such as wearing masks when traveling, washing hands regularly, and disinfecting with alcohol, the chance of infection is reduced to 50%, and the epidemic spreads slower by simulation experiments, but there is still a great risk of infection.

Assuming that after vaccination, residents have 0% chance of infection without protective measures, and at 20% vaccine coverage, the vaccination effectively controls the spread of the epidemic through simulation experiments, but the spread still exists. At 100% vaccine coverage, no one would be infected.

Simulation data during mask wearing and vaccination is shown in Figure . Conclusion: Both wearing masks and vaccination directly reduced the infection rate of the virus and blocked the epidemic significantly, and increasing the vaccine coverage significantly slowed down the spread of the epidemic.

3.4. Blocking Programs

1. Reduce travel, reduce the scope of activities, increase the necessary public facilities, and reduce the distance between necessary public facilities.

2. Strengthen propaganda and raise residents' awareness of self-protection by calling on them to consciously wear masks, increase the distance between them and their contacts during outings, wash their hands regularly, and disinfect items carried out with alcohol.

3. Improve the response capability of hospitals to isolate one case if one case is found, and to treat one case if one case is found.

4. Increase the coverage of vaccines, so that all vaccines should be administered and a certain epidemic is fully covered.

3.5. Recommendation

In December 2019, patients with unexplained pneumonia infections appeared in the Wuhan area and human-to-human transmission was confirmed, followed by confirmed cases in several places. By now, the novel coronavirus infection pneumonia epidemic has swept the world and become the most serious major public health emergency in human history, and it is crucial to interrupt the spread of the epidemic in the face of the sudden outbreak. Therefore, my group has established a mathematical model to sort out the transmission chain of an epidemic through the analysis of the transmission mechanism of an epidemic, and has sorted out the transmission chain and made relevant suggestions to your department.

Based on the analysis of the transmission mechanism of a certain epidemic, my group established a mathematical model for simulation study. The results of the study showed that the activity range, contact distance, activity probability, protection rate, hospital response, and vaccine coverage have a great influence on the transmission of the epidemic, and that reducing travel, improving self-protection awareness, and active hospital response are important guarantees to stop the transmission of the epidemic.

Therefore, in response to the above, we propose the following recommendations to the relevant authorities.

1. Reduce travel, reduce the scope of activities, increase the necessary public facilities, and reduce the distance between necessary public facilities

Studies have shown that reducing travel and narrowing the range of activities are the core elements of interrupting an epidemic. During an epidemic, people should be called upon not to go out without necessity, while taking into account the necessary needs of the resident population and making reasonable responses. For the supply of the necessary living needs of the population is crucial, to reduce the range of activities of the population, it is necessary to reduce the necessary public facilities such as vegetable markets, supermarkets and other spacing. At the same time, the area is divided into areas, the unified management of the population in the area, to the area without communication.

2. Strengthen publicity and raise residents' awareness of self-protection

According to our experiments, residents' awareness of self-protection, consciously wearing masks when going out, increasing the distance between them and their contacts during going out, washing their hands regularly, and disinfecting their belongings carried out with alcohol and other protective measures have an indispensable strategic role in stopping the spread of the epidemic.

3. Improve hospital response capacity

The response capacity of hospitals is crucial. Only when the response capacity of hospitals is improved can one case be found and one case be isolated; one case be found and one case be treated. Improving the response capacity of hospitals is to interrupt transmission by isolating and reducing the sources of transmission.

4. Increase the coverage of vaccines

Increasing the coverage of the vaccine is a top priority. After vaccination, residents are greatly immunized against an epidemic virus, reducing the chance of infection. As the coverage of the vaccine increases, the scope of immunization of residents slowly increases, which can effectively curb the spread of the epidemic.

4. Conclusion

In this paper, based on the obtained data, a mathematical model is established, and the analysis of data visualization using python is carried out to find several factors affecting the spread of the epidemic, and the analysis is carried out using the control variables method, and based on the results of the analysis, a plan to interrupt the chain of epidemic spread is developed.

References

[1] Liang Guizhen, Hao Linli. Stability of a class of SEIQR epidemic models with both latent and contagious periods of transmission [J]. Journal of Southwest Normal University (Natural Science Edition), 2020(03):1-9.

[2] Wang JW, Cui Chiawei, Pan Xiaoxiong, et al. Simulation of the transmission mechanism and intervention effect of neocrown pneumonia based on the generalized SEIR model, Science and Technology Herald. 2020,38(22).

[3] Song YH, Zhong Chongyang, Han Qixing. Smooth distribution of nonlinear SEIR epidemic model [J]. Journal of Northeast Normal University (Natural Science Edition),2022(01):14-18.

[4] Du YF, Xiao P, Cao H. Kinetic properties of the SVEIRS infectious disease model with periodic incidence [J]. Journal of Southwestern University (Natural Science Edition),2016(09):116-122.

[5] Sun Guodao, Yang Yueven, Pan Xiang, et al. A review of visual analysis of epidemiological data [J]. Journal of Computer Science,2022(03):601-623.