Study on Spread Model of Infectious Diseases

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Keywords: Differential Equations; Mathematical Model; Infection; Control

Abstract. This article establishes exponential model according to data provided by the data base and comprehensively evaluates the rationality and practicality of this model. Then conduct a more comprehensive assessment of the issue, based on the introduction of a more comprehensive and reasonable assumptions and establishes analysis model system. Use set of simultaneous differential equations to reflect the epidemic development process inherent causal link between various types of people, and on this basis, this paper establishes the equation solving algorithm with MATLAB Programming (Annex II program) and gets an actual fitted curve and makes the epidemic prediction. The modeling process personal experience illustrates the importance of the establishment of infectious diseases such as SARS forecast model prediction models.

Introduction

SARS (Severe Acute Respiratory Syndrome, severe acute respiratory syndrome, commonly known as: SARS) is first spread of infectious diseases in the 21st century in the world. SARS outbreak and spread to China's economic development and people's life is a big influence, we gained a lot of important experiences and lessons learned, to spread awareness of the law of quantitative research of infectious diseases, to predict and control the spread of infectious diseases create The importance of conditions. Ask you a mathematical model for the spread of SARS, specific requirements are as follows:

Establish the exponential model spread of infectious diseases, and evaluate the reasonableness and practicality.

Establish your own model, explain why superior exponential model; in particular, to show how to build a truly predict and provide reliable, adequate model for the prevention and control of information, difficult to do so, where? For the measures taken by the health sector to make comments, such as: early or delayed five days to take strict quarantine measures, the impact caused by the spread of the epidemic to make estimates. Data provided in Annex 1 for reference.

Mathematical Model

Assumptions of The Model. 1) The spread of the epidemic has a strong, patient (carriers) by contact (air, food) the spread of the disease to healthy people. The number per unit time (one day) a patient can spread the constant k;

2) In the infected people have been cured of them do not consider whether the person is being spread again, the number of cure of the total number in the region is the absolute minority, no longer be cured does not affect the epidemic spread within the time infection rate constant k;

3) Sick spread during the incubation period is unlikely, based upon the healthy treatment;

4) SARS on the prevalence of different age groups are slightly different (or less), but we consider only healthy people it is the same rate of infection;

5) We have taken a very strict quarantine and isolation of patients was no longer infecting others;

The Establishment and Analysis of Mathematical Model. Since the beginning of the beginning of the epidemic is not enough government control, public awareness of SARS is not strong, resulting in the rapid spread of the disease. When the Government to take effective measures to enhance people's awareness of disease prevention, the epidemic is easing, the number of patients declined rapidly. SARS spread so can be divided into two stages:

1) Control Previous: namely that the mode of transmission of the virus is naturally spread.

2) Control Late: virus propagation model after strong government intervention.

According to the analysis of the exponential model and analyze the epidemic trend of differential equation as follows;

$$\frac{d}{dt}N(t) = K[\ N(t) - N(t - L)\ ] \qquad (1)$$

Solving of the Model. If you assume there is an initial outbreak of the time, initially N0 patients suddenly appeared within days of the L (t <L) is N (tL) = 0. In this early period made, the number of cases of equation (1) gives the exponential growth

$$N(t)=N_0(1+K)^t \quad (0<t\leqslant L) \qquad (2)$$

When L <t≤2L time, N (tL) of these people would have no ability to communicate, so we deduce the following model

$$N(t)= N_0[(1+K)^t - (t-L)K(1+K)^{(t-L-1)}] \quad (L<t\leqslant 2L) \qquad (3)$$

When 2L <t≤3L when there following model

$$N(t)= N_0(1+K)^t - N(t-L) \quad (2L< t \leqslant 3L) \qquad (4)$$

L may be understood to mean each patient before and after being found to have a direct infection of the period, after this period he lost contagion effect, possible causes are strictly isolated, no longer contagious illness or death and the like.

At different times in the range of L is not the same, we get the information summed up regardless of the stage for the outbreak of the epidemic, or control phase of the epidemic, this parameter cannot be too small, or not a good description of the various stages The data. This parameter is placed between 15-25 is better, and now the medical community has not determined the value of L, we imagine some people may resist ability, some poor people to resist, so we fixed it in 20 (days) this value has a certain sense statistically.

We value L is set at 20 days, is reasonable value when t is large, this model have an exponential relationship, the gap N (t) between before and after is relatively large, but when t> 60, the before losing the ability to communicate in only a few parts, so the provisions when t> 60 can also be used when (1+K) -N (tL) model N (t) = N.

In fact, the value of K is a variable that daily values are changing. When the epidemic started, the value of K is large, because there may be just may be the government has not enough pay attention to it, it is also not paid attention, the health sector is also not good equipment, doctors of the disease is also not very understanding technically there may be insufficient. But as the disease is increasing, the degree of attention from all aspects has greatly improved, which is the value of K is relatively small.

In this model, we believe that infection rates (K) on the value of the case is equal to the growth rate of the epidemic in the dissemination of the patient when he spread to healthy people, healthy people with the virus he may be, but the heat in the incubation period health state, according to the "national" SARS "science and technology research group published seven research progress," and pointed at 2003-06-03 incubation period reported in patients infected may be small. Relevant departments of the two cases of SARS during the outbreak spread chain conducted a detailed investigation and analysis, these two cases traced to the incubation period of the CPC in close contact with 158 people, no one died.

So we say the infection rate in the model only for patients with infectious diseases to others, and others to the disease, not the disease if not for the infection to others. Growth in value is the infection.

We have all the data provided by the country in the total of confirmed cases have been analyzed calculated the change in data rate of infection K and plotted graphs. Figure 1:

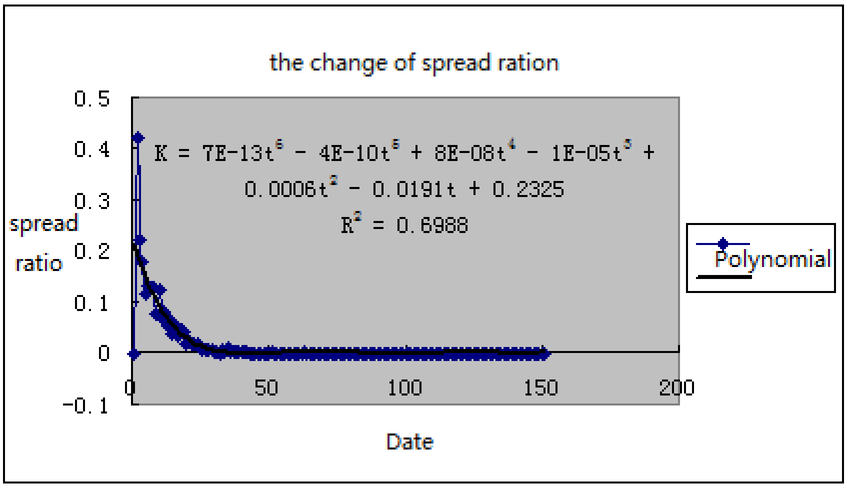

Fig. 1 The change of spread ratio

K (infection) t is a value associated with the curve, we K by the regression formula is:

$$K = 7E\text{-}13t - 4E\text{-}10t + 8E\text{-}08t - 1E\text{-}05t + 0.0006t - 0.0191t + 0.2325 \quad (5)$$

Figure 1 R = 0.6988 for the curvilinear regression mean square, visible presence is not big error. t is the number of days the epidemic.

Model Checking. By this formula can predict when the cumulative total number of patients starting on or after the outbreak.

For example, to predict the cumulative total number of patients a day, and the time t is the number of days into the equation (5) can be obtained K (infection) in size, because the value of L is set at 20 days, so when $0 < t \leqslant 20$ time, the K into (2);

When $20 < t \leqslant 40$ when the K into (3);

When $40 < t \leqslant 60$, the K into (4).

When t = 10, we according to the equation (5) can be obtained by K = 0.0923, we then substituted into K = 0.0923 (2) to give N = 8.

When t = 50, we according to the equation (5) can be obtained by K = 0.0614, we then substituted into K = 0.0614 (2) to obtain N = 308. This is very close to the actual data presented. Our model can explain a comparative model able to predict and can provide information for prevention and control.

The Importance of the Establishment of the Mathematical Model of Infectious Diseases

With the improvement of sanitation, medical standards improve and the continuous development of human civilization, such as the once raging global epidemic cholera, smallpox has been effectively controlled, but in some parts of the world, especially in poor developing countries , does not appear the case of epidemics, and the second at the same time, a number of dangerous infectious diseases are little known transnational cross-border in both countries also include the spread of a wider range of developing countries. All along, the mathematical model to describe the propagation of infectious diseases, the analysis by the variation of the number of infections, infectious forecast climax, etc., It plays an important role.

In recent sudden dangerous infectious disease- take SARS for example. From November 16, 2002 the first case occurred in China, Foshan City, Guangdong onset familial aggregation to May 2003, was the rapid spread of the disease. Currently more than 30 countries and regions around the world have a case report. Dr. Brundtlard World Health Organization (WHO) Director-General pointed out, SARS has been a threat to global human health. Since reliable data at present no reliable statistics on the pathological diagnosis SARS, so only provided under the health sector, the establishment of model to describe the spread of the SARS virus macro process, helping to analyze in terms of the amount of the number of infected trends, grasp the SARS epidemic law, so in a timely manner to control the epidemic and provide scientific data, and understand the basic elements of infection, to provide the necessary basis for the disease prevention.

For example, on May 8, Xi'an Jiaotong University, School of Medicine, Emergency Boot "establish SARS epidemic trend forecasting and control policy mathematical model" research project. On May 19 completed the initial first results, the mathematical model uses actual data fitting parameters, and the national and Beijing, Shanxi and other places of the epidemic were calculated simulation. The results pointed out that the timely isolation of patients is essential for the fight against SARS. Reports said that, the country is concerned, if the delay in isolating SARS patients one day, medical care will increase by about 1,000 people, an increase of about 2,100 people to postpone for two days or so; if 1,000 people outside input contains a patient and a patient lurking, will increase the number of patients 100 people; if after April 21, government quarantine measures are not taken, the number of patients to reach the peak of 60 million people.

While the US "Science" magazine website on May 23 published two recent studies show, if taken strict measures against SARS public health prevention, this new disease was able to get control. And such measures require a predictable, which requires people through modeling of incidence of SARS period, the number of incidence trends, the number of suspected and other trends to analyze and predict. And for the government and health sector decision-making and deployment data provide direct services to provide scientific data for the relevant research department.

As one of the emerging infectious diseases, SARS has its particularity, but also in line with the general propagation of infectious diseases. From the serious harm caused by SARS to people's health, it can be seen in a timely manner to infectious disease modeling and analysis and forecasting is essential for human life and health.

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