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Analysis of COVID-19's infection model and the influence of isolation and Preventive measures on the epidemic situation

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Abstract: *COVID-19's epidemic broke out at the beginning of 2020, and its high infection rate and difficulties in prevention and control led to its rapid spread throughout the country, and led to the death of a large number of patients suffering from COVID-19. In order to control the spread of the epidemic, quarantine measures were implemented all over the country. In view of the current epidemic prevention situation, the isolation policy is extremely correct. Based on the differential equation, this paper studies the propagation law of novel coronavirus and analyzes the function and influence of the isolation measures by establishing the propagation model in the natural state and the propagation model under the isolation measures, and using the statistical data. And compared with the implementation of isolation measures in the case of various data to verify the rationality of the model.*

Keywords: *Infectious disease model, Isolation and prevention, COVID-19, Economic perspective*

1. Introduction

COVID-19 is an infectious disease that spreads all over the world. The outbreak and spread of COVID-19's epidemic situation has had a great impact on the economy and life of our country and even the world [1]. In the face of the COVID-19 epidemic, China has implemented national isolation and prevention measures, while some Western countries claim that isolation and prevention measures do not have much significance for the control of the epidemic, and can not play any role in eliminating the epidemic. Repeatedly advocate the theory of group immunity, and in terms of the current global anti-epidemic situation, China is the most effective country in epidemic prevention, while those Western countries are deeply involved in the epidemic. It is very important for us to analyze the significance of quarantine measures again [2].

By establishing a model reflecting the spread law of COVID-19 epidemic situation, this paper tries to compare the number of infections and deaths between the implementation of isolation prevention measures for ten days and those without postponement of isolation prevention measures. Quantitatively study and predict the spread trend of the epidemic situation, reflect the positive effect of isolation and prevention measures on the prevention and control of COVID-19 epidemic situation, and provide a reliable information model for prevention and control. In addition, the model is further promoted from an economic perspective.

In practice, we can divide the whole population into susceptible people, suspected infected people, infected people and withdrawal groups (including cured people and dead people). Establish a differential equation model by analyzing the transformation relationship between all kinds of people. The development of epidemic situation is mainly affected by daily infection rate λ [3]. The severity of epidemic spread is described by parameter f (t), the relationship between λ and f (t) is determined, and then the relationship between daily infection rate λ and time t is obtained, which well reflects the effect of isolation measures on diseases.

2. Establishment of Communication Model in different situations

2.1 Propagation Model under Natural Propagation

First of all, the transmission model under natural transmission is established, and no isolation and preventive measures are taken under natural conditions, so that the transformation mode and conversion rate between susceptible population, infected population, withdrawal population and suspected infected

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population are exactly the same as those under natural conditions, and it is assumed that the infection rate λ is a fixed value [4].

According to the analysis of the problem, the population is divided into susceptible people, infected people, withdrawal people and suspected infected people. The transformation relationship between the groups is shown in the figure:

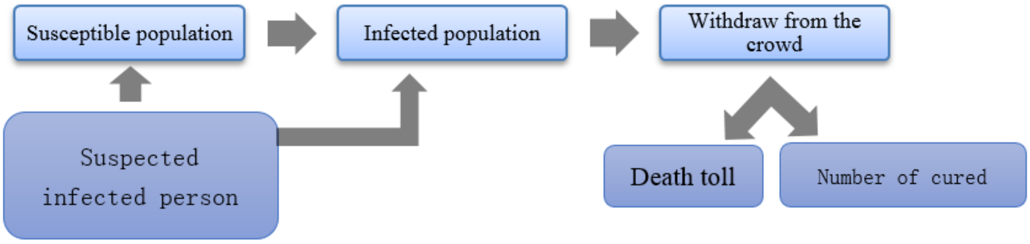

Figure 1: Transformation relationship

It is assumed that the total population of the area remains unchanged during this period, which is N, which is composed of susceptible people and withdrawal groups (the sum of the dead and the cured)[5]. The relationship between the susceptible and the withdrawn (the sum of the dead and the cured) can be expressed as follows:

$$S(t) + I(t) + C(t) + Q(t) = 1 \tag{1}$$

$$D(t) + H(t) = Q(t) \tag{2}$$

When the susceptible person and the infected person are effectively untouched, the infected person will be infected, and the susceptible person will be transformed into the infected person with the proportion of λ I every day; the proportion of the suspected infected person who is excluded from infection and transformed into susceptible person every day is β, then there are:

$$\frac{dS}{dt} = \beta C(t) - \lambda SI \tag{3}$$

Suspected infected people are transformed into susceptible and infected people in a certain proportion every day, the proportion of suspected infected people turning into susceptible people every day is β, and the proportion of suspected infected people diagnosed as infected every day is γ, then there are:

$$\frac{dI(t)}{dt} = \lambda SI + \gamma C(t) - \omega I \tag{4}$$

The change in the number of people who withdraw per unit time is equal to the decrease in the number of people who have been infected, and those who have been infected enter and withdraw in the proportion of ω every day, there are:

$$\frac{dQ}{dt} = \omega I \tag{5}$$

To sum up, we establish the transformation process between people under natural transmission, and also show the theoretical transmission model under natural transmission, which can be expressed as follows:

$$\frac{dS}{dt} = \beta C(t) - \lambda SI \tag{6}$$

$$\frac{dC(t)}{dt} = -(\beta + \gamma) C(t) \tag{7}$$

$$\frac{dI(t)}{dt} = \lambda SI + \gamma C(t) - \omega I \tag{8}$$

$$\frac{dQ}{dt} = \omega I \tag{9}$$

$$S(t) + I(t) + C(t) + Q(t) = 1 \tag{10}$$

2.2 Propagation Model under isolation and Preventive measures

The main factors affecting the development of the epidemic are the daily increase in the number of confirmed cases (m (t)) and the daily increase in the number of deaths (n (t).). For these two factors, the functional expressions of m (t) and n (t) can be obtained by curve fitting. Assume that f (t) has a linear

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relationship with m (t) and n (t). The expression for, f (t) is:

$$f(t) = q1 * m(t) + q2 * n(t) + b. \tag{11}$$

The control of isolation measures has played an important role in the process of controlling the epidemic.

When tasking _ 0, prepare to take isolation measures, at this time v (t) = 0.

1) V (t) increases with the strengthening of the epidemic, and increases slowly in the early stage, because there is no accurate understanding of novel coronavirus's transmission ability and harm in the early stage, and health departments and people do not pay enough attention to it, but when the epidemic develops to a certain extent, the spread of the epidemic will cause great concern of health departments and people, and the intensity of isolation measures will be strengthened in the later stage.

2) With the strengthening of isolation measures, the spread of the epidemic has been gradually controlled, and the growth rate of f (t), an indicator of the severity of the epidemic, has gradually slowed down.

3) When the epidemic situation is most serious, the attention of health departments and people will reach the maximum, and the intensity of isolation measures will also reach the maximum, which is reflected in that v (t) will approach 1, that is, with the increase of the severity of the epidemic, the attention of relevant departments and people will increase, so it seems that there is a positive relationship between, f (t) and v (t). Higher epidemic severity f (t) will lead to greater isolation and preventive measures v (t).

Isolation and prevention measures can effectively reduce novel coronavirus's infection rate (effective contact rate), and with the strengthening of isolation and prevention measures, both infected and suspected infections can be better isolated and observed. Can greatly reduce contact with susceptible people, thus greatly reduce the infection rate (effective contact rate), so. There is a reverse relationship between the intensity of isolation and preventive measures v (t) and the infection rate (effective contact rate) λ (t).

When no isolation measures are taken ((v (t) = 0), the infection rate (effective contact rate) λ (t) reaches the maximum, and with the continuous increase of v (t), λ (t) will gradually decrease, and we think that when the intensity of isolation measures reaches the maximum value 1, the infection rate (effective contact rate) can be reduced to the lowest value of 0.

$$\lambda(t) = k_2(1 - e^{-\frac{(1-v(t))^2}{\sigma}}) \tag{12}$$

3. Solution of the model

3.1 Solution of Propagation Model under Natural Propagation

According to the existing data, the actual existing data are estimated by fitting to determine the specific values of the parameters λ, β, γ and ω, which are brought into the formula (1) ~ (5) above to determine the specific functional relationship between the variables.

After the parameters λ, β, γ and ω are determined, after any four equations of formula (1) ~ (5) and four initial values of S (to), I (to), Q (to) and C (to), the proportions of S (t), I (t), Q (t) and C (t), can be calculated accordingly. In this paper, January 13th is taken as the convenient calculation of to, and the date after to=0, is set, and so on.

In this way, the predicted value in the case of the model is obtained by finding the numerical solution of the system of differential equations. The predicted images from January 13 to May 5 are shown in the following figure:

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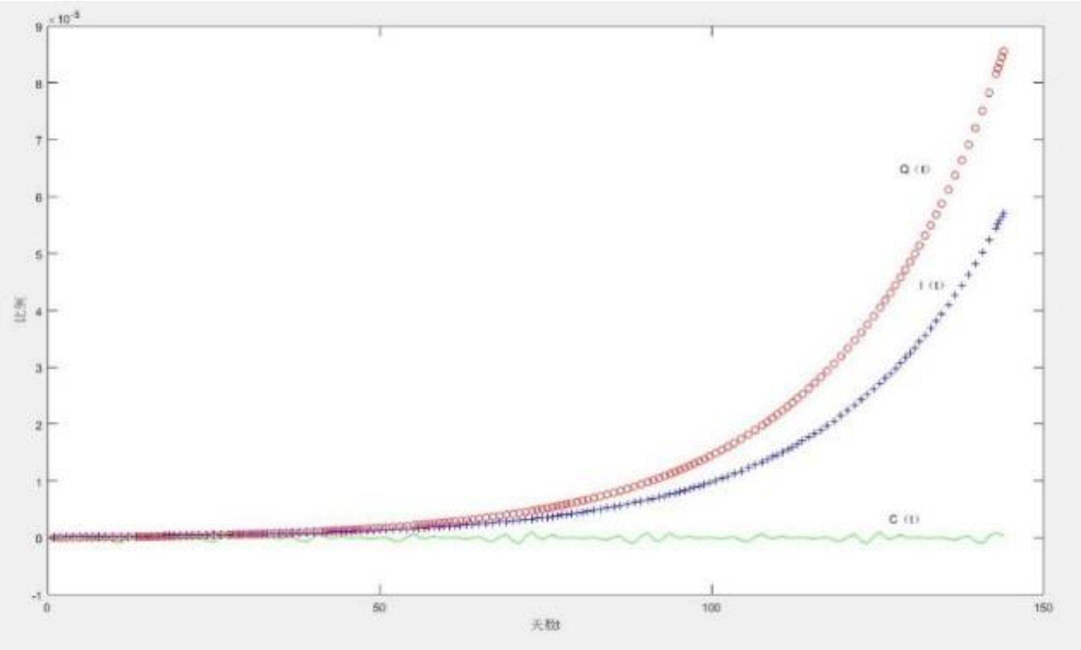

Figure 2: Propagation model under natural conditions

3.2 Solution of Communication Model under isolation and Prevention measures

According to the actual number of new diagnoses and deaths per day, select a more appropriate data pair.

M (t) fits the curve with n (t), and the result is as follows:

The curve fitting results of m (t) are as follows:

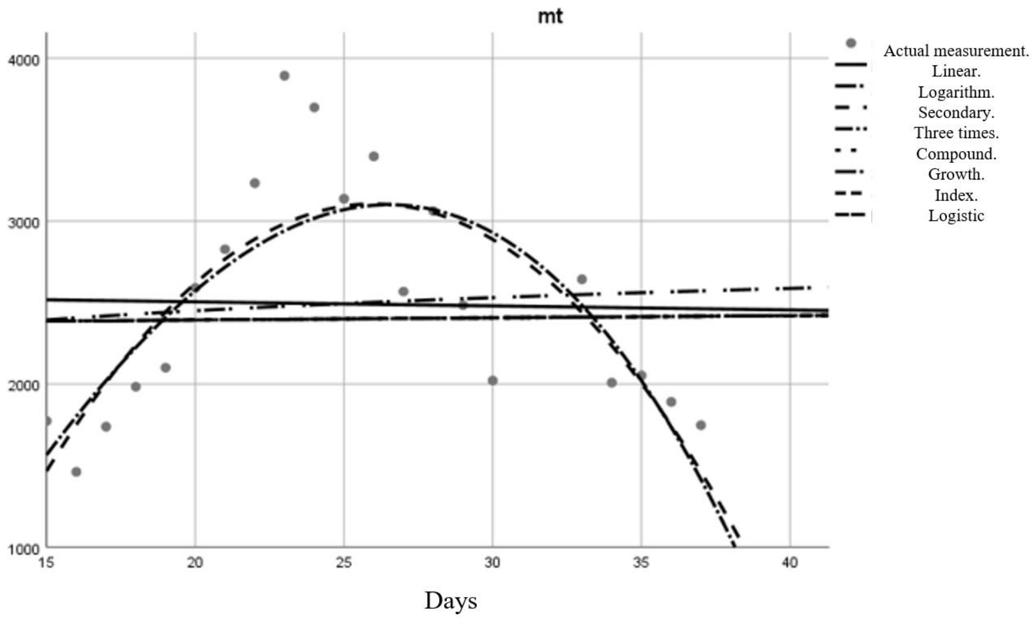

Figure 3: Fitting result

4. Conclusions

After the analysis of the above part of this article, we come to the conclusion that in the face of large-scale infectious diseases with strong contagious ability, fast infectious speed and certain fatality rate, governments of various countries should actively seek cooperation, strengthen communication and realize information sharing. Take isolation measures as soon as possible to control the spread speed and

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development degree of the epidemic, reduce the negative impact of the epidemic, and eliminate the epidemic in the bud. The source of the relevant data in this paper is true and reliable, which can truly reflect the relevant situation of the current epidemic situation, so that the answer and prediction of the question have a strong credibility; the models are all established on the basis of the changing relationship between variables shown by the actual data, which can better reflect the changing relationship between variables. For the situation in which isolation measures are expected to be taken 10 days earlier or 10 days later, through the analysis of the transmission mechanism of novel coronavirus, starting with the effective contact rate λ, the functional relationship between λ and time t is established, and the epidemic situation can be effectively prevented and controlled by controlling λ, and the results are analyzed and verified.

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