Study on the virus transmission based on data analysis of confirmed cases of the new-type coronavirus pneumonia in China

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Abstract: This study was based on the numerical analysis on the number of confirmed cases of new-type coronavirus pneumonia in Wuhan announced by the National Health Commission of the People's Republic of China, and the confirmed cases is collected from 15 January to present (30 January). The analysis results show that during this period, the number of confirmed cases increased strictly according to a single exponential law, indicating that the virus transmission showed a chain reaction. The main conclusion is that the spread of the virus is not only a "human-to-human" transmission, but also that the infectious power of each generation has not changed till to 29 Jan, and the number of people infected has increased tenfold in about 6 days, which are much faster than SARS. Furthermore, the rapid increase in the number of cases suggests that the new virus may have some new transmission channels different from SARS. According to these results, it is suggested to concentrate on studying the new-type coronavirus transmission mechanism and take targeted measures to comprehensively stop the virus infection.

Key words: New-type coronavirus in Wuhan, single exponential growth, virus transmission

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1. Introduction

Since 2020, the outbreak of a new-type coronavirus in the Wuhan region of China has caused great international attention. Although with the experience of fighting SARS in 2003, several research groups have confirmed the new-type coronavirus as a pathogen through electron microscopy, but the virus transmission mechanism, transmission route and pathogenic mechanism have not been understood. As a result, although various unprecedented and severe measures have been taken, such as "closing the city", the spread of the epidemic has not yet been effectively controlled, and the number of confirmed cases has risen sharply. The current situation shows that the new-type coronavirus has different transmission characteristics from the past, and past experience and measures maynot completely stop the spread of the epidemic. Therefore, it is an urgent task to investigate the law of transmission and infection of the new-type coronaviruses. Understanding such laws will help to know the mechanism of virus transmission and infection, and help fill the gaps in current countermeasures.

2. Objects and methods

This work studied the number of confirmed cases of the new-type coronavirus in Wuhan to obtain the virus transmission pattern. The number of confirmed cases comes from data released by the National Health Commission (NHC) of the People's Republic of China [1,2]. The number of confirmed cases from 16 January to 30 January was collected to study the law of virus transmission in the early period of the outbreak.

The data analysis was based on purely mathematical methods, and the mathematical rules of the confirmed cases were fitted. Based on the evolution of the confirmed cases and combined with the basic principles of multi-body system evolution in Physics, the basic inherent characteristics of virus transmission were analyzed.

3. Results and discussions

According to the number of confirmed cases published on the website of the

NHC, the raw data in Table 1 are obtained.

Table 1 Number of confirmed cases

Day	1	2	3	4	5	6	7	8	9	10	11	12	13
Date	16 Jan	17 Jan	18 Jan	19 Jan	20 Jan	21 Jan	22 Jan	23 Jan	24 Jan	25 Jan	26 Jan	27 Jan	28 Jan
Confirmed cases	47	62	121	198	291	440	571	830	1287	1975	2744	4515	5974

Day	14	15
Date	29 Jan	30 Jan
Confirmed cases	7711	9692

The above data is plotted according to the number of days (16 January is day 1) till to present (30 January), and the vertical axis is the logarithmic coordinate, as shown in Figure 1.

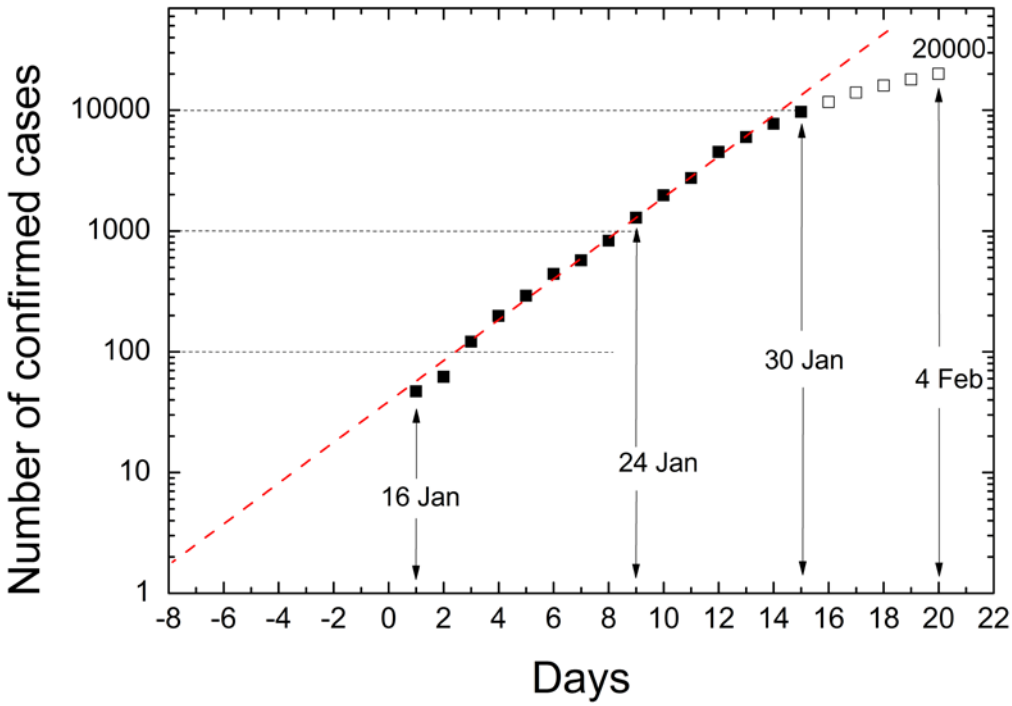

Figure 1 Relationship between the number of confirmed cases and the number of days on a logarithmic scale, where the open squares in the figure are the predicted values.

It can be seen from Figure 1 that from 16 Jan to 29 Jan, the number of confirmed cases has strictly increased in accordance with the single exponential rule, which is a straight line under the logarithmic coordinates. By taking three effective digits, the law obtained by fitting is as shown in formula (1),

$$y=40.1*Exp(x/2.61) \quad (1)$$

where y is the number of confirmed cases and x is the number of days.

The law of this single exponential growth in virus transmission can be clearly seen from Figure 1. It is unlikely to be merely a coincidence for the increase in the number of infected patients strictly follows the single exponential law over a relatively long period (more than 10 days), because this virus has been known an average incubation period of less than 7 days. From the theory of multi-body system evolution in Physics, this strict single exponential law is obviously dominated by certain internal mechanisms. Normally, a single exponential growth means a stable "chain reaction" within the system, that is, the former individuals have a stable and consistent influence on the latter individuals. Specific to this study, it is shown that from the beginning to the 29 Jan., the virus transmission has been in an unrestricted state, and the number of people infected by one patient did not change before the patient being isolated. This clearly shows that the new-type coronavirus in Wuhan is not only a "human-to-human" infection, but also that all infectious generations have the same infectious capacity, and the infectious capacity of the coronavirus has not decreased till to 29 Jan. This suggests that the spread of the new-type virus cannot be understood simply in the traditional theoretical framework , such as "first-generation infection" and "second-generation infection."

Furthermore, since the single exponential growth law determines that all generations and all individuals in the system contribute equally to the growth of the total number, so that during the spread of the new-type coronavirus, this law decides that "Super infectious patients" in the SARS epidemic may not exist, or very few. In other words, every patient is currently a "Super infectious patient". This shows that Wuhan's new-type coronavirus have a completely different transmission behavior from SARS.

In this infectious situation, the intensity of the new-type coronavirus infection is such that the number of infected persons increases tenfold in 6 days. If this situation continues, the number of confirmed cases before the end of January will exceed

10,000. Although the law of the "single exponential growth" obtained in this work definitely will NOT be extended for a long time, at least limited by measures to stop virus transmission and total population in the corresponding areas, the law gives very strong virus transmission at present. If this situation is continued, it is suggesting that the effects of current measures to stop virus transmission have not yet appeared, and the possible loopholes is not ruled out.

According to the fitting parameters, the time coefficient is 2.61, which indicates that under the state of uncontrolled virus transmission, the Wuhan new-type coronavirus has extremely strong infection intensity, which can double the number of infected patients within 3 days. This far exceeds the intensity of the SARS virus infection. At the same time, it is implied that the new-type coronavirus may have unknown transmission routes.

From the extended line of the fitted curve, it can be seen that the large-scale "human-to-human" infection started 10 days before the first data point, that is, around 5 January. It shows that before that day, the spread of the virus did not form a "chain reaction". If all infected people were treated at that time and the environment they contacted were thoroughly disinfected, it would be possible to prevent the large-scale spread of the virus.

According to the results in Figure 1, it indicates that the intensity of the new-type coronavirus infection is much higher than previously expected. According to this high-intensity human-to-human transmission data, there is no exclusion of "second-hand relay transmission" through the environment, that is, it is not directly transmitted to the healthy people through the virus infected people, but transmitted to the environment by the healthy people carrying the virus, later patients become infected through a polluted environment eventually.

The law of the "single exponential growth" proposed in this work can be the basis for judging the spread of the new-type coronavirus. Maintaining this law means that all aspects of virus transmission have not changed. When the number of confirmed cases falls below the law predicted value, it means that the virus transmission is suppressed, even if the absolute number of cases still rises, such as the open squares in Figure 1. Conversely, if the number of the confirmed cases is above the predicted value by this law, it indicates that the spread of the virus has increased, maybe suggesting that the virus has mutated. Fortunately, the case number of 30 Jan is already below the forecast value, which may be a good sign.

4. Conclusions

This paper analyzes the number of confirmed cases from 16 January to 30 January. Although the law of the "single exponential growth" obtained in this work definitely will NOT be extended for a long time, the law gives some basic characteristics of the virus transmission in the early period. This study concludes that (1) Wuhan's new-type coronavirus is highly infectious, and the number of infections has doubled in less than 3 days under the current situation, or 10-fold increase in 6 days; (2) The new-type coronavirus is not only "human-to-human", but also has the same infectious capacity in all generations and infectious generations, which has completely different performance from SARS; (3) As of 30 January, the effect of the current epidemic prevention measures is not very obvious, and the epidemic prevention task is still full of challenges. We must We must pay more attention to study personal protection and environmental disinfection technology and some new strategies to comprehensively block virus transmission and spread.

Compliance and ethics

The author(s) declare that they have no conflict of interest.

References

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