Study on the virus transmission based on data analysis of confirmed cases of COVID-19 coronavirus in China (III)

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Abstract: This study is a continue work of previous results posted on Jan. 31 [<https://doi.org/10.31219/osf.io/ek9n4>] and on Feb. 5. [<https://doi.org/10.31219/osf.io/uaq69>] This study was also based on the numerical analysis and general system evolution principle to analyze the number of confirmed cases and related data of 2019-nCoV coronavirus in China to present (Feb. 14) announced by the National Health Commission. The analysis result shows that since Feb. 7, the increase of confirmed cases has been lower than the linear growth proposed in Ref. 2, and the turning point is on Feb. 7. The main conclusion is that the spread of the virus has been effectively restricted since Jan. 23 in most regions of China, that is, since Wuhan city and many other cities were put on lockdown. Sustained lockdown strategy has significantly prevented the spread of the virus in most regions of China, although it seems that a little more time is needed in Wuhan city and Hubei provinces. The evolution of the case increment shows a clear 7-day period, which is a characteristic parameter of the 2019-nCoV spread. Based on these results, the spread of the virus has already been slowdown, and it is possible that the epidemic will end in a few more 7-day periods.

Key words: COVID-19, virus transmission, system evolution principle

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1. Introduction

Since January 2020, the outbreak of 2019-nCoV coronavirus in the Wuhan region of China has caused great international attention. The confirmed cases is growing sharply through China and other countries during the January. In order to limit the spread of the virus, various unprecedented and severe measures have been taken by Chinese government, such as "closing the city" in Wuhan city and following many other cities since Jan. 23. The spread behavior of the virus in the first stage has been studied as the report posted on Jan. 31.[1] The main results are that the number of confirmed cases increased strictly according to a single exponential law, so that the number of confirmed cases had risen sharply till to Jan. 30. From Jan. 30 to Feb. 4, the spread behavior of the virus in the second stage has been studied as the report posted on Feb. 5.[2] The main results are that the number of confirmed cases increased roughly according to a linear growth, the first turning point is on Jan. 30, which indicates the spread of the virus has been effectively restricted since Jan. 23 in most region of China, that is, since Wuhan city and many other cities were put on lockdown. There are more than 14 days since the first turning point, now is the right time to further evaluate the effectiveness of the lockdown strategy, which is very important to fight with the virus.

In this work, the numerical analysis and general system evolution principle still are the main methods to study the transmission behaviour of the 2019-nCoV coronavirus, based on the number of confirmed cases and related data announced by the National Health Commission (NHC) of the People's Republic of China.[3,4] Although these methods cannot give a microscopic transmission mechanism of the 2019-nCoV, the results from the system evolution view can present the actual impact of the virus on our society and some basic characters of the virus spread. Finally, these results can help to know the mechanism of virus transmission and infection, furthermore to help fill the gaps in current countermeasures.

2. Objects and methods

This work studied the number of confirmed cases of the 2019-nCoV coronavirus in China to obtain the virus transmission pattern. The number of confirmed cases comes from data released by the NHC.[3,4] The numbers of confirmed cases till to Feb. 14 were collected. Early data (before Feb. 5) are already presented in Ref. 2.

The data analysis was based on purely mathematical methods. 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 from Feb. 5 to Feb. 14 are listed in Table 1, where the prediction data are also listed based on linear growth by 2000 cases per day.[2] As same as before, Jan. 16 is the Day 1. For early data, please refer to Ref. 2.

Table 1 Number of confirmed cases and relative data

Day	21	22	23	24	25	26	27	28	29	30
Date	5	6	7	8	9	10	11	12	13	14
	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb
Confirmed cases	28018	31161	34546	37198	40171	42638	44653	59804	63851	66492
Prediction by linear growth	22000	24000	26000	28000	30000	32000	34000	36000	38000	40000
Confirmed daily increment outside Hubei	707	696	558	509	444	381	377	312	267	221
Total number of close contacts	282813	314028	345498	371905	399487	428438	451462	471531	493067	513183
Daily increment of close contacts	30659	31215	31370	26507	27582	28960	23024	20069	21536	20116

After Jan. 30, more and more useful data can be obtained or deduced, which allow us to conduct more studies based on Mathematics and Physics. Table 1 also presents some relative data, including the confirmed daily increment outside Hubei from Feb. 5 to present, total number of close contacts and daily increment of close contacts from Feb. 5 to present.

The number of confirmed cases is plotted according to the number of days (Jan. 16 is day 1) till to present (Feb. 14), and the vertical axis is the logarithmic coordinate, as same as in Ref. 1, 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 symbols in the figure are the predicted values.

It can be seen from Figure 1 that after Jan. 30, the number of confirmed cases has deviated from the single exponential rule, which is a clear signal for the change in the transmission mode of the virus as concluded in Ref. 2. Then the growth of the confirmed cases after Jan. 30 presents a rough linear growth. In principle, the linear growth presents that the system will grow by a fixed growth increment, here 2000 cases per day are set, same as before. [2] The predicated values based on the linear growth are also plotted in Figure 1, which shows approximate consistency, and the major deviation is caused by the confirmed cases in Wuhan and Hubei. The situation in Wuhan and Hubei is difficult, where this outbreak first occurred and thousands of people infected with the virus are waiting for treatment. Due to the relative lack of medical staff and facilities, it takes longer time to diagnose and treat patients. In Feb. 12, the local government changed diagnostic criteria, which led to a sudden rise in the daily confirmed cases, and then it was back to normal daily increment two days later.

Thus, the daily cases of this region is not stable, it is more reasonable to use China's daily increments except Hubei, as plotted in Figure 1. It is clear that the daily confirmed cases increment except Hubei province is stable at around 800 cases per day from Jan. 30 to Feb. 6, which is consistent with the linear growth. Then, the daily increment shifted to a position below the stable range on Feb. 7 and goes down monotonically after that, which is a clear sign of a change in the way the virus spreads out of linear growth. Therefore, Feb. 7 may be the second turning point.

Another interesting thing is that the evolution of the case increment shows a clear 7-day period. It is well known that a patient will undergo multiple stages, such as infection, incubation period, symptoms, diagnosis, treatment etc., but the impact of the lockdown strategy on the spread of the 2019-nCoV will appear in every 7 days. Although the result from the system evolution view cannot give a microscopic mechanism of the 7-days period, but it can be a basic characteristic parameter of the 2019-nCoV spread which should be matched with microscopic theory. Based on the decreasing trend of daily cases, it is possible that the epidemic in most regions of China will end in a few more 7-day periods.

In order to judge the spread of the virus in China in a larger scale, another set of data is used for analysis, i.e. the number of close contacts. The close contacts are those who have had close contact with a person infected with the virus and who have the potential to be infected, such as having a meeting in the same room, taking the same bus, etc. This total number of close contacts represents the largest population affected by the virus, and the data is plotted in Figure 2. The daily increment of the close contacts are also plotted in Figure 2.

Figure 2 Relationship between the total/daily number of close contacts and the number of days.

According to the results in Figure 2, the total number of the close contacts showed a similar trend as the total confirmed cases. After Jan. 30, it showed a linear growth, and the daily increment seems to be stable around 28000 from Jan. 30 to Feb. 11, indicating that the multiple-affect of the 2019-nCoV in the population has been stopped. If the current lockdown strategy can be maintained for 2 more virus

incubation periods which means most of people who were already infected were treated, then the number of potential candidates should be reduced, and finally the daily confirmed cases should decrease too. In fact, since Feb. 12, the daily increment has moved to a position below the stable range, and expected to continue to decrease.

According to above analysis, if there is no more surprise, current state means fewer and fewer patients are wandering out, and we are winning this war. Conversely, if the number of the daily cases is raising again, it indicates that the spread of the virus has increased, maybe suggesting that the virus has mutated, or other something bad.

4. Conclusions

This study analyze the number of confirmed cases and related data of 2019-nCoV coronavirus in China to present (February 14). It is found that the number of confirmed cases has moved to a position below the linear growth in most regions of China, the turning point is on Feb. 7. The main conclusion is that sustained lockdown strategy has significantly prevented the spread of the virus in most regions of China. The evolution of the case increment shows a clear 7-day period, which is a characteristic parameter of the 2019-nCoV spread. Based on the decreasing trend of daily cases, it is possible that the epidemic in most regions of China will end in a few more 7-day periods.

Compliance and ethics

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

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