Research Article

Research on the Fluctuation Trend of the Spread of New Coronary Pneumonia Epidemic under Non-Strict Prevention and Control Conditions: Analysis Based on the Data of India's Epidemic

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Abstract

After a long time of joint efforts, the Covid-19 pandemic in some countries and regions has been effectively controlled, but since April 2021, the outbreak of the epidemic in India has posed new challenges for the prevention and control of the global epidemic. How to understand and interpret the rebound trend of the epidemic in India is an important reference for other regions to prevent and control the epidemic. Based on time-series analysis, this paper uses the system dynamics epidemic model to treat the population in the region as a whole and decomposes the spread of the Covid-19 in India into 4 fluctuating transmission processes. These processes show that the spread of the Covid-19 may have annual periodic characteristics and long-term trends. There is a critical period of about 45 days before the outbreak of the epidemic. The global prevention and control requires the joint efforts of all countries to end as soon as possible.

Keywords: Covid-19; Fluctuating trend; India; Non-strict Prevention and Control Conditions

Introduction

With the implementation of stricter isolation prevention and control measures and the wider application of vaccine, the prevention and control of the Covid-19 has achieved decisive progress in some countries, and the spread of the epidemic has been effectively controlled [1]. However, with the relaxing regional vigilance against the virus and the emergence of new mutations, the epidemic in some regions has a trend of secondary outbreaks, the most typical of which is India.

Since 2020, the epidemic situation in India has undergone several major stages: rapid spread, initial control, and easing. However, since late April 2021, with the holding of several large festivals such as the Big Pot Festival in India and the emergence of new mutant viruses, the Covid-19 in India is showing a trend of second outbreak. In the face of complex situations, quickly judging the trend of the epidemic and identifying key links in epidemic prevention and control are important for government to make effective decisions in the post-epidemic era [2,3].

Based on limited bulletins and demographic data. This paper uses the system dynamics method to establish an estimation model of the spread of the epidemic and make a theoretical estimate of the long-term fluctuating trend of the spread of the Covid-19 under non-strictly controlled conditions in India which has important reference value for in-depth understanding of the severity and extent of the spread of the epidemic.

Data Source

This study uses the daily updated Indian epidemic progress data published in the real-time big data report of the new coronavirus pneumonia epidemic on the Baidu platform. The population and other data come from the Indian census data (Table 1) [4].

Model Construction

Analysis of epidemic spread in India

The growth of the cumulative number of confirmed cases in India can be roughly divided into three main stages. The first stage is the period from India's reporting of the number of infections to July 12, 2020. At this stage, the cumulative number of confirmed infections remains below 1 million, and the cumulative scale of infections is exponentially distributed. The exponential function is used to estimate the scale growth. Goodness of fit $R^2 = 0.9798$, the function form is:

$$P_i^1 = 94289e^{0.023i} \ (i = 1, 2, \ldots, 96) \qquad (1)$$

The second stage is from July 13, 2020 to April 2, 2021. In this stage, the cumulative number of confirmed diagnoses gradually declines after experiencing a rapid increase in a slightly normal distribution. The epidemic control form is basically stable. The cumulative infection scale increases as a function of a long quadratic curve which is used to estimate the scale growth, the goodness of fit $R^2 = 0.9994$, and the function form is:

$$P_i^2 = 0.0115i^4 - 5.9487i^3 + 801.21i^2 + 35756i + 895069 \ (i = 1, 2, \ldots, 264) \qquad (2)$$

The third stage is from April 3, 2021 to May 5, 2021 (Number of changes in the scale of May 5 notified on May 6). At this stage, the cumulative number of confirmed infections returns to an exponential

Table 1: Statistics on the number of newly infected people in India from April 8, 2020 to May 5, 2021.

Date	Number of newly infected people	Date	Number of newly infected people	Date	Number of newly infected people	Date	Number of newly infected people	Date	Number of newly infected people	Date	Number of newly infected people	Date	Number of newly infected people
4.8	565	6.4	9551	7.31	57704	9.26	72404	11.2	63702	1.18	5952	3.16	6490
4.9	809	6.5	9361	8.1	59225	9.27	125885	11.2	41822	1.19	9975	3.17	62246
4.1	875	6.6	10157	8.2	52783	9.28	45816	11.2	23157	1.2	23568	3.18	36330
4.11	846	6.7	10607	8.3	50681	9.29	69268	11.3	51126	1.21	13388	3.19	42635
4.12	759	6.8	9803	8.4	70385	9.3	88682	11.3	45960	1.22	14811	3.2	38393
4.13	1248	6.9	9300	8.5	57258	10.1	77843	11.3	17683	1.23	11166	3.21	17175
4.14	1034	6.1	11311	8.6	62815	10.2	115721	11.3	84288	1.24	15558	3.22	74892
4.15	835	6.11	12247	8.7	61455	10.3	70948	11.3	39036	1.25	10897	3.23	43924
4.16	1060	6.12	8950	8.8	71338	10.4	63762	11.3	42098	1.26	17167	3.24	53793
4.17	922	6.13	11417	8.9	69947	10.5	76778	12.1	21252	1.27	1077	3.25	14250
4.18	1370	6.14	7114	8.1	45334	10.6	73924	12.2	39172	1.28	12451	3.26	66265
4.19	1250	6.15	11703	8.11	78320	10.7	40330	12.3	33203	1.29	18241	3.27	105259
4.2	924	6.16	11636	8.12	49563	10.8	77103	12.4	36807	1.3	19338	3.28	24422
4.21	1541	6.17	11685	8.13	59240	10.9	104785	12.5	31601	1.31	9915	3.29	99523
4.22	1290	6.18	12228	8.14	74689	10.1	51254	12.6	41795	2.1	13953	3.3	20817
4.23	1669	6.19	13542	8.15	24696	10.1	66103	12.7	22218	2.2	4814	3.31	93260
4.24	1408	6.2	15448	8.16	103313	10.1	96850	12.8	25006	2.3	19145	4.01	25837
4.25	1836	6.21	21041	8.17	50058	10.1	45118	12.9	42302	2.4	10888	4.02	90046
4.26	1607	6.22	8943	8.18	47904	10.1	69665	12.1	23876	2.5	6766	4.03	156632
4.27	1561	6.23	18905	8.19	81939	10.2	73702	12.1	33578	2.6	10357	4.04	32141
4.28	1873	6.24	15940	8.2	59016	10.2	67248	12.1	30258	2.7	15132	4.05	116537
4.29	1738	6.25	15626	8.21	52164	10.2	59034	12.1	37035	2.8	14749	4.06	107822
4.3	1800	6.26	20685	8.22	112676	10.2	61197	12.1	20905	2.9	2017	4.7	114706
5.1	2394	6.27	25874	8.23	41912	10.2	37398	12.2	22800	2.1	11012	4.8	130458
5.2	2442	6.28	20416	8.24	69834	10.2	70812	12.2	8935	2.11	19701	4.9	186103
5.3	2806	6.29	14303	8.25	62089	10.2	56386	12.2	32969	2.12	2036	4.1	97141
5.4	3932	6.3	12469	8.26	74664	10.2	25924	12.2	20983	2.13	13844	4.11	183468
5.5	2963	7.1	18777	8.27	91396	10.2	54457	12.2	28024	2.14	15951	4.12	119717
5.6	3587	7.2	18783	8.28	76605	10.2	47480	12.2	31158	2.15	9027	4.13	149858
5.7	3364	7.3	20895	8.29	22737	10.3	44438	12.2	20065	2.16	11876	4.14	246155
5.8	3342	7.4	31107	8.3	106557	10.3	44438	12.2	27605	2.17	11456	4.15	307867
5.9	3113	7.5	23272	8.31	65832	10.3	56861	12.2	16455	2.18	13234	4.16	197356
5.1	4353	7.6	25160	9.1	66292	10.3	31377	12.2	29959	2.19	13048	4.17	266277
5.11	3607	7.7	26726	9.2	94694	10.3	64249	12.3	16688	2.2	20438	4.18	308056
5.12	3475	7.8	21115	9.3	93883	10.3	24047	12.3	20689	2.21	8153	4.19	199100
5.13	3763	7.9	29888	9.4	88904	10.3	84009	12.3	30133	2.22	10844	4.2	288956
5.14	3942	7.1	27998	9.5	99138	11.1	30129	12.3	16072	2.23	19449	4.21	315802
5.15	3787	7.11	28928	9.6	67943	11.2	42177	12.3	12320	2.24	15811	4.22	332503
5.16	4864	7.12	23924	9.7	76468	11.3	54316	12.3	23501	2.25	13008	4.23	326769
5.17	5050	7.13	27181	9.8	76168	11.4	47251	12.3	22006	2.26	21024	4.24	350013
5.18	4463	7.14	34770	9.9	104421	11.5	28216	1.1	10404	2.27	16292	4.25	246812
5.19	3131	7.15	26543	9.1	76839	11.6	58655	1.2	17750	2.28	8697	4.26	402732
5.2	4527	7.16	41870	9.11	111760	11.7	39300	1.3	26291	3.1	18240	4.27	348279
5.21	6659	7.17	34634	9.12	82321	11.8	52731	1.4	8049	3.2	15266	4.28	307219

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5.22	9595	7.18	37407	9.13	100123	11.9	45269	1.5	24396	3.3	15675	4.29	386888
5.23	6433	7.19	50203	9.14	89449	11.1	25248	1.6	18504	3.4	19039	4.3	402110
5.24	7102	7.2	36810	9.15	85055	11.1	57576	1.7	17079	3.5	19485	5.01	392562
5.25	3620	7.21	44165	9.16	97721	11.1	31108	1.8	21310	3.6	13528	5.02	370059
5.26	9085	7.22	48987	9.17	81087	11.1	60633	1.9	21727	3.7	24109	5.03	355828
5.27	4507	7.23	42903	9.18	86573	11.1	39506	1.1	12045	3.8	13702	5.04	382691
5.28	8300	7.24	60135	9.19	95429	11.2	46277	1.11	13517	3.9	18760	5.05	412618
5.29	9239	7.25	59701	9.2	93367	11.2	30820	1.12	11724	3.1	5466		
5.3	8262	7.26	41030	9.21	100327	11.2	19130	1.13	12050	3.11	21327		
5.31	9144	7.27	41857	9.22	62685	11.2	38480	1.14	27982	3.12	39586		
6.1	5072	7.28	63594	9.23	89324	11.2	49443	1.15	14913	3.13	26583		
6.2	8023	7.29	49587	9.24	96134	11.2	46110	1.16	15819	3.14	28898		
6.3	11804	7.3	54966	9.25	77605	11.2	44281	1.17	10536	3.15	21669		
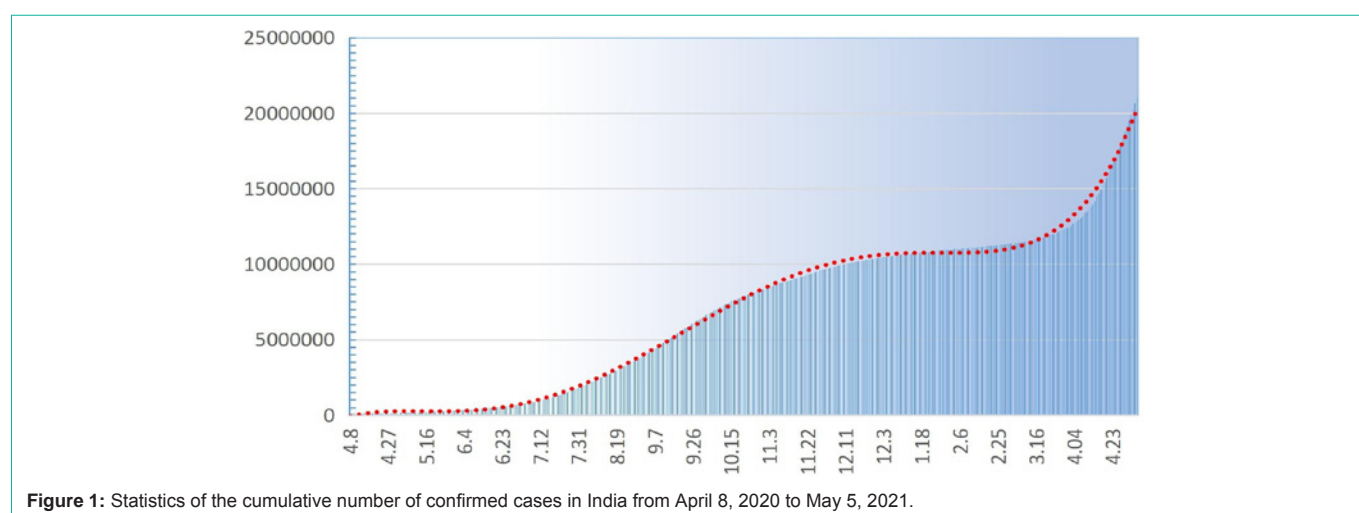
Figure 1: Statistics of the cumulative number of confirmed cases in India from April 8, 2020 to May 5, 2021.

growth pattern. Using the double-exponential function to estimate the scale growth, the goodness of fit R^2 = 0.9997, the function form is:

$$P_i^3 = 1.954E6e^{-0.1129i} + 1.075E7e^{0.0204i} \quad (i = 1, 2, \ldots, 33) \quad (3)$$

From the analysis of the changes in the scale of the cumulative number of confirmed infections, since April 2021 Covid-19 in India has entered a new round of explosive growth (Figure 1).

Establishing a trend-fitting function based on the daily change of the proportion of the cumulative number of confirmed diagnose to the uninfected population

In order to more intuitively observe and analyze the trend of changes in the scale of the cumulative number of confirmed cases in India, this paper uses the bulletin data and the total population of India (1.354 billion people) in the census bulletin to calculate the next day's growth rate of the cumulative number of confirmed cases to the uninfected population since April 8, 2020, and analyze its distribution [5]. A clear trend of fluctuations can be observed. Using Matlab to establish a general model of sum of Sin4 for fitting, Goodness of fit R^2 = 0.8818, the function form is:

$$P_i^t = a_1 \sin(b_1^i + c_1) + a_2 \sin(b_2^i + c_2) + a_3 \sin(b_3^i + c_3) + a_4 \sin(b_4^i + c_4) \quad (i = 1, 2, \ldots, 392) \quad (4)$$

a_1=0.02354, b_1=0.009094, c_1=-0.466; a_2=0.02698, b_2=0.01779, c_2=0.2827; a_3=0.008255, b_3=0.03032, c_3=0.9764; a_4=0.004568, b_4=0.03796, c_4=3.267.

Based on the analysis of the distribution of daily changes in the proportion of the cumulative number of diagnosed people in the uninfected population, the development of the new case in India has experienced three main processes of rise, fall, and slowdown. Now it has a clear trend of entering the rising stage again.

Predictions of the future 60-day change

Assuming that from May 6, 2021, the Indian government continues to adopt stricter epidemic prevention and control measures after July 13, 2020, and can continue to provide medical assistance services, then it can be assumed that the spread of Covid-19 is likely to follow the pattern of spread since July 13, 2020 in India within the next 60 days. The fitting function (4) can be used to estimate the daily change of the cumulative number of confirmed diagnoses to the number of uninfected population in the next 60 days, and then to get the daily newly diagnosed number and cumulative number of confirmed diagnoses. The steps are as follows:

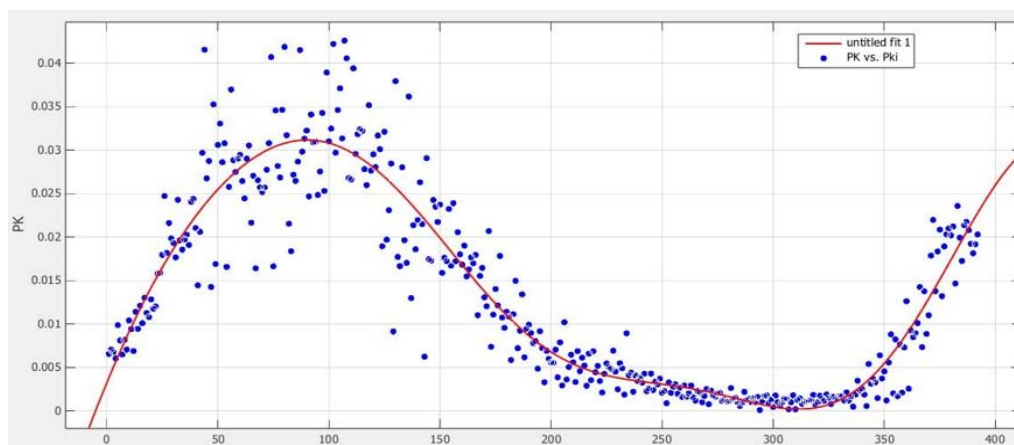$$K_i = K_{(i-1)}(1 + P_i^t) \quad (i = 393, 394, \ldots, 454) \quad (5)$$

Figure 2: Statistics of daily changes in the proportion of the cumulative number of confirmed diagnoses in India to the uninfected population.
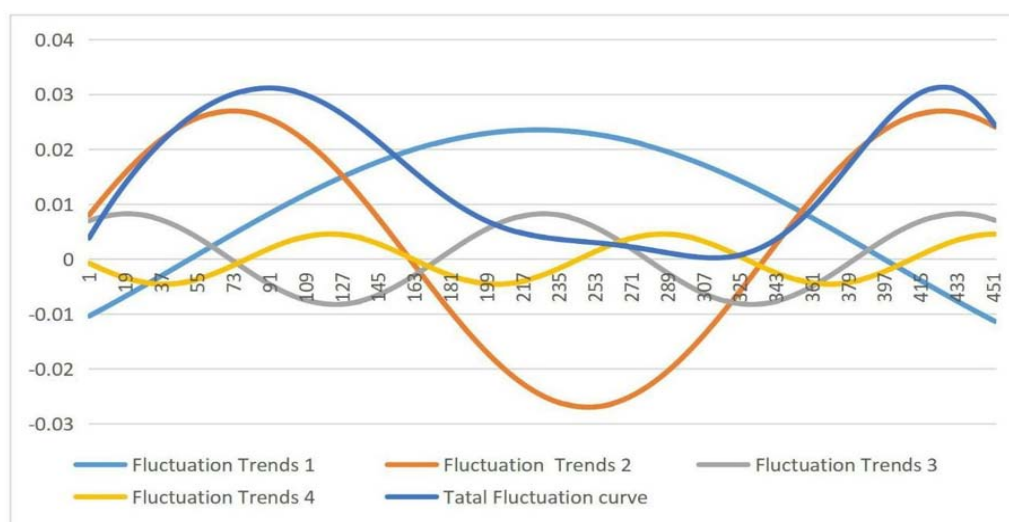

Figure 3: Decomposition of fluctuation trends in the spread of the epidemic in India.

$$P_i^A = \frac{P_{2i}K_i - P_{i-1}^A}{1 + K_i} \qquad (i = 393, 394, \ldots, 454)\ (6)$$

$$P_{2i} = P_{2(i-1)} + P_i^A \qquad (i = 393, 394, \ldots, 454)\ (7)$$

In formulas (5)-(7), K_i, P_i^t, P_i^A, P_{2i} are the proportion of the daily cumulative number of confirmed diagnoses to the number of uninfected people, the change the proportion of the daily cumulative number of confirmed diagnoses to the number of uninfected people calculated by the fitting function (4), the daily number of newly diagnosed and daily uninfected people.

Results

The spread of the Covid-19 in India has entered a new round of rapid growth

If there is no effective epidemic prevention and control to prompt or immediately stop the interpersonal transmission of the virus and treatment methods, India will face an extremely complicated process of explosive transmission in the next 60 days. The total number of confirmed cases after 60 days is likely to exceed 40 million (Table 2).

The number of deaths will continue to increase in India

Calculated based on the estimated death rate of India's Covid-19 reported on May 5, 2021, which is about 1%, if the cumulative number of confirmed diagnoses in India exceeds 40 million, as the pressure of treatment continues to increase, the death toll may exceed 400000 in the next 60 days people.

Adopting strict isolation and control measures is the first choice for India's current response strategy

Based on the experience of epidemic prevention and control in various countries around the world, to maintain moderate social distance and implement strict epidemic prevention and control measures before effective protection measures for vaccination are effective measures for India.

Discussion

From the perspective of time series, the spread of the Covid-19 may have annual periodic characteristics and long-term transmission trends. If we put aside the concern about the transmission pattern

Table 2: Prediction of the number of new and cumulative diagnoses in India within 60 days after May 6, 2021.

Date	Number of diagnoses per day	Cumulative confirmed number	Date	Number of diagnoses per day	Cumulative confirmed number	Date	Number of diagnoses per day	Cumulative confirmed number
5.6	350719	21421571	5.26	404774	29413790	6.15	323210	35801920
5.7	510110	21931681	5.27	355302	29769092	6.16	257365	36059285
5.8	375741	22307422	5.28	528189	30297281	6.17	118326	36177610
5.9	456995	22764417	5.29	323830	30621112	6.18	248560	36426170
5.1	408275	23172692	5.3	291031	30912143	6.19	216715	36642885
5.11	388220	23560911	5.31	350441	31262584	6.2	202830	36845715
5.12	446031	24006943	6.1	337414	31599997	6.21	202830	37048545
5.13	370108	24377051	6.2	184080	31784077	6.22	259533	37308078
5.14	395148	24772199	6.3	351924	32136001	6.23	143215	37451293
5.15	435570	25207769	6.4	478274	32614275	6.24	293254	37744547
5.16	426158	25633927	6.5	233940	32848215	6.25	109759	37854305
5.17	457926	26091854	6.6	301716	33149932	6.26	383445	38237750
5.18	286115	26377969	6.7	442056	33591987	6.27	137519	38375269
5.19	407705	26785674	6.8	205934	33797921	6.28	192510	38567779
5.2	438788	27224461	6.9	317974	34115896	6.29	247916	38815696
5.21	354215	27578677	6.1	336401	34452296	6.3	215669	39031365
5.22	330476	27909153	6.11	306942	34759239	7.1	128787	39160152
5.23	574581	28483734	6.12	269451	35028690	7.2	267721	39427873
5.24	209120	28692854	6.13	279324	35308013	7.3	179378	39607252
5.25	316162	29009016	6.14	170697	35478710	7.4	240682	39847934

Unit: Person.

of how specific cases were infected, and treat the population in the region as a whole, the transmission process of Covid-19 in India can be approximately decomposed into four different cases in a time series (Figure 3). The main reason for the large-scale spread of the epidemic in India since April 2021 can be seen as the superimposed effect caused by the fluctuation trends 2, 3, and 4 in the figure, which have entered the upward space. Among them, the trend 2 that may represent inter-annual fluctuations is the main aspect. From a practical perspective, it can be considered that the increase in the spread of the epidemic has become a reality due to the loosening of prevention and control measures.

The outbreak trend has a critical window period of approximately 45 days for prevention and control. Observing the daily changes in the proportion of the number of infected people in the uninfected population in India, we can find that the critical turning point is the 315th day, and the exact date is February 17, 2021.It took 45 days from this day to April 2nd. During these 45 days, if strict prevention and control measures continue to be implemented, it is entirely possible that the Indian epidemic will continue to maintain a steady decline. Unfortunately, India has relaxed its epidemic prevention and control efforts during this critical period. The rebound trend of the epidemic in India has also provided warnings to other countries and regions where the epidemic is basically under control. After the epidemic is stable and controllable, strict prevention and control measures should be maintained for at least 45 days, especially in areas with strong population mobility. Normalization and strict control will be the most efficient prevention and control strategy.

The predicted value of the model may reflect the serious consequences that India will have if it does not adhere to strict prevention and control measures, but the severity of the consequences is not limited to the upper limit predicted by the model. The prevention and control of the epidemic should not only focus on densely populated urban communities, but rural areas with inconvenient transportation and insufficient medical service provision should be the key areas for strict prevention.

Faced with the risk that the new crown virus may continue to mutate, rapidly expanding the scope of effective vaccines is a permanent solution to the global pandemic of the new crown pneumonia epidemic. As long as the epidemic is still spreading in some areas and the movement of people between regions cannot be stopped, the danger of another outbreak still exists at all times. From this perspective, no matter how different the region, ethnic group, culture, system is, human beings as a group should unite and deal with it together.

The shortcomings of this study are also obvious. It did not systematically summarize the evidence of the previous research, did not do too much authenticity inference about the data source, did not list the cluster analysis process and results due to space limitations, and did not explicitly give the estimated results and process of the scale of the cured population and the dead population. These problems will be solved in detail in other follow-up studies.

Funding

Prevention and Control and Emergency Management Decision Support Based on Health and Medical Big Data (GSWSKY2020-34).

References

1. "WHO: The new crown pneumonia epidemic poses a global pandemic threat 'very real' People's Daily. 2020.

2. Hong Liang Liu, Hong Wen Jia, et al. System Dynamics Model Estimation Method and Evaluation of the Early Spreading Scale of New Coronary Pneumonia-A Case Study of Gansu Province. Journal of Electronic Science University. 2020.

3. Yan Wang, Jiyu Wu, et al. Model construction and analysis of the growth law of the mid-term scale of the spread of new coronary pneumonia--a study based on the Italian epidemic data. Northwest Population Journal. 2020: 114-126.

4. Baidu Epidemic.

5. India population.