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When COVID-19 will decline in India? Prediction by combination of recovery and case load rate

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ABSTRACT

Background: The World Health Organization (WHO) declared COVID-19 as a pandemic on March 11, 2020. There is sudden need of statistical modeling due to onset of COVID-19 pandemic across the world. But health planning and policy requirements need the estimates of disease problem from clinical data.
Objective: The present study aimed to predict the declination of COVID-19 using recovery rate and case load rate on basis of available data from India.
Methods: The reported COVID-19 cases in the country were obtained from website (https://datahub.io/core/covid-19#resource-covid-19_zip/). The confirmed cases, recovered cases and deaths were used for estimating recovery rate, case load rate and death rate till June 04, 2020.
Results: A total of 216919 confirmed cases were reported nationwide in India on June 04, 2020. It is found that the recovery rate increased to 47.99% and case load rate decreased to 49.21%. Death rate is found to be very low 2.80%. Accordingly, coincidence of the difference of case load rate and recovery rate (delta) will reveal a declination in expected COVID-19 cases.
Conclusion: The epidemic in the country was mainly caused by the movement of people from various foreign countries to India. Lockdown as restricting the migration of population and decision taken by the government to quarantine the population may greatly reduce the risk of continued spread of the epidemic in India. This study predicts that when the case load rate gets lesser than recovery rate, there after COVID-19 patients would be started to decline.

1. Introduction

Since, December 2019, a pneumonia infection broke out in Wuhan, Hubei province and spread in entire China and many other countries. Chinese health authorities observed notoriously a cluster of pneumonia cases of unknown aetiology.[1] Relations between the key cases and the city's South China Sea food market were found. The chance of another zoonosis or severe acute respiratory syndrome (SARS) outbreak was at the top of the priority, investigations were attempted which result in recognition of a novel coronavirus, SARS-CoV-2 (formerly 2019-nCoV), as the agent has entered as international outbreak in Hubei. China has revealed total of 72,528 confirmed cases till February 17, 2020.[2,3] The novel coronavirus 2019 (COVID-19) has spread across 210 nations and regions with 1.2 million confirmed cases and 67594 deaths reported on April 6, 2020. The WHO declared public health as an emergency at international level. The worldwide community gets worried about COVID-19 and its impact on public health. WHO is trying to control the impact of pandemic through identification, testing, treatment of patients, clinical trials for drugs and development of new vaccines.[4] In India, first case of COVID -19 was reported on January 30, 2020 who returned from Wuhan, China. Considering the first case as a matter of great worry, screening of traveller at airport had been started, immediately Chinese visas had been cancelled, and people who were found affected with COVID-19 had been quarantined.[5] The Ministry of Health and Family Welfare (MoHFW) of India had primarily warned to avoid travelling to China and advised quarantine of those returning from China.[6] However, India is at high risk forbeing the second highest populated country in the world. Most of the studies show the prediction of COVID -19 through modeling for growth of infected population. In the absence of a licensed vaccine or effective therapeutics for COVID-19, other advises from hand cleanliness to quarantine, a basic strategy to control spread of epidemic and alleviation mediation towards the

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early detection and quarantine of cases can break the chain of transmission. The SARS-CoV-2 pandemic is currently a great challenge for researchers, clinicians, health-care workers, and decision makers. We depict the most striking difficulties for statisticians who need to provide support in this pandemic with their proficiency. Having a knowledge of the dynamics of case load rate and recovery rate of COVID-19 can enhance the basic understanding to a large extent based on the current patterns of the severity of the epidemic. As COVID-19 cases are increasing day-by-day, case load rate will be of utmost importance in predicting the declination of the epidemic. In this article, we want to predict the date when the recovery rate of patients would be more than case load rate in India. This date is defined as disease declined date.

2. Materials and methods

2.1. Data sources

Data safety, patient's consent, ethical approvals are essential in non-pandemic circumstance but there are administrative barriers to get access to clinical data. Pandemic circumstances need precise handling of these issues and should be examined nationwide. Clinical data are extremely time-dependent and involve progressive statistical methods.[7] Data has been obtained with parameters as confirmed cases, recovered cases and deaths from the online website (https://datahub.io/core/covid-19#resource-covid-19_zip/). Total 216919 confirmed cases, 104107 recovered cases and 6075 deaths were- reported till June 04, 2020 and included in the study.

3. Methodology

The whole analysis has been carried out with data available on cumulative confirmed cases, recovered cases and number of deaths. Recovery rate is defined as the proportion of number of recovered cases to confirmed cases, while the case load rate is defined as the proportion of case load to confirmed cases. Following formulae have been used for estimation purpose in (Table 1).

$$\text{Recovery rate} = \frac{\text{Recovered cases}}{\text{Confirmed cases}} * 100$$

$$\text{Case load} = \text{Confirmed cases} - \text{Recovered cases} - \text{Deaths}$$

$$\text{Case load rate} = \frac{\text{Case load}}{\text{Confirmed cases}} * 100$$

$$\text{Death rate} = \frac{\text{Deaths}}{\text{Confirmed cases}} * 100$$

$$\text{Delta} = \text{Case load rate} - \text{Recovery rate}$$

4. Result

Total 2169191 confirmed cases and 104107 recovered cases were involved in the study. Recovery rate had been estimated as 47.99% on the basis of confirmed and recovered cases. Total case load was found to be 106737 cases and case load rate was estimated as 49.21%. Death rate was obtained as 2.80% based on 6075 dead patients. Delta, being the difference of case load rate and recovery rate was obtained as 1.21% on June 04, 2020 as evident from (Table 1). The value of delta has been estimated from January 30, 2020 to June 04, 2020. It has been predicted that the value of delta would be least on June 12, 2020; it means the difference between case load rate and recovery rate would approach a negligible value. This indicates that confirmed cases expected would start to decline thereafter with respect to recovered cases as shown in (Fig. 1).

5. Discussion

2019-nCoV is a new coronavirus, which is unique in relation to SARS infections and has never been found in the human population afore.[8] The cases caused by 2019-nCoV has evidently confirmed strong relational correspondence ability and that the population is usually vulnerable.[9] This study deals with the estimation of the recovery rate and case load rate in India. The impact might be decreased with the prevention and control actions implemented by the Indian government. The results of this study suggest that actively adopting a containment strategy will continue to increase the control of the epidemic in India . Lockdown quarantine, clinical perception and suspected cases and imposing restrictions on population movement (complete lockdown) as well will help to reduce the risk of COVID -19 in India.[10] Explicitly various kinds of models have been utilized by the investigators keeping in view the main objective for which the models have been created with conclusion. The confirmed cases and evolving reports of better understanding and better expectation of the imminent estimates from other nations have resulted in emerging mathematical tools for forcasting the validity of different preventive and management policies. In India, initially the recovery rate has been decreasing till April 10, 2020 with some peaks in between. After that, it is approximately increasing with its maximum value of 47.99% on June 04, 2020. This finding suggests that lockdown strategy has played a great role in reducing the spread of the disease. Similarly, case load rate is inconsistent in starting till April 10, 2020. After that, it is continuously decreasing and is least on June 04, 2020 having a value of 49.21%. In this article, proposed models have resulted in findings regarding the recovery rate and case load rate associated with COVID-19 disease using application of Statistics. Estimates of delta have been used for prediction purpose.

6. Conclusion

Investigations have been made on the issue of COVID-19 pandemic spread in India in the current challenging scenario. Trend knowledge has been observed with the help of recovery rate and case load rate obtained for the data available. The various strategies implemented as lockdown, quarantine of population have played a significant role in reducing the risk of spread of epidemic. This study predicts that when the case load rate gets lesser than recovery rate, there after COVID-19 patients would start to decline.

7. Limitation

This study is restricted within the time period of analysis till June 04, 2020 in India. Different models were considered to estimate COVID-19 extent, and claimed to be precise, however they critically revealed data gaps and prerequisite to adjust difficult variables such as effect and uncertainty of lockdown, risk factors and social distancing might be reflected before generalizing the findings.

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Table 1
Estimate of recovery rate, case load rate based on confirmed and recovered cases.

Date	Confirmed cases	Recovered cases	Deaths	Recovery rate	Case load	Case load rate	Death rate	Delta
04-03-2020	28	3	0	10.71	25	89.29	0.00	78.57
05-03-2020	30	3	0	10.00	27	90.00	0.00	80.00
06-03-2020	31	3	0	9.68	28	90.32	0.00	80.65
07-03-2020	34	3	0	8.82	31	91.18	0.00	82.35
08-03-2020	39	3	0	7.69	36	92.31	0.00	84.62
09-03-2020	46	3	0	6.52	43	93.48	0.00	86.96
10-03-2020	58	3	0	5.17	55	94.83	0.00	89.66
11-03-2020	60	3	0	5.00	57	95.00	0.00	90.00
12-03-2020	74	3	0	4.05	71	95.95	0.00	91.89
13-03-2020	81	3	1	3.70	77	95.06	1.23	91.36
14-03-2020	84	10	2	11.90	72	85.71	2.38	73.81
15-03-2020	110	13	2	11.82	95	86.36	1.82	74.55
16-03-2020	114	13	2	11.40	99	86.84	1.75	75.44
17-03-2020	137	14	3	10.22	120	87.59	2.19	77.37
18-03-2020	151	14	3	9.27	134	88.74	1.99	79.47
19-03-2020	173	20	4	11.56	149	86.13	2.31	74.57
20-03-2020	223	23	4	10.31	196	87.89	1.79	77.58
21-03-2020	283	23	4	8.13	256	90.46	1.41	82.33
22-03-2020	360	24	7	6.67	329	91.39	1.94	84.72
23-03-2020	433	24	7	5.54	402	92.84	1.62	87.30
24-03-2020	519	40	9	7.71	470	90.56	1.73	82.85
25-03-2020	606	43	10	7.10	553	91.25	1.65	84.16
26-03-2020	694	45	15	6.48	634	91.35	2.16	84.87
27-03-2020	724	67	17	9.25	640	88.40	2.35	79.14
28-03-2020	909	80	19	8.80	810	89.11	2.09	80.31
29-03-2020	1024	96	27	9.38	901	87.99	2.64	78.61
30-03-2020	1251	102	31	8.15	1118	89.37	2.48	81.22
31-03-2020	1397	124	35	8.88	1238	88.62	2.51	79.74
01-04-2020	1834	144	41	7.85	1649	89.91	2.24	82.06
02-04-2020	2069	156	53	7.54	1860	89.90	2.56	82.36
03-04-2020	2547	163	62	6.40	2322	91.17	2.43	84.77
04-04-2020	3072	213	75	6.93	2784	90.63	2.44	83.69
05-04-2020	3577	275	83	7.69	3219	89.99	2.32	82.30
06-04-2020	4281	319	111	7.45	3851	89.96	2.59	82.50
07-04-2020	4789	353	124	7.37	4312	90.04	2.59	82.67
08-04-2020	5274	411	149	7.79	4714	89.38	2.83	81.59
09-04-2020	5865	478	169	8.15	5218	88.97	2.88	80.82
10-04-2020	6761	516	206	7.63	6039	89.32	3.05	81.69
11-04-2020	7529	653	242	8.67	6634	88.11	3.21	79.44
12-04-2020	8447	765	273	9.06	7409	87.71	3.23	78.66
13-04-2020	9352	980	324	10.48	8048	86.06	3.46	75.58
14-04-2020	10815	1190	353	11.00	9272	85.73	3.26	74.73
15-04-2020	11933	1344	392	11.26	10197	85.45	3.29	74.19
16-04-2020	12759	1515	420	11.87	10824	84.83	3.29	72.96
17-04-2020	13835	1767	452	12.77	11616	83.96	3.27	71.19
18-04-2020	14792	2015	488	13.62	12289	83.08	3.30	69.46
19-04-2020	16116	2302	519	14.28	13295	82.50	3.22	68.21
20-04-2020	17656	2842	559	16.10	14255	80.74	3.17	64.64
21-04-2020	18985	3260	603	17.17	15122	79.65	3.18	62.48
22-04-2020	20471	3960	652	19.34	15859	77.47	3.18	58.13
23-04-2020	21700	4325	686	19.93	16689	76.91	3.16	56.98
24-04-2020	23452	4814	723	20.53	17915	76.39	3.08	55.86
25-04-2020	24893	5210	779	20.93	18904	75.94	3.13	55.01
26-04-2020	26605	5914	826	22.23	19865	74.67	3.10	52.44
27-04-2020	28160	6362	886	22.59	20912	74.26	3.15	51.67
28-04-2020	29834	7027	937	23.55	21870	73.31	3.14	49.75
29-04-2020	31709	7797	1008	24.59	22904	72.23	3.18	47.64
30-04-2020	33330	8373	1075	25.12	23882	71.65	3.23	46.53
01-05-2020	34972	9065	1152	25.92	24755	70.79	3.29	44.86
02-05-2020	37157	9951	1218	26.78	25988	69.94	3.28	43.16
03-05-2020	40124	10887	1306	27.13	27931	69.61	3.25	42.48
04-05-2020	42836	11762	1389	27.46	29685	69.30	3.24	41.84
05-05-2020	46711	13161	1583	28.18	31967	68.44	3.39	40.26
06-05-2020	49391	14183	1694	28.72	33514	67.85	3.43	39.14
07-05-2020	52952	15267	1783	28.83	35902	67.80	3.37	38.97
08-05-2020	56342	16540	1886	29.36	37916	67.30	3.35	37.94
09-05-2020	59662	17847	1981	29.91	39834	66.77	3.32	36.85
10-05-2020	62939	19358	2109	30.76	41472	65.89	3.35	35.14
11-05-2020	67152	20917	2206	31.15	44029	65.57	3.29	34.42
12-05-2020	70756	22455	2293	31.74	46008	65.02	3.24	33.29
13-05-2020	74281	24386	2415	32.83	47480	63.92	3.25	31.09
14-05-2020	78003	26235	2549	33.63	49219	63.10	3.27	29.47
15-05-2020	81970	27920	2649	34.06	51401	62.71	3.23	28.65
16-05-2020	85710	30153	2752	35.18	52805	61.61	3.21	26.43

(*continued on next page*)

Table 1 (*continued*)

Date	Confirmed cases	Recovered cases	Deaths	Recovery rate	Case load	Case load rate	Death rate	Delta
17-05-2020	90637	34109	2872	37.63	53656	59.20	3.17	21.57
18-05-2020	95759	36824	3029	38.45	55906	58.38	3.16	19.93
19-05-2020	100325	39174	3163	39.05	57988	57.80	3.15	18.75
20-05-2020	106750	42298	3303	39.62	61149	57.28	3.09	17.66
21-05-2020	112359	45300	3435	40.32	63624	56.63	3.06	16.31
22-05-2020	118447	48534	3583	40.98	66330	56.00	3.02	15.02
23-05-2020	125101	51784	3720	41.39	69597	55.63	2.97	14.24
24-05-2020	131868	54441	3867	41.28	73560	55.78	2.93	14.50
25-05-2020	138845	57721	4021	41.57	77103	55.53	2.90	13.96
26-05-2020	145380	60491	4167	41.61	80722	55.52	2.87	13.92
27-05-2020	151767	64426	4337	42.45	83004	54.69	2.86	12.24
28-05-2020	158333	67692	4531	42.75	86110	54.39	2.86	11.63
29-05-2020	165799	71106	4706	42.89	89987	54.27	2.84	11.39
30-05-2020	173763	82370	4971	47.40	86422	49.74	2.86	2.33
31-05-2020	182143	86984	5164	47.76	89995	49.41	2.84	1.65
01-06-2020	190535	91819	5394	48.19	93322	48.98	2.83	0.79
02-06-2020	198706	95527	5598	48.07	97581	49.11	2.82	1.03
03-06-2020	207615	100303	5815	48.31	101497	48.89	2.80	0.58
04-06-2020	216919	104107	6075	47.99	106737	49.21	2.80	1.21

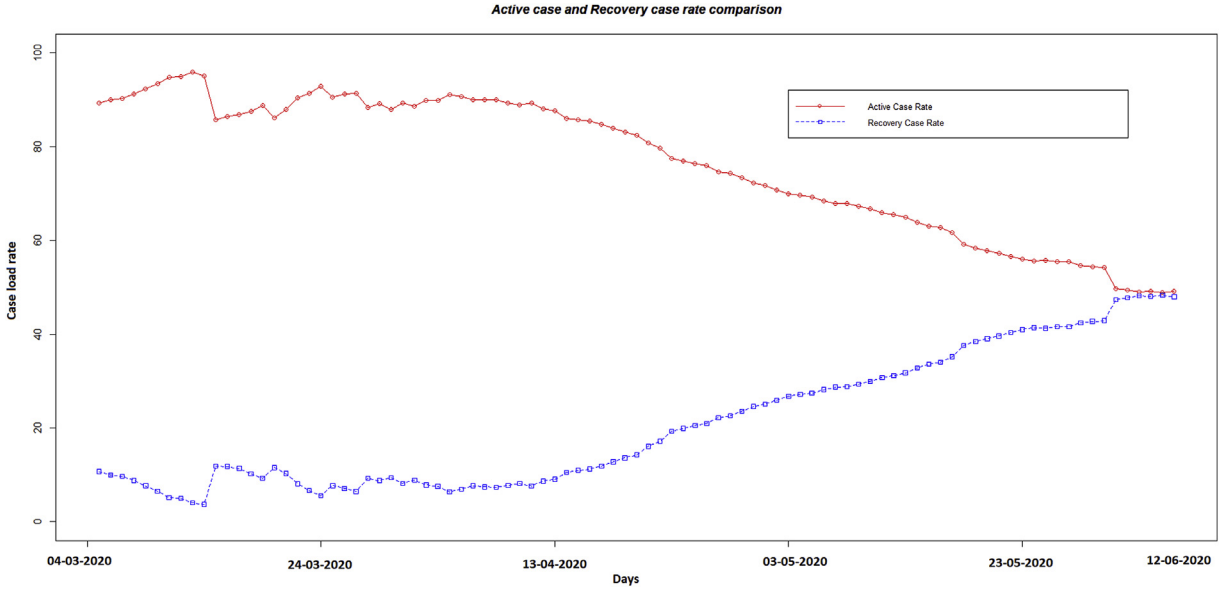

Fig. 1. Comparison of recovery rate and active case rate of COVID-19 patients in India.

Declaration of competing interest

The authors declare no conflict of interest.

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References

1. Liu T, Hu J, Xiao J, He G, Kang M, Rong Z, Zeng W. Time-varying transmission dynamics of Novel Coronavirus Pneumonia in China. *BioRxiv*. 2020.
2. Wu JT, Leung K, Leung GM. Now casting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modeling study. *The Lancet*. 2020;395(10225):689–697.
3. Chen W, Wang Q, Li YQ, Yu HL, Xia YY, Zhang ML, ... Yang XK. Early containment strategies and core measures for prevention and control of novel coronavirus pneumonia in China. *Zhonghua yu fang yi xue za zhi [Chinese journal of preventive medicine]*. 2020;54(3):1–6.
4. https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov).
5. https://boi.gov.in/content/advisory-travel-and-visarestrictions-related-covid-19-0.
6. https://www.mohfw.gov.in/.
7. Wolkewitz M, Puljak L. *Methodological challenges of analysing COVID-19 data during the pandemic*. 2020; 2020.
8. Lake MA. What we know so far: COVID-19 current clinical knowledge and research. *Clinical Medicine*. 2020;20(2):124.
9. Chen ZL, Zhang WJ, Lu Y, Guo C, Guo ZM, Liao CH, Lu JH. From SARS-CoV to 2019-nCoV outbreak: Similarities in the early epidemics and prediction of future trends. *Chinese Medical Journal*. 2020.
10. Mandal S, Bhatnagar T, Arinaminpathy N, Agarwal A, Chowdhury A, Murhekar M, Sarkar S. Prudent public health intervention strategies to control the coronavirus disease 2019 transmission in India: A mathematical model-based approach. *The Indian journal of medical research*. 2020;151(2-3):190.