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Doubling Time and Its Interpretation for COVID-19 Cases: A Comparative Study in Pimpri Chinchwad Municipal Corporation, Pune, Maharashtra, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: COVID-19, also known as Novel Corona Virus, causes respiratory disorder in humans and has been declared as a global pandemic in the first quarter of the year 2020 by the World Health Organization. As this pandemic persists the second, third and fourth quarters had shown variation in COVID-19 cases. In the first quarter of the year 2021 again there seems to be a rise in cases of COVID-19. So, a comparative analysis from March 2020 – April 2021 of COVID-19 cases has been studied.
Methodology: An exponential statistical model was used to calculate the predicted value of COVID-19 using doubling time for a short duration. The cases of COVID-19 were predicted from 10th April 2021 to 10th June 2021 using doubling time and exponential regression method.
Results: The distribution of cases showed a curve-linear trend over the last one year. We explored various models like exponential, logarithmic (lo-linear), linear, quadratic, and generalized linear

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model (GLM) to fit into the observed distribution of cases. Since the distribution of cases was perfectly following a linear trend in each of the four segments, we applied a linear regression model to observed distribution and then predicted the anticipated no. of cases by extending this linear trend to a future period (120 day). With the help of the exponential statistical model, doubling time/rate based on prior 9 days, the predictions of up to 2.61 lakhs cases have been done by the end of June 2021.

Conclusion: This study will be useful for the Government of India and Maharashtra state-specific to Pimpri- Chinchwad Municipal Corporation (PCMC), Administrative Units, Frontline health workforce, researchers, and scientists. From this study it has been evident that during the pre-lockdown period, in the initial stages there seems to be rise in cases. While, during lockdown period it was observed that there was relatively decrease in the number of cases. After the government authorities imposed the unlock strategies the cases began to rise as compared to the lockdown period. Thus, it appears that only essential services should be open for the citizens of India and the state lockdown should be carried on for the next 3 months (April 2021 - June 2021).

Keywords: COVID-19; doubling time; generalized linear model.

1. INTRODUCTION

COVID-19, also known as Novel Corona Virus, causes respiratory disorder in humans and has been declared as a global pandemic, in the first quarter of the year 2020 by the World Health Organization [1,2]. As this pandemic persists the second, third and fourth quarters had shown variation in COVID-19 cases. In the first quarter of the year 2021 again there seems to be a rise in cases of COVID-19. To help the Government of India and Maharashtra state-specific to Pimpri-Chinchwad Municipal Corporation (PCMC, Fig. No.1), Administrative Units, Frontline health workforce, researchers, and scientists in the management of COVID-19, the analysis of doubling time is required. So, a comparative analysis of the year March 2020 – April 2021 has been studied.

Doubling time of the mentioned duration (March 2020 – April 2021) is studied wherein the number of days required for the number of cases in an pandemic to double, based on the rate of the cumulative increase in the number of cases has been demonstrated. However, the doubling time is a rudimentary analysis of the current proportion of the spread of the virus. Doubling time provides comparable data across time as well as continents at different stages of the spread of infection. On an additional note, the proportion of true cases that are being identified doesn't alter, if the proportion does not change considerably. Doubling time remains constant in uncontrolled exponential growth. Ideally, if measures are being effective, we ought to see the doubling time increasing [3,4]. A higher doubling time means it is taking longer for the cases to double and indicates that the infection is spreading slower. Conversely, a lower doubling time suggests a faster spread of infection. For an infection growing at a constant exponential rate, the doubling time is constant. However, as observed in the COVID-19 situation, due to interventions like social distancing, lockdown, and containment of hotspots of infection, the doubling time fluctuates and is a function of time. It also varies between districts, states, and countries that may be in different stages of infection [5-7]. The main purpose of this article is to demonstrate and interpret the doubling time for COVID-19.

1.1 Objective

The primary objective of this article was to calculate the doubling time of COVID19 cases and their interpretation.

2. METHODOLOGY

According to the objective of this study the data was taken from the Website of Pimpri-Chinchwad Municipal Corporation and covers the time from 10th March 2020 to 3rd April 2021 to calculate doubling time/rate based on the prior 9 days [5-7].

2.1 Short Duration Predicting Analysis using the Exponential Statistical Model

The exponential statistical model used to calculate the predicted value of COVID-19 using doubling time for a short duration. The cases of COVID-19 were predicted from 10th April 2021 to 10th May 2021 using doubling time and exponential regression method.

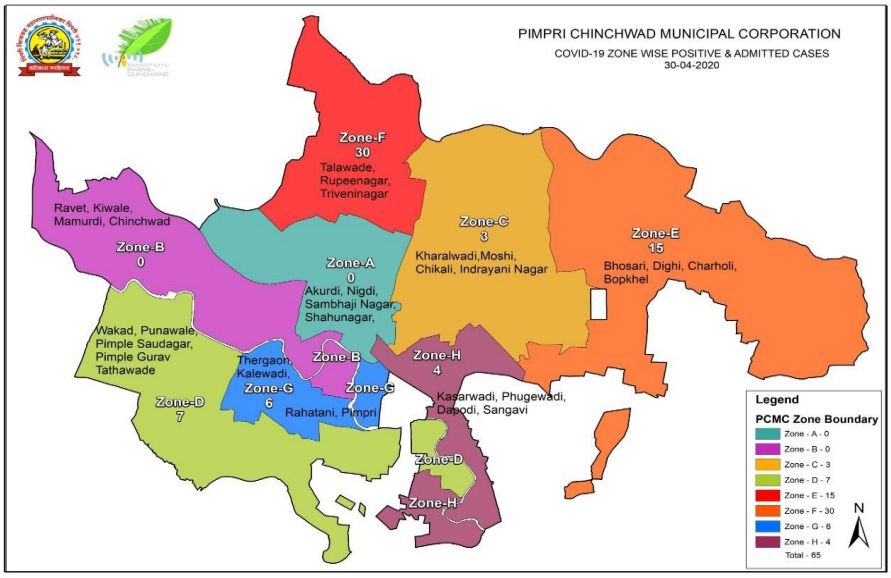

Fig. 1. Study area [8]

3. RESULTS

The distribution of cases showed a curve-linear trend for the last year (Fig. 2). We explored various model…s like exponential, logarithmic (lo-linear), linear, quadratic, and generalized linear models (GLM) to fit into the observed distribution of cases. Since the distribution of cases was perfectly following a linear trend in each of the four segments (Fig. 3.), we applied a linear regression model to observed distribution and then predicted the anticipated no. of cases by extending this linear trend to a future period (120 day).

Following four segments can be identified (having a linear pattern of growth) from this curve.

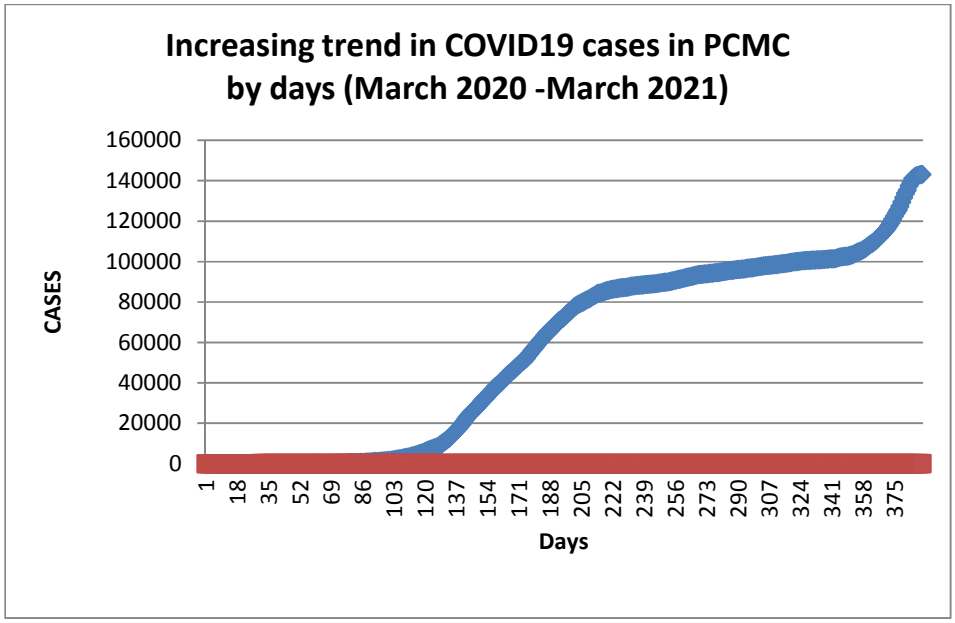

Fig. 2. Increasing trend in COVID-19 cases in PCMC by days (March 2020 -March 2021)

Details of cases, days, weeks, months and addition per segment are given in the following Tables 1 & 2.

Table 1. Details of cases, days, weeks, months and addition per segment

Segments	Period	Cases	Days	Weeks (approx)	Months	Addition of cases
1	March - June2020	0- 1	1- 106	15	3.7	0
2	July- Sept 2020	2-80,000	107- 206	14	3.5	80,000
3	Oct 2020- Jan2021	80001- 100,000	207-320	16	4.0	20,000
4	Feb 2021- March2021	1,00,001 - 1.43.190	321- 390	10	2.5	43,190
Overall	March2020 - March 2021		390	56	13	1,43,190

A segment-wise summary of mean no. of cases and % distribution is given below.

Table 2. Segment-wise summary of mean no. of cases and % distribution

Segment	Mean	Std. Dev.	Days	%
1	383.9906	558.4925	106	27.2
2	37104.59	25365.36	100	25.6
3	92019.41	5002.895	114	29.2
4	111939.8	14051.71	70	18.0
Total	**56608.1**	**45647.74**	**390**	**100.0**

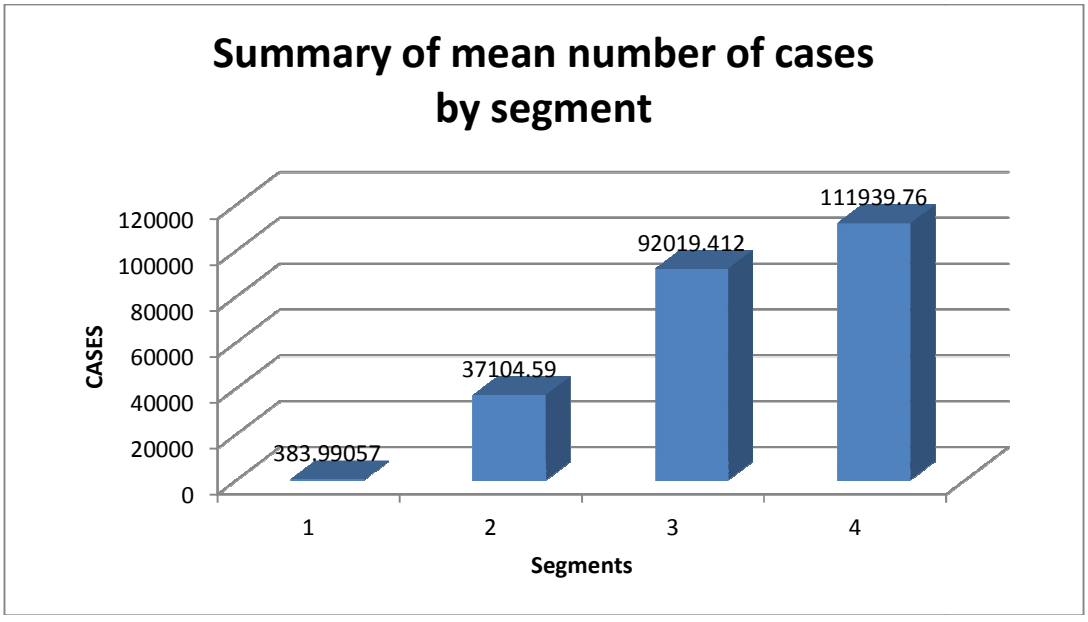

Fig. 3. Summary of the mean number of cases by segment

GLM model was applied (Poisson regression with log-linear link function) to understand the growth rate by fragmenting the total period (390 days) into 43-sub-intervals of 9-days each (Table 3.).

Table 3. Growth rate per day

Days	Growth rate per day	Growth rate per 9 day
9	4.322413	38.90172
18	4.322413	38.90172
27	4.322495	38.90246
36	4.322903	38.90612
45	4.323365	38.91029
54	4.324072	38.91665
63	4.324821	38.92338
72	4.32701	38.94309
81	4.329825	38.96843
90	4.335496	39.01947
99	4.344024	39.09621
108	4.363064	39.26757
117	4.393201	39.53881
126	4.440013	39.96011
135	4.533771	40.80394
144	4.665582	41.99024
153	4.780516	43.02464
162	4.895259	44.05733
171	4.98846	44.89614
180	5.109785	45.98807
189	5.232267	47.0904
198	5.339	48.051
207	5.419634	48.77671
216	5.474918	49.27426
225	5.503709	49.53338
234	5.520736	49.68663
243	5.531916	49.78724
252	5.546699	49.92029
261	5.573246	50.15921
270	5.596502	50.36852
279	5.609137	50.48223
288	5.626639	50.63975
297	5.640389	50.7635
306	5.656859	50.91173
315	5.670146	51.03131
324	5.686507	51.17856
333	5.694735	51.25261
342	5.702473	51.32226
351	5.724954	51.52459
360	5.781816	52.03634
369	5.878621	52.90759
378	6.054809	54.49328
387	6.259298	56.33368
Mean	45.83	
SD	5.59	
Min	38.9	
Max	56.43	
Median	47.79	

On average around 38 cases were added per 9 days in the initial phase (from March to June 2020, Fig. 4.), but it increased to 48 per day in the next 4 months (July to Oct 2020, Fig. 4.) and then furthermore at an average rate of 56 in next 5 months (Nov 2020 to March 2020, Fig. 4.).

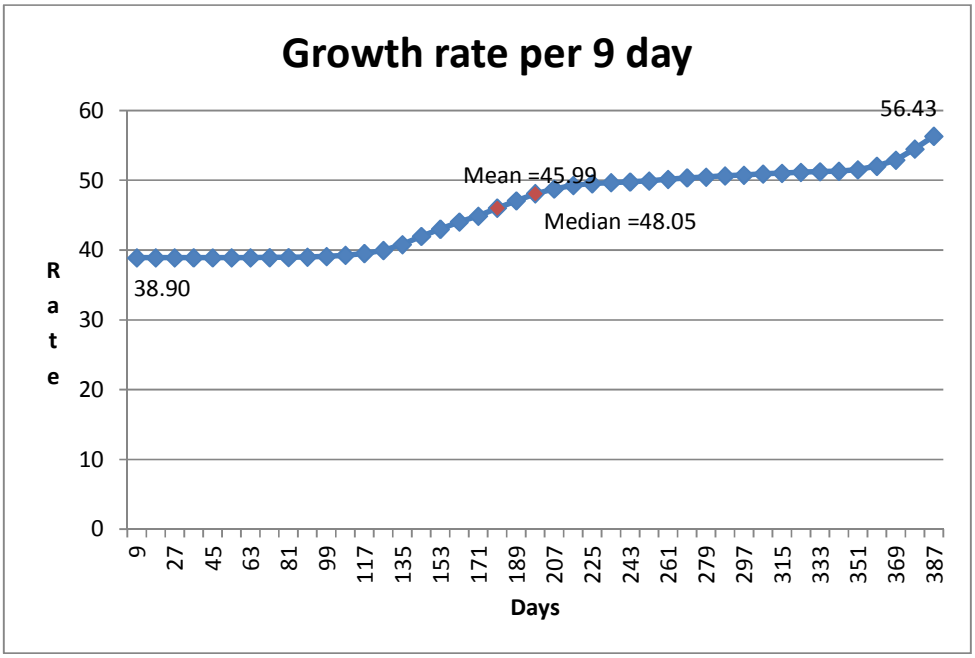

Fig. 4. Growth rate per 9 day

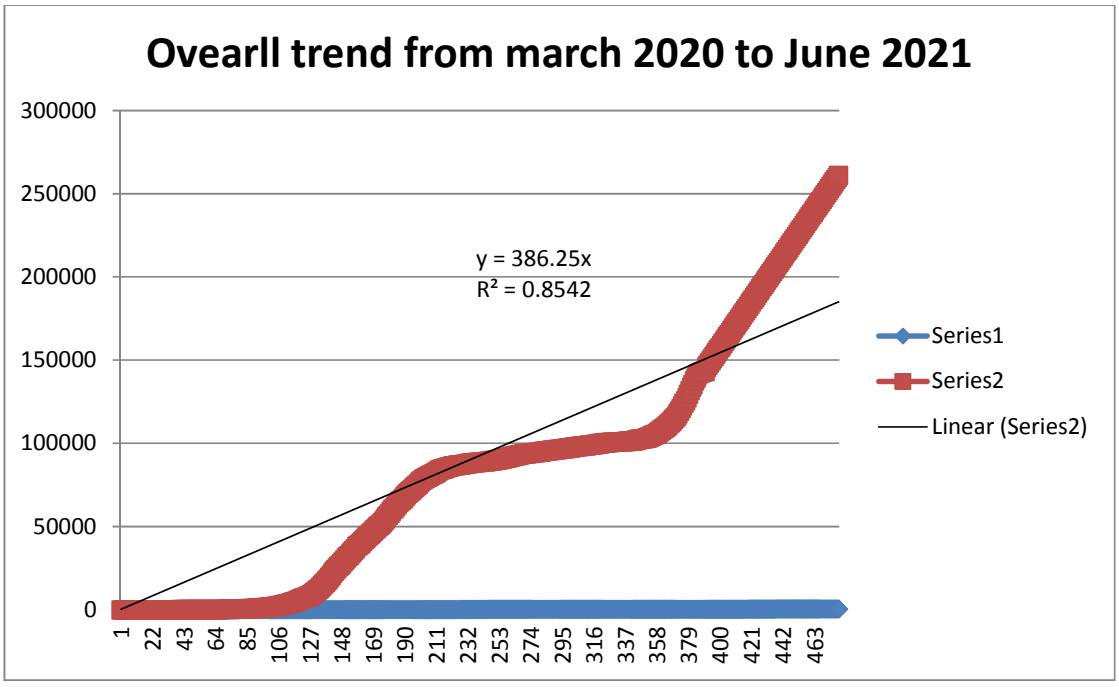

Fig. 5. Overall trend from March 2020 to June 2021 Predicted number of cases on 1st July 2021 = 2.54 lakhs

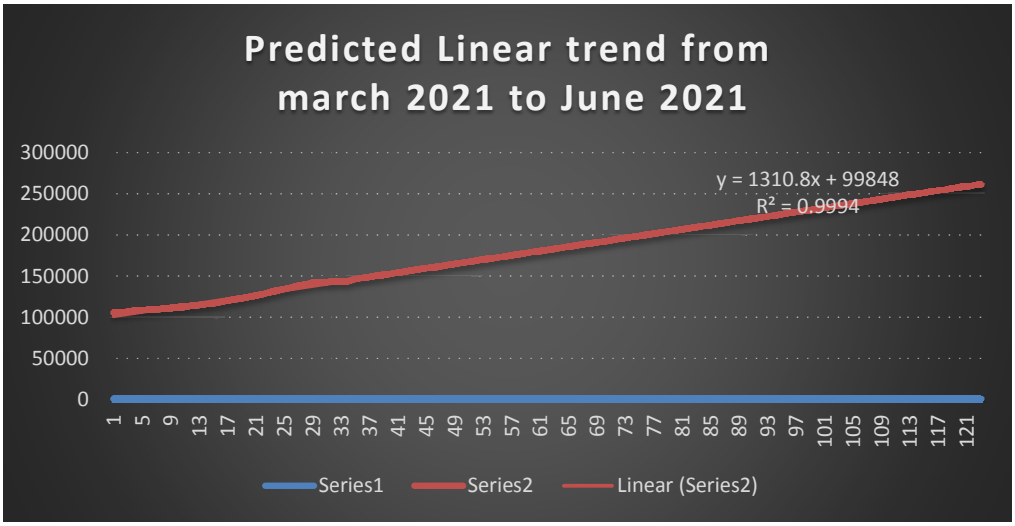

Fig. 6. Predicted Linear trend from March 2021 to June 2021 Predicted number of cases on 1st July 2021 = 2.61 lakhs

Table 4. Doubling time

Period	From	To	Days	Addition
10/03/20 To 24/01/21	0	1.3 lakhs	321	1.3 lakhs
25/01/20 To 25/05/21	1.3 lakhs	2.6 lakhs	115	1.3 lakhs
26/05/21 T0 30/06/21	2.14 lakhs	2.41 lakhs	36	27000
Total	**56608.1**	**45647.74**	**390**	**100.0**

4. DISCUSSIONS

4.1 Observations and Predicted Outcomes of GLM

From 0 to 1.43 lakhs (10 March 2020 to 3rd April 2021) in 390 days (1.43 lakhs have been added in a little > 1 year (i.e., average 367 cases per day). From 1.43 to 2.61 lakhs (4th April 2021 to 1st June 2021) in 89 days (1.18 lakhs will be added in approx. 3 months (i.e., average 1326 cases per day). Almost 1000 more cases will be added daily in the coming months (Table 4.), (from April 2021 onwards) as compared to the previous months (March 2020 to March 2021, Figs. 5 & 6.).

4.2 Restrictions Implementation Imposed in Maharashtra [8-10]

1. No restrictions (10th March 2020 – 24th March 2020)
2. Lockdown Phase 1 (25th March 2020 – 14th April 2020)
3. Lockdown Phase 2 (15th April 2020 – 3rd May 2020)
4. Lockdown Phase 3 (4th May 2020 - 17th May 2020)
5. Lockdown Phase 4 (18th May 2020 – 31st May 2020)
6. Unlock Phase 1 (1st June 2020 – 30th June 2020)
7. Unlock Phase 2 (1st July 2020 – 31st July 2020)
8. Unlock Phase 3 (1st August 2020 – 31st August 2020)
9. Unlock Phase 4 (1st September 2020 – 31st September 2020)
10. Unlock Phase 5 (1st October 2020 – 21st March 2021)
11. Janta Curfew (22nd March 2021 – 4th April 2021)
12. Mini lockdown (5th April 2021 to 30th April 2021)

4.3 Probable factors responsible for the increase in the rate of doubling time for COVID-19

1. No intervention of vaccination or immunization specific to COVID-19 was observed from 10th March 2020 – 10th January 2021.
2. Literacy rate for understanding Coronavirus infection, Case definition, Investigational procedures, Disease diagnosis, Line of treatment or management of infection might have decreased in healthcare workers.
3. Knowledge, Attitude and Practice regarding COVID-19 community behaviour might have been neglected.
4. Community hygiene and household practices might have been neglected.
5. No appropriate intervention of AYUSH guidelines specific to COVID-19 was implemented.
6. New variant of Coronavirus strain B.1.1.7 (UK), B.1.351 (SA), P.1 (Brazil), E484K (India), L452R (California) variant is an hour of concern, as the availability of a line of treatment might be resistant.
7. Sensitizing pharmacovigilance session on COVID-19 concerning patent, product information, trial registration, advertisement, post-marketing surveillance and adverse event (AE) or serious adverse event (SAE) or adverse drug reaction (ADR) reporting was not implemented.
8. Failure in delivering Health care services in COVID-19 for manpower (physicians), supply of drugs & supplements, occupancy ratio of ICU & Isolation wards or General wards for admission, oxygen supply, the literate ratio of physician-specific to pulmonologist & AYUSH.

4.4 Further Interventions and Predicted Outcomes in COVID-19

1. Post-vaccination campaigning and intervention trials.
2. Post vaccination adjunct comparative trials for Homoeopathy.
3. Sensitizing community behaviour of Healthcare workers about pandemic interventions and disaster management Act.
4. Sensitizing the early intervention of AYUSH in pandemic outbreaks.
5. The outcome of immunization against COVID-19 with respect to mortality rate, survival rate.
6. Demographic changes in disease pattern of COVID-19 and its impact on existing health care delivery system (Primary, Secondary & Tertiary)
7. The outcome of AYUSH interventions against COVID-19 with respect to mortality rate, survival rate.
8. Sensitizing pharmacovigilance session on COVID-19 with respect to patent, product information, trial registration, advertisement, post-marketing surveillance and adverse event (AE) or serious adverse event (SAE) or adverse drug reaction (ADR) reporting.

5. CONCLUSION

With the help of the exponential statistical model, the predictions of up to 2.61 lakhs cases have been done by the end of June 2021. Consistency in delivering Health care services in COVID-19 with respect to manpower (physicians), supply of drugs & supplements, occupancy ratio of ICU & Isolation wards or General wards for admission, oxygen supply, the literate ratio of physicians specific to pulmonologist & AYUSH needs to be implemented on a larger scale. Also it is observed that there has been a sudden surge of cases during the unlocking phases. This needs to be addressed on priority basis if further waves of COVID-19 are to be prevented. It appears that only essential services need to be opened for the citizens of India and the state lockdown should be carried on for the next 3 months (April 2021 - June 2021).

CONSENT

It's not applicable.

ETHICAL APPROVAL

It's not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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