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AN ANALYSIS OF THE SPREAD OF THE COVID-19 EPIDEMIC IN INDIA'S LOCKDOWN

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Abstract: *India's response to the Covid-19 pandemic was an unprecedented total lockdown beginning from March 25th, 2020. The present study extends the scope of an earlier study (Dash, 2020b) to analyse the spread of the Covid-19 pandemic across the phases of the lockdown. The results of the study indicate that the lockdowns have been successful in reducing the propagation rate of Covid-19, but concurrently increasing the projected limiting level of cumulative cases to as high as 26,51,699.30, probably due to the migrant crisis. The results of the study also suggest that the propagation of Covid-19 may be exponential in nature, particularly based on the data from May. Thus the central and state governments have to urgently address the twin challenge of constraining the propagation of Covid-19 and mitigating the plight of the daily labourers and wage workers.*

Keywords: Covid-19 pandemic, lockdown, propagation rate, limiting level of cumulative cases, migrant crisis.

Introduction

The Covid-19 epidemic started spreading in India in early March 2020, as the world watched the epidemic proliferate alarmingly across Italy, Spain, France, Germany, UK, and USA. Many observers around the world wondered how the epidemic could be controlled, given that countries with some of the most advanced public heath systems in the world had failed to do so. One by one the European and American governments were forced to turn to some form of lockdown, as was shown to be very effective in the case of China (Dash, 2020a).

The Indian central government started to plan for handling the epidemic in mid March 2020, setting up testing, treatment, and quarantine facilities across the country. Travellers from abroad were required to undergo a 14-day quarantine with regular health check-ups. However, the measures lacked long-term planning and coordination, and seemed to be merely imitating those taken by European and American governments. Many state governments closed down educational institutions by March 14th, 2020, just days after state governments in the USA had done the same. Companies were asked to facilitate work-from-home wherever possible. Inter-state travel and transportation was restricted, except for essential goods/services. Social distancing was advised from

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mid March 2020, at least two weeks after it was advised in Europe and USA.

The Indian central government finally imposed a total lockdown (except for essential services) from 25th March, 2020 to curb the spread of Covid-19. The first phase of the lockdown was from 25th March, 2020 to 14th April, 2020, and was near-total and quite strict. The second phase was from 15th April, 2020 to 3rd May, 2020, extending the first phase as several states felt that the epidemic was not sufficiently contained; however, due to the concerns of the economic impact of the lockdown, the central government allowed some relaxations in some zillas/districts after 20th April, 2020, depending on the extent of spread of the epidemic in the zilla/district. The third phase was from 4th May, 2020 to 17th May, 2020, again extended due to the spread of the epidemic in some states. The fourth phase was from 18th May, 2020 to 31st May, 2020.

India's first lockdown has been reportedly praised by the WHO[1] for successfully slowing down the spread of Covid-19. However, an unforeseen adverse impact of the lockdown may have hindered the effectiveness of the lockdown, viz. the migrant crisis. The central government had not adequately planned for millions of daily labourers and wage workers mostly in the informal sector, who were left with no money, no food, and no guarantee about their future with the closure of their workplaces. Within days of the imposition of the first lockdown, thousands of migrants started to return to their native states, mainly Uttar Pradesh, Bihar, Jharkhand, and West Bengal. In response, the central and state governments did take measures, providing food grains and shelter for the starving migrants and arranging transportation for them to return to their native places, but by that time, millions of migrants had started to return home, many of them on foot. Of course, this undermined the philosophy behind the lockdown, viz. containment of the epidemic; in fact, it meant that the virus was carried to remote parts of the country that were hitherto uncontaminated.

Methodology

The present study extends the scope of an earlier study (Dash, 2020b) to analyse the spread of the Covid-19 pandemic across the phases of the lockdown. The variables considered for the study were the daily number of new infections and the cumulative number of infections by the Covid-19 virus, collected from the Worldometer website[2]. The study period considered was 01/03/2020 to 25/05/2020.

To analyse the nature of the spread of Covid-19, the exponential and logistic growth models were used (Batista, 2020; Dash, 2020a, 2020b; Jia et al, 2020; Wu et al, 2020). Exponential growth was estimated by a linear regression (through the origin) of the daily number of new cases (x_t) on the cumulative number of cases (y_{t-1}):

$$x_t = ry_{t-1} + \epsilon_t,$$

while logistic growth was estimated by a quadratic regression (through the origin) of the daily number

[1] https://www.ndtv.com/india-news/coronavirus-who-praises-indias-tough-and-timely-actions-to-stop-covid-19-spread-2211807

[2] https://www.worldometers.info/coronavirus/country/india/

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of new cases (x_t) on the cumulative number of cases (y_{t-1}):

$$x_t = ry_{t-1} - r/M\, y_{t-1}^2 + \epsilon_t,$$

These models were also applied to the data for May alone, for comparison. The three lockdown periods were also considered in the analysis using dummy variables D_1 (for the first lockdown period from 25th March), D_2 (for the second lockdown period from 15th April), and D_3 (for the third lockdown period from 4th May) were introduced. The linear dummy variable regression model was of the form:

$$x_t = by_{t-1} + b_1D_1y_{t-1} + b_2D_2y_{t-1} + b_3D_3y_{t-1} + \epsilon_t,$$

while the quadratic dummy variable regression model was of the form:

$$x_t = by_{t-1} + b_1D_1y_{t-1} + b_2D_2y_{t-1} + b_3D_3y_{t-1} + cy_{t-1}^2 + c_1D_1y_{t-1}^2 + c_2D_2y_{t-1}^2 + c_3D_3y_{t-1}^2 + \epsilon_t$$

Further, as the effect of the lockdown would take some time to show an effect, the analysis was also performed with seven days' lags. The analysis was also carried out with two dummy variables, representing April and May, for comparison

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Analysis

The overall linear and quadratic regression results are presented below.

Panel Ia: Linear regression (overall)

	Coeff	*Std Error*	*t Stat*	*p-value*
cumulative cases(-1)	0.055182	0.000952	57.9916	0.0000

adj R^2 = 96.36%, F Stat = 3363.02, p-value = 0.0000

Panel Ib: Quadratic regression (overall)

	Coeff	*Std Error*	*t Stat*	*p-value*
cumulative cases(-1)	0.069679	0.002571	27.0989	0.0000
cumulative cases(-1)2**	-0.000000	0.000000	-5.9351	0.0000

adj R^2 = 97.05%, F Stat = 2376.18, p-value = 0.0000

According to the exponential model, the overall growth rate in the daily number of new cases was 5.52%, whereas, according to the logistic model, the overall growth rate in the daily number of new cases was 6.25%. Also, the logistic model yields a projection for the limiting level of cumulative cases of 4,65,835.92. Further, the logistic model was found to be a somewhat better fit, with a slightly higher adjusted R^2.

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The linear and quadratic regression results for May alone are presented below.

Panel IIa: Linear regression (May)

	Coeff	*Std Error*	*t Stat*	*p-value*
cumulative cases(-1)	0.054524	0.001427	38.2191	0.0000

adj R^2 = 94.22%, F Stat = 1460.70, p-value = 0.0000

Panel IIb: Quadratic regression (May)

	Coeff	*Std Error*	*t Stat*	*p-value*
cumulative cases(-1)	0.067614	0.004582	14.7564	0.0000
cumulative cases(-1)2**	-0.000000	0.000000	-2.9673	0.0069

adj R^2 = 94.43%, F Stat =972.27, p-value = 0.0000

According to the exponential model, the growth rate in the daily number of new cases was 5.45%, whereas, according to the logistic model, the growth rate in the daily number of new cases was 6.76%. Also, the logistic model yields a projection for the limiting level of cumulative cases of 5,18,707.34. However, both the exponential model and the logistic model were found to have similar fit (adjusted R^2), suggesting that the epidemic could at this stage be spreading exponentially.

The results of the dummy variable quadratic regressions for April and May are presented below.

Panel IIIa: Quadratic regression (April and May)

	Coeff	*Std Error*	*t Stat*	*p-value*
cumulative case(-1)	0.213493	0.418811	0.5098	0.6116
D_1*cumulative case(-1)	-0.093294	0.418983	-0.2227	0.8244
D_2*cumulative case(-1)	-0.052586	0.012352	-4.2572	0.0001
cumulative case(-1)2**	-0.000080	0.000439	-0.1813	0.8566
D_1*cumulative case(-1)2**	0.000078	0.000439	0.1765	0.8603
D_2*cumulative case(-1)2**	0.000002	0.000000	4.1814	0.0001

adj R^2 = 97.25%, F Stat = 934.01, p-value = 0.0000

The results of the quadratic regression model indicate that the growth rate in the daily number of new cases was initially 21.35%, decreased to 12.02% in April, and decreased significantly to 6.76% in May. On the other hand, the limiting level of cumulative cases was initially projected at 2678.93, increased to 56,636.72 in April, and increased significantly to 5,18,707.34 in May.

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The results of the dummy variable quadratic regressions for the lockdown periods are presented below.

Panel IIIb: Quadratic regression (without lag)

	Coeff	*Std Error*	*t Stat*	*p-value*
cumulative cases(-1)	0.281756	1.055252	0.2670	0.7902
D_1*cumulative cases(-1)	-0.099245	1.056378	-0.0939	0.9254
D_2*cumulative cases(-1)	-0.100999	0.050139	-2.0144	0.0474
D_3*cumulative cases(-1)	-0.015285	0.012017	-1.2720	0.2072
cumulative cases(-1)2**	-0.000297	0.002774	-0.1071	0.9149
D_1*cumulative cases(-1)2**	0.000289	0.002774	0.1042	0.9173
D_2*cumulative cases(-1)2**	0.000008	0.000006	1.2468	0.2162
D_3*cumulative cases(-1)2**	0.000000	0.000000	1.0226	0.3096

adj R^2 = 97.17%, F Stat =675.50, p-value = 0.0000

Panel IIIc: Quadratic regression (7-day lag)

	Coeff	*Std Error*	*t Stat*	*p-value*
cumulative cases(-1)	0.213493	0.383060	0.5573	0.5789
D_1*cumulative cases(-1)	-0.059029	0.383689	-0.1538	0.8781
D_2*cumulative cases(-1)	-0.084262	0.022871	-3.6842	0.0004
D_3*cumulative cases(-1)	-0.015280	0.007410	-2.0620	0.0425
cumulative cases(-1)2**	-0.000080	0.000402	-0.1983	0.8434
D_1*cumulative cases(-1)2**	0.000075	0.000402	0.1868	0.8523
D_2*cumulative cases(-1)2**	0.000005	0.000002	2.9448	0.0043
D_3*cumulative cases(-1)2**	0.000000	0.000000	0.6321	0.5292

adj R^2 = 97.47%, F Stat = 839.57, p-value = 0.0000

The results of the quadratic regression model indicate that the growth rate in the daily number of new cases was initially 28.18%, decreased to 18.25% in the first lockdown period, decreased significantly to 8.15% in the second lockdown period, and decreased to 6.62% in the third lockdown period. On the other hand, the limiting level of cumulative cases was initially projected at 947.85, increased to 22,446.40 in the first lockdown period, to 1,60,071.30 in the second lockdown period, and to 5,60,814.19 in the third lockdown period. Taking into account a seven-day lag for the effect of the lockdowns showed significant decrease in the growth rate in the daily number of new cases in the second and third lockdown periods; however, the projection of the limiting level of cumulative cases increased from 2678.93 initially to 33,430.23 in the first lockdown period, 6,56,519.20 in the second lockdown period, and 26,51,699.30 in the third lockdown period.

Discussion

The results of the study indicate that the lockdowns have been successful in reducing the propagation rate of Covid-19 to about 6-7%, significantly less than the estimate of 17.51% - 25.06% with 95% confidence given by Dash (2020b). This can be considered as a major achievement, of 'flattening the curve.' However, concurrently, the projected limiting level of cumulative cases has increased to as high as 26,51,699.30, significantly higher than the estimate of 12,246.65 - 22,800.33 with 95% confidence given by Dash (2020b). This latter result is probably due to the mass exodus of migrant labourers from metropolitan cities, particularly in the third lockdown period. This can be considered as a major failure on the part of the central and state governments to manage/coordinate the lockdowns. Unless the central and state governments take immediate steps to mitigate the plight of the daily labourers and wage workers, this has the potential of becoming a colossal humanitarian disaster with far-reaching social and economic consequences.

The results of the study are a cause for alarm, suggesting that the propagation of Covid-19 may be exponential in nature, particularly based on the data from May. This implies that, though there is evidence of slowing down of the rate of propagation of Covid-19 due to the lockdowns, the government needs to act urgently to constrain the propagation of Covid-19 into a logistic growth. Thus, a prolonged lockdown looks inevitable.

There are several limitations inherent in the study. The study period is short, just eighty-six days, which may not be adequate for assessing the effect of particularly the third lockdown period. Also, many of the dummy variable regression coefficients were not statistically significant. The most serious limitation is that of the lack of wide-spread testing of the population, so that the official number of reported cases is an underestimate of the true numbers. This is another step that must be taken immediately, as the future of managing/containing Covid-19 can only be through vigorous testing and isolation (Potluri and Lavu, 2020).

References

Batista, M. (2020), "Estimation of the final size of the coronavirus epidemic by the logistic model," *Working Paper*: https://www.medrxiv.org/content/10.1101/2020.02.16.20023606v2.full.pdf

Dash, M. (2020a), "Analysing the Propagation of the Coronavirus Epidemic: The Case of Wuhan in Hubei Province, China." *Epidemiology International* 5(1) [Special Issue on SARS-CoV-2 (COVID-19)], 39-43.

Dash, M. (2020b), "Analysing the Coronavirus Epidemic in India: Exponential vs Logistic Growth," *Academic Journal of Current Research* 7(4), 85-91.

Jia, L., Li, K., Jiang, Y., Guo, X., and Zhao, T. (2020), "Prediction and analysis of Coronavirus Disease 2019," *Working Paper*: https://arxiv.org/ftp/arxiv/papers/2003/2003.05447.pdf

Potluri, R. and Lavu, D. (2020), "Making Sense of the Global Coronavirus Data: The Role of Testing

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ISSN (2343 – 403X);
p –ISSN 3244 - 5621
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Rates in Understanding the Pandemic and Our Exit Strategy," *SSRN Working Paper, No. 3570304*: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3570304

Wu, K., Darcet, D., Wang, Q., and Sornette, D. (2020), "Generalized logistic growth modelling of the COVID-19 outbreak in 29 provinces in China and in the rest of the world," *Working Paper*: https://arxiv.org/ftp/arxiv/papers/2003/2003.05681.pdf

Appendix The data for the study is presented in the table below

date	new cases	cumulative cases	date	new cases	cumulative cases	date	new cases	cumulative cases
01-03-2020	0	3	**30-03-2020**	227	1251	**28-04-2020**	1873	31324
02-03-2020	3	6	**31-03-2020**	146	1397	**29-04-2020**	1738	33062
03-03-2020	1	7	**01-04-2020**	601	1998	**30-04-2020**	1801	34863
04-03-2020	22	29	**02-04-2020**	545	2543	**01-05-2020**	2394	37257
05-03-2020	1	30	**03-04-2020**	516	3059	**02-05-2020**	2442	39699
06-03-2020	1	31	**04-04-2020**	529	3588	**03-05-2020**	2806	42505
07-03-2020	3	34	**05-04-2020**	701	4289	**04-05-2020**	3932	46437
08-03-2020	6	40	**06-04-2020**	489	4778	**05-05-2020**	2963	49400
09-03-2020	7	47	**07-04-2020**	573	5351	**06-05-2020**	3587	52987
10-03-2020	15	62	**08-04-2020**	565	5916	**07-05-2020**	3364	56351
11-03-2020	0	62	**09-04-2020**	809	6725	**08-05-2020**	3344	59695
12-03-2020	12	74	**10-04-2020**	875	7600	**09-05-2020**	3113	62808
13-03-2020	8	82	**11-04-2020**	846	8446	**10-05-2020**	4353	67161
14-03-2020	18	100	**12-04-2020**	759	9205	**11-05-2020**	3607	70768
15-03-2020	14	114	**13-04-2020**	1248	10453	**12-05-2020**	3524	74292
16-03-2020	15	129	**14-04-2020**	1034	11487	**13-05-2020**	3763	78055
17-03-2020	14	143	**15-04-2020**	883	12370	**14-05-2020**	3942	81997
18-03-2020	26	169	**16-04-2020**	1060	13430	**15-05-2020**	3787	85784
19-03-2020	25	194	**17-04-2020**	922	14352	**16-05-2020**	4864	90648
20-03-2020	55	249	**18-04-2020**	2013	16365	**17-05-2020**	5050	95698
21-03-2020	83	332	**19-04-2020**	1250	17615	**18-05-2020**	4630	100328
22-03-2020	64	396	**20-04-2020**	924	18539	**19-05-2020**	6147	106475

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23-03-2020	103	499	**21-04-2020**	1541	20080	**20-05-2020**	5553	112028
24-03-2020	37	536	**22-04-2020**	1290	21370	**21-05-2020**	6198	118226
25-03-2020	121	657	**23-04-2020**	1669	23039	**22-05-2020**	6568	124794
26-03-2020	70	727	**24-04-2020**	1408	24447	**23-05-2020**	6629	131423
27-03-2020	160	887	**25-04-2020**	1836	26283	**24-05-2020**	7113	138536
28-03-2020	100	987	**26-04-2020**	1607	27890	**25-05-2020**	6414	144950
29-03-2020	37	1024	**27-04-2020**	1561	29451			

Source: Worldometer