Covid-19: Has Kerala turned the tide – Three tell-tale signs

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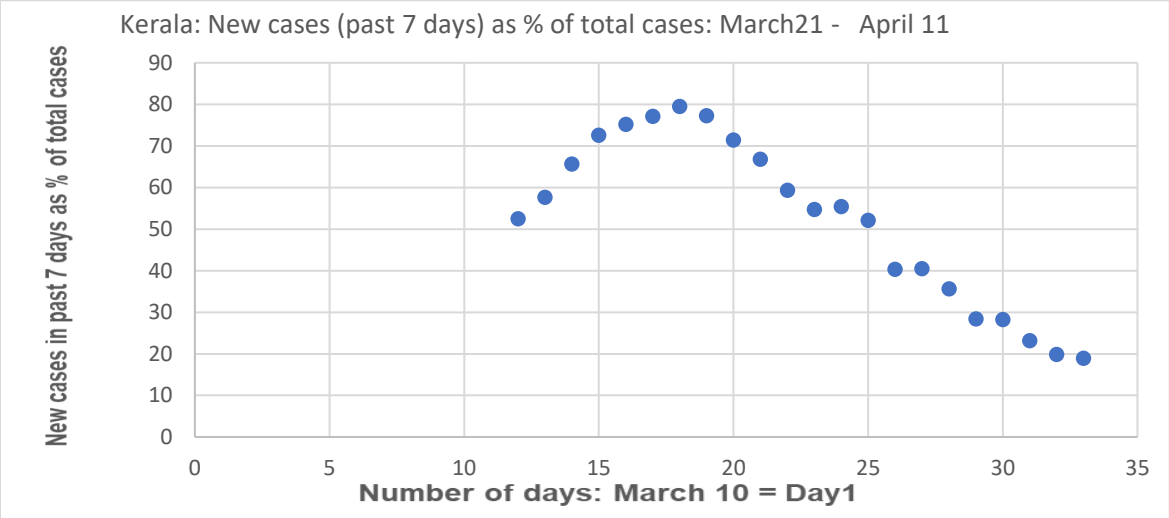
Covid-19 cases made an early appearance in Kerala. The State was quick to contain these and was acknowledged for its efforts. However, this was a short-lived satisfaction with the numbers starting to spike from about 21st March (please see https://bit.ly/Covid19-India-District-DataVizualization). In fact, Kerala and Maharashtra kept occupying the top and the next position in terms of number of cases between 21st March until April 2nd. Only on 3rd Kerala went down to third position when Tamilnadu overtook it in terms of number of cases. Since then Kerala has steadily moved to 4th position (April 5), 5th position (April 7) and 8th (April 9) position and has remained there.

Have other states just overtaken Kerala or has the state been successful in stemming the tide of Covid-19 cases? We present three tell-tale signs that the State appears to have turned the tide. The analysis is based on the MoHFW data from March 10 to April 11 in terms of the number of cases every day and cumulatively.

To begin with, it is worth examining whether new cases as fraction of the total cases have been on the rise or have these slowed down. We examine the ratio of the new cases of past 7 days as percentage of the total cumulative cases. The reason for taking last 7 days cases is to dampen the fluctuation in the number of cases on a day to day basis.



The graph above shows an unmistaken trend that the new cases as a fraction of the total cases have steadily come down and the turnaround has begun from 29 March.

We also noticed that Kerala is bucking the trend of exponential growth a pattern seen at all India level and in most other states, (With exception of Punjab but the trend is still somewhat fragile).

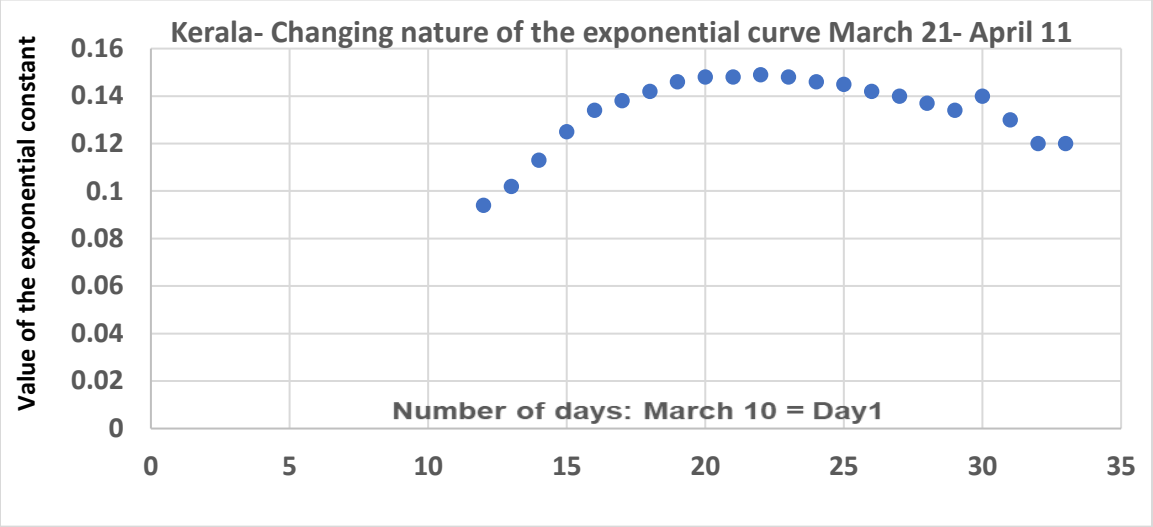
$y = Ae^{Kx}$ (y is the number of cases, x the number of days and K is a constant). Lower the value of K the better. For India, the exponential growth is given by the equation

$y = 39.3e^{0.1656x}$ with a value of $R^2 = 0.99$.

While for Kerala the equation is

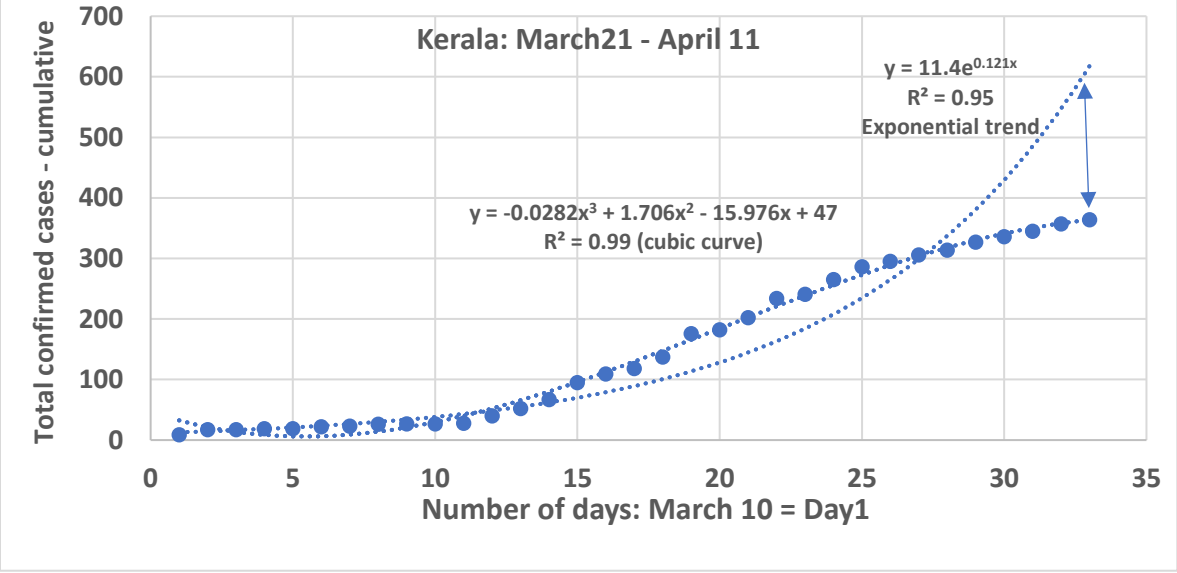
$y = 11.4e^{0.121x}$ with a value of $R^2 = 0.95$ (as of 11 April)**.**

However, when we examine the exponential equation on an ongoing basis, the value of K has shown a clear turn around starting from March 29-31with a steady reduction thereafter.



An equally interesting corroboration of these two trends is provided by the best fit for Kerala through a cubic equation. The negative coefficient of the x^3 term means that cases will go down as x increases.

$y = -0.0282x^3 + 1.706x^2 - 15.976x + 47$ with a $R^2 = 0.99$



One can clearly see the move away from exponential trend from 27 March, if not before, and this is not a flash in the pan. The table below provides the cubic equations for every day beginning from March 21.

Date	Day	Kerala (KL)	K values in $y = Ae^{Kx}$	R-Sq (Exp)	New cases in last 7 days as % of Total cases	Polynomial Fit (X=3)	R Sq (Poly)
10-Mar	**1**	9				**Notice the coefficient of the x and the x3 terms increasing, then coming down closer to zero and then turning negative and continuing to do so.**	
11-Mar	**2**	17					
12-Mar	**3**	17					
13-Mar	**4**	19					
14-Mar	**5**	19					
15-Mar	**6**	22					
16-Mar	**7**	23					
17-Mar	**8**	26					
18-Mar	**9**	27					
19-Mar	**10**	27					
20-Mar	**11**	28					
21-Mar	**12**	40	0.094	0.84	53	$y = 0.057x^3 - 1.0607x^2 + 7.3556x + 3.6$	0.935
22-Mar	**13**	52	0.102	0.87	58	$y = 0.079x^3 - 1.4469x^2 + 9.2084x + 1.5$	0.96
23-Mar	**14**	67	0.113	0.88	**66**	$y = 0.0876x^3 - 1.6101x^2 + 10.045x + 0.47$	0.98
24-Mar	**15**	95	0.125	0.88	**73**	$y = 0.1075x^3 - 2.0104x^2 + 12.231x - 2.3$	0.986
25-Mar	**16**	109	0.134	0.90	**75**	$y = 0.0924x^3 - 1.6879x^2 + 10.363x + 0.19$	0.989
26-Mar	**17**	118	0.138	0.92	**77**	$y = 0.0627x^3 - 1.0123x^2 + 6.2241x + 6$	0.981
27-Mar	**18**	137	0.142	0.93	**80**	$y = 0.0445x^3 - 0.575x^2 + 3.4004x + 10.2$	0.982
28-Mar	**19**	176	0.146	0.94	77	$y = 0.0475x^3 - 0.651x^2 + 3.9161x + 9.4$	0.988
29-Mar	**20**	182	0.148	0.95	71	$y = 0.0309x^3 - 0.2112x^2 + 0.783x + 14.4$	0.987
30-Mar	**21**	202	0.148	0.95	67	$y = 0.0188x^3 + 0.1272x^2$ **$- 1.7397x$** $+ 18.6$	0.987
31-Mar	**22**	234	0.149	0.96	**59**	$y = 0.0152x^3 + 0.2329x^2 - 2.5631x + 20.03$	0.99
01-Apr	**23**	241	**0.148**	0.96	**55**	$y = 0.0044x^3 + 0.5613x^2 - 5.2302x + 24.8$	0.989
02-Apr	**24**	265	0.146	0.97	**55**	**$y = -0.0016x^3 + 0.7501x^2 - 6.8266x + 27.8$**	0.99
03-Apr	**25**	286	0.145	0.97	**52**	$y = -0.0059x^3 + 0.892x^2 - 8.0741x + 30.2$	0.99
04-Apr	**26**	295	0.142	0.97	**40**	$y = -0.012x^3 + 1.1005x^2 - 9.9758x + 34.1$	0.99
05-Apr	**27**	306	0.14	0.97	**41**	$y = -0.0174x^3 + 1.2922x^2 - 11.788x + 37.8$	0.99
06-Apr	**28**	314	0.137	0.97	**36**	$y = -0.0221x^3 + 1.4678x^2 - 13.506x + 41.5$	0.99
07-Apr	**29**	327	0.134	0.96	**28**	$y = -0.025x^3 + 1.5765x^2 - 14.606x + 43.9$	0.99
08-Apr	**30**	336	0.14	0.96	**28**	$y = -0.027x^3 + 1.6563x^2 - 15.44x + 45.8$	0.99
09-Apr	**31**	345	0.13	0.96	**23**	$y = -0.0282x^3 + 1.7048x^2 - 15.964x + 47$	0.99
10-Apr	**32**	357	0.12	0.95	**20**	$y = -0.0283x^3 + 1.71x^2 - 16.022x + 47.15$	0.99
11-Apr	**33**	364	0.12	0.95	**19**	$y = -0.0282x^3 + 1.706x^2 - 15.976x + 47$	0.99

Initially the coefficients of x and x^3 are positive. One can gradually notice the unmistakable reversal of sign of the coefficient of x first (becoming negative), followed by the coefficient for x^3. More importantly, the value of the coefficient of x^3 is steadily decreasing which means that the cases will continue to taper as days go by i.e. x increases.

There are thus clear signs that Kerala has turned the tide and the trend has been consistent. Barring an episodic spike, one can expect Kerala to continue the trend. Only time will tell.