Covid-19 in the Southern states: a cautious sigh of relief?

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21 April was an important date for Kerala. A state that was earlier going neck to neck with Maharashtra as a state with highest number of Covid-19 cases, dipped below the 10th rank in terms of number of cases of Covid affected patients (see https://bit.ly/Covid19-India-District-DataVizualization). Earlier we had analyzed the case of Kerala and concluded that between 27th March and 3rd April the state did decisively turn the tide as far as the emergence of new Covid-19 cases was concerned (ibid – Has Kerala turned the tide – three tell-tale signs http://www.cps.iitb.ac.in/covid-19-has-kerala-turned-the-tide-three-tell-tale-signs/).

We did this by looking at the changing nature of three different indicators:

- First is the ratio of new cases to total cases.
- Second is the steepness of the exponential curve.
- Third is by looking at the coefficients A, B and C in a polynomial (cubic) equation

  $\mathbf{Y = Y_0 + Ax + Bx^2 + Cx^3}$ where Y is the number of cases detected so far, x the number of days and Y_0 the cases on day zero.

A similar turn of tide has happened for Karnataka, but within a time window of 27 March 9 April (Is Karnataka turning the tide? Ibid see https://bit.ly/Covid19-India-District-DataVizualization). It provided the motivation, in a way, to see how the other three southern states have fared.

Let us look at the three criterion briefly.

The virus spreads, as is well known by now, in an exponential fashion in that the new cases are proportional to the existing cases say "n". Mathematically, this is described by stating that Δn (Delta n), or the increase in the number of cases, is proportional to n, which is the number of already existing cases. Each of these n affected persons will pass on the virus to certain number of people depending on the nature of his/ her contact with them giving rise to new cases.

As new cases begin to rise, they add to the total cases. As these total cases increase, more new cases will arise in turn, and the number will exponentially grow until such time that an affected person is no longer left with new cases to pass on the virus. However, the new cases can also slow down if effective preventive measures are implemented, such as hand hygiene, cough etiquette, mask usage, quarantine and isolation of exposed and suspected/symptomatic cases, isolation of high-risk individuals, pharmaceutical interventions, social distancing and frequent hand washing. When these preventive measures are taken

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and they are effective, the ratio of new cases to existing cases will reach a peak and then start coming down.

This exponential rise is described by a simple equation: $\mathbf{Y = Ae^{Kx}}$

Where,

Y is the number of cases on day x,

A is the number of cases on day zero, and

K is a measure of the 'steepness' of the exponential curve.

When the rise in the number of cases is slower than the exponential trend, a cubic equation described above give a better fit. The coefficients of x and x^3, i.e A and C which are initially positive, become negative, implying thereby that the number of cases will start coming down as the number of days (x) increases.

Therefore, the first tell-tale sign that emerges is that the ratio of new cases to existing cases starts coming down. Since the day-to-day number of cases are subject to fluctuations, we take the total number new cases of last seven days as a fraction of the total cases. For Kerala this parameter reached a peak on 27 March and thereafter declined continuously (ibid). For Karnataka, a similar turn around took place on 28 March (ibid).

A similar pattern was shown by the parameter K, the steepness of the exponential curve. For Kerala, it showed a decline from April 2, 2020. For Karnataka a similar decline was seen from 27 March but is was a very slow one. Nonetheless, it has continued to decline steadily.

The cubic curve gave a corroborative evidence of the above trends. For Kerala, the cubic curve on 30th March could be represented as

$y = 0.0188x^3 + 0.1272x^2$ **- 1.7397x** $+ 18.6$, with a R^2 or (R Squared) value of 0.99. One can notice the coefficient of x having become negative. However, it took three more (anxious!) days for the coefficient of x^3 to become negative on 2nd April. It has continued to remain so thereafter, with increasing magnitude.

$y = \mathbf{-0.0016x^3} + 0.7501x^2 - 6.8266x + 27.8$, with a R^2 or (R Squared) value of 0.99

(The coefficient of determination R^2 is always $0 < R^2 < 1$ and denotes the strength of the association between X and Y).

Hence, the number of cases would start coming down as the number of days go up.

For Karnataka, the corresponding change took considerable time. The coefficient of x turned negative on 28 March;

$y = 0.0003x^3 + 0.2115x^2$ **- 1.1771**$x + 5$ {with a R^2 or (R Squared) value of 0.97}, while it took 12 more days for the coefficient of x^3 to turn negative

$y =$ **-0.0014**$x^3 + 0.3097x^2 - 2.3948x + 8$, with a R^2 value of 0.99

Needless to say, it has continued to remain negative, and increasingly so

The two southern states have been lucky, for, they did not witness the sudden spikes as witnessed by Tamilnadu, Andhra Pradesh and Telangana, in the first week of April, with Tamilnadu reaching the second position in terms of number of cases on April 6. It has hovered between the 2nd and the 6th position since.

Nonetheless, these three southern states have also shown the signs of turning the tide in terms of all these indicators.

Telangana has turned the tide during the time window of 8-13 April. The ratio Δn / n and the steepness started to decline from 8 April and has continued to do so. The coefficient of x and x^3, turned negative on the 12th and 13th April,

$y = 0.0066x^3 + 0.8683x2$ - **26.016**$x + 187$, with a R^2 value of 0.97 (12 April)

and

$y =$ **-0.0064**$x^3 + 1.643x2 - 40.287x + 268$, with a R^2 value of 0.97 (13th April)

respectively.

Andhra has also turned the tide during the time window 8-16 April. The ratio Δn / n started to decline from 8 April and has continued to do so. The Steepness of the exponential curve started declining from about the same time and has declined slowly while the coefficient of x and x^3, turned negative on the 11th April and 16th April,

$y = 0.0069x3 + 0.7269x2$ - **24.189**$x + 170$, with a R^2 value of 0.99 (April 11)

and

$y =$ -**0.0245**$x3 + 2.584x2 - 58.201x + 361$, with a R^2 value of 0.99 (April 16)

respectively.

Tamilnadu, notwithstanding its strong spike during the week of April 01 to April 06, and current high position among the states with large number of cases, has turned the tide during the time window 6-16 April.

The ratio Δn / n started to decline from 6 April and has continued to do so. The Steepness of the exponential curve started declining from about the same time and has declined slowly while the coefficient of x and x^3, turned negative on the 9th April and 12 April ,

$y = 0.0317x3 + 0.8141x2 - \mathbf{39.543}x + 294$, with a R^2 value of 0.99 (April 9)

and

$y = -0.0246x3 + 4.0136x2 - 96.166x + 602$, with a R^2 value of 0.99 (April 12)

respectively.

We thus notice that the five southern states have slowly, yet steadily, turned the tide as far as the increase in the Covid -19 cases is concerned. They have done it quietly, without much ostentation and with good management. Kerala and Karnataka were lucky to not have large spikes, but even Andhra, Telangana and Tamilnadu could contain the problem even though they had faced a sudden spike. One hopes that this trend will continues in days to come and has a clear message on the relation between good governance and pandemic management.

The method of analysis used above can be used for studying similar trends in a given state, or a hot spot for that matter, to assess whether the tide has begun to turn or not. We will look at the case of Punjab, Haryana and Himachal Pradesh as the next stage of our work.

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