"CURRENT INFECTION VS TESTING RATIO IN INDIA IS INADEQUATE TO FLATTEN THE CURVE EARLY"

COVID-19 has already earned the dubious distinction of being the century's worst pandemic. The outbreak of novel coronavirus, which has — as of May end — infected 5.54 million and killed 350,000, has led to an almost complete lockdown across the world for the first time. The healthcare systems in most countries have been strained to the point of breakdown, while entire economies lie in tatters. There is an urgent need for a better understanding of the disease and its progression. Several data and analytics agencies have developed predictive models to help governments across the world take decisions on preventive measures, resource allocation and procurements for healthcare, and to analyse the overall impact on the economy. A team of scientists and engineers from the department of physics and the department of mechanical engineering at Indian Institute of Technology, Kanpur — with engineers from Sibley School of Mechanical and Aerospace Engineering, Cornell University — have come out with a paper called Evolution of COVID-19 Pandemic: Power-law Growth and Saturation. It analysed real-time infection data for 21 nations up to May 18 and observed critical patterns. One of the key findings in this study was that COVID-19 infection curves for many nations exhibited power-law growth after showing an exponential phase and a gradual flattening of the curve, thanks to proportional interventions in terms of preventive measures. However, **PROF MAHENDRA K VERMA** from IIT-Kanpur, who led the study, warns that India, which exhibited linear growth and has now reached exponential growth, is yet to show a similar succession or signs of flattening the curve. Edited excerpts of his Straight Talk with **CH UNNIKRISHNAN:**

❓ What was the scope of the study?

ⓐ Epidemiologists have made many models to understand and forecast epidemics. One of the first models was called the SIR model, where the variables S and I describe the number of susceptible and infected individuals respectively. The third variable R represents the removed individuals who have either recovered or died. An advanced model, called SEIR model, includes exposed individuals E, who are infected, but not yet infectious. In the present paper, we analysed the publicly available national COVID-19 infection data up to May 18 using this advanced model and observed that the COVID-19 infection curve for many nations exhibited power-law growth after an exponential growth. We compared all the reported data with this model prediction and observed a good agreement among them. For most of these 21 nations, we found that the total number of infected individuals exhibited a succession of exponential growth and power-law growth before the curve was flattened. In particular, we found a universal t-growth before they reach saturation.

SARS-CoV-2 is one of the seven human coronaviruses which have been identified so far. It is the most dangerous among all of these because of its highly infectious nature and lethality. Asymptomatic carriers or individuals who do not exhibit any symptoms have carried the virus to far off places where it has spread rapidly. Even symptomatic patients manifest symptoms two to three days after turning transmissible. To stop the spread of the deadly virus, various nations have employed lockdowns, mandatory social distancing and quarantines for the affected among other measures.

In this paper, we analyzed the COVID-19 infection data for all these countries and observed that all of them are following the transition from exponential to power-law growth. Many of them are close to flattening their curves, with some exceptions. Our study also showed that three epidemics—Ebola, COVID-19, MERS—have had a similar evolution: exponential growth, power-law growth and then the flattening of the curve. In addition, we compared the predictions of an extended SEIR model and a delay-differential equation model with real-time data and

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observed good agreement among them. Though India, Singapore and Sri Lanka had reached up to the linear growth stage, they are yet to flatten their curves. Curiously, certain states in India actually went back to the exponential phase, perhaps triggering a second wave.

❓ What were the key observations?

🅰 A key feature of our analysis was the emergence of power-law behaviour after an exponential growth. This has also been observed by other researchers. The exponential growth is easily explained using $\dot{I} = \beta I$ relation, which arises due to the spread by contact. For power-law growth, $I(t) \sim t^n$, and then this relation is modified to $\dot{I} \sim I^{1-1/n}$. This (suppression) is attributed to lockdowns and social distancing etc. A careful analysis of the epidemic models helped yield this feature. Interestingly, Ebola and MERS also exhibited a similar behaviour. This generic feature is very useful for the forecast of the epidemic evolution in future.

> " Curiously, certain states in India actually went back to the exponential phase, perhaps triggering a second wave.

The I(t) curve needs to turn from convex (during the exponential growth) to concave for flattening. Hence, a transition from exponential growth to a power-law growth is expected. Lockdowns and social distancing are likely to make the transition faster, thus suppressing the exponential growth to some degree. Since we only studied the infection counts, it was evident that during the growth phase, active cases and death counts would also follow a similar pattern as I(t). The total death count too flattens along with the infection count, but the active cases decrease with time during saturation.

❓ Were there any other similarities while comparing with other epidemics?

🅰 Obviously, one question that we had in mind when the study was started was whether the epidemic evolution of COVID-19 differs from the spread of Ebola and MERS. So, we performed a comparative study of these three epidemics. We digitised the data for these epidemics from

their respective time periods. Clearly, the three curves looked similar to regimes exhibiting exponential, power-law, and linear growth before flattening. But a major difference was that COVID-19 has two subparts, which is essentially due to the spread of COVID-19 by asymptomatic carriers.

COVID-19 pandemic involves many factors; for example, asymptomatic carriers, lockdown, social distancing, quarantine, etc. Considering these complex issues, we focused on data analysis. In particular, we analysed the real-time infection data of COVID-19 epidemic for multiple countries up to a particular period and it showed that many nations are close to flattening the epidemic curve.

A key feature of our analysis was the emergence of power-law behaviour after an exponential growth. Of course, that had been observed by others as well. But in our model, the exponential growth was easily explained using $\dot{I} \propto \beta I$ relation, which arises due to spread by contact. For power-law growth, $I(t) \sim t^n$, the above relation is modified to $\dot{I} \sim I^{1-1/n}$. Interestingly, Ebola and MERS also exhibit similar behaviour. This generic feature is very useful for the forecast of the epidemic evolution, while you may note that the $I(t)$ curve needs to turn from convex (during the exponential growth) to concave for flattening. Hence, a transition from exponential growth to power-law growth was expected. The lockdowns and social distancing were likely to make the transition earlier, thus suppressing the exponential growth to some degree. An earlier study had conjectured that the power-law growth might occur due to asymptomatic carriers and/or community spread. This conjecture needs a closer examination.

In another interesting analysis of COVID-19 epidemic and as some of the earlier studies had argued, the total death count could be modelled using the error function. Using this result, we might be able to predict the asymptomatic behaviour of $I(t)$ that may yield valuable clues regarding the extent and duration of the epidemic. The epidemic spread has similarities with rumour spread and the growth of a network. A comparison of the power-law growth in these systems will yield fruitful results for the epidemic forecast. In summary, COVID-19 epidemic data revealed interesting properties that can be used for its forecast. This regime is a striking feature that might have connections with other aspects of physics and mathematics. We leave these considerations for future studies.

❓ Why have India's count of new cases continued to rise even after a stricter implementation of the lockdown?
🅰 In India, different states behaved differently. Kerala, UP and Odisha have demonstrated better interventions and thus good control. But many others like Maharashtra, Tamil Nadu, Gujarat and Delhi behaved in a completely different manner. Of course, early lockdown helped in keeping the contagion at a comparatively low percentage when compared to our population size and other complexities.
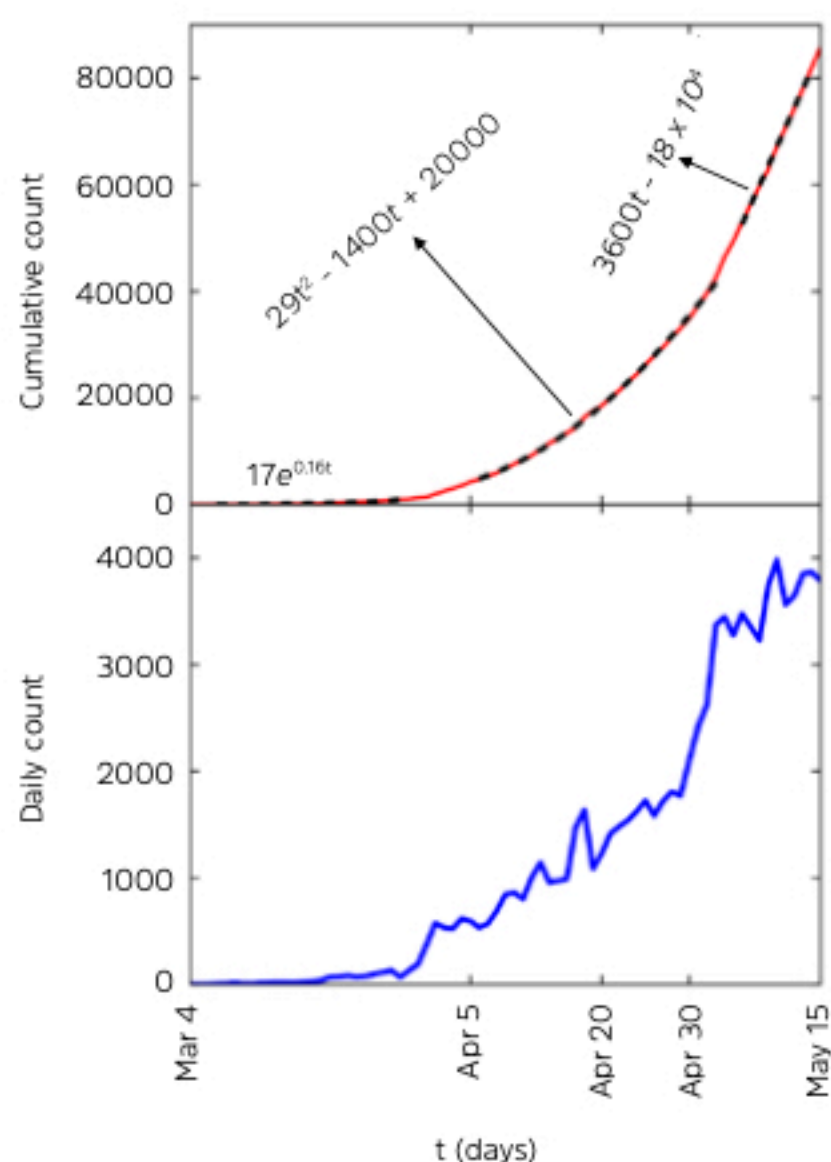
However, many of the states failed to strictly implement additional measures like social distancing, travel restrictions, tracking the infection by testing, contact tracing, and controlling the spread by quarantine and patient isolation. This has resulted in an uneven pattern of the disease spread within the country. Unequal distribution of resources, lack of uniform planning for healthcare across the country and the improper handling of the migrant labourer issue also led to unpredictable spread. Going by current data of a daily increase of more than 6000 cases and the count of daily testing of a lakh or little more than that, the ratio between the two seems grossly inadequate and thus, there is no sign of flattening the curve. India was at the maximum feasible ratio of 4,000 new cases, which means one positive in every 25 tests, till May 18. But it has already crossed that feasible ratio in the last few weeks. Hence the solution now is to at least double the testing and continue with strict implementation of other preventive measures across the country uniformly. 🔲