



# A Model-Based Analysis of COVID Spread in India

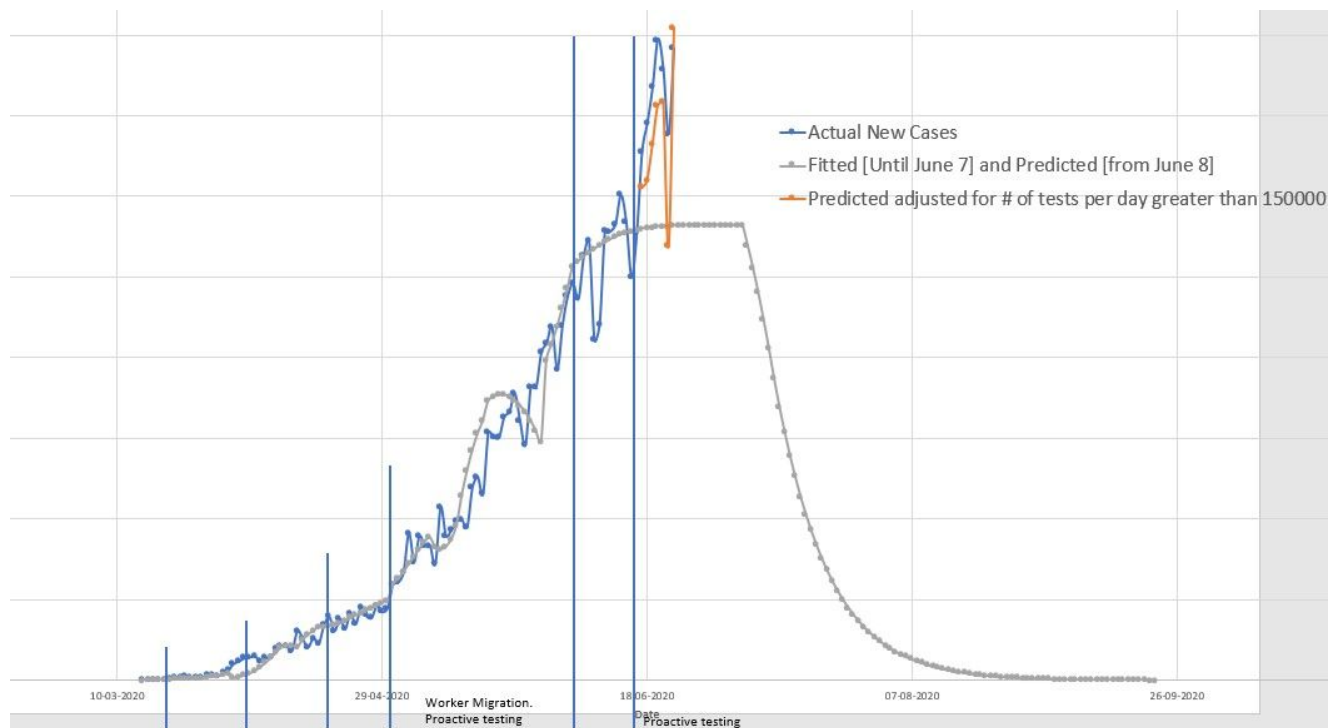
**Author: Dr Trichy V. Krishnan, Professor, Great Lakes Institute of Management,  
Chennai; and NUS Business School, Singapore**



A key factor that makes this COVID virus spread difficult to control is the following. A person identified as a COVID case would have actually been infected 5 to 14 days earlier because symptoms show up late. Even with tests done proactively, a positively identified case would have been infected a few days earlier. This implies that the underlying 'actual' infection current surfaces only a few days later to be observed and reported.

## Analysis (along with the key time points):

I gathered virus spread data from [covid19india.org](https://covid19india.org). I used data from mid-March until June 7 for model fitting and predict June 8-25 infections. I used an epidemic model<sup>1</sup> but with modifications to accommodate the double-layered infection current and some key exogenous forces (lockdown and partial lockdowns) as applied to the unobservable but actual infection current. The observed infection current was used to check for fit with the virus spread data<sup>2</sup>.



**Figure 1**

**Until March 21:** Infection started showing up in tens per day.

**Mar 22/25 - April 14:**

The nation-wide complete lockdown was enacted. It was very effective in containing the virus spread –the contagion rate dropped significantly– except for the impact created by the infamous Delhi meet attended by hundreds from infected countries. However, if India had the complete

<sup>1</sup> Bass (1969) model, published in 1969 in Management Science journal, qualifies for this study. It is actually a marketing model but built on an epidemic model framework to capture how word-of-mouth (i.e. contagion process) shapes up the sales growth of a new product in a market (i.e. spread of a new virus in a society). It is the most cited paper across all management journals.

<sup>2</sup> I used Excel and relied on simple eyeballing of the fit instead of using a statistical program.

lockdown continued beyond April 14 for another 2 months, the estimated potential number of infectable people (i.e. who would eventually be infected) would have been only 80000<sup>3</sup>.

Note that against the estimated total of 80000, only 11500 were found infected as of April 14, i.e. at the end of the complete lock-down period.

### **April 15 - May 2:**

Lockdown was relaxed, although only partially, to enable some revival of livelihood for millions of people. And, people started moving around with masks and maintaining social distance. Sellers of groceries, vegetables and other essential goods were allowed to operate for a few hours but people in many places started thronging the markets. More people got exposed to the virus as a result, and the estimated potential number of infectable people (i.e. who got exposed to the virus) started increasing from 80000 and went up to 1.2 Lakh, although interestingly the contagion rate remained the same.

Migrant workers, many of whom got paid in March-April, could find no work and food, and so started moving to their respective home states like UP and Bihar from commercial cities like Chennai, Mumbai and Delhi. This mass exodus reduced the good effects of social distancing and mask-wearing in markets, bus stops, railway stations, etc., further exposing more and more people to the virus.

### **May 3 - May 31:**

India further relaxed the lockdown through localizing the restrictions and opening up the less-infected areas for more economic activity. India used Red/Orange/Green zoning (total 733 zones) to bring in localized restrictions and control instead of country-wide control. Red zones are those with max infections and hence the movement of only essential goods are allowed; green zones are with the least restrictions, and orange being in the middle. Movement of goods across the districts are restricted depending on this zoning<sup>4</sup>.

This is the worst period for India. Our model estimates that the potential number of infectable people jumped from 1.2 lakh to 12 lakhs, although, again, interestingly the contagion rate remained the same! A lot and lot more people have got exposed to the virus. We are seeing close to 10000 cases per day in June, as against tens per day in early March. This trend will continue but is expected to start declining in July and August.<sup>5</sup>

Why did India see a major acceleration of this spread in May, which may continue into to June and probably July also?

---

<sup>3</sup> If the Delhi meet had not happened, the lockdown, if it were extended until May-June in the same condition, would have restricted the total infected to a mere 10000, as per our model estimate.

<sup>4</sup> After May 17 the states took more control of these zoning and other activities.

<sup>5</sup> See Figure 1.

**Reason 1:** Easing of the lockdown seems to be the main reason. Traders moving goods, people thronging the markets, housemaids and technicians like plumbers and electricians taking up domestic contract work, and migration of migrant labour all have an effect of exposing more people to the virus.

**Reason 2:** Localized control through zoning could be blamed but many cities like Indore, Agra, Meerut, Gurugram, Udipi, Calcutta, etc. have been able to contain the virus and subdue the spreading. Except for really hot concentrated zones, namely, Chennai, Delhi and Mumbai, things seem to be favouring localized control.

**Reason 3:** The three top hot zones, namely, Chennai, Delhi and Mumbai, are uniquely associated with a high concentration of migrant labour. In this time period, with fewer restrictions, the mass exodus of migrant workers continued unabated creating another fertile environment for more people to get exposed to the virus.

**Reason 4:** Test kits are 100% accurate. Those are designed to possibly avoid giving false negatives would give rise to more false positives in the sense that even people without the virus would be declared as infected. While it is impossible to know what fraction of the reported figures is false positive, it could be substantial<sup>6</sup>. This is supported by the fact that the recovery rate is more than 50%.

How might this virus spread pan out in the near future in India?

The model was designed and calibrated using data from March until June 7 and was extrapolated to make predictions for the near future. But there is a catch. On June 17, the government decided to increase the number of pro-active tests. What it used to be 1 lakh tests per day in May has increased to 1.5 lakh per day, and to 2 lakhs per day in June 3<sup>rd</sup> week. A higher number of proactive tests would surely reduce the time lag between the two infection currents but there is a limit to reducing that time lag. What complicates the numbers is the possible presence of false positives in the reported numbers. In order to account for the possible false positives, I have given two predictions: Prediction 1 assumes 1.5 lakh tests per day throughout, and Prediction 2 is for a short time period and it accommodates the higher number of tests undertaken from June 17 until June 25. You can see how closely the prediction is tracking the reported cases. Given that we don't know how the number of tests would change in the future, I have not ventured beyond Jun 25 for Prediction 2. Depending upon the number of tests, Prediction 1 would have to be modified to get Prediction 2.

Note that our model estimates that the potential number of infectable people stands at 12 lakhs, out of which 4.85 lakhs have been identified (including some false positives) until June 25. Hence, over the next few weeks/months, another 7 to 10 lakhs would be tested positive,

---

<sup>6</sup> <https://science.thewire.in/the-sciences/covid-19-icmr-antibody-kit-elisa-kavach-specificity-sensitivity/>

including possible false positives. This is an optimistic estimate. A pessimistic estimate would put the estimated total number of infectable people at around 20 lakhs<sup>7</sup> and the infection spreading until August-Sep before declining in Oct-Nov.

**Conclusion:**

Complete lock-down from Mar 25 till April 14 was very effective but India, unfortunately, could not continue that. While many countries lifted the lockdown after convincingly observing the slow-down in virus spread, India couldn't do that but lifted partially the lockdown to perhaps prevent the economy from sliding into a deep hole. But this has resulted in a massive virus spread. As our honourable Prime Minister Modi put it bluntly, it was the case of "life vs. livelihood", and there is no optimal solution here.

---

<sup>7</sup> For example, with religious places opening up in non-red zones, there is a clear and present danger for more people to get exposed to the virus.