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COVID 19 in India: Guidance from the IndiaSIM Model

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The Model

We use IndiaSIM, a well validated agent-based model of the Indian population. This has been published widely over many years and has been used for government decision-making including by NTAGI for vaccine introduction. A brief summary of the model is attached. The model describes the actual Indian population in full detail of demography (age, gender), location, socio-economic characteristics and access to healthcare. Our unit of analysis is an actual simulated Indian and estimates are reliable down to the district level. The model is fitted to the most recently available NFHS and census data and uses state-of-art agent-based modeling methods.

We fitted the model to available data from China and Italy. Key parameters include force of infection, age- and gender-specific infection rates, severe infection and case-fatality rates. Seasonality was assumed based on the idea that most respiratory infections decline in the summer and although Covid-19's temperature and humidity is not well understood, it is reasonable to assume that some characteristics of seasonal influenza apply here.

What did we find?

1. Community transmission of Covid-19 most likely started in early March.
2. National containment is not an option any more in India. However, state or local (temporary) containment and mitigation is the best option.
3. At baseline (without interventions) overall between 300 and 400 million Indians likely to be infected by July. Most of these cases will be mild. At the peak (somewhere between April and May 2020) 100 million individuals will be infected of which about 10 million will be severe and about 2-4 million will require hospitalization. This is the most critical period.
4. Generalized social distancing can, in theory, reduce this peak load by as much as 75% although this may be hard to enforce in India.
5. Our model is sensitive to hospital outbreaks of COVID19 induced by admission of infected patients into hospitals. Need for large, temporary hospitals to handle this load over the next three-month period. Secondary, hospital based transmission fuels the epidemic.

What do we recommend?

1. Social distancing
    a. Immediate social distancing, focused on the elderly population is essential. Anyone above the age of 65 should essentially shelter in place, while everyone else should practice significant social distancing

   b. We have modeled a three-week period of complete isolation for the elderly. The longer this period, the more we are able to delay infections into the post-July period.
   c. We have assumed high compliance with non-elderly social distancing in our model. Even if moderate, this may be the most useful option given where we are in the epidemic in order to contain the peak.

2. Testing: Containment is not an option. However, testing is essential for the purpose of identifying Covid-19 positive cases, especially in the elderly and the under-five population, preventing local hotspots of transmission, separating patients in healthcare facilities to keep infected and uninfected patients apart and for tracking the course of the epidemic. It may be difficult to scale RT-PCR for the general population. Focus should be on
   a. Test anyone who with flu-like symptoms who approaches the healthcare system to ensure that Covid19 cases do not mix with the general hospitalized population. An epidemic in healthcare institutions, both public and private would amplify transmission and peaks.
   b. Expand testing to private labs immediately.
   c. Would also suggest making a point that testing should be expanded to public + private labs widely
   d. Early, at home testing for anyone over the age of 60 who report these symptoms with the view of offering early access to care. This could limit their exposure to healthcare facilities. Where possible, a separate cohort of trained lab technicians would need to be developed. Where these are not present, existing ANMs should be trained in infection control and deployed. A rapid assay should be used rather than RT-PCR. There is a risk of over-identifying cases in this population but that is preferable to under-identification. All patients should ideally under RT-PCR before admitting to the facility, lest we expose them Covid19 inadvertently. This may not be possible in all locations but the benefit of over-identification and early admission to care would outweigh delays in careseeking.
   e. Nationally, testing will require multi-pronged approach—which means both RT-PCR and assay based rapid tests that were used in South Korea.

3. Mitigation
   a. Current ICU- and ventilator-equipped bed capacity in India is wholly inadequate to the number of infections at peak. Current capacity is estimated at 30-50K ventilators nationwide and about 70-100K ICU beds. We are awaiting better estimates from the government, but is likely to need expansion immediately. We will need upwards of 700,000 and as many as one million ventilators to address the peak. An alternative may be to use tracheostomy and and lower-cost ventilators. Supplementary oxygen is essential. Suction can be done using closed suction devices where infection control is better done without PPEs.
   b. Oxygen and and non-invasive positive pressure ventilation (e.g CPAP) are needed. This capacity is inadequate outside of tier 1 metro hospitals.
   c. Given the high risk of infections and low levels of infection control in hospitals including in urban areas, it is important to avoid admitting Covid19 patients to regular facilities. We need to consider how much care can be delivered at home, but important to note that CPAP will generate aerosols. See our point on testing above.

   d. Given the significant peak of infections in the next 4-10 weeks and the likelihood of this recurrence in November/December, plans should be made for temporary treatment facilities across India but focused on areas where severe cases are most likely to reach by July. The lack of adequate testing data makes it hard to model this well at this time.
   e. Mortality in healthcare workers could further increase deaths in the general population. Healthcare workers need personal protective equipment (i.e., masks and gowns) to protect themselves. Healthcare staff cohorting is essential and upscaling hospital infection control in all NHA facilities is essential. Without them they get sick further straining the capacity of the healthcare system to respond.

4. Research
   a. Reliable data on case loads would help us with data on targeting resources pro-actively. At this point, all cases of flu-like illness should be tested for Covid in *both inpatient and outpatient settings*, at least in tier 1 cities and expanding further.
   b. Immediate and continuing state-level representative, serological surveys needed to monitor the stage of the epidemic. The government has now permitted notified DBT research labs to begin this work, and this should be expedited.
   c. There be 1 or 2 centers in the country where a larger number of COVID patients are expected, and where there is research capacity, to be supported for more detailed and systematic data collection including understanding clinical course in the Indian context, viral shedding (both NP and stool—which is documented, and a particular concern in the south Asian context), pediatric illness in the context of malnourished children. In the data from China of about 2000 children with COVID indicated that 20-30% (including those 1-5 yr old) do have severe or critical illness. The total number of kids is small compared to the total; but children can get sick and are at greater risk in India.
   d. We have assumed no treatment options in this model. The validation of antiretrovirals immediately could help reduce the mortality rate among the elderly population.
   e. We have not assumed any vaccination options for the next 12-month period.

Summary for Policy

1. Delays in testing are seriously reducing ability of the population to self—protect. This is the most important way in which we can contain the epidemic. An increase in the official number of detected cases in the short term could encourage the population to take distancing more seriously and will reduce panic compared to a big spike later.
2. Border closures, at this stage have little to no impact and add further economic disruption and panic. Domestic transmission is far more important than international entry, which was important during the first stage of the epidemic.
3. A national lockdown is not productive and could cause serious economic damage, increase hunger and reduce the population resilience for handling the infection peak. Some states may see transmission increase only after another 2 weeks and lockdowns should be optimized for when they could maximize the effect on the epidemic but minimize economic damage. State level lockdowns in the most affected states could change the trajectory of the epidemic but should commence *immediately*. Any delay is allowing for more secondary cases to emerge. Lockdowns should be guided by testing

and serological survey data and should be planned on a rolling basis. We will expand these recommendations shortly.

4. Preparedness for case load should be the highest priority at this time. We will be issuing guidance based on the model for state level needs for bed capacity, oxygen flow masks and tanks and ventilators.
5. Temperature and humidity increases should help us in reducing case load. Although the evidence is limited, it is plausible.
6. We need to focus on both children under the age of five and the elderly. Early testing and healthcare in this population could help significantly reduce the mortality toll of the epidemic.
7. We should be prepared for multiple peaks in the model (we have only shown what happens in July) and we should be prepared for more cases and deaths later in the year.

Next IndiaSIM Guidance will be issued at 1 pm, March 24, 2020.

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About IndiaSIM

IndiaSIM is a well-validated, agent-based microsimulation model (ABM), which captures geographic and temporal variations in population, health services provision, socio-demographic characteristics, immunization status, and antimicrobial consumption in India. ABMs have been widely used to model complex systems in many disciplines, including epidemiology and economics [1–3]. In the context of healthcare provision, they are based on simulated populations in which agents are autonomous. Individual-based microsimulation models do not always simulate autonomous agents, but they do model at the individual level and have been extensively applied to disease dynamics and health- intervention evaluation [4–8]. The understanding that health interventions are complex, with feedback loops arising from disease dynamics and healthcare utilization, has led to novel ABM modeling in recent years [9–14]. Agents' actions and behavior are factors of their background characteristics, such as socioeconomic and demographics factors, and their environment, including access to healthcare and public goods. IndiaSIM modelers represent extensive experience in conceptualizing, developing, and utilizing models including ABMs, to estimate costs and benefits of interventions [9–12,15].

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