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COVID-19 Curve Guides India’s Health Infrastructure Growth Needs

Dear Editor:

The coronavirus disease 2019 (COVID-19) crisis has brought the entire world to a standstill over the past 4 months. Major countries across the world, including the United States, Spain, the United Kingdom, Italy, France, Germany, Russia, India, Iran, and Brazil have been prominent victims, with each country crossing the 100,000 mark for COVID-19 cases and the US going beyond 1.8 million cases. Lockdowns, along with behavioral changes such as physical distancing, using face masks, frequently washing hands with soap, following respiratory etiquette, and updating self-health awareness are proving to be effective measures in slowing the COVID-19 curve in many countries. With the world staring at a potential economic recession, many countries across the world have slowly and steadily started easing their respective lockdowns in the hope that the aforementioned measures will prevent an uncontrollable rise in COVID-19 cases. In this letter, we discuss why the cases may keep on increasing, especially in India.

Multiple lockdowns since March 25, 2020 have helped slow the COVID-19 curve in India immensely and have given much needed time to the central and state governments to scale up health infrastructure as well as to sensitize the population on various preventive measures, which will go a long way in keeping the curve within control in the coming months. Economic slowdown has caused large-scale migration from the urban pockets, which in turn has led to an increase in the COVID-19 curve in India. Thus, the government has started relaxing the lockdown to start various organized and unorganized economic sectors and to ease the movement of people in a bid to give relief to the ones in need. Such relaxations, coupled with the large population and population density, are likely to increase the number of COVID-19 cases in the coming months.

Highlighting the federal government structure in India, the COVID-19 containment strategy has been implemented state-wise. Various Indian states are adopting a strategy of 14 days of quarantine for any individual coming from outside the state. But the number of individuals coming from outside these states is huge. For example, Bihar is expecting a total of 2.7 million migrants to come back. Institutional quarantine has its own infrastructural limitations. Home quarantine seems to be a possible option for asymptomatic and mildly symptomatic cases, but should be strictly implemented. The social fabric and the culture of joint (extended) families can help in the successful implementation of the home quarantine scheme. The states are aggressively ramping up the number of COVID-19 tests per day so as to comb through and detect, at least in the hotspots, all the positive cases that are already inside the state and are mostly asymptomatic owing to India’s young population.

Combing through the entire population is an extremely difficult and nearly impossible task. India is currently carrying out more than 100,000 tests per day. Even if India scales up to 400,000 tests per day (nearly what the US is doing right now), it will take 3,425 days (9.3 years) to test its population of 1.37 billion. Even if we focus on combing only the hotspots, the high number of asymptomatic cases will keep on causing more hotspots at different locations, and further, a person tested today might get infected tomorrow because of easing of the lockdown norms.

The disease incidence usually decreases only when herd immunity is reached in a community. Herd immunity is a phenomenon where a considerable size of a community becomes immune to a particular communicable disease, thereby reducing the number of disease carriers. Usually vaccination assists in achieving herd immunity but a vaccine for COVID-19 is still far away. The other method is by natural infection where a sizable portion of the community is exposed to the virus in a controlled manner such that they develop antibodies in response and become immune to the disease.
such natural infections, the major point to consider is the life span of the developed antibodies. The life span of antibodies developed against other coronavirus strains such as Severe Acute Respiratory Syndrome is 2 years whereas for Middle East Respiratory Syndrome, it is 4 years.\(^7\) Although there are a few COVID-19 re-infection cases reported in South Korea, nothing conclusive has come out yet.\(^7\)

Easing of lockdowns in various countries without a vaccine in sight is building a case for naturally developed herd immunity.\(^8\) The threshold population to reach herd immunity is linked to the reproductive rate of a disease (\(R_0\)). The reproductive rate of a disease is the number of new individuals infected by an already-infected individual. If \(R_0 < 1\), then the virus transmission dies out.\(^8\) \(R_0\) for COVID-19 is predicted to be between 2 and 3.\(^9,11\) Thus, according to the equations given below, the threshold population to reach herd immunity should be between 50% and 66.66%.\(^7,9\)

\[
Y = \left(\frac{(R_0 - 1)}{R_0}\right) \times 100 \\
\text{thus, for } R_0 = 2, \\
Y = \left(\frac{2-1}{2}\right) \times 100 = 50\% \\
\text{and for } R_0 = 3, \\
Y = \left(\frac{3-1}{3}\right) \times 100 = 66.66\%
\]

In a country like India, with a population of 1.37 billion,\(^12\) the threshold to reach herd immunity will be 913.2 million. The COVID-19 curve will flatten either when the total number of COVID-19 cases approaches the threshold herd immunity population or when all the current cases (both symptomatic and asymptomatic) are strictly isolated and no new cases are allowed into the population. Both conditions are extremely difficult to achieve, making it clear that COVID-19 is going to stay for a very long time.

The compounded daily growth rate (CDGR) calculated over 7 days, from January 28, 2020 to May 25, 2020, for India, US, Brazil, and Spain is plotted in Figure 1. The initial spikes are majorly due to a small number of cases, but a generic trend observed in the plot is that lockdowns have played a significant role in slowing down the CDGR of the countries. The CDGR for countries such as the US and Spain over 7 days was 1.44% and 0.23% as of May 25, 2020, whereas in other countries such as India and Brazil, the CDGR over 7 days was 5.4% and 6.03% as of May 25, 2020. Figure 2 shows a plot of the CDGR of total cases and active cases plotted from March 25 to May 25, 2020. Since March 25, 2020, India has had 4 lockdowns.\(^16,19\) The first (March
25–April 14) and second (April 15–May 3) lockdowns had severe restrictions on the movement of people, and all nonessential services and activities were closed. From the third lockdown, norms were eased and movement of people was allowed in a graded manner. The major highlight of the third lockdown was the government’s initiative to send back willing and in-need interstate migrants to their respective home states. Approximately 4.4 million migrants were sent back by train until May 25, 2020.

Certain restrictions on movement, activities, and services will become a norm of the society until a vaccine is developed for COVID-19. The rate of increase in total cases, active cases, and recoveries during the third (May 4–May 17) and fourth (May 18–May 31) lockdowns shall give us an approximate idea on how the COVID-19 curve will progress in India and how India should scale up its health infrastructure in time. As seen in Figure 2, the CDGR of total cases and active cases show an excellent correlation across all stages of lockdown. The correlation across the 4 stages of lockdown is 0.99825 whereas the correlation across the third and the fourth lockdown is 0.841. The CDGR of total cases calculated from third lockdown onwards is approximately 5.32% whereas the CDGR of active cases over the same period is 4.26%. Active cases represent the total cases minus the total recovered and the total dead cases. This means that the Indian government has to scale up the health facilities for cases, which are increasing at a daily rate of 4.26%. It means supplies such as beds, ventilators, oxygen supplies, hospital staff, gloves, and personal protective equipment have to be scaled up accordingly.

On the basis of the severity of the cases, the patients are kept in COVID-19 health centers, COVID-19 care centers, and COVID-19 hospitals. Separate quarantine facilities are also available. Those with mildly symptomatic and asymptomatic corona cases are put on home care treatment routines as well. As of May 17, 2020, India has 916 dedicated COVID-19 hospitals with 180,473 beds (161,169 isolation beds + 19,304 intensive care unit [ICU] beds). In addition, there are 2,044 dedicated COVID-19 health centers with 128,304 beds (117,775 beds + 10,530 isolation beds + 1,004 ICU beds).
isolation beds + 10,529 ICU beds). Further, there are 9,536 quarantine centers and 6,309 COVID-19 care centers with 564,632 beds.\textsuperscript{21}

As of May 17, 2020, 3.1% patients needed ICU, 2.7% needed oxygen support and 0.45% needed ventilators.\textsuperscript{21} These percentages have remained mostly stable across the course of COVID-19 in India. Taking these numbers into consideration, the Table shows the health infrastructure needs in the coming 3 months in India. India needs to focus all its might on reducing the CDGR of health infrastructural needs to as close to 0 as possible. At 0, the need of scaling up the health infrastructure will cease to exist.

The average of the daily percentage of new cases to the total active cases from May 4 to May 25, 2020 (since third lockdown) is 9.71% with a variance of 1.02. Similarly, the average of the daily percentage of recoveries and deaths to the total active cases over the same period is 3.82% with a variance of 0.88. If the daily new cases become equal to the daily recovered plus death cases, the CDGR of active cases becomes 0. Thus, another straightforward target is to bring the percentage of daily new cases to as close to the percentage of daily recoveries and deaths as possible. These numbers are averaged out and represent a macro level analysis. A similar regional analysis should be performed to frame policy guidelines. Similar analysis can be carried out for other countries as well.

With the lockdown being eased, it looks more prudent to focus on containing the spread within manageable limits. The government should focus on bringing the CDGR of active cases close to 0 or to bring the percentage of daily new cases as close to the percentage of daily recoveries and deaths with respect to the total active cases. This will reduce the health infrastructure growth needs of India. Virus containment efforts will be assisted by strategies including localized lockdowns; use of face mask; frequent hand sanitization; physical distancing of 6 feet; touchless, foot-controlled water dispensers; management policies on the basis of crowd density; promotion of work from home; adoption of digital payment; segmentation between patients in hospitals; sanitization of standard operating practices for public places including hotels, restaurants, taxis, and utilities; and sanitized handling of home food delivery.—Vaibhav Pratap Singh, MS (by Research), Senior Technical Officer, Real Time Systems and Internet of Things, C-DAC, Bangalore, India; E-mail: vaibhavpratapsingh07@gmail.com; Haribabu Pasupuleti, ME, Associate Director, Real Time Systems and Internet of Things, C-DAC, Bangalore, India; and Bindhumadhava Bapu Sundaramurthy, MS, Senior Director, Real Time Systems and Internet of Things, C-DAC, Bangalore, India

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**Coronavirus Disease: 4 Million Cases Worldwide and the Importance of Multidisciplinary Health Care Teams During the Pandemic**

**Dear Editor:**

On May 12, 2020—International Nurses Day—4 million cases of coronavirus disease (COVID-19) were recorded, with a total of 292,000 deaths worldwide. Brazil, at that point, recorded a total of approximately 178,000 cases and 12,404 deaths caused by the disease. At that period in time, Brazil appeared in the seventh position regarding number of cases, sixth in number of deaths, and second in number of active and serious cases (N = 8,318), with a low number of real-time polymerase chain reaction (RT-PCR) examinations per million inhabitants (N = 3,459).1,2

During the COVID-19 pandemic, a multidisciplinary health care team (nurses, biologists, nutritionists, physiotherapists, medical doctors, pharmacists, and psychologists), working exhaustive and continuous hours, is acting intensively to promote a better outcome for all patients with COVID-19, mainly those in intensive care units. Health professionals take all the steps involved in the treatment of patients with COVID-19, after the diagnosis by RT-PCR, by providing medical support during ventilatory maneuvers as well as psychological support to the patients and their relatives, mainly in cases of deaths. The multidisciplinary health care team should be better recognized for its actions during and after the COVID-19 pandemic.