Note on Prioritization of Districts for Aid

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With 15 million new cases confirmed since March, India is grappling with a second wave of COVID-19. While several vaccines in development have shown remarkable efficacy against the disease, scaling production and distribution will take time. As a result, it may be 2-3 years before everyone in need is able to get vaccinated. This begs an immediate question of how governments should allocate vaccine doses across states and districts. Toward that end, we have developed a framework that takes available data on the status of the COVID pandemic and generated a district priority rank for aid.

I. Critical factors

There are 4 factors that go into our prioritization of districts:

1. Probability of first-time infection going forward
2. Case fatality rate
3. Population
4. Hospital capacity

Probability of first-time infections. To model the probability of first-time infections, we assume that the hazard rate is constant conditional on attributes z (which includes location) and is equal to the probability of getting COVID in the future. Therefore, with a constant hazard rate (and no replacement), we seek to estimate $\lambda_k(z) = P(\text{COVID at } t | r(t) = 0, z)$. Suppose that the first day of the epidemic is called date t = 0 and we know the fraction of people with attributes z who have previously had COVID as of date t_0. With a constant hazard rate λ, this would be

$$P(r(t0) = 1; t_0, z) = 1 - S(t_0) = 1 - \exp\left(-\int_0^t 0\lambda(z)ds\right) = 1 - \exp(-\lambda(z)t_0)$$

Taking logs and rearranging gives:

$$\lambda(z) = -\frac{ln\,(1 - P(r(t0) = 1; t_0, z))}{t_0}$$

Where $P(r(t0) = 1; t_0, z)$ is the fraction recovered (referred as R) and t_0 is the number of days since the start of the epidemic (days since January 31, 2020). Here we assume that natural immunity is perfect.

We calculate the fraction recovered, R in the following way. First, we calculate the fraction of the population with antibodies to COVID. This is obtained in multiple steps. We start with the Tamil Nadu serological survey in October/November 2021 and extrapolate to districts outside Tamil Nadu using the rate of fraction of population in urban areas (non-villages). Then, for each district, we project out from October to April 15 using the trajectory of confirmed cases. Second, to each district's fraction that has previously been infected, we add the fraction that has been vaccinated.

Case fatality rate. We calculate the CFR as the total number of confirmed COVID deaths until May 7 in a district divided by total number of confirmed COVID cases as of that date[1].

Population. We use the 2011 census data to obtain district level population estimates.

Hospital capacity. We obtained hospital capacity from Rural Health Statistics 2019. We calculate hospital per capita by dividing hospitals by population.

II. Rankings

We create 2 composite rankings.

Future risk ranking. For distribution of masks, we rank district based on the future harm from infection. This is the product of the (i) number of people at risk, (ii) the probability of infection, and (iii) the probability of harm. To capture this, we simply multiply factors 1, 2 and 3 and then rank order districts. (We are implicitly assuming that the overestimate of IFR by using CFR is a constant multiplicative factor across all districts.)

Risk and logistics ranking. For distribution of oxygen and other components used at hospitals, we also consider the capacity of hospitals to use these equipment. Data on hospitals is limited in quantity and quality. We simply ask whether an area has hospitals that can absorb additional resources. In this ranking we take a weighted average of our future risk ranking and our hospital capacity ranking. The weight is 0.75 on future risk and 0.25 on hospital capacity.

[1] Data extracted from covid19india.org

It is critical to note that the rankings will not change over time as we use a constant hazard rate to estimate the probability of first-time infections.

III. Caveats

For some relatively small states (e.g., Delhi, Manipur, and Nicobar), we do not have district level values. We report state or territory-level R. Similarly, CFR values for Assam, Goa, Sikkim and Telangana are reported at the state-level.