A Simple Supply-Demand Planning Framework for Corona Covid 19 Hospital Management

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(uses data as on 4th April, 2021)

Preamble

As India reels under the second wave of Corona Covid-19, the numbers and the speed of the infection has stressed the medical infrastructure to a great extent. As a result, the administration is looking at lockdowns as a means to lower the growth rate of the epidemic, while people in general, especially those who cannot work-from-home are alarmed at the prospect of further disruption. The fact is that lockdowns do reduce mobility and the interaction rates between people and hence do tend to lower infection growth rates. But given its negative impact on society, in the current scenario, these must be used only to bring infection rates within regional medical capacity.

This note proposes a simple ready-reckoner for the above problem of measuring the demand and supply for medical facilities and to compute the stress. We use Maharashtra as a running example.

Method

We use Covid-19 mortality as the principal indicator. For this, we use the data from covid19india.org. The other count, i.e., the total number of cases, is an unreliable metric. This is because of different testing regimes, even with the same region, e.g., Pune, will lead to a vastly different number of cases. Thus, we use DDR, the daily death rate (averaged weekly) as the metric to measure the current state of the epidemic for a given region, in our case, districts of Maharashtra. This is the “demand side”.

We now come to the “supply side”. Here, since most of the cases are either asymptomatic, mild or medium, we consider the needs of the seriously ill who will need supervised care in a room equipped with oxygen or in an ICU. We use O2+ICU beds in a region as the metric of supply. It is assumed that such beds come equipped with doctors, nurses, and the usual supplies, but see below for separate Oxygen estimation. This data is available for the state of Maharashtra on the webpage of the Department of Health and is updated regularly.

Let us now come to the treatment given. Just as an example, we propose 3 classes of treatment, viz., A, B and C, which is no treatment. Important parameters of the treatment are the number of days and the mortality. This data can be gathered from the facilities in the region or should be published by the nodal agencies. Once this is computed, it is easy to compute the beds required to serve a given DDR. This is given in Table 1 below. It should be noted that Treatment A may also be more expensive than Treatment B and may be available only in a few facilities in the region.

Treatment	Days	Mortality (%)	Number of Beds per unit death rate	Total numbers of beds required
A	12	5	100/5 X 12 =240	DDR X 240
B	8	10	100/10 X 8 =80	DDR X 80
C	0	25	0	0

Table 1: Computing bed requirements from daily death rates.

The above parameter may be called as the Critical Care Mortality Rate (CCMR), .i.e., the number of deaths to expect per day from a Critical Care facility.

Data

We now present the above two data sets in a comparative form as in Table 2 below for a selected subset of districts of Maharashtra as on 4th April, 2021. The previous two weeks' DDR is used to estimate the next week's DDR by a linear extrapolation. This is used to compute the O2+ICU bed requirement as per Treatment A and B. This is compared with the actual beds available and a category is awarded: Red if the number of beds is below Treatment B, Yellow if it is between that for Treatment B and A, and green if the number of beds is above that required for Treatment A.

Analysis

We now draw conclusions from the above table. Firstly we see that the districts in RED are Raigad, Akola and Parbhani, i.e., largely those with a large rural fraction. Even Ahmednagar, which is YELLOW, is at the border. Thus, it is likely that a large number of rural patients are unable to access medical care. This has indeed been reported in the newspapers. Moreover, these are so largely due to poor provisioning of beds per capita. Thus here, instead of restrictions, immediate increase in the number of beds is required. The other two YELLOWs are Nagpur and Nanded. While bed provisioning is high and there is a large urban population, the category of care has slipped. Thus, here restrictions on movement may be required. Moreover, it has been reported that these districts receive a large number of patients from neighboring RED districts. Finally, we come to Mumbai, Pune and Amravati. These are currently well provisioned. Indeed, the more expensive Treatment A, if affordable is available to its citizens.

	Daily Death Rates			Bed Requirement		Beds as on 30th March, 2021	Population (lakh, 2011)	Beds per lakh	Category
District	18-24 March 2021	25-31 March 2021	1-6 April 2021	Treatment B	Treatment A				
Ahmednagar	1	1	5	400	1200	430	45	10	
Akola	2	6	10	800	2400	392	18	22	
Amravati	5	4	3	240	720	1511	29	52	
Aurangabad	2	2	2	160	480	752	37	20	
Nagpur	15	20	25	2000	6000	4229	47	90	
Nanded	4	7	10	800	2400	1349	34	40	
Parbhani	1	5	9	720	2160	363	18	20	
Pune	8	14	20	1600	4800	6005	94	64	
Raigad	2	3	4	320	960	102	26	4	
Mumbai	8	11	14	1120	3360	7927	124	64	

Table 2. Comparison of demand and supply for O2+ICU beds (based on data upto 4th April, 2021).

Limitations and Extensions

The DDR may be an inaccurate measure of prevalence if there is already substantial stress, for example, if the region is largely undergoing Treatment C, or if there is substantial migration.

The method may be easily extended to other constraints such as medical supplies, oxygen or manpower. More attributes may be added pertaining to geography, rural/urban distribution etc., to draw more pointed conclusions. The clinical data in Table 1 may be computed for each medical facility and will serve to compare them. For example, assuming a consumption of 15 kgs of Liquid Medical Oxygen (LMO) per patient in O2+ICU, we get a requirement of 3.6 MT per day per unit DDR for Treatment A and 1.2 MT for Treatment B. Thus, the estimated daily requirement for Pune for the week of 1-6 April, 2021 at a DDR of 20 would be 24-72 MT of Oxygen every day.

India has an installed capacity of 7000 MT of Oxygen per day. Assuming a clinical utilization of 6000 MT per day, a CCMR of 200 and about 15 kgs per day gives us a mortality of 3000 deaths per day, i.e., about 2.2 deaths per million per day, a rate routinely seen across the world.

The color categorization may also be used to “triage”, that is, to schedule movement of patients between usual beds, to O2 and further to ICU. It can also be used to screen hoarding of precious ICU capacity.

Conclusion

Our note proposes a simple method of setting up the supply-demand scenario for a given region. This allows a combination of clinical, administrative and infrastructural data to be brought together in a common framework. Such a framework should be promoted by nodal agencies and states guided in its use and in publishing the data and the analysis in a transparent manner. This will help make decision-making more transparent, identify problematic areas, improve social comprehension and compliance to restrictions.

In summary, the following data sets and analysis should be made public for every district and every major city. This would enable substantial amounts of planning, mobilization of resources and induce good behaviour from citizens.

1. The Daily Death Rate (DDR) for the past few weeks and the official estimate of the DDR for the next two weeks.
2. Current regime of care in ICU+O2, i.e., the average number of days of stay in hospital and mortality.
3. DDR for out-of-state, out-of-district and rural patients.
4. Official estimate of number of ICU+O2 beds in city/district.
5. Existing number of ICU+O2 beds in city/district and classification of district as RED / YELLOW / GREEN.