COVID-19 Medical Inventory Prediction

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Abstract

This document describes the assumptions behind the estimated medical inventory requirement for attending to COVID-19 patients in hospitals, as projected in https://covid19medinventory.in. The estimated patient counts have been obtained from https://mesoscalelab.github.io/covid19/. The projections are themselves dynamic, and can change every week depending on newly available evidence. The medical inventory list and the formule for its dependence on the type of patients is also dynamic, and will change as we find better relationships with actual field data.

1 Basic Assumptions

The number of COVID-19 positive patients obtained from the district-wise projection[1] is denoted as N. This could be the current number or the projected number in future weeks. According to WHO statistics[2], the number of patients who actually need various levels of care[3] is given in the table below:

Type of patient	Type of care	approx %	Symbol used here
Total positive	–	100%	N
Mild	Symptomatic, Home Quarantine/isolation (out-patients)	40%	N_{q}
Moderate	In-patient ward	40%	N_{i}
Severe	Supportive care, oxygen therapy	15%	N_{s}
Critical	ICU, mechanical ventilation	5%	N_{cr}
Deceased	–	2.5%	N_{d}

2 Inventory Estimates

The tables below gives the inventory list, the estimation logic, and formula, and an example calculation for $N = 100$ positive cases.

In the example case the patient estimates are given below. In the website, some of the numbers are rounded higher to the nearest 10 or 50, depending on their magnitude.

Category	Symbol	Estimate
Total positives	N	100
Mild	N_{q}	40
Moderate	N_{i}	40
Severe	N_{s}	15
Critical	N_{cr}	5
Deceased	N_{d}	2.5

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Table 1: Persons and Protective Equipment. The last column is rounded number assuming a total positive cases of $N = 100$.

Item [Unit]	Estimate	Formula	$N = 100$
Doctors [per day]	2 per 12-hr shift for 10 critical and severe patients and 2 per 12-hr shift for 15 in-patients	$\frac{2}{5}\left(N_{\mathrm{cr}} + N_{\mathrm{s}} + \frac{N_{\mathrm{i}}}{1.5}\right)$	19
Nurses [per day]	1 per 8-hr shift for 3 critical and severe patients and 1 per 8-hr shift for 5 in-patients	$\left(N_{\mathrm{cr}} + N_{\mathrm{s}} + \frac{N_{\mathrm{i}}}{1.5}\right)$	47
Total staff [per day]	Doctors, Nurses	$S \equiv \frac{7}{5}\left(N_{\mathrm{cr}} + N_{\mathrm{s}} + \frac{N_{\mathrm{i}}}{1.5}\right)$	66
Staff PPE (Gowns, Masks, Goggles etc.) [per day]	Two per staff	$2\,S$	132
Patient PPE: Masks [per day]	4 per severe and moderate patients	$4(N_{\mathrm{s}} + N_{\mathrm{i}})$	220
Sterile gloves [per day]	3 per patient per 6-hr shift for critical and half that for severe and moderate	$12N_{\mathrm{cr}} + 6(N_{\mathrm{s}} + N_{\mathrm{i}})$	390
Non-sterile gloves	6 per patient per 6-hr shift for critical and half that for severe and moderate	$24N_{\mathrm{cr}} + 12(N_{\mathrm{s}} + N_{\mathrm{i}})$	780
Dead body bags	1 per deceased	N_{d}	3

Table 2: Medical Equipment. The last column is rounded number assuming a total positive cases of $N = 100$.

Item [Unit]	Estimate	Formula	$N = 100$
Ventilators, Ambu bags, Glass case	1 per critical patient	N_{cr}	5
Laryngoscopes, Defibrillator	3 per 10 critical patients	$3N_{\mathrm{cr}}/10$	2
ECG	1 per 20 critical patients	$N_{\mathrm{cr}}/20$	1
Arterial BP monitors	1 per critical patient	N_{cr}	5
Arterial blood gas machine	1 per 30 critical patients	$N_{\mathrm{cr}}/30$	1
Bedside X-ray	1 per 20 critical patients	$N_{\mathrm{cr}}/20$	1
Infusion pumps	3 per critical patient	$3N_{\mathrm{cr}}$	15
Oxymeter	1 per 20 severe patients	$N_{\mathrm{s}}/20$	1
High flow nasal canula	1 per severe patient	N_{s}	15
Nebuliser	1 per severe patient	N_{s}	15
Non-contact Thermometer	1 for 20 out-patients	N_{q}	2
Patient cot	1 per severe and moderate	$N_{\mathrm{s}} + N_{\mathrm{i}}$	55
Wheel chair	1 per 20 severe patients	$N_{\mathrm{s}}/20$	1
Stretcher	1 per critical and 3 per 20 severe patients	$N_{\mathrm{cr}} + 3N_{\mathrm{s}}/20$	7
Ambulance	3 times total positive cases, each making 20 trips per day	$3N/20$	15

Table 3: Medical Consumables. The last column is rounded number assuming a total positive cases of $N = 100$.

Item [Unit]	Estimate	Formula	$N = 100$
Needles [per day]	10 per critical, 5 per severe, 2 per moderate	$10N_{\mathrm{cr}} + 5N_{\mathrm{s}} + 2N_{\mathrm{i}}$	205
Disposable Bags [per day]	3 per critical 2 per severe and 1 per 4 moderate	$3N_{\mathrm{cr}} + 2N_{\mathrm{s}} + 0.25N_{\mathrm{i}}$	55
Sanitizer [lt/day]	250 ml per all in-patients	$0.25(N_{\mathrm{cr}} + N_{\mathrm{s}} + N_{\mathrm{i}})$	15
Endotracheal Tube [per day]	1 per critical patients for 3 days	$N_{\mathrm{cr}}/3$	2
Oxygen (medium) [cylinders per day]	4 cylinders per critical patient	$4N_{\mathrm{cr}}$	20
Central and Peripheral lines [per day]	1 per critical patient for 3 days	$N_{\mathrm{cr}}/3$	2
IV Fluids [lt/day]	5 bottles of 500 ml per critical patient	$2.5N_{\mathrm{cr}}$	13
Suction catheter [per day]	1 per critical patient	N_{cr}	5
Test kits [per day]	3 times the number of positive cases	$3N$	300

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4 Errors and Omissions

Though the authors have taken sufficient care in estimating the quantity of the inventory, the proportions used here may change depending on the actual field data in India for the patients and the inventory usage pattern. Please email your comments and suggestions with justifications to p.sunthar@iitb.ac.in for inclusion in the future updates of the software.

A Patient projection model

The key formulae from patient prediction model[1] is given here. Let the case fatality rate (CFR) as defined by number deceased N_d to the total number of cases N be

$$m = \frac{N_\mathrm{d}}{N} \tag{1}$$

It is assumed that the CFR is same for all districts of a state.

The number of critical patients N_cr is taken to be bounded by the two different death rates (as per predictions given under):

$$2\,N_\mathrm{d,low} \leq N_\mathrm{cr} \leq 4\,N_\mathrm{d,high} \tag{2}$$

where the lower bound factor (2) is based on world averages[2] and the upper bound is based on ??. Here, $N_\mathrm{d,low}$ and $N_\mathrm{d,high}$ are the deaths predicted by the lower and higher death-growth rates, respectively (see below).

A.1 Growth predictions

The weekly growth of number of deaths is given by

$$N_\mathrm{d}(t+n) = g(n)\,N_\mathrm{d}(t) = g(n)\,m\,N(t) \tag{3}$$

where g is a weekly growth factor and n is the number of weeks from a reference date at t. There are two scenarios for the values of g: Low growth and High growth, which are bounds of the death growth rates obtained by fitting the growth rates across the world[1]. The low growth factor for values of $n = \{1, 2, 3, 4\}$:

$$g_\mathrm{low} = \begin{cases} \{4, 27.85, 85, 160\} & N_\mathrm{d} < 10 \\ \{5.5, 20.70, 150\} & N_\mathrm{d} \geq 10 \end{cases} \tag{4}$$

Similarly the high growth factor for values of $n = \{1, 2, 3, 4\}$:

$$g_\mathrm{high} = \begin{cases} \{6.5, 42, 110, 300\} & N_\mathrm{d} < 10 \\ \{7.6, 35, 108, 230\} & N_\mathrm{d} \geq 10 \end{cases} \tag{5}$$

These growth factors provide the corresponding projected $N_\mathrm{d,low}$ and $N_\mathrm{d,high}$ from Eq. (3).

References

[1] Santosh Ansumali and Aloke Kumar. A district-wise projection map for covid-19 in india. Technical report, JNCASR and IISc, 2020.

[2] *Operational considerations for case management of COVID-19 in health facility and community*. World Health Organisation. 19 March 2020.

[3] *COVID-19 Preparedness document*. AIIMS, New Delhi. 27 March 2020.