How should we prepare for the COVID 19 health crisis in Telangana?

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The COVID 19 epidemic in Telangana as in many other states is now driven by full-blown community spread. The rates of infection, hospitalization and death are by all accounts increasing at an exponential rate. Different calculations point to the fact that cases will continue to rise in the coming months. The epidemic may be expected to peak in the months September-December 2020 and die down by the first quarter of 2021. For an example of the worst-case scenario, see an elementary calculation of cumulative morbidity and mortality based on an assumption of constant herd immunity in this the paper.

As per this calculation, by the time the epidemic subsides, the cumulative mortality figure will be around 57,360, more than 90% of them being over sixty years old. This mortality will lead to an approximate increase in annual deaths of those over sixty years of age of about 16% over that which may be expected in that age group according to normal death rates.[*]

The cumulative number of people infected *seeking hospitalization* will be approximately 239,260 individuals. The numbers seeking hospitalization on a daily basis, especially over the later part of epidemic period when requirements will gallop, will have to be met by the coordinated use of all private and public hospital beds in the state (estimated to be 99,919) to tackle the epidemic. It is also necessary to highlight the need to strategically bring together skilled and appropriate manpower in this exercise. However, the prospects of such a coordination seems to be bleak currently.

The need for ICU units and ventilators is more critical where the numbers needing ICU care over the epidemic period would be around 43,540 whereas the available ICU units across government and private hospitals are just under 5000 with a preponderance in the private sector. Here again, daily requirement will start out low and accelerate as the epidemic reaches its peak. If manpower is a concern at the general level, it is a critical bottleneck at the level of ICU and ventilator care, as is evident from the Gachibowli COVID Specialty Hospital's struggles to function well.

All resources will have to be shared with non-COVID 19 use and this is also a key problem area since it is now emerging that non-COVID 19 critical care is suffering a serious lack of beds, resources and attention due to the epidemic.

While this is a worst-case estimate, an actual problem of even 50% of this magnitude will remain at an unmanageable level if appropriate steps are not taken immediately.

[*] This line has been updated from the previous version to indicate that the 16% increase is in the 60+age group.

The state of Telangana will have an unprecedented medical crisis towards the latter half of the period of epidemic spread. This crisis is likely to add to the deaths of those uncared for in the system as it struggles to cope with the load.

Suggestions for health care preparation

To mitigate the effects of the crisis, the following steps need to be taken starting immediately (these steps are proposed in the knowledge that some are already underway, to endorse them and emphasize the need to strengthen them and increase their number):

1. Begin negotiations for coordinated private and public emergency treatment of large numbers of COVID 19 patients from September 2020 to May 2021.

2. Immediately advertise and employ on a short-term basis (12 months) skilled and semi-skilled personnel to take care of patients. Investigate the possibility of teaching unskilled volunteers how to handle COVID patients in non-critical situations.

3. Prepare to deal with overcrowding of hospitals beyond bed capacity with some treatment protocol for the overflow to ensure a degree of care, and with some security measures to educate and comfort patients, relatives and the bereaved. This will help a great deal in maintaining the operational stability of the hospital environment.

4. Prepare plans and strategies to access more ventilators *and skilled personnel* based on need from any other sources possible. This will have implications for onetime investments in equipment and recurring expenses in terms of salaries, consumables and upkeep.

5. Most of all, develop a strong leadership in COVID treatment facilities to provide direction, attend to crises and keep the morale of the treating personnel high.

6. Set up quarantine facilities (both government operated and community based) to hold people suspected of infection so that further spread is avoided. This would be needed especially in densely populated areas.

7. Trace, isolate and care for early cases of COVID 19 patients to further mitigate the burden of hospital admissions. *This is crucial to slow down the spread of infection and the barrage of hospitalization requirements since the patients are most infective in days immediately around symptom appearance.*

8. Investigate the possibility of using existing small hospitals and other such infrastructure to set up temporary isolation facilities for mild and moderate cases of COVID 19 to mitigate the demands of hospital care and pressure on doctors, thus freeing needed care for critical patients. This could be dovetailed on the one side to community quarantine facilities so that people who fall ill during quarantine could be taken into these temporary care arrangements. On the other side these temporary treatment facilities could be supported by tertiary care hospitals which receive the more serious cases. In reverse these facilities could also quarantine early releases from the hospital as per ICMR guidelines.

9. Explore the possibility of the army running large COVID Isolation centres.[1]

10. Develop protocols to handle as many cases of treatment as possible through home care and gear up home care services to handle this load. Earmark resources like oxygen and other consumables for effective home care of more serious patients. Ensure that the home care packages are regulated for price and package contents to ensure care.

11. Rapidly develop and communicate improved medical self-care protocols for the ill before they are likely to be hospitalized to minimize the burden of hospitalization. This will also ensure that those who do not seek hospitalization follow practices that minimize their suffering and help their survival chances.

12. ***Educate people on the need to maintain hand washing, use of masks, cough/sneeze etiquette, physical distancing, avoidance of large gatherings in closed spaces, especially to sing or shout, etc. This is needed to reduce the effective reproduction ratio and lower the slope of the epidemic as much as possible, thus leveling the peak demand for hospitalization and critical care***.

13. Advise and encourage the elderly to self-segregate to avoid getting the disease.

Situational demands, externalities and collateral effects

There is little doubt that the COVID epidemic will have extremely serious health consequences in the medium term of up to 18 months. The level of medical care required will stretch treatment capacity to its limit. It would be necessary to prepare ahead to be able to sequester needed resources quickly when needed. It would also require the public and private hospitals to coordinate with a positive goal of overcoming the emergency.

The level of morbidity, loss of life and the levels of quarantine, zoning and isolation will have a serious impact on the economy of the state. Coupled with the heavy drain on emotional resources of the people surrounded with disease, these will dampen industrial stability, leading to economic depression. The purchasing power of the people will be curtailed by their having to take care of the diseased and also by having to absorb layoffs, cuts in salary and living expenses due to distribution constraints placed on everyday goods in order to deal with the spread. ***Now is the time for the medical care industry to go into a social responsibility mode to give back to the society which has led to its wealth. Medical care whether public or private must be free or at heavy subsidy to repair the social fabric that is being destroyed by the disease. On the one hand, doctors should remember their true calling to care for the patient. On the other hand, repair of social damage will mean better markets more quickly in the future.***

There is a great deal at stake for the incumbent political party in a strategy of active control of the health care strategy. This active engagement will have a high visibility and ensure the gratitude of the electorate. It would be worthwhile to put up the best efforts to face this great difficulty. Such a focus may be used as a starting point for a stronger network of health care in the state. It is hoped that there will be political and administrative wisdom to use this opportunity to look at strengthening wider social determinants of good health in the long run.

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Elementary pessimistic calculation of cumulative morbidity and mortality

The COVID 19 situation in Telangana (as perhaps in many other states) is not fully known or understood. Unproductive anxiety cripples action and lack of information because of governmental reluctance adds to the problem. Lack of information also makes estimates questionable because of doubtful data.

I have tried to evade these questions by choosing to work backwards using a conservative estimation of herd immunity in Telangana.

And yet there are the gaps in knowledge of the disease. What is its infection pathway? How does it affect the body? What do we do to prevent and cure it? How long before the disease stabilizes? Is there a nation or region-specific difference in response to the disease? The estimates here are subject to these many gaps in our knowledge of the disease and I will point them out as far as I know. In general, the estimates are pessimistic, and I would be happy to be proved completely wrong in my excessive estimates by the actual progress of the disease!

I have followed the model of Prof. JP Muliyil, who has very kindly shared his sources and work sheets with me. This model uses as a source of its estimates the robust study by Henrik Salje, et. al., "Estimating the burden of SARS-CoV-2 in France" done by the Pasteur Institute in France.[2]

Method

This sketch has the following parts.

1) Discussing acceptable estimates made by others which I will use for herd immunity and the time to reach it.

2) Computing the mortality of the 60+ age group which will comprise 91% of deaths associated with COVID 19.

3) Computing the overall morbidity statistics, and requirement of hospitalization and ICU beds (Salje et.al. has no information about needs of ventilators) of patients who fall ill with COVID 19.

Caveat

It must be remembered that what follows is not exactly what will happen. It is a rough estimate based on a concept, with what is in my judgment the best available data according to my limited competence. It is more a starting hypothesis for ongoing refinement based on more appropriate inputs for the assumptions made here, rather than a conclusion.[3]

Estimates, assumptions and discussions

A. Selecting a value of herd immunity[4] and approximate time to reach it

It is not the intent of this exercise to propose a health strategy of unfettered infection of the population till herd immunity is acquired. Indeed, it is the opposite, that without serious intervention, the costs of 'natural herd immunity' will be unbearably high.

In general, uncontrolled herd immunity is the course of an infectious disease like COVID 19 without any intervention. However, barriers to infection have historically been achieved through immunization. With COVID 19 there is no vaccine in sight, therefore the time to acquire herd immunity would be dependent on social factors which reduce the effective reproduction ratio (such as lockdowns, quarantine, physical distancing, interpersonal etiquette, and personal hygiene). Currently the broad informal position emerging from the expert discussions seems to be that this immunity will be afforded for a period of at least a year if not more. Since the exact status of any pre-existing immunity due to BCG vaccine, history of use of chloroquine, or hydroxychloroquine is as yet unknown, we cannot be sure that the situation would be much better than it seems to be in this estimate.

I will take Muliyil's estimates as the basis of my calculations[5]:

Percentage of population which would have to be infected and immune for herd Immunity in:

Urban India: 60%

Rural India: 40%

The time to acquire herd immunity

D'Souza and Dowdy assess that herd immunity of COVID 19 (presumably working from its base reproduction ratio R_0 and generation time), unmitigated by vaccine, isolation, quarantine, and distancing measures, is likely to occur in as little as a few months. However, with lockdowns, quarantine, isolation and physical distancing, could result in a time to acquire herd immunity of about a year (D'Souza and Dowdy (ibid.) estimate it to be a year or more).[6]

Recent Developments

New research in the University of Nottingham suggests that based on activity levels, herd immunity (in England presumably) may be achieved by 43%, rather than 60% based on the normal assumption of R_0=2.5. This would be because of specific activity levels, rather than simple age specific effects. This model suggests that the herd immunity levels will be different in different distributions of both age and activity. More needs to be verified before the assumptions in my exercise are corrected.[7] There are further efforts to understand the heterogeneity of susceptibility in populations, with new estimates of herd immunity ranging from 20% to 40%.[8] As these corrections are verified, the models used here would have to be updated. Even with a herd immunity level as low as 20%, there will be a health crisis in Telangana.

So far, the picture has been that of India as a whole. At this point, I will bring the focus down to Telangana to arrive at specific estimates of mortality and morbidity.

B. COVID 19 Mortality in the 60+ year old population in Telangana

In order to arrive at ballpark figures for mortality in Telangana I have used the estimates from Salje et.al.(Pasteur Institute, 2020), who have computed age specific infection fatality rates for COVID 19 based on the hospital and death data related to COVID 19 in the various districts of France and validated using the data from outbreak on board the *Diamond Princess*.

We do not know how much these numbers will increase depending on the significantly lower levels of access to hospital care in Telangana than in France, but we proceed with this spot estimate bearing in mind this major caveat.

Expected infection fatality ratio of population as a whole: 0.53%[9]

Table S2 (p 25, Probability of death by age and sex, Salje et.al.) may be summarized for our purposes as follows:

Expected infection fatality ratio of the population a) 60-69 years: 0.9%; b) 70-79 years: 2.2%; above 80 years: 8.3%. Roughly speaking one may compute the infection fatality ratio of the 60+ age group at 3.77%. The other age groups have relatively insignificant infection fatality ratios.

If one applies these ratios to Telangana using the Telangana Government population statistics, the national age pyramid statistics and the herd immunity levels discussed for rural and urban populations in the previous section, we arrive at the following estimated mortality assessments (skip table for summary).

Table 1. Telangana 60+ population mortality estimates:

	Population above 60 years of age[1]	Percentage infected[2]	Numbers infected a x (b/100)	Infection fatality ratio[3] (%)	Numbers dying c x (d/100)	ASMR[4] (e/a)x100,000
	a	b	C	D	e	f
Rural	1,925,203	40	770,081	3.77	29,006	1506.7
Urban	1,254,910	60	752,946	3.77	28,361	2260.0
Total	3,180,114	47.8	1,523,027	3.77	57,367	1803.9

1. The population fraction above 60 years in Telangana is computed by
    a. using the Telangana Population computed from 2011 Census as given in https://www.telangana.gov.in/about/state-profile;
    b. Extrapolating using the 2001-2011 decadal growth rate as per https://censusindia.gov.in/2011-prov-results/data_files/andhra_pradesh/DCOAP-PAPER-1-BROCHURE.pdf and
    c. Extracting the age fraction in the 60+ age group as per the SRS Statement 3, p 12. (https://censusindia.gov.in/vital_statistics/SRS_Report_2017/9.%20Chap_2-Population_Composition-2017.pdf). The assumption is that the age fractions of the National and Telangana populations are the same.
2. Percentage infected is the herd immunity level of urban and rural respectively as assumed in previous section
3. Infection fatality ratio in this cohort is the mean of the fractions above 60 years in Table S2,

p 25, in Henrik Salje et. al. (2020).
4. Age Specific Mortality Rate for COVID 19 in deaths per 100,000.

To summarize, according to this model, in the population above 60 years of age, it is likely that 29,006 people will die after infection with COVID 19 in the rural areas, 28,361 in the urban areas, leading to a sum total of 57,367 deaths during the estimated period to herd immunity, i.e., approximately one year.

This number of 57,367 deaths will have to be compared with the annual deaths of 183,175 among the population over 60 years, computed at the age specific death rate of 57.6 per 1000 in Telangana.[10]

The normal death figures of 183,175 would have within it deaths of persons who have died because of other diseases such as heart attack, diabetes, stroke, etc. Some of the COVID 19 deaths among this vulnerable population would simply be a tipping over of causation from comorbidities to COVID 19 when they may have died the same year due to these comorbidities. Given no possibility of acquiring such data at this point, we may take a random distribution of COVID 19 deaths leading to a 50% overlap of comorbid deaths who may have otherwise died of other causes within the year. With this assumption, the deaths over the year would be 183,175 + (0.5 x 57,367) = 211,858. In other words, there would be an increase of 15.65% over the expected annual mortality of the 60+ age group if COVID 19 had not struck

Recent developments

1. The latest US CDC report (as of 21 June 2020) based on surveillance of 1.3 million cases calculates actual case fatality ratio among the 65+ population of nearly 18%, and an overall case fatality ratio of 5.86%.[11] This variable (CFR) however would be higher than the infection fatality ratio which would estimate mortality as a proportion of all those who fell ill and were not necessarily reported for surveillance. The report assesses that community transmission in the US is ongoing even if cases show a reduction in daily incidence.

2. The recent IIPS study of COVID (pre-publication release to news media on 20th June) is reported to find that the percentage of the 30-65 year age group hospitalized for COVID 19 is showing a much higher case fatality rate (58%) than in other countries.[12] The information is disturbing, but the report is not available as of July 1, 2020, the press reports are not yet clear and the peer reviewed publication of this data is awaited to see how this affects the estimates of infection fatality ratios and further computations in this paper.

C. Covid 19 Morbidity in Telangana

While deaths will be largely (over 90%) among the 60+ year olds of the population, those infected and requiring hospitalization or qualified medical treatment is a different story. Here estimates and computations are made for the whole population (including those above 60) to arrive at a picture of requirements of normal and ICU beds in the onslaught of this epidemic. Here again, we use the rates arrived at by Henrik Salje et. al. as the basis for our estimates.

The added wrinkle in our case is that unlike in France where everybody needing hospitalization will access hospital care thus having a 100% access rate, in India, this will vary in diverse and complex ways: depending on age, sex, rural/urban residence, distance from hospital, transportation, precarity, family dynamics, general patterns of reporting illness, etc. The insights provided by different sources with respect to health seeking behaviour make it clear that the unprecedented stress, precarity of everyday life and family demands of the health situation during this crisis will indeed give rise to health seeking responses that would be unique and unpredictable.[13]

Based on

a) age profiles of those requiring hospitalization biased strongly towards the elderly in Salje et. al. on the one hand; and

b) my intuition regarding the manner in which the elderly in Telangana (who would need the most hospitalization) may report and seek healthcare for respiratory or other acute disorders during this crisis on the other;

c) I hazard a guess that about 30% of the rural and 70% of the urban infected persons overall *needing* hospitalization, according the norms of the French population as per Salje et. al. will actually *seek* hospitalization in Telangana.

d) Table 2. Telangana overall population morbidity data (skip table for summary)

	Population[1] (a)	Fraction infected[2] (b)	Numbers infected (a x b) ©	Fraction of infected *needing* hospitalization (at 2.6%)[3] (d)	Assumed Percentage of those *needing* hospitalization *seeking* it[4] (e)	Numbers *seeking* hospitalization (d x e%) (f)	Fraction of (f) requiring ICU care (at 18.2%)[5] (g)
Rural	23,767,944	0.4	9,507,178	247,187	30%	74,156	13,496
Urban	15,119,399	0.6	9,071,639	235,863	70%	165,104	30,049
Total	38,887,343	0.4779 (approx.)	18,578,817	483,049	49.5% (approx.)	239,260	43,545

1. Population is computed using
   A) the Total Population computed from 2011 Census as given in https://www.telangana.gov.in/about/state-profile; by
   B) extrapolating using the Andhra Pradesh 2001-2011 decadal growth rate as per https://censusindia.gov.in/2011-prov-results/data_files/andhra_pradesh/DCOAP-PAPER-1-BROCHURE.pdf
   C) The rural and urban fractions are based on the percentages of rural and urban populations to the total given in the source mentioned in A above.
2. Fraction infected is the fraction infected at herd immunity as estimated in previous section
3. This is the probability of objective need for hospitalization overall of those infected (Henrik Salje et. al. p 24)
4. However, the objective need is modified by health seeking behaviour. The numbers are a rough guess that need to be improved with further inputs. See text.
5. This is the probability of objective need for ICU care among those hospitalized overall (Henrik Salje et. al. p 24)

In summary, 239,260 will seek hospitalization and 43,545 will need ICU care. The usual caveats about the variability of these numbers apply. Unlike with the mortality statistics which have the

normal age specific death rates for comparison, there seems to be no such convenient statistic to compare these levels of morbidity.[14] To comprehend these numbers I found it useful to look at available hospital resources for the same as estimated by researchers from the CDDEP of Princeton University.[15] The relevant data for hospital beds, ICUs and ventilators for Telangana according to their estimates is as follows:

Table 3. Number of hospitals, hospital beds, ICU beds and ventilators in Telangana as estimated on 20th April 2020

	Government	Private (including Corporate)	Total
Hospitals[1]	863	3,247	4,110
Hospital beds	20,983[2,3]	78,936	99,919
ICU beds	1,049[3]	3,947	4,996
Ventilators	525[3]	1,973	2,498

Note:

The authors have made the following assumptions:

- Number of private hospitals in each State/UT can be estimated based on specific percentage break-up of hospitals (as provided in NSS) and number of government hospitals (as provided in NHP) in that State/UT
- Number of private hospital beds in each State/UT can also be estimated by using the same percentage break-up as used to calculate the number of private hospitals, since the number of government hospital beds were available for each State/UT
- Number of private hospitals at India level is equal to sum total of private hospitals across all States/UTs
- Number of private hospital beds at India level is equal to sum total of private hospital beds across all States/UTs
- Critical care beds constitute 5-8% of total bed strength in large public teaching hospitals.
- 50% of ICU beds may have ventilators.

1. Though this estimate is dated 20th April 2020, we may assume that the Gachibowli COVID 19 specialty hospital's 1500 beds, ICU units and ventilators are not counted in because the corroborating evidence in the following note:
2. The Telangana Statistical Yearbook 2017 gives this figure of government hospital beds as: 20,829. (https://www.telangana.gov.in/PDFDocuments/Statistical-Year-Book-2017.pdf).
3. The 25th June 2020 Telangana Media COVID Bulletin gives the beds earmarked for COVID 19 as 17,081; Vacant Isolation beds in COVID hospitals: 11,152; Vacant beds with oxygen support: 3482; Vacant ICU beds: 901; Vacant ventilator beds: 463. (https://covid19.telangana.gov.in/wp-content/uploads/2020/06/Media-Bulletin-25-06-2020.pdf)

Beyond this it is difficult to say much because we have no idea of how in practice the daily rate at which those seeking hospital care, needing ICU admission and ventilator support will increase as a proportion of the growth rate of infections through this period, which itself would have to be estimated in a dynamically updated model. Modeling and prediction of resource use would be essential because of the time lag in acquiring resources for a given excess of requirement over availability.

Limitations of this exercise

1. There is no knowledge of the actual pre-existing immunity due to BCG vaccines etc. status for this disease, which may significantly reduce the numbers who fall ill and die.

2. We do not have any idea about how the great difference between France and Telangana in levels of hospitalized care will affect the infection fatality ratio we have assumed from Salje et.al. This has the likelihood of significantly modifying mortality.

3. We have scant idea about the pattern or statistics of access to care by those who need it and therefore the demand for hospitalization and advanced care is likely to be widely divergent from the estimate.

4. We also have truly little knowledge about the regional differences in attack rates of the age groups and this may also affect seriously the morbidity and mortality rates estimated here. For example, the old in India live not in institutions for the elderly but within families, which may lower the effective infection risk. Similarly, the urban young live without family in crowded one room urban tenements as they pursue a livelihood, leading to a higher risk of infection. In other words, we have no idea about the actual heterogeneity of susceptibility.

5. Though the exercise focuses on Telangana as a whole, the perspectival bias of the implications and recommendations is urban. This reflects the limitations of my own urbanized thinking.

6. All variable and assumptions in this exercise are dynamic and changing through the progress of the infection. Actual results be can only be seen at the end of the crisis. However, constant monitoring and evaluation of these parameters will be essential to plan resources to deal with it.

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Notes:

[1] https://www.sify.com/news/worlds-largest-covid-19-care-facility-with-10000-beds-inaugurated-in-delhi-news-national-uhfhahcjcebbh.html

[2] Henrik Salje, Cécile Tran Kiem, Noémie Lefrancq, Noémie Courtejoie, Paolo Bosetti, et al. "Estimating the burden of SARS-CoV-2 in France". 2020. pasteur-02548181.

[3] A forthcoming Editorial in IJMR, "Lessons learnt during the first 100 days of COVID-19 pandemic in India" (Indian J Med Res Epub ahead of print DOI: 10.4103/ijmr.IJMR_1925_20) argues against mathematical

modelling on the grounds that the actuality is far from the model's predictions. However, this cannot be an argument against modelling, rather it should be a case for an iterative empirical-mathematical modelling exercise which corrects its assumptions, variables and formulae according to the best possible evidence at the time. This is because local responses will also use implicit models, biased understanding and unreal assumptions based on 'experience'. A dynamic model based on the best possible evidence at any given time would be a safer bet.

[4] Herd immunity is the percentage of a population that must be infected and thereafter immune to the disease thus reducing the effective reproduction ratio (the R of the disease) to a value below 1 (i.e., there are not enough susceptible persons left in the community to let each one infected person infect one more person, leading to a reduction in numbers infected).

[5] There are different estimates of herd immunity. According to D'Souza and Dowdy of the Johns Hopkins Bloomberg School of Public Health, any given population (presumably like the US) would require at least about 70% of the population to be infected before the infection rate goes down.5 In another estimate, Kwok et.al., have provided a tabulation of herd immunity based on observed base reproduction ratios (R0) of the disease in different countries5 (India does not figure since the disease hadn't yet made its mark here at the time). However, if one assumes that R0 is around 2.5, one may expect from that table that India's requisite infection percentage for herd immunity is likely to be around that of Italy, i.e., 59%.

[6] Note: the 'flattening of the curve' by distancing, lockdowns, quarantine, isolation and other social measures, in practical situations, cannot stop the spread of the epidemic in its tracks – it means slowing the effective reproduction ratio or reducing the steepness of the climb rate of infections. In the absence of a vaccine or pre-existing immunity and with lockdowns, social distancing, personal hygiene and cough/sneeze etiquette, natural herd immunity levels will come to rule later if not sooner since there is not much likelihood of the virus mutating to a benign variant soon. My guess based on the above estimates in this sketch is that it will take about a year from the beginning of the epidemic, i.e., the infection will begin to die down by the early part of the year 2021. This seems to be close to the general opinion among health groups too.

[7] https://www.webmd.com/lung/news/20200626/herd-immunity-threshold-could-be-as-low-as-43-percent

[8] https://www.quantamagazine.org/the-tricky-math-of-covid-19-herd-immunity-20200630/

[9] Salje et.al., pp 3-4. Infection fatality ratio is expressed here as the percentage of people who will die if a hundred are infected.

[10] As given in the Sample Registration System Statistical Report of 2017 (p 133) (https://censusindia.gov.in/Vital_Statistics/SRS_Report_2017/SRS%20Statistical%20Report%202017.pdf) .

[11] CDC, "Coronavirus Disease 2019 Case Surveillance — United States, January 22–May 30, 2020" (https://www.cdc.gov/mmwr/volumes/69/wr/mm6924e2.htm?s_cid=mm6924e2_w#T2_down)

[12] The Telegraph Online, "Covid-19 eats away at workforce". https://www.telegraphindia.com/india/coronavirus-outbreak-covid-19-eats-away-at-indias-workforce/cid/1782262

[13] Two examples: A) The NSSO report *Key Indicators of Social Consumption in India: Health,* p A-4 (http://www.mospi.gov.in/sites/default/files/publication_reports/KI_Health_75th_Final.pdf) provides relative use of different forms of medicine, but not how many of the sick do seek care. B) Shobhit Srivastava, and Anayat Gill, "Untreated morbidity and treatment-seeking behaviour among the elderly in India: Analysis based on National Sample Survey 2004 and 2014" *SSM – Population Health* April 2020 provides a detailed study of the various factors which determine untreated morbidity in India in the absence of a critical event like the COVID 19 pandemic (https://doi.org/10.1016/j.ssmph.2020.100557). There are many more studies relating to specific age groups, morbid conditions and geographical access.

[14] Spot estimates from government and other sources abound though. E.g., the MoHFW website: https://pib.gov.in/PressRelease|framePage.aspx?PRID=1611676; Also see htts://www.hindustantimes.com/Mumbai-news/maximum-covid-patients-in-31-40-age-group-data/story-nwF3NzKSQAH9KJ9Y8cQXvI.html

[15] Geetanjali Kapoor, Aditi Sriram, Jyoti Joshi, Arindam Nandi, Ramanan Laxminarayan, "COVID-19 in India : State-wise estimates of current hospital beds, intensive care unit (ICU) beds and ventilators (20 April 2020)". A copy may be downloaded from: https://cddep.org/publications/covid-19-in-india-state-wise-estimates-of-current-hospital-beds-icu-beds-and-ventilators/ (Accessed on June 19, 2020). Unfortunately there was very little corroborating data about any of the numbers, excepting that of hospital beds as noted in the table.