Estimates of COVID-19 infection fatality rate (IFR) in Hyderabad

(Murad Banaji, July 1, 2021)

"Hyderabad" is taken to be the population under the Greater Hyderabad Municipal Corporation (GHMC). The population under GHMC was around 7M at the time of the 2011 census, and is around 10M in 2020-21 (this estimate is given in a wastewater study, and also at World Population Review). While the city has been growing fast, a reported 4.7 lakh interstate migrants left Telangana following the national lockdown in March, 2020, and it is likely that many of these were from Hyderabad.

Telangana does not provide district-wise data on case or fatality data making the COVID-19 epidemic hard to track. There were a number of reports of systematic undercounting of COVID-19 deaths in the state during the first COVID-19 wave in 2020 (e.g., here, and here). There were also reports by early August, 2020, of a surge in mortality in the city. Indeed, the claim in the latter report that cremations were running at double normal levels is consistent with all-cause mortality data from July 2020 (see below for a link) when death registration was at twice 2019 levels.

Mortality data

According to the 2019 CRS report, an estimated 97% of deaths were registered in Telangana in 2019, a major increase from an estimated 58.5% the previous year. The National Family Health Survey (2019-2020), estimates that 79% of deaths were registered in urban areas of the state during the three year period prior to the survey, which seems to be roughly consistent with this data.

Some civil registration data for the city was reported in The Hindu, and the data itself was kindly shared by the authors and is available on github. During 2016-2019 death registrations in the city showed an increasing trend, with an increase of about 5000 registered deaths per year. It is unclear to what extent this increase reflects the increasing population of the city and to what extent it reflects increased death registration.

A large increase in registered deaths (over 11,000) occurred in 2019; a 21% rise above 2018 values. This is qualitatively consistent with the CRS 2019 estimate of improved registration in the state.

Excess mortality during the pandemic

In order to calculate excess deaths during the pandemic, we need to estimate expected deaths. This is complicated by the trends in registered deaths described above. We use four different approaches: the first three are fairly consistent, while the fourth, used in the article in The Hindu linked above, gives considerably higher estimates. The methods are described - and possible biases discussed - in the Appendix.

Excess registered deaths during June-December, 2020, and January to May 2021, calculated by the four different methods in the Appendix, are summarised in the table below.

	Method 1 excess	Method 2 excess	Method 3 excess	Method 4 excess
June-Dec, 2020	9549	11349	11882	18216
Jan-May, 2021	8827	9773	10384	14332
Total	18376	21122	22266	32548

On a denominator of 10M, the methods give excess mortality of between 0.18% and 0.33%.

Monthly excess deaths during 2020 and Jan-May 2021 calculated by each method are shown in the Figure below. We see that the majority of excess mortality in the city occurred during June to September 2020, and April to May 2021. Only Method 4 suggests some continuing excess mortality during late 2020 and early 2021.

Note that the data suggests that the mortality impact of the pandemic on Hyderabad was far from over when the data ends: there were likely more excess deaths to come during June, 2021.
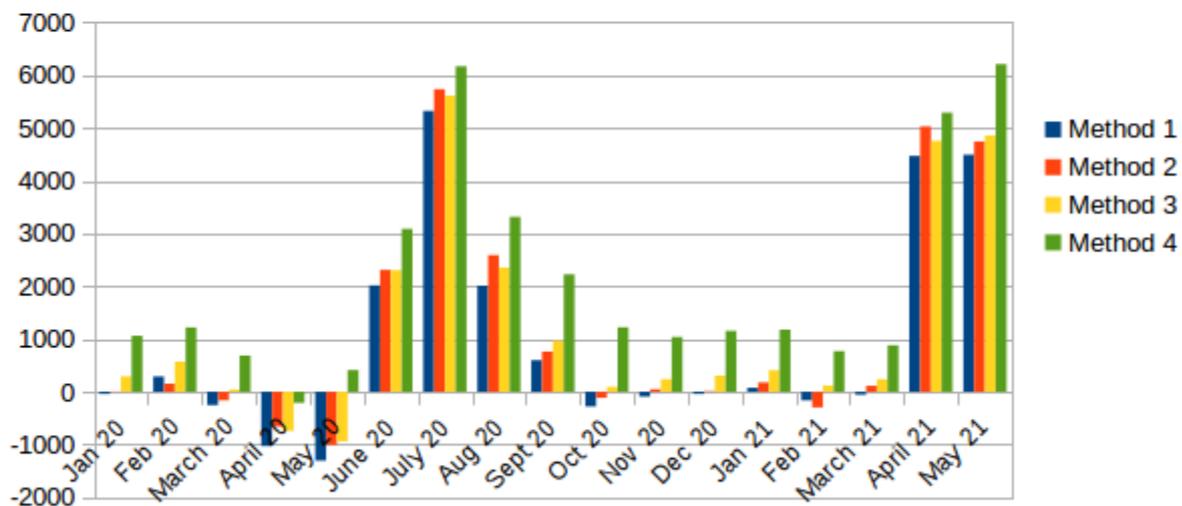
Serosurveys, and the spread of COVID-19 in the city

There is only limited seroprevalence data available from Hyderabad to help estimate disease spread in the city. During August-September, 2020, a serosurvey of employees of the Council of Scientific and Industrial Research (CSIR) across India found seroprevalence to be highest in Hyderabad, where 18% seropositivity was reported amongst 2073 people tested in the city. However there is no particular reason to believe that this sample was representative of the city's population.

Another serosurvey, jointly conducted by the Centre for Cellular and Molecular Biology, the ICMR National Institute of Nutrition, and Bharat Biotech, was reported in early March 2021. This involved around 9000 individuals, and found 54% seropositivity amongst those sampled. Technical details of this survey are lacking, so it is hard to assess for possible biases. The antibody test used was apparently a novel one [pdf], developed in-house.

A tripling in seroprevalence between September 2020 and February 2021 is not consistent with the trajectory of excess deaths in the city, or cases in the state. Hyderabad is a slum-heavy city and, based on data from several cities showing that COVID-19 spread rapidly in slums and more slowly in urban non-slum areas during 2020, it is possible that the survey of CSIR employees considerably underestimated citywide prevalence.

A prior infection rate of around 50% by the end of 2020 would be comparable to estimates from Mumbai and Delhi.

Expected values of COVID-19 infection fatality rate (IFR) based on age structures

Before estimating values of IFR, it is helpful to consider what international age-stratified data suggests Hyderabad's COVID-19 IFR to be.

An up-to-date population pyramid for the city could not be found. The city's [2011 population pyramid](#) [.xls file] gives an estimated IFR of 0.17% to 0.28% based on data in [O'Driscoll *et al*](#) and [Levin *et al*](#) respectively. However, we expect an ageing population to push up these estimates. Indeed, based on the [shifting population pyramid for the state as a whole](#) we might expect an increase of around 40% in IFR above estimates based on 2011 data. This would take expected IFR in Hyderabad up to around 0.24% to 0.39%.

Estimates of IFR based on excess deaths

Each estimate of excess mortality and prevalence gives us an excess-deaths based estimate of IFR. For example, suppose we assume 5M infections by the end of 2020 (equivalent to 50% of the city's population), and assume that the Method 2 estimate of excess registered deaths (11349) is an accurate reflection of COVID-19 mortality. We then obtain an estimate of COVID-19 IFR of **0.23%** by the end of 2020.

If we assume 7.5M infections by May, 2021 (equivalent to 75% of the city's population), and again take Method 2 estimate of excess deaths (21122), we get an excess deaths based IFR estimate of **0.28%** by May, 2021.

Using the same approach, but with Method 4 estimates of excess mortality, gives considerably higher IFR values of **0.36%** at the end of 2020, and **0.43%** by May 2021.

Monte Carlo simulations

We can try to obtain some confidence intervals on IFR estimates if we are prepared to estimate the uncertainties. One example is presented.

Suppose we use 2019 as a baseline, and assume that the population of the city did not change subsequently. We set death registration during 2019 to be a random variable, uniformly distributed between 94% and 100%. Death registration during June 2020 to May 2021 is again taken to be a random variable, uniformly distributed between 94% and 100%.

Infections by the end of 2020 are normally distributed around 5M with an SD of 0.5M. Infections by May 2021 are normally distributed around 7.5M with an SD of 0.75M. With these values and 10,000 simulations, we find mean (95% CI):

- Excess deaths during June-December 2020: **12.2K (10.3K-14.2K)**.
- Excess deaths during June 2020-May 2021: **23.0K (19.8K-26.3K)**.
- Excess-deaths based IFR estimate by the end of 2020: **0.25% (0.20%, 0.31%).**
- Excess-deaths based IFR estimate by May 2021: **0.31% (0.25%, 0.38%)**.

Recall that expectations of IFR based on international data: **0.24-0.39%**.

Conclusions

The range of excess-deaths based IFR values in Hyderabad by the end of 2020, and again by the end of May, 2021, has large overlap with the expectations based on international meta-analyses.

It is unclear whether COVID-19 IFR increased during the second wave: in the simulations above, the increase in IFR was significant at alpha=0.1, but not at alpha=0.05. Given the lack of both case and recorded fatality data in the city, and the lack of detail around serosurveys, it is hard to say more.

Undercounting. By the end of May 2021, the entire state of Telangana had only officially recorded 3281 COVID-19 fatalities, around 18% of the excess deaths for Hyderabad alone. Given that Hyderabad holds around a quarter of the state's population, this suggests a high level of death undercounting in the state.

Appendix: excess deaths calculations

Hyderabad (like many other places) showed a significant dip in registered deaths below expectations during April and May, 2020; these were 16% below 2019 values. We can presume that some, at least, of this was a result of fewer registrations as a consequence of national lockdown. Some part of the drop might also have been connected with the exodus of migrants from the city.

The following assumptions seem reasonable:
- a trend of increasing death registrations was halted during the pandemic period.
- a trend of increasing population was likely offset by the exodus of migrants from the city

Four methods for calculating expected registered deaths are as follows:

Method 1. We note that registered deaths during Jan-March 2020 were ~6% higher than during the same period in 2019. For June 2020 to May 2021, we consequently take expected registered deaths to be ~6% higher than 2019 values. This method ignores possible effects of lockdown/pandemic on registration, and could underestimate excess mortality.

Method 2. Extrapolation over 2015-2019 data shows an increasing trend in registration. However January-March 2020 values were around 2% lower than expected from the extrapolation. For June-December 2020, we use extrapolated values reduced by this percentage. January to March 2021 registered deaths were around 10% less than extrapolated values (during this period, Telangana was reporting relatively few COVID-19 cases). Consequently, we reduce expected deaths during January-May, 2021 by this percentage.

Method 3. We take 2019 values as the baseline. The data indicates a significant increase in registered deaths during 2019; and the assumption here is that there was no further improvement in registration overall during the pandemic (but no fall either), and that any increase in population was offset by the exodus of migrants from the city.

Method 4. We take the average of 2016-2019 values as the baseline. The assumption here is that significant increases in registration and/or population during 2016-2019 were effectively reversed by the pandemic.

Note: all four methods give excess *registered* deaths. But how we interpret the data has different implications for excess mortality.