Estimates of COVID-19 infection fatality rate (IFR) in Chennai during 2020

(Murad Banaji, May 28, 2021, updated to correct typos on June 26, 2021, updated to correct the date of the second serosurvey, and some estimates on July 27, 2021)

Chennai district, governed by the Greater Chennai Corporation, has an estimated population of 7.1 million. Data on cases and infection is taken from covid19india.org.

Chennai has seen several **seroprevalence surveys** ("serosurveys" for short). The IFR calculations here are based on three serosurveys, detailed below.

Naive IFR is defined as the ratio of recorded fatalities to estimated SARS-CoV-2 infections. **Excess deaths-based IFR** (or **excess IFR** for short) is defined as the ratio of estimated excess deaths to estimated SARS-CoV-2 infections.

All estimates here are point estimates, but the work could set the scene for a more complete Monte Carlo simulation-based approach. In IFR estimates, death counts are taken with a delay of either 10 days, or one month, after the approximate serosurvey mid-point. The longer interval is to avoid possible right-censoring in the estimates.

Seroprevalence surveys and naive IFR estimates

Survey 1. A serosurvey in July 2020 (12,405 samples, dates given here as 17-28 July) found an estimated seroprevalence of 18.4% in the city, corrected for demographic features of the population and sensitivity and specificity of the test. The survey found highly uneven spread in the city with some wards reporting much higher seropositivity than others. Additionally, seroprevalence was considerably lower amongst the elderly than amongst younger groups.

By August 2 (about 10 days after the survey mid-point), the city had seen 2,154 recorded COVID-19 fatalities, giving a naive IFR of **0.16%**. By August 23 (about one month after the survey mid-point), the city had seen 2,578 recorded COVID-19 fatalities, giving a naive IFR of **0.20%**.

Survey 2. A second serosurvey (6,389 samples) was conducted in October 2020, and reported a raw seroprevalence of 32.3% in the city.

By October 25 (assumed to be about 10 days after the survey mid-point), the city had seen 3,589 recorded COVID-19 fatalities, giving a naive IFR of **0.16%**. By November 15 (assumed to be about one month after the survey mid-point), the city had seen 3,762 recorded COVID-19 fatalities, giving a naive IFR of **0.16%**.

Survey 3. A state-wide serosurvey was carried out during October 19 to November 30, 2020, and included Chennai (3,613 samples). It reported a seroprevalence of 41% in the city. This appears to be corrected for demographic features of the population and test properties. The result is reported with a 95% CI of 38.2-43.7%.

By November 19 (about 10 days after the survey mid-point), the city had seen 3,789 recorded COVID-19 fatalities, giving a naive IFR of **0.13%**. By Dec. 9 (one month after the approximate survey mid-point), the city had seen 3,890 recorded COVID-19 fatalities, giving a naive IFR of **0.13%**.

Thus, naive IFR values based on the three serosurveys range from 0.13% to 0.20%, with a decrease after the first survey. We next look at estimates based on excess deaths data.

IFR estimates based on excess deaths

By April 30, 2020, Chennai had only seen 910 confirmed COVID-19 cases and 15 confirmed COVID-19 deaths. There is evidence that prior to the pandemic taking off, mortality in the city was lower than expected from historical data. During January to March 2020, there were 4.7% fewer deaths than expected from historical data (see the Appendix for details).

National lockdown likely further reduced mortality in the city. During April 2020, prior to many cases or fatalities being reported, there were 18% fewer deaths than expected from historical data.

Bearing these observations in mind, when estimating excess deaths in the city during the pandemic, we use mortality data from May 1. We use two different methodologies, detailed in the Appendix. Method 1 is a simple linear extrapolation to get expected deaths in 2020 from the trend over the previous five years. Method 2 corrects the values obtained by Method 1 to take account of a fall in mortality below expectations during January-March 2020.

Survey 1. Method 1: by August 2, the city had seen 3481 excess deaths, giving an excess IFR of **0.27%**, and by August 23, the city had seen 4297 excess deaths, giving an excess IFR of **0.33%**. Method 2: by August 2, the city had seen 4310 excess deaths, giving an excess IFR of **0.33%**, and by August 23, the city had seen 5297 excess deaths, giving an excess IFR of **0.41%**.

Survey 2. Method 1: by October 25, the city had seen 6819 excess deaths, giving an excess IFR of **0.30%**. By November 15, the city had seen 6497 excess deaths, giving an excess IFR of **0.28%**. Method 2: by October 25, the city had seen 8385 excess deaths, giving an excess IFR of **0.37%**, and by November 15, the city had seen 8277 excess deaths, giving an excess IFR of **0.36%**.

Survey 3. Method 1: by November 19, the city had seen 6494 excess deaths, giving an excess IFR of **0.22%**. By December 9, the city had seen 7208 excess deaths, giving an excess IFR of **0.25%**. Method 2: by November 19, the city had seen 8310 excess deaths, giving an excess IFR of **0.29%**, and by December 9, the city had seen 9188 excess deaths, giving an excess IFR of **0.32%**.

Summary of the estimates and interpretation

The estimates so far are gathered in the following table.

Serosurvey	Naive IFR (10 day delay)	Naive IFR (one month delay)	Excess IFR by Method 1 (10 day delay)	Excess IFR by Method 1 (one month delay)	Excess IFR by Method 2 (10 day delay)	Excess IFR by Method 2 (one month delay)
1	0.16%	0.20%	0.27%	0.33%	0.33%	0.41%
2	0.16%	0.16%	0.30%	0.28%	0.37%	0.36%
3	0.13%	0.13%	0.22%	0.25%	0.29%	0.32%

The IFR estimates thus range from around 0.13% to 0.41%. Interestingly, later estimates (based on recorded fatalities or excess deaths) are lower than earlier ones. This is different from the pattern observed in both Mumbai and Delhi.

Excess IFR estimates are roughly between 65% and 150% greater than naive IFR estimates. We cannot take this discrepancy as a direct proxy for the level of COVID-19 fatality underreporting because of uncertainty about what fraction of the excess deaths were COVID-19 deaths.

Appendix: estimating excess deaths

Excess deaths data is taken from the github site (many thanks to Rukmini S and collaborators for gathering this data and putting it into an easily usable form). Death counts are recorded by date of death.

Method 1. To estimate excess deaths in a given period of 2020, we compute total mortality during the same period in each of 2015 to 2019, and calculate a line of best fit through these five data points to estimate expected deaths during this period in 2020. The difference between observed and expected deaths is then the excess.

Note that Chennai has a fairly strong trend of increasing mortality during 2015-2019. If we ignored this trend and used the previous five-year average as a measure of expected deaths, we would get considerably higher excess mortality estimates. For example, the city saw 11,433 more deaths during May 1 to December 9, 2020 compared to the previous five-year average. This compares to excess deaths of 7,208 estimated using Method 1 and 9,188 using Method 2 (below). Given the likelihood of bias, estimates based on the previous five-year average are *not* used.

Method 2. Deaths during January to March 2020 inclusive (roughly speaking, normal times, when there were few cases of COVID-19 in the city and largely before national lockdown), were 4.7% lower than expected from Method 1. This suggests that mortality in 2020 may have been lower than expected from Method 1 if not for the pandemic. If we assume the trend from January to March, 2020 continued for the rest of the year, we must reduce expected deaths during subsequent periods by around 4.7%. In this approach, we calculate expected deaths via Method 1, and then reduce these by 4.7%, and use the reduced values to get excess deaths estimates used in the IFR calculations.

A final note on data from December, 2020. One interesting observation is that December 2020 saw 23% more deaths than expected from Method 1, even though COVID-19 cases and recorded fatalities were relatively low during December, averaging about 315 per day, and 5 per day respectively. If delays between a rise in seroprevalence and the corresponding rise in deaths were, indeed, longer than one month, then this would considerably increase excess IFR estimates based on the third serosurvey.