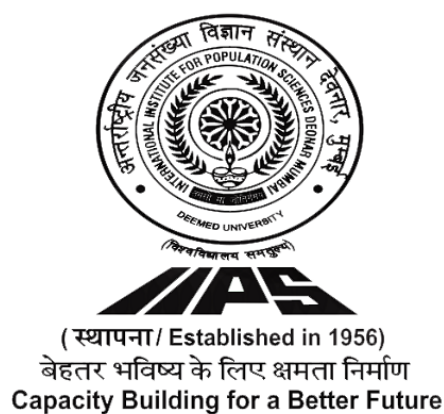# Case-Fatality Ratio and Recovery Rate of COVID-19: Scenario of Most Affected Countries and Indian States

Preeti Dhillon, Sampurna Kundu, Chander Shekhar, Usha Ram, Laxmi Kant Dwivedi, Suryakant Yadav, Sayeed Unisa

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Case-Fatality Ratio and Recovery Rate of COVID-19: Scenario of Most Affected Countries and Indian States

Abstract

Understanding the dynamics of case-fatality and recovery rates of COVID-19 would enhance the knowledge base on the current trends of the severity of the epidemic. This study presents the trend analysis of mortality and recovery rate in the most affected countries and among Indian states. The data for India were retrieved from the www.covid19india.org, a data-sharing portal and for other countries from the Johns Hopkins University & Medicine webpage on Our World in Data, and Worldometer.

The case-fatality ratio (CFR) has been increasing rapidly in the most affected countries during the outbreak. On an average it increased from 3.4% (as of 25 February 2020) to 7.0% (as of 21 April 2020) across countries. Italy and Iran showed an early increment in CFR. However, the Iran curve has been flattened by late March 2020, but Italy continued to be at the top until mid-April, 2020. Thereafter Belgium and later United Kingdom joined with Italy. Among most affected countries, Germany has registered lower CFR than other nations. The observed CFR to total confirmed cases in India increased from 1.9 (as of 15 March 2020) to 3.6 (as of 12 April 2020) and thereafter recorded a decline to 3.2% (as of 20 April 2020). Among the most affected states, Maharashtra and Madhya Pradesh stand at the top with higher levels of CFR as against Kerala and Tamil Nadu with significantly higher levels of recovery rates. CFR among 60 plus aged in India was 14% as compared to only 2.4% among 40-60 and less than 1% among below age 40 years. Narrow difference in CFR among males (3.3%) and females (2.9%) ae also observed in India.

The higher rate of mortality in most COVID-19 affected countries of the West may be on account of the failure of the health system to cater to the large number of daily inflow of patients. On the contrary, India is able to control the spread of virus and entering into stgage-3 with immediate action like national level lockdown. The pattern, however, also shows rapid increase in the cases in hotspot regions, and it indicates the local transmission of COVID-19. The slow growth of the pandemic has contributed to the lower CFR in the country. At the same time, the possibility of under-reporting of the cases due to less number of testing and miss-reporting of other comorbidity are possible in the India which needs to be monitored by health providers.

Introduction:

The past 20 years have seen several epidemics like the acute respiratory syndrome coronavirus during 2002-2003 and H1N1 influenza during 2009 (Cascella et al., 2020). According to the World Health Organisation (WHO), coronaviruses are the family of viruses which include Severe Acute Respiratory Syndrome (SARS) and Middle Eastern respiratory syndrome (MERS) that is experienced in Saudi Arabia in 2012. The current novel coronavirus known as COVID 19, is now pandemic and has never been encountered before. A disease that initiated in the Hubei province of Wuhan, in China has now spread like fire all over the world. The COVID 19 cases are increasing day by day with currently over 2,481,287 and 170,436 deaths (as of 8:30 IST, April 21, 2020) (Worldometer). Though China which was the first to hit the most cases, in the beginning, has presently flattened the curve by continuous testing and aggressive quarantine measures. Outside China, South Korea being the country that had the most significant initial outbreak has managed to slow down the spread and flatten the curve without imposing lockdown in the country. Their only way of slowing and containing outbreak was mass diagnostic testing and quarantining. South Korea and China have set an example of how the battle is to be won against the virus. Nevertheless, scientists are at their best efforts to invent a potent vaccine against the virus.

Taking a global view, India ranked at 57th positions in the list of 195 countries in terms of preparedness of a pandemic, according to the Global Health Security (GHS) Index (GHS, 2019). To tackle the pandemic situation in India, on 24th March 2020 Hon'ble Prime Minister of India declared a 21-day lockdown till 14th April to break the chain of coronavirus transmission, followed by, continuing nationwide lockdown till 3rd May 2020. In a nationwide address, PM urged people to practice social distancing in order to combat this pandemic at an individual level. Governments of each state are taking all measures to prevent the spread of coronavirus and trying to follow the lockdown strictly.

The total number of COVID-19 patients, deaths and recovered persons are continuously increasing in the Globe at varying pace. Understanding the dynamics of case-fatality and recovery rate in the most affected countries and Indian states would enhance the knowledge base. It will be helpful for the planning in the current and additional potential hotspots of COVID-19. Therefore, this paper presents a review of case-fatality ratio and recovery rates in India in comparison to the most affected countries and also across most affected states in India

to date. We also discussed the testing pattern and treatment practices of COVID-19 with a special focus on India.
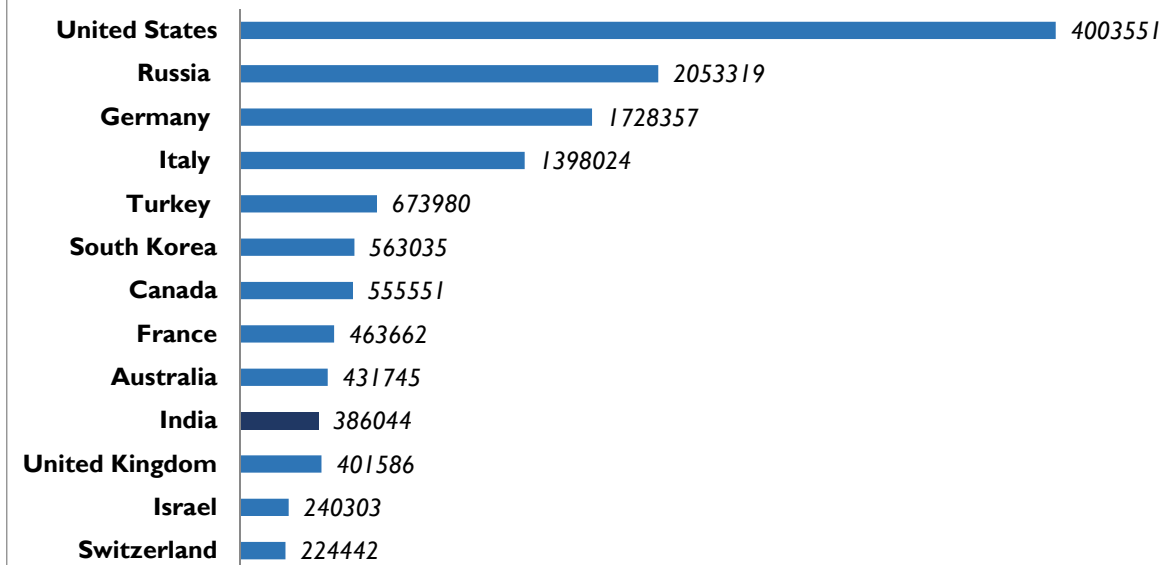
Data and methodology:

This paper compiled data on COVID-19 from different sources. For India, it was taken from the covid19india.org(COVID-19India), a data-sharing portal that provides the most updated information on the daily and total confirmed cases, recovered cases, and deaths for each affected states. This portal data matches with the data provided by the Ministry of Health and Family Welfare, Government of India and also with ICMR on testing statistics. We collected information on death and recovery for the period 14th of March to 20th of April 2020 for the most affected states (had more than 800 confirmed cases) - Maharashtra, Gujarat, Delhi, Rajasthan, Tamil Nadu, Madhya Pradesh, and Uttar Pradesh. For other countries, data was collected from Johns Hopkins University & Medicine (JHU, 2020), Our World in Data (Roser et al., 2020) and Worldometer.

In epidemiology, the case-fatality rate/ratio is defined as the proportion of people who die due to disease to total persons infected. We calculated the case-fatality ratio defined as the ratio of the total number of deaths to the total number of confirmed cases. Similarly, the recovery rate is defined as the ratio of the total number of recovered cases to the total number of confirmed cases. These rates are sensitive to data reporting and testing. We have also analysed the trends of death and recovery rate of COVID-19 to total closed cases.

India's CFR and recovery rates were calculated by sex and age of the patients. However, the data for these characteristics are missing for most cases (9.3% of cases with age reporting, 22% of the case with sex information). As it is difficult to get any pattern of age-sex distribution of missing data by state or overtime, we carried out analysis based on the available information. CFR was adjusted for missing cases (with the assumption that there was no pattern in underreporting by age and sex).

Figure 1: Total number of sample tested as of April 20, 2020

Country	Value
United States	4003551
Russia	2053319
Germany	1728357
Italy	1398024
Turkey	673980
South Korea	563035
Canada	555551
France	463662
Australia	431745
India	386044
United Kingdom	401586
Israel	240303
Switzerland	224442

Source: Authors compilation from database "Total Tests for Covid-19" of Our World in Data

Figure-2: Total Tests for COVID-19 per thousand people
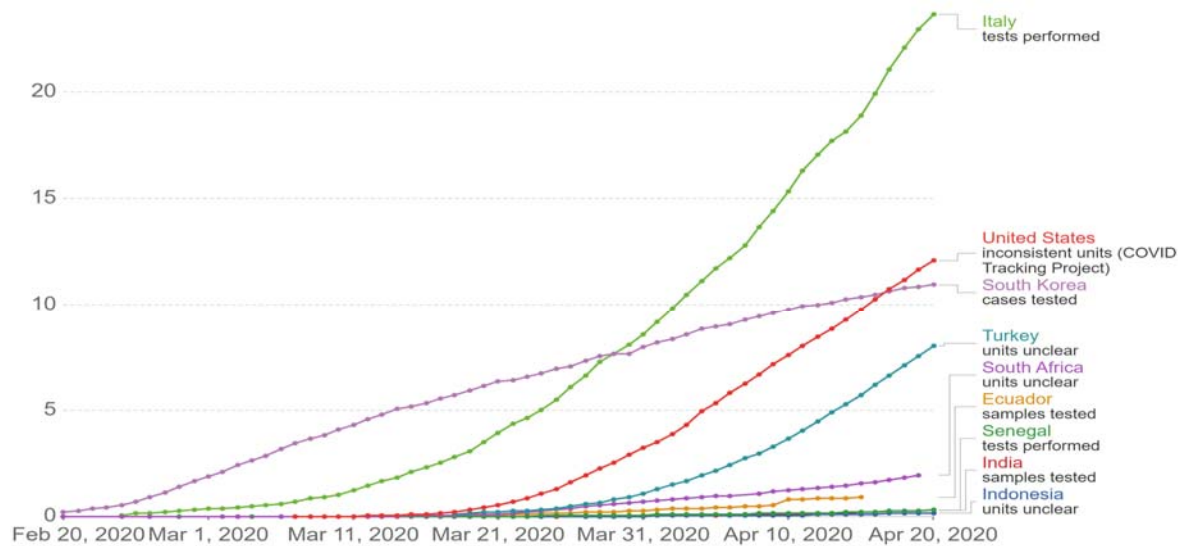
Source: Official sources collated by Our World in Data   OurWorldInData.org/coronavirus • CC BY
Note: There are substantial differences across countries in terms of the units, whether or not all labs are included, the extent to which negative and pending tests are included and other aspects. Details for each country can be found at ourworldindata.org/covid-testing.

Testing in different countries and India:

India's total number of the sample tested ranks at 10th in 63 infected countries (Our World Data) as of 19th April 2020 (Figure-1). However, some of these countries, the unit was not same as of India. India reported total samples tested, while some countries reported number of individuals tested for COVID-19.

The total number of test performed in proportion to India's population (0.199 tested per thousand population) lags quite behind in comparison to countries like Israel (26.12), Switzerland (25.52), Germany (20.9), Italy (22.1), Russia (13.56), South Korea (10.85), United States (11.16), and Turkey (7.14) (Figure-2). There are substantial differences across countries in terms of the units (sample or person), whether or not all labs are included, the extent to which negative and pending tests are included and other aspects. Details for each country can be found at ourworldindata.org/COVID-testing.

Figure-3 shows a continuous increase in samples tested in India. As given by the recent press release of ICMR, the testing status in India that total of 4,01,586 samples from 3,83,985 individuals have been tested as on 19th April 2020, 9 PM IST. According to this report, 17,615 individuals have been confirmed positive among suspected cases and contacts of known positive cases in India.

Figure -3: Testing trends in India: Total number of sample tested
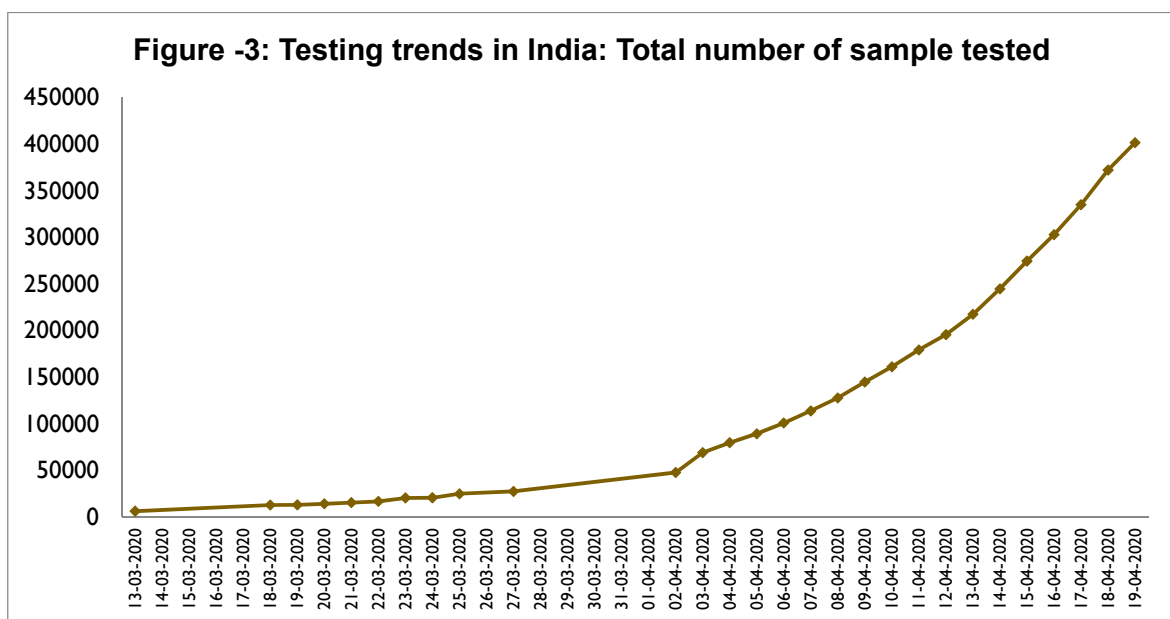
Source: Compilation by author from database "Total Tests for Covid-19" of Our World in Data

Current testing strategy as of 20th April, ICMR

The COVID-19 spread in India is increasing day by day and covering most of the geographies of the country. Ministry of Health and Family Welfare has declared 170 hotspots of the pandemic. The primary mode of transmission started from a person's travel history, which leads to local transmission, mainly imported cases and then to its immediate cases (ICMR, 20th March 2020). The current testing strategy adopted by ICMR includes all the symptomatic individuals who have an international travel history for 14 days, all symptomatic confirmed cases, all symptomatic health care workers, patients with severe acute respiratory illness. Asymptomatic persons with high-risk contacts of the COVID-19 positive cases should be tested on the fifth day and 14th day of coming into contact with that COVID 19 person. Further, in the hotspots/cluster (as per MoHFW) and in large migration gatherings/ evacuees' centres testing should be done in all symptomatic Influenza-like-illness (fever, cough, sore throat, runny nose) within seven days of illness – rRT-PCR and after 7 days of illness – Antibody test (If negative, confirmed by rRT-PCR) (ICMR, 2020) (ICMR April, 9, Press release). Recently as reported by the Economic Times on 3rd April 2020, at least four multinational manufacturers of COVID-19 test kits are gearing up to supply more than a million diagnostic kits to India, as the country looks to ramp up testing for the novel coronavirus.

The government is making efforts to scale it up testing by allowing private labs to do the test. However, this hit a roadblock due to limited availability of kits for the RT-PCR tests. ICMR has revealed that the screening measures like temperature check at airports were not sufficient to test for symptoms. They reported that 46% of passengers might have been missed in screening at the airports because most of the passengers do not show symptoms at the initial screening. Recent studies have shown that asymptomatic can be as infectious as the patient with symptoms, hence post-travel testing and quarantining was initiated.

Case fatality rate due to COVID-19 in different countries:

The case-fatality ratio (CFR) defines as a ratio of total deaths to total infected cases appears to be highly variable between countries, within countries across different ages and sexes and in persons with co-morbidities. It is noteworthy that the comparison of CFR across countries should be made with caution. In the countries where extensive screening and testing has been done, CFR is lower as a possible inclusion of mild and asymptotic cases which have less risk

of dying (Vincent & Taccone, 2020). On the other hand, countries where less amount of testing has been done, mild or asymptotic cases might remain undiagnosed and therefore, has not been counted in the total infected cases and consequently, lead to a higher CFR. Therefore, in the latter case, CFR is derived mostly from the hospitalised cases that were tested positive for COVID-19. The WHO-China joined report on COVID-19 (WHO, Feb. 28, 2020) reported that CFR was higher in the early stages of the outbreak in China, and then it reduced. CFR is significantly higher among the older population as observed across the countries- China-6.4% among 60+ (Verity et al., 2020), 14.8% in 80+ (Novel Coronavirus Pneumonia Emergency Response Epidemiology (NCPERE, 2020)) Italy 11.8% for those 70-79, 18.8% for 80-89 (Dowd et al., 2020). Further, mortality among ICU patients of above age 65 in Italy was 36% (Grasselli et al., 2020).

According to the database from JHU, as of 21 April (09:03 PM EDT)-In the most affected countries (with more than 80 thousand confirmed cases), CFR varies from 3.4% in Germany to 14.6% in Belgium. Italy and the UK stand at second place with 13.4% of CFR. India observed 3.3% of CFR by this date (JHU, 2020). Our World in Data (Roser et al., 2020) track the progress of outbreak overtime. World trends suggest an increase in CFR from 3.37% (as of 25 February, 2020) to 6.98% (as of 21 April 2020). CFR has been increasing rapidly in the most affected countries during the outbreak (Figure-4). Italy and Iran showed an early increment in CFR, though Iran curve flattened in late March 2020, Italy continued to be at top until 14 April, 2020, afterwards Belgium took over the first place and the United Kingdom joined Italy. Among all most affected countries (with more than 80,000 confirmed case), Germany has maintained the bottom place in CFR; however, it has been continuously increasing at a lower rate.

## Case fatality ratio and recovery rates in India and states:

Trend analysis on Indian data as shown in figure-5 reveals that the observed CFR in India increased from 1.9 (as of 15 March 2020) to 3.6 (as of 12 April 2020) and reduced slightly to 3.2% (as of 20 April 2020) to total confirmed cases. State-level variation is vast, as of 20 April, among the most affected states (with more than 800 cases), Tamil Nadu observed only 1.1% of deaths of 1,520 confirmed cases. However, Maharashtra reported 5% of deaths of total 4,666 confirmed cases, and Madhya Pradesh reported 5.1% of deaths of total 1,485cases.

Maharashtra and Madhya Pradesh reported the highest level CFR up to 7.5% (as on 12 April, 2020) and 8.5% (as on 30 March, 2020) respectively.

**Table1: A review of literature/database on Case-fatality Ratio in the World**

Study	Area/Country	CFR per confirmed case	As of date
(Wu & McGoogan, 2020); (NCPERE, 2020)	China	2.3% deaths among 44,672 confirmed cases	11 February, 2020
(Verity et al., 2020)	China	3.67% of deaths of (n=44,672) (adjusted estimates for censoring); 1.38% (adjusted for censoring, demography and under-ascertainment) 6.4% among 60+ age.	11 February, 2020
(Deb & Majumdar, 2020)	China	4.01% deaths of 81305 confirmed cases	21 March, 2020
(Onder et al., 2020)	Italy	7.2% deaths	17 March, 2020
(Deb & Majumdar, 2020)	Italy	9.01% deaths among 53578 confirmed cases	21 March, 2020
(Deb & Majumdar, 2020)	Spain	5.42% death among 25374 confirmed cases	21 March, 2020
(Deb & Majumdar, 2020)	Germany	0.38% deaths among 22213 confirmed cases	21 March, 2020
(Deb & Majumdar, 2020)	India	1.52% among 330 confirmed cases	21 March, 2020
Bulut and Kato (2020)	Affected countries	Varies from 15.23% in France to 0.8% in Russia. Vary country to country. With increasing age the CFR increases.	13 April, 2020
(Kumar et al.)	All coronavirus affected countries	Highest deaths per 1000 is in United States with 173 deaths per 1000 cases India: 33 deaths per 1000 cases	17April, 2020
Johns Hopkins University & Medicine(JHU, 2020)	All coronavirus affected countries	Belgium is top among most affected countries with CFR-14.6% of 40,956 cases), followed by, Italy and United Kingdom (13.4% of 130,172) CFR in US: 5.4% 823,786 confirmed cases CFR in India: 3.3% 20,080 confirmed cases Lowest in Qatar 0.1% of 6,533 and Singapore 0.1% of 9,125)	21 April, 2020 at09:03 PM EDT

Figure-4: Trends of Case Fatality rate (CFR) for COVID-19 in World and most affected countries
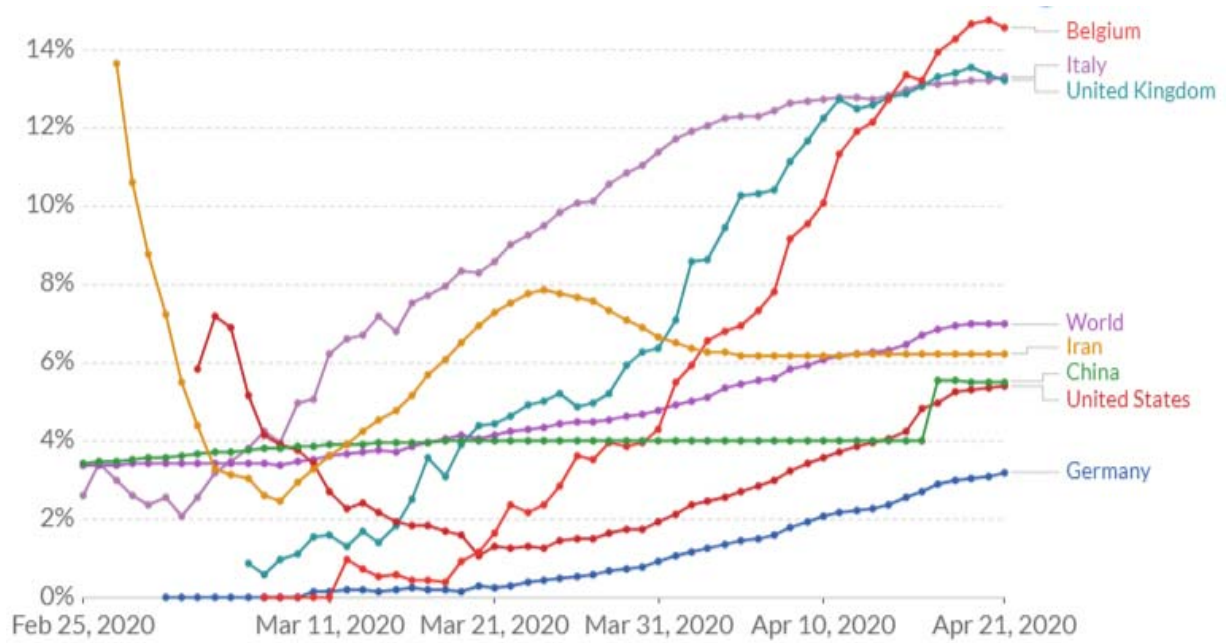
Source: Our World in Data (Roser et al., 2020)
Note: Most affected countries include countries having more than 80,000 confirmed cases as of 22th April, 2020
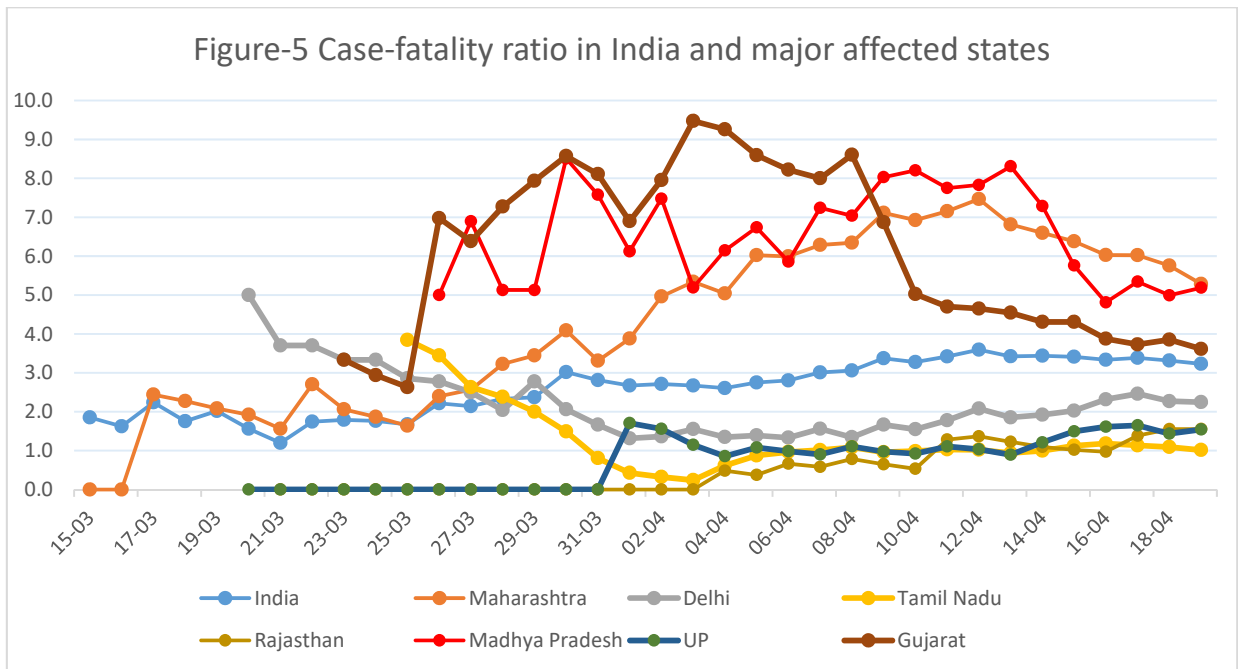
Source: `Authors calculation based on data from https://www.covid19india.org/., CFR are not estimated if total number of confirmed cases were below 20.

India's recovery rate from COVID-19 is 17.7% as of 20th April 2020. Overall, it shows almost stagnant or slight improvements in recovery rate in India. The state of Kerala, where the epidemic started early in the country, has reached 72% of recovery rate. While among other most affected states, recovery rate varies from only 6.8% in Gujarat to 30.1% in Tamil Nadu and 56% in Haryana.

Table 2: Recovery rates and CFRs of all India and affected states			
	Total confirmed cases	*Recovery rate*	*Case fatality rate*
India	**18539**	17.7	3.2
Maharashtra	4666	12.3	5.0
Delhi	2081	20.7	2.3
Gujarat	1939	6.8	3.7
Rajasthan	1576	13.0	1.6
Tamil Nadu	1520	30.1	1.1
Madhya Pradesh	1485	9.3	5.1
Uttar Pradesh	1184	11.8	1.5
Telangana	872	21.3	2.6
Andhra Pradesh	722	12.7	2.8
Karnataka	408	27.5	3.9
Kerala	407	71.5	0.5
Jammu and Kashmir	368	19.3	1.4
West Bengal	339	19.5	3.5
Haryana	251	56.2	1.2
Punjab	245	15.5	6.5
Bihar	113	37.2	1.8
Odisha	74	32.4	1.4
Uttarakhand	46	39.1	0.0
Jharkhand	42	9.5	4.8
Himachal Pradesh	39	41.0	5.1
Chhattisgarh	36	69.4	0.0
Assam	35	54.3	2.9
Chandigarh	26	53.8	0.0

Source: Authors calculation based on data from https://www.covid19india.org/., (as of April 20, 2020 at 10:22 PM EDT), CFR and recovery rates are not estimated if total number of confirmed cases were below 20

COVID-19 closed cases (recovery vs death) overtime in most affected countries, India and states:
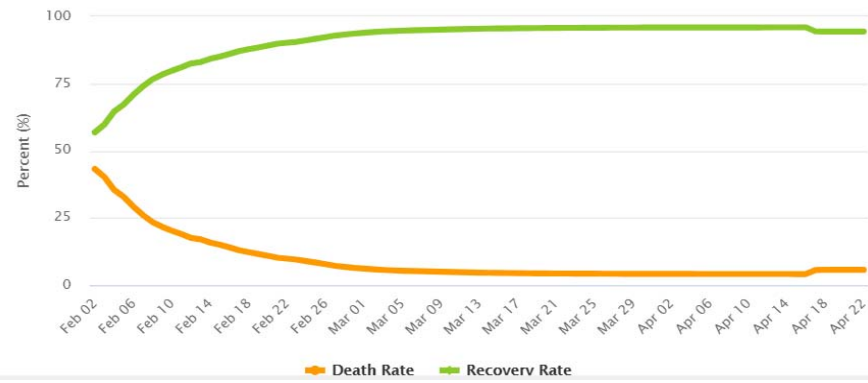
In India, observing the trend of recovery and deaths over time cumulatively is 80%-20% to total closed cases, which is almost consistent. The pattern in Kerala and Rajasthan are at par with the country pattern, where the proportion of total deceased to total closed cases at the lower side. The Maharashtra, Gujarat and Madhya Pradesh had an initial higher proportion of deceased rate than the recovery rate. This pattern suggests that the initial cases may be diagnosed late in these states(Figure-7). The pattern suggests a definite decreasing proportion of diseased to closed cases in all affected states.

The analysis from raw data of COVID-19 patients (18,541 cases as of 20th April) is shown in Table-3. Only 9% (1,718) cases were reported with age. Around 64% of these confirmed cases belong to age 25-59, and 15% were above age 60 years. About 22% of cases were reported with information on sex, out of them, 67% were males, and 33% were females.

The result suggests in India, CFR among 60 plus aged was 14% as compared to only 2.4% among 40-60 and less than 1% among below age 40 years. There is little difference in CFR among males (3.3%) and females (2.9%). As evident from other country statistics too, 83% of the death cases in Italy were over 70 years of age group, and a similar pattern was followed in the United States and South Korea as well (Bulut & Katao, 2020). There is a data limitation, and around 78% and 90% missing cases in gender and age data, respectively, of the COVID-19 cases, due to poor reporting. Still, with the available data, we get an insight onto the prevailing scenario age and gender wise distribution in India

Figure-6: Outcome of total closed cases (recovery or death) in most affected countries
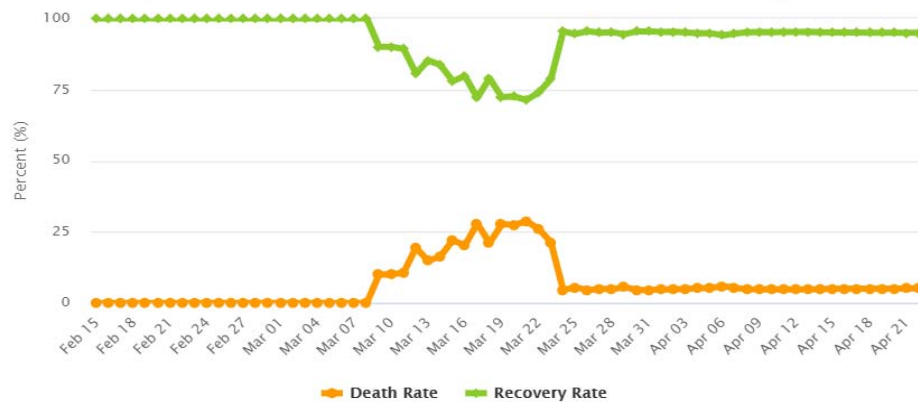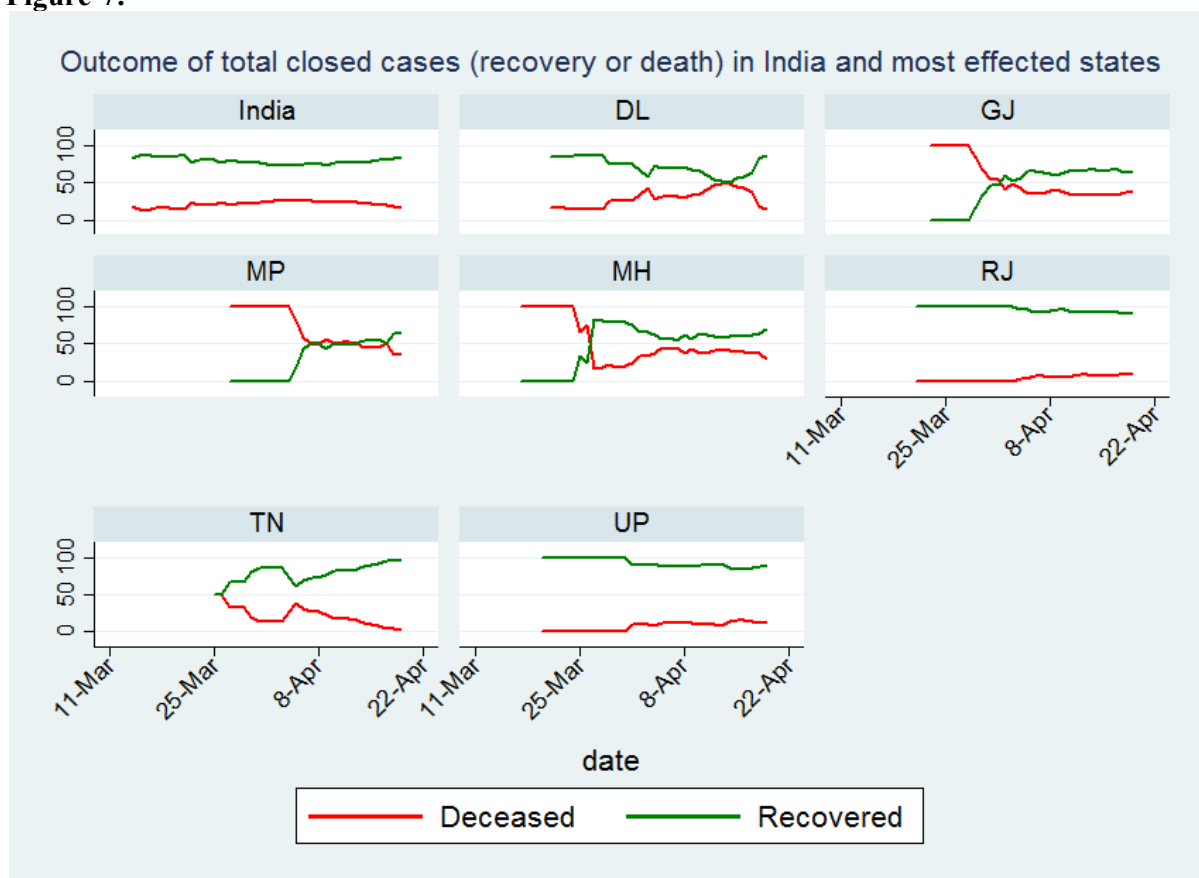
China

Spain

Italy

German

Source: Worldometer, https://www.worldometers.info/coronavirus/

Figure-7:

Outcome of total closed cases (recovery or death) in India and most effected states

Source: Calculation based on data from https://www.covid19india.org/. Rates are not calculated if total number of confirmed cases were below 20.

Table 3: Confirmed COVID-19 cases and CFR by age and sex

	Confirmed cases	Percentage	Number of Deceased	CFR	Adjusted CFR[#]
Age					
<25	354	20.6	2	0.6	0.7
25-39	565	32.9	2	0.4	0.5
40-59	540	31.4	10	1.9	2.4
60+	259	15.1	29	11.2	14.3
Total (age reported)	1718	100	43	2.5	
Sex					
Female	1,316	33	13	1.0	2.9
Males	2,674	67	30	1.1	3.3
Total (sex reported)	3,990	100	43	1.1	
Total confirmed case	**18,541**		**593**		**3.2**

Source: `Calculation based on data from https://www.covid19india.org/..,

Note: [#]adjusted for under reporting of age/sex (assuming under-reporting is not varying by age and sex)

Discussion and conclusion:

Global trends suggest a pattern in CFR over time, which increased from 3.4% (as of 25 February 2020) to 7.0% (as of 21 April 2020). CFR has been increasing rapidly in the most affected countries during the outbreak. Earlier research showed that China, where the pandemic began had lower CFR. Data revealed that CFR in China is stabilised at 4% from 25 February to 16 April. Italy and Iran showed early increment in CFR. However, Iran curve has flattened in late March 2020, Italy continued to be at top until mid-April, 2020, afterwards, Belgium took over the first place, and the United Kingdom joined with Italy. Among all most affected countries, Germany has maintained the bottom place in CFR. However, it has been continuously increasing at a lower rate.

As compared to the global scenario, India's CFR has been at the lower side. In India, the CFR had been rising till 12 April, 2020 (3.6%), after that dropped to 3.2% (as of 20 April, 2020). The lockdown in India which was started on 25 March, 2020, has been now extended up to 3 May, 2020. It has played a significant role in decelerating the spread. The effect of lockdown and social distancing is quite likely to slow down the growth of cases, and the cases are expected to be less than around 66,224 by 1 May, 2020 (Das, 2020). Efforts and containment measures are going on in full fledge at the local level in India with the strict lockdown.

The highest observed CFR in most affected states is in Maharashtra and Madhya Pradesh. Maharashtra has to put up many efforts as it has higher CFR (5%), lower recovery rate (12.3%). On the positive side, the recovery rate has reached 72% in Kerala, 56% in Haryana and 32% in Tamil Nadu. Kerala has set up an example for other states of India. The CFR pattern is quite low in comparison to the recovery pattern, which indicates the positive aspectes of the treatments which is going on in the state. As indicated by ICMR, India is conducting clinical trials for plasma treatment which had been adopted by other affected countries, like China and the United States. Kerala has become the first state in India to use plasma treatment. The donors for the plasma therapy would be the patients who have recovered and have no signs of infection for 2-3 weeks at least and not having any co-morbidities like hypertension, diabetes, lung infection or heart problem and is less than 60 years of age. As of now, the therapeutic plasma treatment is only for clinical trials in India and is not recommended immediately as per the ICMR guidelines, though anecdotal pieces of evidence of treatment efficiency have been observed in other countries.

A large proportion of males are found in the confirmed cases. It is expected in the country where male work participation, mobility and migration is predominately higher than that of females. According to the Economic Survey of India (2020), labour-force participation among women is only 25%, and 60 percent of (15-59) women are involved in household work. The mobility among men is quite high as compared to females (Bannerjee & Raju, 2009), which increases the chances of getting the infection. Men have shown markedly increased risk of developing complications in comparison to women. Also, in a meta-analysis, it was found that there is increased severity and fatality rate among males. It might be due to sex-differentials in cellular compositions and immunological microenvironment of lungs (Wei et al., 2020). However, the present study observed a little gender gap in CFR. Males reported slightly over CFR than that of females.

In contrast to other counties, only 15% of the confirmed cases are above age 60 years in India, and the majority of them (64%) are from age bracket 25-59. Around 84% of the COVID-19 patients (104) were men, and 82% patients overall were above 40 years of age, as reported in an ICMR study (Gupta et al., 2020). India's age structure is comparatively younger, and metropolitan cities comprise of more young population (labour/workforce). Further, India constitutes more proportion of the elderly population in the rural area than urban. Among 60+ patients, 14 % CFR is found, which is very high as compared to other age groups. As evident from other country statistics too, 83% death cases in Italy were over 70 years age group and a similar pattern was followed in the United States and South Korea as well (Bulut & Katao, 2020). Most of the studies have indicated that patients aged 60 or more are at higher risk than children. Children are likely to be less infected or may show milder symptoms or even asymptomatic infection (Velavan & Meyer, 2020).

We understand measuring CFR during the outbreak is not very appropriate, as it is sensitive to under-reporting, testing and time of reporting and robust estimate of CFR is possible only at the end of the pandemic. However, the dynamics of fatality and recovery rates across affected countries and states would enhance the knowledge base and provide useful information in the ongoing outbreak of COVID. In response to the lockdown, India has not yet entered stage-3 of the pandemic. However, the rapid increase in the cases in the Delhi and Mumbai and other hotspots indicates that it might be the local transmission of COVID-19. Although cases are increasing in hotspots, if we can contain the virus with the ongoing efforts and the innovations in treatment, CFR of India would not further increase.

Acknowledgement:

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