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COVID-19 and Mortality: India's Perspective

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Abstract

The outbreak of COVID-19 is by far the single most public health challenges in twenty-first century. Emergence of COVID-19 epidemic has led to both health and economic crisis worldwide. Though much of the economic impact is likely to be realised in coming days, it has certainly increased the mortality level across countries. In the wake on increasing COVID-19 pandemic and COVID-19 attributable deaths, one of the key research interests is to understand its effect on the life expectancy.

Using 310 deaths, 2519 confirmed cases and case fatality ratio of 3.4% from India, this paper examines the effect of COVID-19 on longevity in India. The age specific death rate from Sample Registration System (SRS), country specific data from worldmeter and unit data from covidi19india.org is used in the analyses. Descriptive statistics, case-fatality ratio, case fatality ratio with 14 days delay, recovery death ratio and the abridged life table is used in the analyses. Under the assumption that all deaths attributed to COVID-19 would have been avoided in absence of COVID-19, the probability of death due to all causes other than COVID-19 would be similar as observed in 2013-17, the case fatality rate of 3.4%, the COVID-19 infection of 0.5%, 1% and 2% in India would lower the life expectancy by 0.3, 0.7 and 1.3 years respectively. The case fatality ratio with 14 days delay is 8.4 compared to 3.4 of case fatality ratio. The recovery rate (28.9) and recovery-death ratio (8.6) is lower than many other countries. The state variation in CFR and CFR with 14 days delay is highest in West Bengal followed by Gujarat and lowest in Kerala. Use of case fatality ratio with 14 days delay and continued effort to limit the community transmission at each administrative unit is recommended to save human lives from COVID-19 pandemic.

Key Words: COVID-19, life expectancy, longevity, mortality, India

Key Message

1. The case fatality ratio with 14 days delay for India is at least twice higher (8.4) than the case fatality ratio (3.4). The state variation in these indicators are large.
2. If the community spread of COVID-19 would be 0.5%, 1% and 2% , the life expectancy would reduce by 0.3 years, 0.7 years and 1.3 years respectively in India.
3. Recovery-death ratio (number of patients recovered per one death) is 8.6 in India; lower than Germany, Turkey and Iran (19.1, 22.8 and 12.8 respectively).
4. For population aged 60 years and above, the probability of deaths from COVID-19 is four times higher than those under 60 years.
5. Great effort has been taken to provide COVID-19 patient data on daily basis but missing data of key variables such as age, sex, patient status need to be minimised. Organisation/ health workers/official updating such records need to be sensitise on utility of such data.

1.1 Introduction

With an additional deaths of over 253 thousands within five months (December 2019- 6th May 2020), the COVID-19 attributable death has increased the share of global death by 0.04% (https://population.un.org/wpp/DataQuery/). If the current trends of mortality continues, the life expectancy would began to decline by end of the year. Since the first case was detected in Wuhan city of China in December, the estimated number of confirmed COVID-19 cases has reached over 3.7 million by 6th May 2020 (https://www.worldometers.info). Despite short duration of the diseases outbreak, the epidemic has spread to almost every country in the world. The COVID-19 virus is highly contagious, has longer survival period and affect the critical organ including respiratory system. It has set challenges to medical science and altered the public health priority globally.

The outbreak of COVID-19 has created health emergency and economic crisis worldwide. The global recession following COVID-19 epidemic is projected to be worst ever in human history. In a span of last four months, the SENSEX is three year low in emerging economies, and unemployment has reached the peak. In developing countries, it has hit hard on the migrant labourer, small and petty shopkeeper and the poor; many of those lost their livelihood (Bhagat et al. 2020). Many adverse economic effect will be realised in coming days. Similarly, the adverse impact of COVID-19 on human health is most immediate and immense. Among others, it has raised the mortality and morbidity level, complicated the medical treatment and increased the medical expenditure. The case fatality rate from the epidemic is high for elderly, critically ill patients such as cancer patient, hypertensive, diabetic and patients with heart disease.

The medical know-how on treatment of COVID-19 is limited. No vaccine exist to treat the deadly virus and the use of hydro chloroquine and plasma therapy seems to be effective in some cases. The vaccine for the COVID-19 is set between six month and two years from now.

Thus, quarantine and social distancing is recommended to control the spread of epidemic. Besides, the health care system across countries is not prepared to meet the health infrastructure for treatment of COVID-19. Countries such as Italy, United States and Spain with better health care system in the world could not limit the human loss in wake of COVID-19 epidemic. As of 6th May, 2020, the United States of America has recorded over 1.3 million confirmed cases (the largest number of cases) and over 75,000 deaths due to this epidemic. The Institute for Health Metric has predicted that over next four months there will be additional 81,114 deaths from COVID-19 in United States leading to shortage of medical beds and equipment (Murray, 2020).

The first empirical study of 619 infected patients of Diamond Princes cruise ship of Japan estimated the corrected case fatality ratio due to COVID-19 at 2.6% for all age group and 13% among the older aged 70 and above (Russell et al. 2020). The infection fatality rate was estimated at 1.3%. The mortality rate due to COVID-19 were correlated with life expectancy and the incidence was higher in countries with higher proportion of adults and elderly (Lai & Wanga et al). The overall crude fatality rate from COVID-19 in China was higher for elderly aged 60 years and over (Verity et al., 2020). The risk of mortality is affected by the characteristic of the population including age and health care resources (Dilcher et al. 2020; Ji et al 2020). A study from china has found that the case fatality ratio (CFR) of 2.8% among male and 1.7% among female and the morbidity ratio was higher in the age group 50-59 years (Dudley & Lee, 2020). In Italy, a higher proportion of older patients with confirmed COVID-19 infection and deaths were mainly among the older, male patients who had multiple comorbidities (Onder et al. 2020). The overall fatality rate of COVID-19 is low, but the older adults and patients with comorbidities are more likely to have severe disease and mortality (Guan et al. 2020). Myocardial injuries were significantly associate with the fatal outcome of COVID-19 (Guo et al. 2020).

2. Indian Scenario of COVID-19

India with a population of nearly 1.35 billion is at high risk of community transmission of COVID-19. The densely populated cities, higher proportion of slum population, poor health infrastructure, low income level and high dependence on informal activities make vulnerable to spread of COVID-19 pandemic. The first case of COVID-19 in India was detected in 30st January, 2020 in the state of Kerala. Since than the spread of epidemic is rapid in the country and reached 30,000 mark by end of April 2020. Projection suggests that the number of cases in India, under exponential growth pattern the number of active COVID-19 cases was predicted at 474,694 with 34,319 deaths by 3rd May, 2020 (Dwivedi et al., 2020). A study by Bhramar Mukherjee has predicted that by May 15, about 97,000 -1.3 million people may be infected across India. Studies suggests that the estimated cases are underreported due to low testing rate (Goli and James 2020). The case-fatality ratio of India is lower than many countries but higher than Russia, South Korea and Turkey. Although the fatality rate of COVID-19 in India is low, high diabetes and hypertension prevalence (7.3% and 28.9% respectively) made population at increasing health risk (Pal & Bhadada, 2020).

Resources, both physical and financial, are limited to scale up the COVID-19 testing nationwide. The national and state government has taken several measures and increased public spending to reduce the spread of the epidemic. Among these, the lockdown of the entire country since 23rd March till 17rd May, 2020, identification of hotspot (containment zone), development of *Arogya Setu Aap*, increasing testing centres across districts and spreading awareness are said to be effective in reducing the spread of the deadly virus. The containment zones have been identified and classified into red zone (at least one case was detected in last 14 days), orange zone (no case reported in last 14 days) and green zone (no case reported in last 28 days) that restrict the movement. These effective measures are said to have averted the more number of deaths and active cases.

3.Need Of The Study

Despite concerted efforts by national, regional and local governments, the spread of the disease is alarming in many countries. The COVID-19 is now a threat to global public health and beginning of recession of world economy. The immediate effect of COVID-19 is loss of human life due to its high case-fatality ratio. The case-fatality ratio varies by age, sex and geographies. In the absence of vaccine and medical know-how to treat the novel virus, the number of deaths attributed to COVID-19 is likely to increase many fold. Though attempt has been made to project the number of COVID-19 cases, no attempt has been made to understand the COVID-19 and morality pattern in India. The aim of this paper is to examine the effect of COVID-19 on longevity in India.

4. Research Question

This paper attempt to address an important research question " What is the pattern of mortality due to COVID-19 and how would it would affect longevity in India"?

5. Data And Methods

5.1 Data

Data on COVID-19 at national and global level was available at a faster pace than any other disease. A number of key variables such as number of cases, number of deaths and recoveries were available from smallest geographic unit such as district to country level on daily basis. We have used data from multiple sources. These includes the unit COVID-19 data from the https://www.covid19india.org/ , worldmeters (https://www.worldometers.info), the Sample Registration System (SRS) and the population projection of expert committee (MoHFW 2019). A brief description of variables used from each of these sources is given below.

The covid19india.org is developed and managed by a group of volunteers who validate data from various sources such as state press bulletin, official handles, PBI , ANI) and provide for public use (https://www.covid19india.org/about). It provides the number of cases, deaths and

recoveries for each districts and states of India. Besides, it provides micro data of patients on various domain such as demographics (raw data), death and recovered, testing number, travel history etc. These data are available in CSV format in https://api.covid19india.org/csv. We have used raw data (patients data) and death and recovered data, as of 26th April, 2020 in the analyses. The raw data file provides selected variables such as detected district, state and city, age and sex, current status (hospitalised, recovered and death), nationality and status change date. While data on detected state, nationality and current status are available for most of the cases, data are largely missing for other variables. As of 26th April 2020, there were 26,498 cases of which age data was available for 2,252 cases only. Of these 2,252 cases, we have used a total of 2,209 hospitalised and recovered cases and death cases from death and recovery data file. In the death and recovered file, there were 6,854 cases and complete information was available for date of admission, current status and state. The demographic data in death and recovery file is better than raw data file. We found 421 cases for which age data is available, of which 310 were of deceased. It may be mentioned that as of 26th April, 2020, there were 27,889 confirmed cases of which 873 were deceased, 6,397 were recovered and 20,619 cases were active cases. While age data were available for 36% of death cases, the age data were available for 23% hospitalised and recovery cases. Similarly, the worldmeters provides aggregate information on a number of variables such as total number of confirmed cases, active cases, new cases, deaths cases, death per million and number of test conducted for most of the countries (https://www.worldometers.info/coronavirus). Unlike national data, these data are available at aggregate level (country). As of 7th May 2020, there were 38,70,581 cases of which 267,741 were died. Besides, data from SRS abridged life table 2013-17 is used for the analyses (ORGI 2019). We have used the SRS estimate as base line estimates of deaths without COVID-19 since COVID-19 infection started in 2020. The expert committee on population projection

provided population projection of India using 2011 base year and the same has been used in the analyses (MoHFW 2019).

5.2.Methods

The methods used includes descriptive statistics, computation of case-fatality ratio, lag case fatality ratio, recovery-death ratio (number of recovered to number of deaths) and estimation of longevity by five year age group. A set of assumptions and the various steps used in estimation procedure is given below.

5.2.1Assumptions on Mortality without COVID-19 and with COVID-19

1) All deaths occurring due to COVID-19 are additional deaths in the population and would have been avoided if there were no COVID-19 cases in India
2) The age pattern of mortality obtained from SRS, 2013-17 was related to deaths without COVID-19 and assumed to remain same for all diseases other than COVID-19 for 2020.
3) Missing age data on hospitalisation and deaths have similar distribution as that of reported age
4) Effectiveness of medical treatment of COVID-19 will remain same in the till end of the year 2020 as of now
5) In case COVID-19 is equally likely any other flu, the probability at death across age group will be similar as of now (from 30th March to 26th April 2020)

Along with these assumptions, the following **steps** were used to estimate the life expectancy at birth.

5.2.2 Steps Used in Estimation of Life Expectancy with and without COVIOD-19

Step 1: Age data on COVID-19 attributable mortality was available for 36% of all deceased (310) and that of hospitalised and recovery cases were available to 23% of total confirmed cases (2209). We have distributed the total cases (9810) in each of the five year age group as per the distribution of 2,519 (death, hospitalised and recovery case) for which age data is known.

Step 2: To estimate life expectancy at 0.5%, 1% and 2% community spread in a year time, we have re-estimated the number of deaths with and without COVID-19 across age group. The official population projection of 2020 , the age distribution of 2021 (2020 is not available) and the age specific death rate of SRS is used to arrive number of deaths without COVID-19 (MoHFW 2019). Under the case fatality rate of 3.4% deaths, COVID-19 deaths are obtained at three scenarios and distributed across age group as per their current share in deaths due to COVID-19 by five year age group. Deaths due to COVID-19 are added to deaths obtained without COVID-19 and new age specific death rate is computed

Step 3: Estimation of Deaths Without COVID-19

The projected population of 2020 was distributed as per the age distribution of 2021 population. From the age specific death rates of SRS, we have estimated the expected number of deaths without COVID-19 for 2020.

Step 4: Estimation of deaths with COVID-19

To account for COVID-19 attributable deaths, we have estimated the community infection at three scenarios, 0.5% , 1% and 2%. Using the case fatality ratio of 3.4 as observed in recent days, we have estimated the number of deaths under each of the scenarios. We have distributed the deaths in five-year age group (separately for 0-1 and 1-4) as per the age distribution of COVID-19 deaths observed from covid19india.org data. The total number of deaths with COVID-19 is sum of deaths with and without COVID-19. The age specific death rate (ASDR) was estimated from all deaths including COVID-19 deaths and the key input in construction of Abridge Life Table.

Step 5: Construction of Abridged Life Table

The abridged life table is used to estimate the life expectancy at birth at various ages. Life table is estimated under each of the four scenario including that of without COVID-19.The details steps used in estimation of abridged Life Table and the empirical vales are shown in Table 2.

In construction of abridged life table, we have used 0-1 and 1-4 and then subsequently 5 years' age group to account for high infant and child mortality.

5.2.3. Estimation of case fatality ratio and lag case fatality ratio (LCFR)

The case fatality ratio has been used to monitor the mortality due to COVID-19 worldwide. It is defined as the cumulative number of confirmed cases and cumulative number of deaths. Though it is a simple indictor and easy to understand, it underestimate the true mortality in the population (Baud et al. 2020). There are at least two limitations of the CFR. First, even if there is no further new infection, there will be additional deaths from hospitalised/ infected cases. Second, deaths occurring due to COVID-19 does not relate to infection on same day. The maximum incubation period of COVID-19 infection is 14 days and hence a refined measure that relate the deaths to number of infection 14 days prior to death (henceforth referred as Lag Case Fatality ratio (LCFR)) may reflect true mortality of a population.

Lag Case Fatality Ratio (LCFR): Cumulative number of deaths/Cumulative number of confirmed cases 14 days ago

6. Results

6.1 COVID-19 in Selected Countries

Table 1 presents the selected indicators of COVID-19 cases across 16 worst affected countries (with respect to number of confirmed cases) as of 7th May 2020. We also present world aggregate and that of excluding China as the epidemic duration of China is longer than other countries and China said to be controlled the number of cases. The table is arranged based on number of cases per million population. India is at the advantages position with lower number of death per million population due to large size of population. Col 10-14 of Table 1 presents five key indicators computed from the given data. These are fatality rate, recovery rate, recovery-death ratio, test and detection ratio and days since outbreak of first COVID-19 case.

Case fatality ratio (ratio of death to confirmed case) is low in Russia followed by Turkey and India. It is much highest in Belgium followed by France and UK. India's recovery rate is lower than countries such as Switzerland, Russia, Turkey and Iran where duration is even lower or similar to India. Recovery-death ratio (number of recovered per death) is a good indication of chance of recovery from the disease. Among 16 worst affected counties it varies from 1.5 to 22.8; lower value indicate poor chance of survival and high ratio suggests higher chance of survival. It was lowest in Belgium followed by France and USA (less than 3) and highest in Turkey followed by Germany and China (over 9). India with a recovery- death ratio of 8.6 is higher than global average but lower than many countries. The days since date of first diagnosis of COVID-19 in India is similar to many countries except China (148 days) and Turkey (48 days)

Table 1: Selected indicators of COVID-19 in sixteen largest affected countries as of 7th May 2020

Country (1)	Total Population (2)	Total number of cases (3)	Total Deaths (4)	Total Recovered (5)	Number of cases per million population (6)	Death per million population (7)	Number of tests (8)	Number of Tests Per Million (9)	Case Fatality Rate (10)	Recovery Rate (11)	Recovery-death ratio (12)	Test and detected cases ratio (13)	Date since outbreak of first case (14)
India	1380	53045	1787	15331	38	1	1357413	984	3.37	28.90	8.58	25.59	98
China	1439	82885	4633	77957	58	3	N/A	N/A	5.59	94.05	16.83	N/A	158
Russia	146	177160	1625	23803	1214	11	4803192	32913	0.92	13.44	14.65	27.11	97
Brazil	212	127389	8605	51370	599	40	339552	1597	6.75	40.33	5.97	2.67	72
Turkey	84	133721	3641	82984	1586	43	1265119	15000	2.72	62.06	22.79	9.46	58
Iran	84	103135	6486	82744	1228	77	544702	6485	6.29	80.23	12.76	5.28	78
Canada	38	63895	4280	28171	1693	113	973558	25795	6.70	44.09	6.58	15.24	103
Germany	84	168765	7322	139900	2014	87	2755770	32891	4.34	82.90	19.11	16.33	101
USA	331	1271007	75558	213562	3840	228	8081734	24416	5.94	16.80	2.83	6.36	108
Switzerland	9	30126	1810	25700	3481	209	290365	33550	6.01	85.31	14.20	9.64	72
Netherland	17	41774	5288	N/A	2438	309	249655	14570	12.66	N/A	N/A	5.98	70
UK	68	206715	30615	N/A	3045	451	1448010	21330	14.81	N/A	N/A	7.00	97
France	65	174191	25809	53972	2669	395	1100228	16856	14.82	30.98	2.09	6.32	104
Italy	60	215858	29958	96276	3570	495	2381288	39385	13.88	44.60	3.21	11.03	98
Spain	47	256855	26070	163919	5494	558	1932455	41332	10.15	63.82	6.29	7.52	97
Belgium	12	51420	8415	12980	4437	726	493325	42566	16.37	25.24	1.54	9.59	93
World	7794	3870581	267741	1326693	497	34.3	N/A	N/A	6.92	34.28	4.96	N/A	N/A
World Excluding China	**6355**	**3787696**	**263108**	**1248736**	**439**				**6.95**	**32.97**	**4.75**		

Sources: Col 2-9 from Worldmeters.org, UN world population prospectus accessed on 7th May 2020 , https://population.un.org. Col 10-15 computed by authors. Date of first outbreak is taken from Wikipedia and duration is as of 7th May 2020 computed by authors

Fig 1 presents trends in CFR and LCFR with 14 days lag period in India on daily basis for over 54 days. The CFR is in the range of 3.1-3.4 during this period. The LCFR was fluctuating in early days of infection but remained stable since 18th April, 2020. From the graph, we at least infer that 1) the mortality level due to COVID-19 is at least twice higher than CFR 2) The LCFR has declined in initial period but remains stable over last 20 days.

Fig 1: Trends in case fatality ratio and case fatality ratio with 14 days lag period in India, 28th March-6th May, 2020

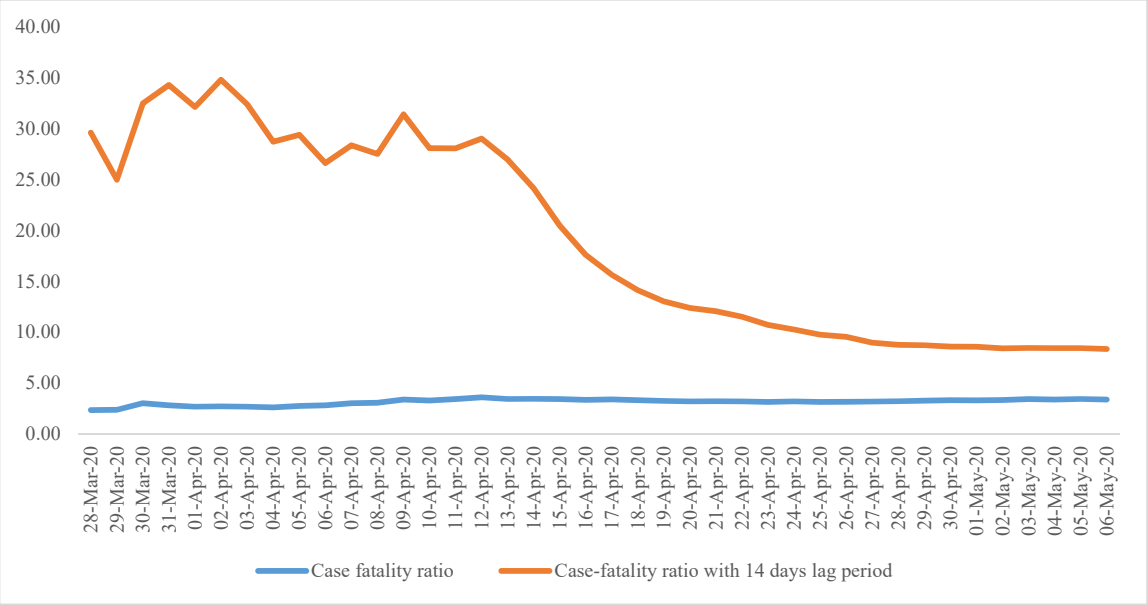


Table 2 presents the cumulative number of cases, death cases, the CFR and LCFR for selected states of India. Fig 2 compares the CFR and LCFR in these states, arranged in ascending order of LCFR. Among the states that are affected by COVID-19, the LCFR was lowest in Kerala followed by Telangana and highest in West Bengal (18.82) followed by Gujarat (16.45) and Madhya Pradesh (11.72).

Table 2: Cumulative number of confirmed cases, deaths, case fatality ratio and case-fatality ratio with 14 days lag period in selected states of India during 30th Jan-7th May, 2020

States	Cumulative number of total cases	Cumulative number of death cases	Case fatality ratio (CFR)	Cumulative number of cases with 14 days lag period	Lag Case fatality ratio (LCFR)
Kerala	503	4	0.80	438	0.91
Telangana	4829	29	0.60	1629	1.78
Haryana	594	7	1.18	264	2.65
Bihar	542	4	0.74	143	2.80
Delhi	5532	65	1.17	2248	2.89
Tamil Nadu	1107	35	3.16	943	3.71
Uttar Pradesh	2998	60	2.00	1449	4.14
Andhra Pradesh	1777	36	2.03	813	4.43
Rajasthan	3317	93	2.80	1888	4.93
Karnataka	693	29	4.18	427	6.79
India	**53006**	**1784**	**3.37**	**21372**	**8.35**
Maharashtra	16758	650	3.88	5649	11.51
Madhya Pradesh	3138	186	5.93	1587	11.72
Gujarat	6625	396	5.98	2407	16.45
West Bengal	922	48	5.21	255	18.82

For West Bengal data is taken till 2nd may, 2020

Fig 2: Case fatality ratio and case-fatality ratio with 14-days lag period of COVID-19 in states of India (Jan 30-May 6, 2020)

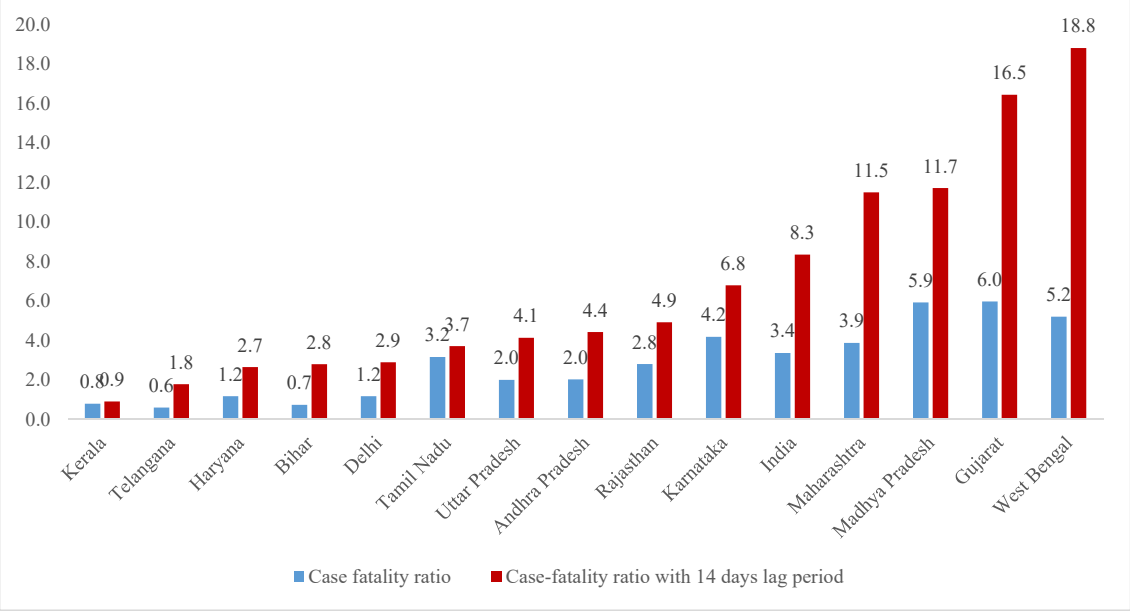


Table 3 presents the actual number of confirmed cases, adjusted number of cases and the case fatality ratio of COVID-19 only. The adjusted number of cases are arrived by taking moving average of respective number (three age group). In doing so the first and last age group are left unchanged. Total number of adjusted cases in India are distributed as per the percent distribution of total cases for which age is known and total number of confirmed cases (col 5). With given number of deaths cases and number of cases we have estimated the case-fatality ratio by age group.

Table 3 : Actual number of confirmed cases, adjusted number of confirmed cases, hospitalised , death cases and the case-fatality ratio of death due to COVID-19 only, India, 2020

	Actual Number of Cases				Adjusted Number of Cases						
Age Group	Hospitalised and recovery (col 1)	Death (col 2)	Total number of cases (col 3)	Percent distribution of known hospitalised and death data (col 4)	Moving average-Hospitalisation (col 5)	Smoothed cases adjusted-Hospitalisation (col 6)*	Moving average-Death (col 7)	Smoothed cases adjusted-Death (col 8)*	Percent distribution of COVID-19 deaths (col 9)	Total Adjusted cases (all) (col 10)	Case Fatality Ratio (col 11)
0-4	30	5	35	1.39	30	30	5	5	1.60	136	3.65
5-9	44	0	44	1.75	49	50	2	2	0.75	171	1.35
10-14	74	2	76	3.02	77	77	1	1	0.43	296	0.45
15-19	113	2	115	4.57	140	141	2	2	0.53	448	0.37
20-24	233	1	234	9.29	193	194	2	2	0.53	911	0.18
25-29	234	2	236	9.37	241	243	3	3	0.86	919	0.29
30-34	257	5	262	10.40	252	254	4	4	1.39	1020	0.42
35-39	266	6	272	10.80	237	239	9	9	2.78	1059	0.81
40-44	189	15	204	8.10	213	214	16	16	5.03	794	1.96
45-49	183	26	209	8.30	177	178	27	27	8.56	814	3.26
50-54	159	39	198	7.86	160	161	38	37	12.09	771	4.86
55-59	137	48	185	7.34	137	138	42	42	13.58	720	5.84
60-64	116	40	156	6.19	115	115	48	47	15.29	608	7.80
65-69	91	55	146	5.80	82	82	42	41	13.37	569	7.29
70-74	39	30	69	2.74	51	52	34	34	10.91	269	12.59
75-79	24	17	41	1.63	22	22	21	21	6.84	160	13.29
80-84	20	17	37	1.47	20	20	17	17	5.45	144	11.73
Total	**2209**	**310**	**2519**	**100**	**2197**	**2209**	**312**	**310**	**100.00**	**9810**	**3.16**

*To arrive smoothed hospitalisation (col 6) a scaling factor of 1.01 and that of death (8) a scaling factor of 0.995 is used.

Table 4 provides detail steps used and estimates of deaths without and with COVID-19. Estimates with COVID-19 are at three scenarios; 0.5%, 1% and 2% level of community infection. We arrive at the estimated death of 2020 using population and ASDR of SRS, 2013-17 which we consider the death without COVID-19. We have estimated the number of deaths

assuming community infection of 0.5%, 1% and 2% and with case fatality rate of 3.4. The estimated deaths due to COVID-19 are distributed as per the age distribution of deaths of COVID-19 patients. The deaths due to COVID-19 are added with that of without COVID-19 to arrive total expected deaths with COVID-19. Using the population in col1, the ASDR is estimated under each of the scenario. The probability of death under each of the scenarios is estimated and shown in col 14-17. The probability of death increases with age under each scenarios. The increase in COVID-19 deaths may largely affect the working and older age group.

6.4 Probability of Dying with and without COVID-19

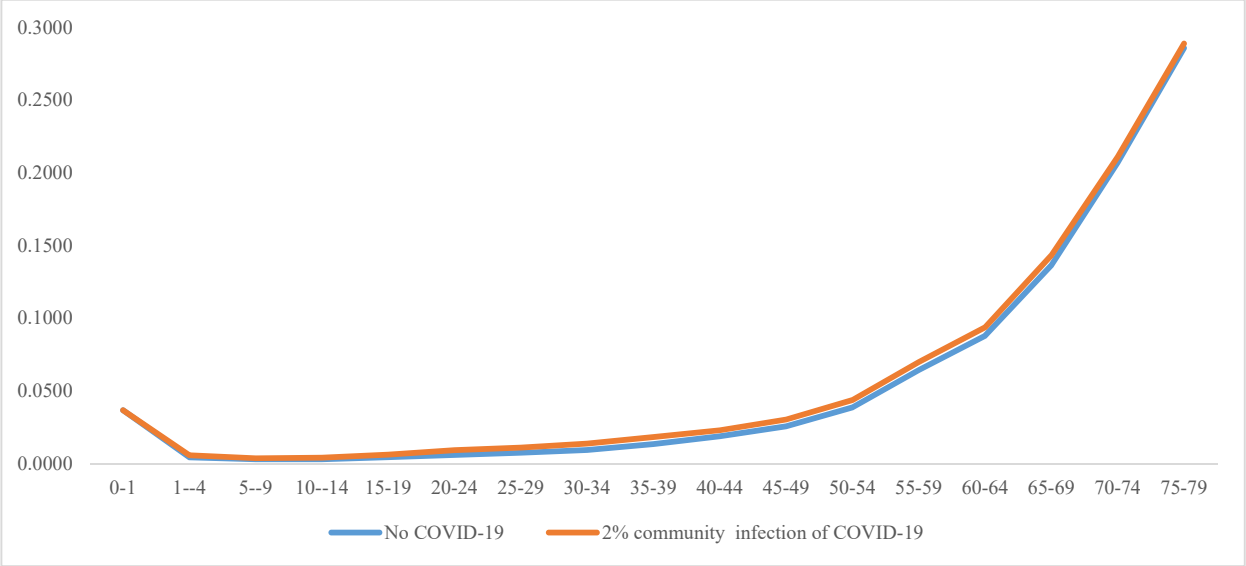
Fig 3 compares the probability of death with and without COVID-19 in India. We have estimated the probability of death from SRS data 2013-17 and those represents the probability of death without COVID-19 as there was no COVID-19 cases prior to this period. Under the assumption that all deaths due to due to COVID-19 would have been avoided if there would not have been COVID-19 , a community infection of 2% and the case fatality rate of 3.4% we have estimated life table probability of death with COVID-19. The estimated probability refer to end of year 2020 for India under the assumption that the pattern of mortality without COVID-19 would remain similar as that of 2013-17. Under this hypothetical situation, the age pattern of mortality clearly suggests that the COVID-19 is likely to affect the older adults in India. Beyond age 60, the probability of death due to COVID-19 would be at least four times higher among elderly compared with non-elderly.

Table 4: Estimated deaths without COVID-19 and with varying level of community infection of COVID-19 in India, 2020

Age group	Population (in 000) (col 1)	ASDR (SRS, 2013-17) without COVID-19 (col 2)	Estimated number of deaths without COVID-19 (col 3)	% distribution of deaths of COVID-19 (col 4)	Estimated number of deaths due to COVID-19 only 0.5% infection (col 5)	Estimated number of deaths due to COVID-19 only 1% infection (col6)	Estimated number of deaths due to COVID-19 only 2% infection (col 7)	Estimated total number of deaths due to COVID-19 and all other causes 0.5% infection (col 8)	Estimated total number of deaths due to COVID-19 and all other causes 1% infection (col 9)	Estimated total number of deaths due to COVID-19 and all other causes 2% infection (col10)	ASDR with COVID-19 0.5% infection (col 11)	ASDR with COVID-19 1% infection (col 12)	ASDR with COVID-19 2% infection (col 13)	Probability of dying ($_nq_x$) No COVID-19 (col 14)	0.5% infection(col 15)	1% infection (col 16)	2% infection (col17)
0-1	84442	37.4	3158149	0.64	1479	2957	5915	3159627	3161106	3164063	37.42	37.44	37.47	0.0367	0.0367	0.0367	0.0368
1-4	28057	1.1	30863	0.96	2218	4436	8872	33081	35299	39735	1.18	1.26	1.42	0.0044	0.0047	0.0051	0.0058
5-9	115210	0.6	69126	0.75	1725	3450	6900	70851	72576	76027	0.61	0.63	0.66	0.0030	0.0032	0.0033	0.0037
10-14	117921	0.6	70753	0.43	986	1972	3943	71739	72724	74696	0.61	0.62	0.63	0.0030	0.0033	0.0036	0.0042
15-19	123343	0.9	111009	0.53	1232	2464	4929	112241	113473	115937	0.91	0.92	0.94	0.0045	0.0049	0.0053	0.0062
20-24	127409	1.2	152891	0.53	1232	2464	4929	154123	155355	157820	1.21	1.22	1.24	0.0060	0.0068	0.0077	0.0093
25-29	119277	1.5	178915	0.86	1972	3943	7886	180887	182858	186801	1.52	1.53	1.57	0.0075	0.0084	0.0093	0.0111
30-34	109789	1.9	208599	1.39	3204	6407	12815	211802	215006	221414	1.93	1.96	2.02	0.0095	0.0105	0.0116	0.0138
35-39	98945	2.7	267153	2.78	6407	12815	25630	273560	279968	292782	2.76	2.83	2.96	0.0134	0.0146	0.0159	0.0184
40-44	88102	3.8	334788	5.03	11583	23165	46331	346371	357953	381119	3.93	4.06	4.33	0.0188	0.0199	0.0209	0.0230
45-49	79970	5.2	415842	8.56	19715	39430	78861	435557	455272	494703	5.45	5.69	6.19	0.0257	0.0268	0.0280	0.0303
50-54	69126	7.9	546098	12.09	27848	55695	111391	573945	601793	657488	8.30	8.71	9.51	0.0387	0.0400	0.0413	0.0438
55-59	56928	13.3	757136	13.58	31298	62596	125191	788434	819732	882327	13.85	14.40	15.50	0.0644	0.0658	0.0671	0.0699
60-64	44729	18.4	823009	15.29	35241	70482	140963	858250	893491	963973	19.19	19.98	21.55	0.0880	0.0894	0.0909	0.0938
65-69	33885	29.3	992843	13.37	30805	61610	123220	1023648	1054453	1116063	30.21	31.12	32.94	0.1365	0.1382	0.1399	0.1433
70-74	25753	46.2	1189785	10.91	25137	50274	100547	1214922	1240059	1290332	47.18	48.15	50.10	0.2071	0.2081	0.2091	0.2110
75-79	17620	66.7	1175282	6.84	15772	31544	63089	1191054	1206826	1238371	67.60	68.49	70.28	0.2858	0.2866	0.2874	0.2890
80+	14910	138.6	2066603	5.45	12568	25137	50274	2079171	2091740	2116876	139.45	140.29	141.98	1	1	1	1
Total	**1355417**		**12548842**		**230421**	**460842**	**921684**	**12779263**	**13009684**	**13470526**							

Col 1: Expert committee population projection 2019, Col 2:SRS, 2013-17, Col 3=col1*col2 col 4: covid19india.org
Col 5 is derived in two steps. In first step, total number of estimated death is estimated as total population *0.05 *0.034. In second step, the total deaths is distributed across age group as per distribution of COVID-19 deaths. Col 6 and 7 are estimated assuming the community infection of 1% and 2% respectively.
Col 8=Col5+Col3 , Col 11=Col8/Col1
Col 14-17 is estimated as ($_nq_x$)= (2*n* $_nm_x$)/ (2+n* $_nm_x$)
$_np_x$=(1- $_nq_x$)

Fig 3: Life table probability of death without COVID-19 and with 2% community infection of COVID-19 in India, 2020



On comparing the case-fatality ratio of COVID-19 in India with that of global average we found that the case-fatality ratio of death under 40 years is similar in India with that of global average while in the range of 40-80, it is higher for India. For 80+ population, the global average is higher than that of India (table not shown). The premature mortality (probability of dying before age 70) would increase from 0.38 with no COVID to 0.39 with 0.5% community infection, 0.40 under 1% community infection and 0.42 under 2% community infection. Similarly, the probability of dying in 15-60 age group would increase from 0.17 without COVID-19 to 0.18 with 0.5% community infection, 0.19% with 1% community infection and 0.20 with 2% community infection.

6.5 Life expectancy with and without COVID-19

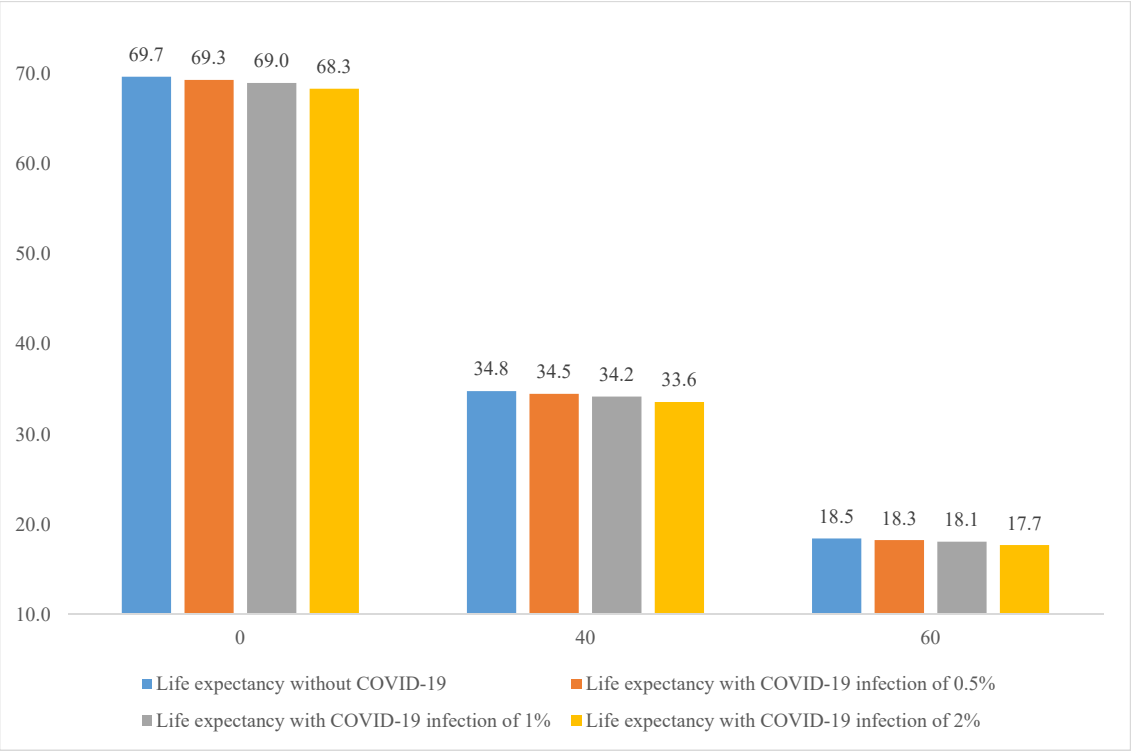
Fig 5 presents the life expectancy in four scenarios for India. If the community infection reaches at 0.5% by the end of the year, the life expectancy is likely to reduce by 0.3 years from 2013-17 level. If the infection is at 1% level, the life expectancy would reduce by 0.7 years

while that of 2% would reduce the life expectancy by 1.3 years. Table 5 provides life expectancy and reduction in life expectancy at each age under three scenarios. It may be noticed that the life expectancy will be reduced in most of the age group under each scenario. However, reduction in life expectancy with case fatality rate of 14 days ago (8.35%) would result in reduction of life expectancy by 0.8 years under 0.5% community infection, 1.6 years under 1% community infection and 3.1% under 2% community infection in India.

Table 5: Life expectancy without COVID-19 and with COVID-19 under alternative scenario in India, 2020

Age group	Life expectancy without COVID-19 (col.1)	Life expectancy with COVID-19 infection of 0.5% (col.2)	Life expectancy with COVID-19 infection of 1% (col.3)	Life expectancy with COVID-19 infection of 2% (col.4)	Reduction in life expectancy with COVID-19 infection of 0.5% (col.5)	Reduction in life expectancy with COVID-19 infection of 1% (col.6)	Reduction in life expectancy with COVID-19 infection of 2% (col.7)
0-1	69.7	69.3	69.0	68.3	0.3	0.7	1.3
1-4	71.3	71.0	70.6	69.9	0.4	0.7	1.4
5-9	67.6	67.3	67.0	66.3	0.3	0.7	1.3
10-14	62.8	62.5	62.2	61.5	0.3	0.6	1.3
15-19	58.0	57.7	57.4	56.7	0.3	0.6	1.3
20-24	53.2	52.9	52.6	52.0	0.3	0.6	1.3
25-29	48.6	48.2	47.9	47.3	0.3	0.6	1.3
30-34	43.9	43.6	43.3	42.6	0.3	0.6	1.3
35-39	39.3	39.0	38.7	38.1	0.3	0.6	1.2
40-44	34.8	34.5	34.2	33.6	0.3	0.6	1.2
45-49	30.4	30.1	29.8	29.3	0.3	0.6	1.2
50-54	26.2	25.9	25.6	25.1	0.3	0.5	1.0
55-59	22.1	21.9	21.6	21.2	0.2	0.5	0.9
60-64	18.5	18.3	18.1	17.7	0.2	0.4	0.7
65-69	15.0	14.9	14.7	14.4	0.1	0.3	0.5
70-74	12.0	11.9	11.8	11.6	0.1	0.2	0.4
75-79	9.4	9.4	9.3	9.2	0.1	0.1	0.2
80+	7.2	7.2	7.1	7.0	0.0	0.1	0.2

Fig 5: Life expectancy at exact age (0,40 and 60) by varying level of community infections of COVID-19 in India, 2020



6. Discussion

This is the first ever study that examine the likely effect of COVID-19 spread on mortality in India. It also compared the selected indicators related to COVID-19 in 16 of the worst affected countries and compares a situation with varying levels of community infection of COVID-19. The followings are the salient findings of the study. First, India fares better than global average and many worst affected countries on fatality rate, recovery rate and test detection ratio. However, it lags behind countries such as Germany and Turkey that have performed better to combat COVID-19. Second, this paper suggest the computation of case fatality rate with 14 days delay (lag), as the deaths reported are from those detected earlier. We found the case fatality ratio with 14 days delay was at least twice higher than CFR and varies largely across states of India. West Bengal is the worst performing state followed by Gujarat whereas Kerala had the lowest value among these states. Third, we also found large variations in recovery-

death ratio across countries. India with a recovery-death ratio of 8.6 is much lower than Turkey, Germany and China that have similar or lower duration in spread of COVID-19. Fourth, the test-detection ratio of India is second highest among these 16 countries while Russia has even larger ratio of 27.1. This suggests to increase the testing at least by 50% from its current limit. Fifth, in case the COVID-19 turns spread to 0.5% of the population in India, the life expectancy would reduce by 0.4 years. Sixth, the impact of full scale COVID-19 on premature mortality, particularly among working adults is very high. Last, the public health system demonstrate how effectively it can provide the patient level and aggregated COVID-19 data for research, analyses and public use in a very short span of time. However, care has to be taken to sensitise the officials/health workers in providing complete information on key variables without which the data may not be much use.

We provide some explanation and suggestion in support of the findings. The low fatality rate and high test-detection ratio are primarily due to effective measured taken by Govt. of India in controlling the community spread of the disease. The lockdown measures of about two month is the most proactive step taken by the national government in curbing the epidemic. However, though the country performs better than, many countries and global average, the recovery-death ratio is much lower than many other countries. It is interesting to note the control of COVID-19 in Kerala and the best practice adopted in the Kerala may be ptractised in worst affected states of India. Efforts to minimise the loss of human life by improving the health facility to severe patients may be strengthen.

We suggests to continue the social distancing norm and lock down measures in high prevalence states of Maharashtra, Delhi, Gujarat and selected cities such as Mumbai, Pune, Indore and Jaipur to minimise the community spread. We do not recommend community testing but

suggests to make health facility accessible, available and equipped with COVID-19 in every town and cities of the country.

6.2. Limitations

We put-forward the following limitations of the study.

1.Our estimates are derived from incomplete data on age distribution of deceased and hospitalised cases. Within this constraint we have adjusted the data to derive valid inferences. It would have been idle to derive this exercise using complete age data.

2.We believe that our estimates for elderly is underestimated as missing data is likely to be higher among elderly compared to younger population.

3.Our assumption of all deaths due to COVID-19 would have been avoided if there were no COVID-19 cases may not always hold true.

4.Our assumption of SRS death rate of 2013-17 would prevail is illustrative.

Despite these limitations, we believed that this study is a pioneering study on impact of COVID-19 on longevity in India. It has provided scope to replicate similar analyses elsewhere and may guide the health programme globally and nationally.

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