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Coronavirus Pandemic

Trends of Epidemiological and Demographic Indicators of COVID-19 in India

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Abstract
Introduction: This study was planned to assess the trends of epidemiological indicators and demographic determinants related to the COVID-19 in India.
Methodology: This was a descriptive analysis of the COVID-19 cases and their outcomes between 1st March to 31st May 2020 in India. Unpaired t-test and ANOVA were used to determine the statistical differences. Linear regression models were prepared to estimate the effect of testing on the fatalities. The Infection Fatality Rate (IFR)/Case Fatality Rate (CFR), doubling time, and Basic Reproduction Number (R_0) per week were calculated.
Results: Two-thirds of the cases were between 21-50 years of age, while three-fourth of deaths were among people above 50-years of age. The mean age of people infected with COVID-19 was declining throughout the study period. The mean age of infected males and females was significantly different. The male-female ratio of both infection and deaths due to COVID-19 was near about 2:1. IFR/CFR was 3.31 (95% CI = 3.13-3.50) in April, which reduced to 2.84 (95% CI = 2.77-2.92) in May. An incremental trend was observed in the recovery rates (9.42% to 48.18%), tests conducted / million population (12 / million to 2708 / million) and doubling time (3.59 to 17.71 days). The number of tests was significantly influencing the fatalities ($\beta = 0.016$, 95% CI = 0.012-0.020). The overall R_0 was found to be 1.72.
Conclusions: Public health interventions were likely effective in containing the spread of COVID-19. There is a need to further improve the testing capacity. The high-risk category of individuals being prioritized for hospital admission should be redefined to include individuals older than 50 years.

Key words: COVID-19; CFR; demographic trend; epidemiological trend; positivity rate.

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Introduction

In December 2019, a novel coronavirus (SARS-CoV-2) emerged in Wuhan, China, and spread its wings all over the world due to its high transmissibility, adaptability in every environment, and absence of definitive treatment or vaccine against it. In India, the first case of COVID-19 was reported on 30th January 2020 and another two cases were reported on 2nd and 3rd February 2020. From 3rd February to 1st March 2020, no case was reported. The first death due to COVID-19 in the country was reported on 12 March 2020 [1]. In response, the Government of India initiated preventive interventions such as – restriction on cross-border travel, nation-wide lockdown, stay-at-home measures, and self-quarantine measures. These interventions apparently reduced the COVID-19 transmission as there was only a gradual rise in cases and deaths from mid-March to mid-April [2]. Later on, the stringency index of the country varied widely. As a result of that, from mid-April to mid-May, the number of cases and deaths increased comparatively rapidly. In the second half of May, the epidemic showed a nearly exponential increase. As per the data available in the public domain, as of 31st May 2020, India had 1,90,648 cases and 5,407 deaths due to COVID-19 [3].

Since the inception COVID-19 pandemic, many studies have been published to address the issues related to transmission dynamics, case trends and projections. As this pandemic has spanned three months in India, it was felt necessary to explore the possible age and gender-specific differences in COVID-19 infection and mortality along with the case-trend. Further epidemiological indicators related to COVID-19 such as infection fatality rate (IFR) / case fatality rate (CFR), recovery rate, doubling time of cases, testing capacity, and basic reproduction number (R_0) have changed since the beginning of the epidemic in India. Therefore, this study was planned with the objective to assess the trends of epidemiological indicators and demographic determinants related to the COVID-19 in India.

Methodology

We conducted a descriptive analysis of the laboratory-confirmed SARS-CoV-2 infections and their outcomes reported in India. All the available raw data reported between 1st March 2020 to 31st May 2020 was retrieved from the crowdsourced databases, which include the reporting from state and central government agencies [3–5]. All the retrieved data sheets were compiled and cleaned to retrieve the epidemiological and demographic information.

Data were analyzed using Microsoft Excel 2010 and SPSS v. 23. Weekly tends of IFR/CFR, recovery rate, tests per million, doubling time of cases, and R_0 were illustrated by line diagrams. Error bars were plotted to express the week-wise mean age of infection and deaths due to COVID19 and month-wise differences in the mean age of infection and deaths among males and females. Stacked bar charts were prepared to show the trend in gender-wise proportional distribution of COVID-19 infection and deaths. Unpaired *t*-test and ANOVA were used to determine the time trend and gender-wise statistical differences in the mean age of infection and deaths due to COVID-19. Linear regression models were developed to assess the effect of testing on the CFR, in which the number of deaths was the dependent variable while the number of cases and the number of tests were independent variables. The infection fatality rate (IFR) / case fatality rate (CFR) per week was calculated for cumulative deaths per cumulative confirmed cases and cumulative death per closed case i.e the cumulative confirmed cases who had their outcome reported as recovery or death [6].

The doubling time of cases was calculated using the formula:

$$\frac{T\ (days)}{ln_2\ (Total\ cases\ on\ last\ day) -\ ln_2(Total\ cases\ on\ the\ first\ day)}$$

In order to assess the weekly doubling time, the T was considered a week time (7 days). Accordingly, 'total cases on the last day' were taken as cumulative cases on Sunday of that week and 'total cases on the first day' were considered as cumulative cases on Monday of the same week [7].

The Basic Reproduction Number (R_0) was calculated using the formula "$R_0 = 1 + (T \div \text{td}) \times \ln_2$", where T is the Serial Interval and td is doubling time and $\ln_2$ is the natural logarithm of 2 [8]. Serial Interval was taken as 6.28 days by taking the mean of serial intervals reported in a published systematic review [9].

Results

Around two-thirds of the infected cases were in the age group between 21 to 50 years, while almost three fourth deaths were reported among people above 50-year of age (Table 1). The population by age group and sex in India has also been mentioned in the table to estimate the prevalence of COVID-19 in these subgroups [10,11].

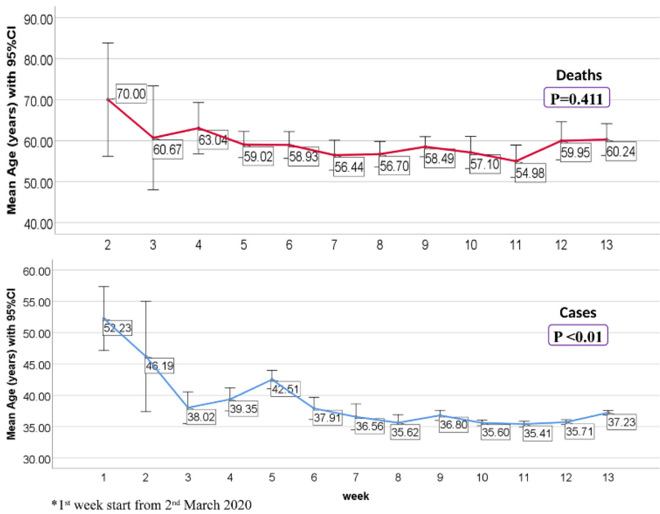
Figure 1 depicts that a significant declining trend was observed in the mean age of people infected with COVID-19 throughout the study period (March 2020 to May 2020). It was 40.2 ± 17.2 years in March, which was reduced to 37.5 ± 17.5 in April and 36.2 ± 16.6 in May. The overall mean age of people infected with COVID-19 was 36.4 ± 16.7 years. Similarly, a declining trend in the mean age of people who died due to COVID19 was also observed during this period, though this drop was not statistically significant. The overall mean age of deaths due to COVID-19 was 58.3 ± 14.8 years.

Figure 2 illustrates that the declining trend in the mean age of people infected with COVID-19 was detected for both sexes. In March the mean age of females infected with COVID-19 was higher (41.7 ± 19.1) than the males (39.0 ± 16.7), though this difference was statistically not significant.

Table 1. Age and gender-wise distribution of COVID-19 cases and deaths.

Age groups (years)	Cases, n (%)			Deaths, n (%)			Population (Million)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
≤ 10	797 (4.3)	704 (7.3)	1501 (5.3)	6 (1.3)	3 (1.3)	9 (1.3)	123.1	111.8	234.9
11-20	1923 (10.4)	1102 (11.4)	3025 (10.7)	1 (0.2)	6 (2.6)	7 (1)	133.0	119.2	252.2
21-30	4673 (25.2)	2420 (24.9)	7093 (25.1)	7 (1.6)	4 (1.7)	11 (1.6)	126.9	113.0	239.9
31-40	4378 (23.6)	1909 (19.7)	6287 (22.2)	29 (6.4)	10 (4.3)	39 (5.7)	112.9	102.8	215.6
41-50	3120 (16.8)	1474 (15.2)	4594 (16.3)	65 (14.4)	36 (15.5)	101 (14.8)	87.4	82.3	169.7
51-60	2171 (11.7)	1192 (12.3)	3363 (11.9)	131 (29.1)	64 (27.6)	195 (28.6)	65.4	62.8	128.1
61-70	1012 (5.5)	619 (6.4)	1631 (5.8)	138 (30.7)	70 (30.2)	208 (30.5)	43.9	43.3	87.2
71-80	370 (2)	240 (2.5)	610 (2.2)	65 (14.4)	31 (13.4)	96 (14.1)	18.7	20.5	39.2
> 80	117 (0.6)	48 (0.5)	165 (0.6)	8 (1.8)	8 (3.4)	16 (2.3)	6.0	7.3	13.3
Total	18561 (100)	9708 (100)	28269 (100)	450 (100)	232 (100)	682 (100)	717.1	662.9	1380.0

Figure 1. Week wise trend in mean age of infection and deaths due to COVID19.



*1st week start from 2nd March 2020

Figure 2. Gender wise differences and trends in mean age of infection and deaths due to COVID-19.

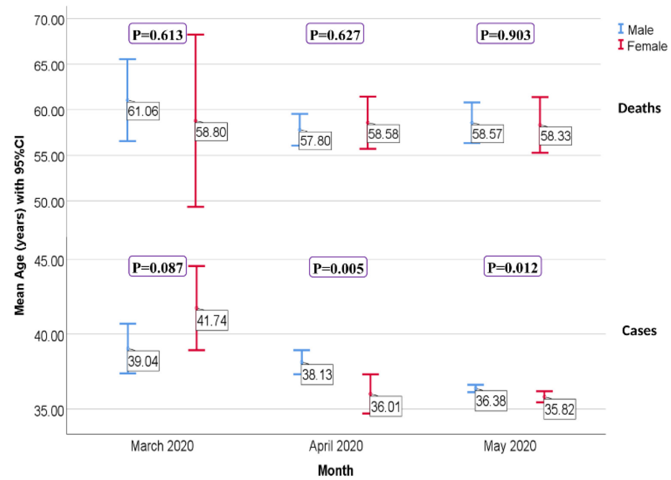
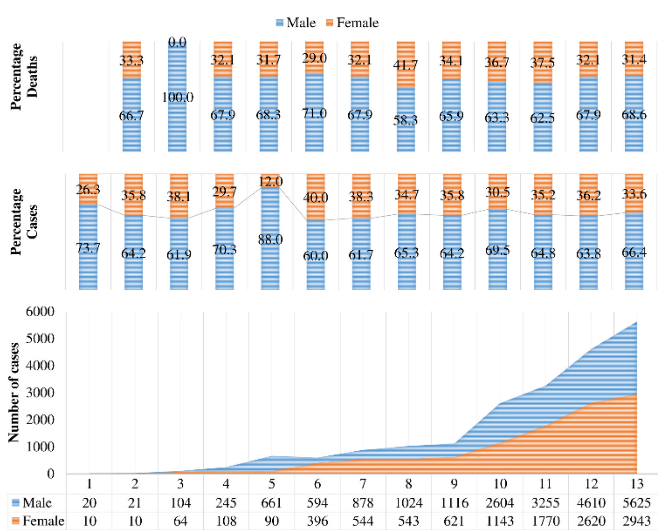


Table 2. Trend of the test positivity rate in the country from March to May 2020.

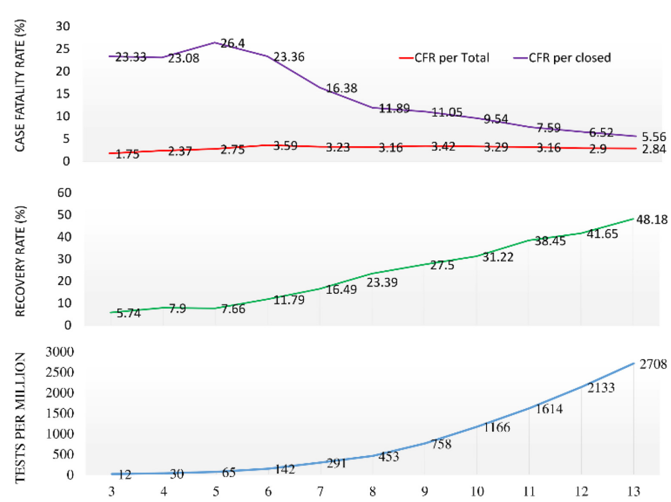
Month	Cumulative Tests	Cumulative Cases	Test per Month	Cases per Month	Positivity rate (95% CI)
March	47,951	1,635	47,951	1,635	3.41 (3.25-3.58)
April	830,201	34,867	782,250	33,232	4.25 (4.21-4.29)
May	3,737,027	190,645	2,906,826	155,778	5.36 (5.33-5.39)

Figure 3. Trend in gender wise proportional distribution of COVID-19 infection and deaths.



*1st week start from 2nd March 2020

Figure 4. Week wise trend of CFR, Recovery rate and Tests per Million of COVID19 in India.



*3rd week start from 16th March 2020

In April and May, this situation was reversed and the mean age of females infected with COVID-19 was significantly lower than males. The overall mean age of cases infected with COVID-19 was 36.6 ± 16.2 years for males and 35.9 ± 17.8 years for females. There were no significant differences in the mean ages of death of males and females due to COVID-19 during all three months.

It is evident from Figure 3 that, the male-female ratio of both infection and deaths due to COVID-19 was near about 2:1. This ratio was almost constant during the entire duration of thirteen weeks.

Figure 4 depicts that the IFR/CFR per total cases was varying during the entire period of 13 weeks. It was 2.81 (95% CI = 2.11-3.73) in March which was increased to 3.31 (95% CI = 3.13-3.50) in April and reduced to 2.84 (95% CI = 2.77-2.92) in May. But, CFR per closed cases was declined with time. A drastic incremental trend has been observed in the recovery rates during the last three months. It was 9.42% (95% CI = 8.10-10.93) in March which was increased to 25.98% (95% CI = 25.52-26.44) in April 2020 and 48.18% (95% CI = 47.96-48.40) in May. During these three months, the test conducted per million populations in the country also increased radically. It was 12 tests per million populations in the third week of March, which increased to 2708 tests per million towards the end of May. But, at the same time, the positivity rate also increased during these three months (Table 2).

Figure 5 represents the linear regression model for the estimation of fatalities since the report of the first death from COVID-19 in India. The deaths were increasing with increment in the number of cases (β = 0.025, 95% CI = 0.023-0.027). On further analysis (Table 3), it was found that the number of tests was a significant covariate in affecting this relationship (β = 0.016, 95% CI = 0.012-0.020).

The doubling time of the cases has increased from March to May 2020 (Figure 6). At the same time, the R_0 was found declining. The overall R_0 was found to be 1.72.

Discussion

In the present study, the trends of various epidemiological indicators and demographic determinants of COVID-19 in India have been explored. SARS-CoV-2 infection was found to be mostly affecting the economically productive age group (20 to 50 years), and the mean age of the commencement of the infection was significantly declining with time. The higher prevalence in this age group could be due to the existing population structure of the country with a predominance of younger age

Figure 5. Linear regression model to predict the fatalities due to COVID-19.

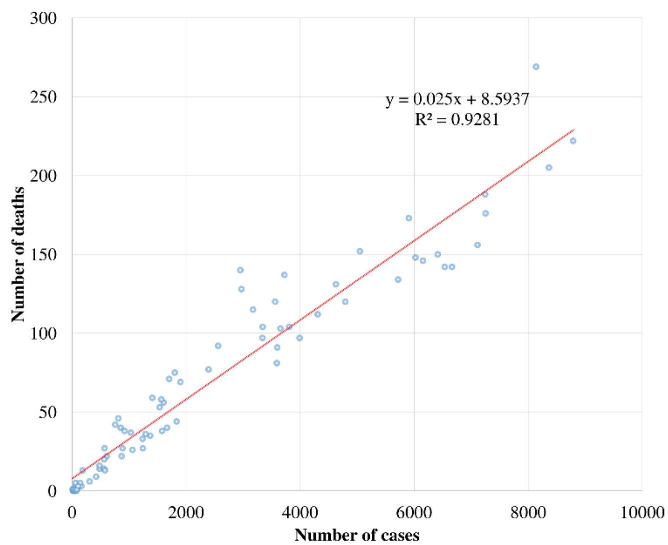


Figure 6. Trend of doubling time and R_0 per week for COVID-19 cases in India.

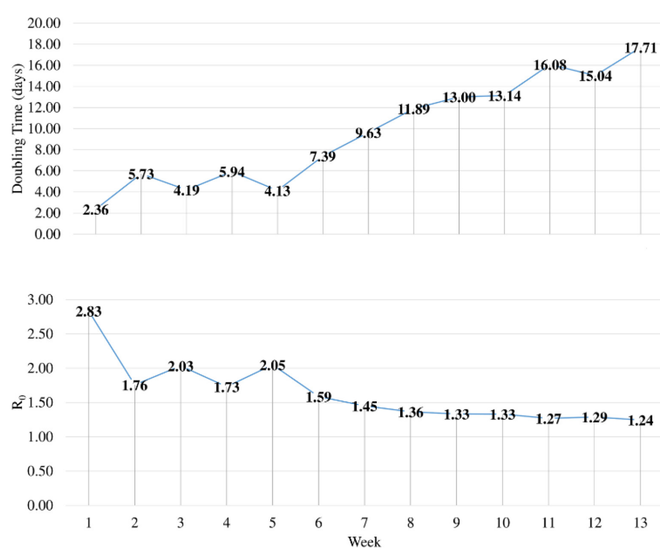


Table 3. Regression models to assess the effects of testing on the prediction of the fatalities due to COVID-19.

Dependent variable	Model 1		Model 2	
	β (95% CI)	R^2	β (95% CI)	R^2
Cases per day	0.025 (0.023-0.027)	0.927	0.016 (0.012-0.020)	0.942
Tests per day			0.001 (0.0001-0.001)	

groups. Another reason could be that public health interventions at the beginning of this pandemic were stringent (especially lockdowns) and fear among people was also quite on the higher side [12]. Consequently, almost all economic activities were adversely affected. As time progressed, the government had to strategically relax the norms in subsequent phases of the lockdowns, so that the economic activities could be restored. In all the phases of lockdowns, the guidelines for restriction of movement outside the home was maintained for the elderly, children, and pregnant women [13]. Consequently, people in the economically productive age group were presumably at a higher risk of infection due to mixing with already affected individuals while performing their occupational activities. Most of the studies in India and abroad have reported the most common age of infection of COVID-19 within the economically productive age-group of 20-50 years [14–16].

It has been reported in the published literature that individuals above 60 years were at higher risk of deaths due to COVID-19 [16]. However, the analysis in the present study suggests that it is also necessary to protect the 50 to 60-years age group, as almost 30% of deaths were reported among them. On further analysis, it was found that this proportion of deaths had increased to almost 40% when the 45 to 60 years' age group was considered. These findings reveal that the middle-aged population is also at a higher risk of death due to COVID-19. This could be due to the early age onset of non-communicable diseases (NCDs) among the Indian population as compared to other countries [17–19].

The male preponderance of cases and deaths was observed in the country-level data. These findings are in accordance with the observations made by other authors in India [20]. Almost similar proportional distributions of male and female of COVID-19 cases and deaths were reported in USA [21], while in China, the male to female ratio of COVID-19 infection was roughly equal [16].

Though the CFR per total cases has not varied much in the previous three months, it has slightly decreased in May as compared to April. It is evidenced in the scientific literature that the CFR decreases as the surge capacity of testing increases in any country [22,23]. The finding of regression analysis in the present study also support this statement. The COVID-19 testing capacity in the country has ramped up considerably with time. Indian Council of Medical Research (ICMR) has broadened the COVID-19 testing criteria from being initially focused on those with foreign travel and contact history to subsequently include individuals with severe acute respiratory illness (SARI) and symptomatic influenza-like illness (ILI) [24]. As of 31st May 2020, a total of 3,737,027 samples had been tested for SARS-CoV-2 [25]. As far as CFR per closed cases is considered, it has sizably reduced with time. This reduction is a proxy indicator of improvement of recovery in the country, which is reflected by improvement in the recovery rate in the last three months.

An increment in the test positivity rate is a commonly observed epidemiological phenomenon in the initial phases of an epidemic, which indicates the cumulative rise of the proportion of infected individuals in the general population before reaching a peak. As appreciated from the susceptible – infected – recovered (SIR) compartmental models, the proportion of infected individuals follows a gamma-distribution and is a sensitive indicator of the course of the epidemic [26]. A similar trend in the positivity rate was observed for COVID-19 in India. At this time, there is a need to give more focus on preventing fatalities and saving lives. At the same time, this constant increment in the positivity rate indicates to further improve the testing capacity and implementation of wider scale contact tracing in the country.

This phase of the exponential growth of this early epidemic can be characterized by the doubling time, which is the time taken for the number of infections to double from a given day. The doubling time is inversely proportional to R_0 [27]. The findings of the present study regarding the increment in doubling time of the cases are supported by reports of the Union Health Ministry, Government of India [28,29]. This increment in doubling time could be attributed to public health interventions [30]. This trend also in accordance with the reduction of R_0 in the country.

Conclusions

The favorable trend in the testing capacity, recovery rate, doubling time, and CFR per closed cases represents that in the initial phase of this pandemic preventive interventions were likely proved effective in containing the spread of COVID-19 infection and mortality in the country. However, the battle against COVID-19 has not finished yet and there is a need to further improve the testing capacity in the country so that the IFR/CFR and positivity rate can be brought down further.

The middle-aged people, and not just the elderly, and males are at higher risk of dying from COVID-19. There is a need to explore the clinical profile of all these deaths in the country through analysis of individual patient-level data to find out the underlying factors responsible for deaths at an early age. In order to reduce the mortality due to COVID-19 in the country, it is necessary to redefine the risk categories with special consideration of age and gender during the formulation of guidelines in the future.

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