



The Trend of COVID-19 Pandemic in India: A Methodical Comparison with Italy, UK, and the US

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ABSTRACT

Introduction: To statistically compare the trends of epidemiological indicators of COVID-19 in India with Italy, the UK, and the US.

Methodology: In this descriptive analysis, epidemiological indicators were calculated and their trends were plotted and compared statistically. Regression analysis was done to predict the fatalities.

Results: The trends of total and active cases per million populations are rising in India and US, while Italy has achieved the plateau in the total cases per million populations, and active cases have been sharply declining with time. The UK is about to achieve the same. India has remained far behind the other three countries in the number of tests per million populations ($p < 0.05$). In the initial phase, the test positivity rate of India was quite lower but has overtaken Italy and UK. India has always reported a higher recovery rate than US and lower than Italy. CFRs have achieved a plateau in Italy and UK, in US it is declining, while it remained almost constant in India throughout the pandemic. Testing was a significant covariate in predicting the fatalities.

Conclusions: India was able to manage the initial phase of this pandemic due to early and strict government interventions and strong public health responses.

Keywords: COVID-19, Pandemic, Disease Outbreak, CFR, Recovery Rate

INTRODUCTION

The novel coronavirus (SARS-CoV-2) was emerged in Wuhan, China in December 2019. Due to its high transmission potential, easy environmental adaptability and absence of definitive pharmacological treatment or vaccines, it has spread its wings all over the world. This COVID-19 pandemic has rapidly evolved to be the largest pandemic of the 21st century so far. Since its inception, the number of cases has been increasing worldwide. This upsurge of cases had been slower in India during the early phase of

the pandemic. However, India's COVID-19 tally crossed Italy, UK and Russia in the first and second week of June and the first week of July, respectively, and became the third worst-hit country in the world.¹⁻³ As on 5th July 2020, India accounts for around 6.03% of the global caseload, despite having 17% of the world's population.^{4,5}

Each country has tried a different approach to handle the COVID-19 pandemic. Upon literature search, it was observed that India, Italy, UK and the US were having contrasting differences in strategies adopted

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to curb this pandemic. Italy allegedly reacted late to the pandemic, which led to the COVID-19 tragedy in the very early stage of the pandemic.⁶ UK initially experimented with herd immunity and thus delayed any intervention.⁷ In the initial 80 days US did not announce any major restriction on public movements at the federal level.⁸ In the US, there had been variations in the stay-at-home policies and business closures at the level of different states. India went into pre-emptive lockdown at a very early stage. As of 5th July 2020, India, Italy, UK and US have approximately 6.7, 2.4, 2.8 and 28.4 lakh cases, respectively. While the total numbers of deaths are 19268 in India, 34854 in Italy, 44198 in UK and 129676 in US.⁹ Considering these wide variations in and figures of infection and mortality, it was felt interesting to see that how the curves of epidemiological indicators panned out due to differing preventive strategies (pre-emptive versus relatively delayed/ relaxed ap-

proach) in these four countries. Therefore, this study was planned with the objectives to statistically compare the trends of epidemiological indicators of COVID-19 in India with that of Italy, UK and US.

METHODS

This is a descriptive analysis of the COVID-19 data available from crowd sourced databases which include the reporting from state and central government agencies.⁹⁻¹³ All the available raw datasets of India, Italy, UK and US till 5th July 2020 were retrieved, which were having day-wise numbers of cases, deaths, recoveries and tests conducted. To avoid the extreme variations due to spikes in cases on particular days all raw data was converted into seven days moving average before calculating the following epidemiological indicators.

| | |
|--|--|
| Total cases per million populations: | Cumulative number of cases on a day / Total Population on that day |
| Active cases per million populations: | Active cases were calculated by subtracting the deaths and recovered cases out of total cases. |
| Average Growth Rate of cases (%): | This was calculated for each week by using the formula: (Total cases on 1 st day – Total cases on 8 th day) / Total cases on 1 st day. Each successive Sundays were considered as 1 st and 8 th days. |
| Doubling Time of cases (days): | This was calculated for each week by using the formula: $7 / (\ln_2 (\text{Total cases on last day}) - \ln_2 (\text{Total cases on first day}))^{14}$. Monday was considered as the first day and Sunday as the last day of the week. |
| Tests conducted per million populations: | Cumulative number of tests on a day / Total Population on that day |
| Test Positivity Rate (%): | Cumulative number of tests positive on a day / Cumulative number of tests conducted on that day |
| Recovery Rate (%): | Cumulative number of cases recovered on a day / Cumulative number of infected cases on that day |
| Case Fatality Rate (CFR): | Cumulative number of deaths on a day / Cumulative number of infected cases on that day |

To avoid the clumsiness in graphs, the trends of all the indicators were plotted by taking a fixed day (Sunday) at the x-axis. Active cases per million and recovery rates could not be calculated for UK due to the unavailability of data related to recovery.

Data were analyzed using Microsoft Excel 2010 and SPSS v.23. Analysis of co-variances (ANCOVA) was used to assess the significance of the differences in the trends of epidemiological indicators among these four countries. For the trend of each epidemiological indicator (dependent variable), time was considered as the covariate and countries as the grouping variable. To predict fatalities with the number of cases and tests conducted in each country linear regression models were developed. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Throughout the pandemic, the trends of total and active COVID-19 cases per million populations have been significantly ($p < 0.05$) different in India as compared to the other three countries. Italy has achieved

the plateau in the total cases per million populations, and active cases have been sharply declining with time. UK is about to achieve the same in a very short period. In India and US, although the gaps between total and active cases per million populations are widening, yet both the parameters are still progressing. No significant difference was found between the trends of the growth rate of COVID-19 cases among these four countries. (Figure 1)

The trend of doubling time of the COVID-19 cases in Italy has been significantly ($P < 0.05$) different from India, UK and US. Italy achieved a fast rise in the average doubling time, while UK and the US were at a relatively slower pace. This increment has been very slow in India. Immediately after the detection of the first case, exponential growth was observed in Italy, UK and the US. Since the reporting of first case, it took 110 days for India to reach the 1,00,000 mark of COVID-19 cases, while in Italy, UK and US this duration was 60, 77 and 67 days, respectively. In the further progression of cases from 1 lakh to 2 lakhs, it took only 6 days for US and 15 days for India, while Italy and UK touched the figure in 29 and 23 days, respectively. (Figure 2)

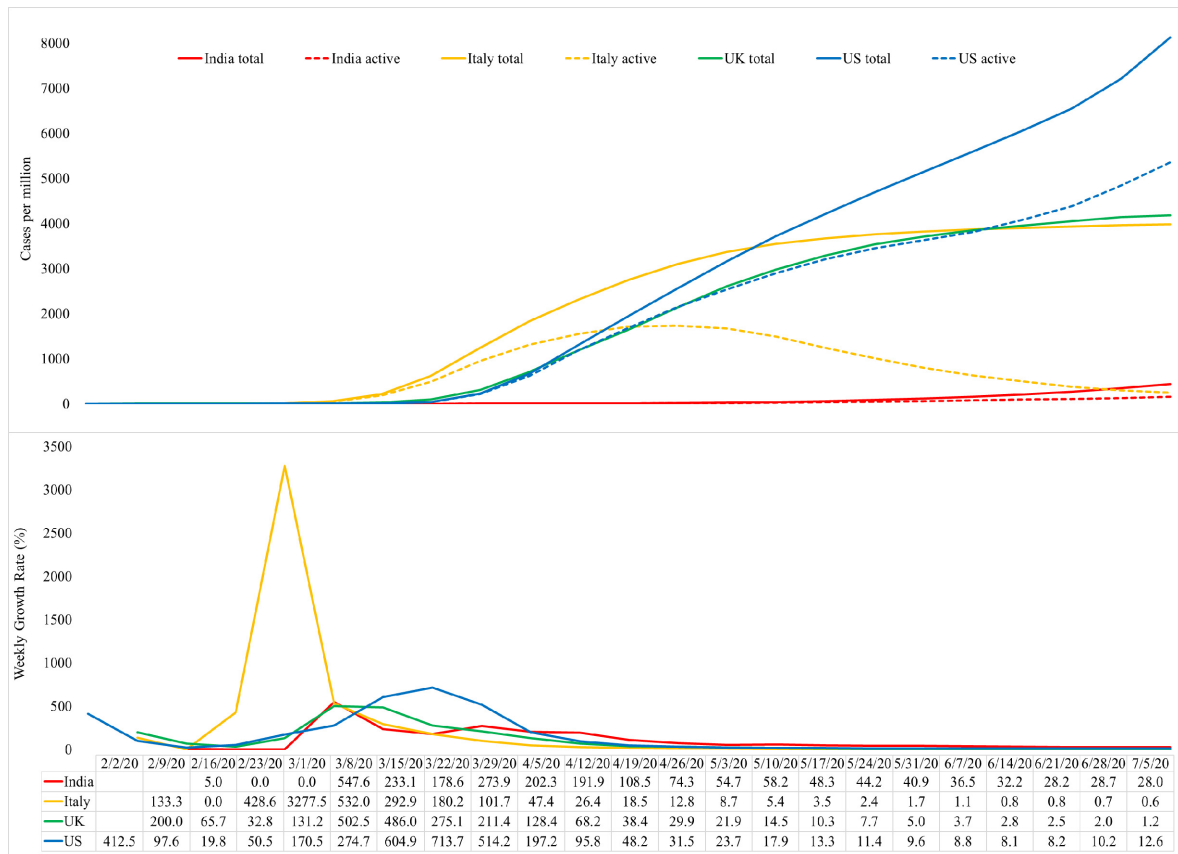


Figure 1: Trends of total and active cases per million populations and growth rate of cases

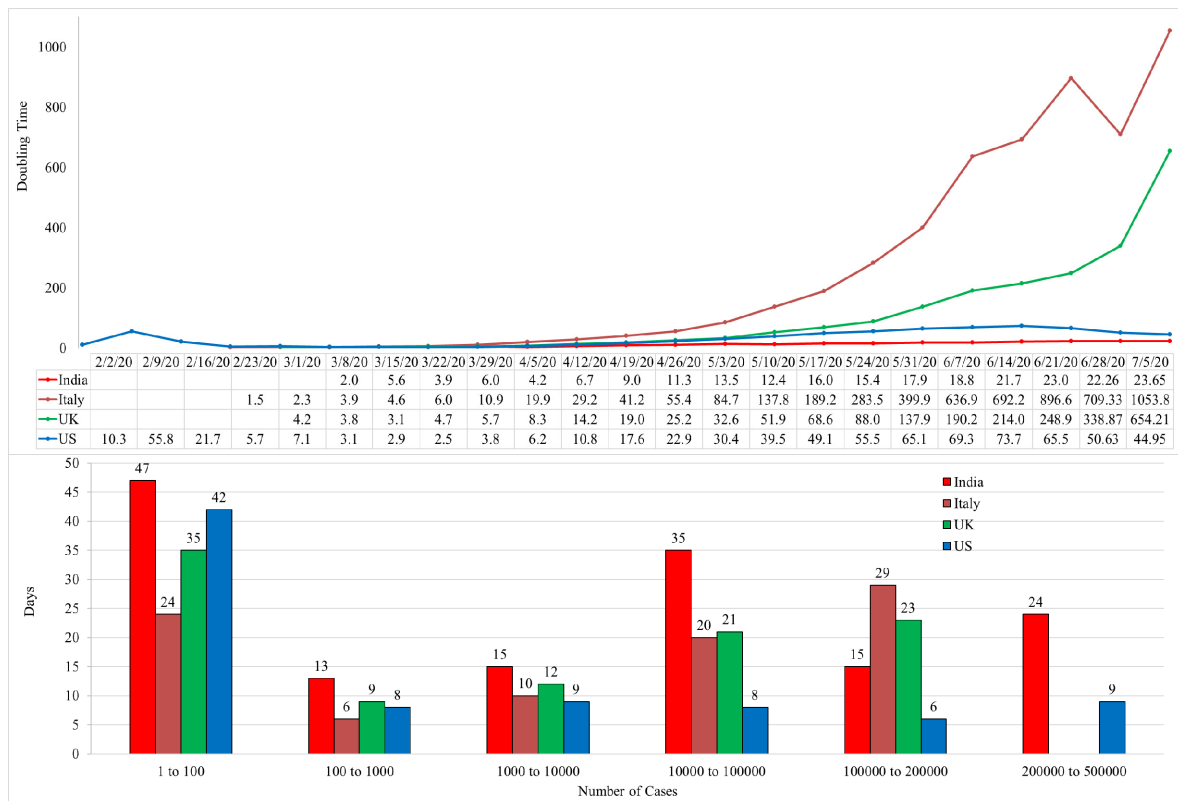


Figure 2: Trends of doubling time and time to increase the COVID-19 cases

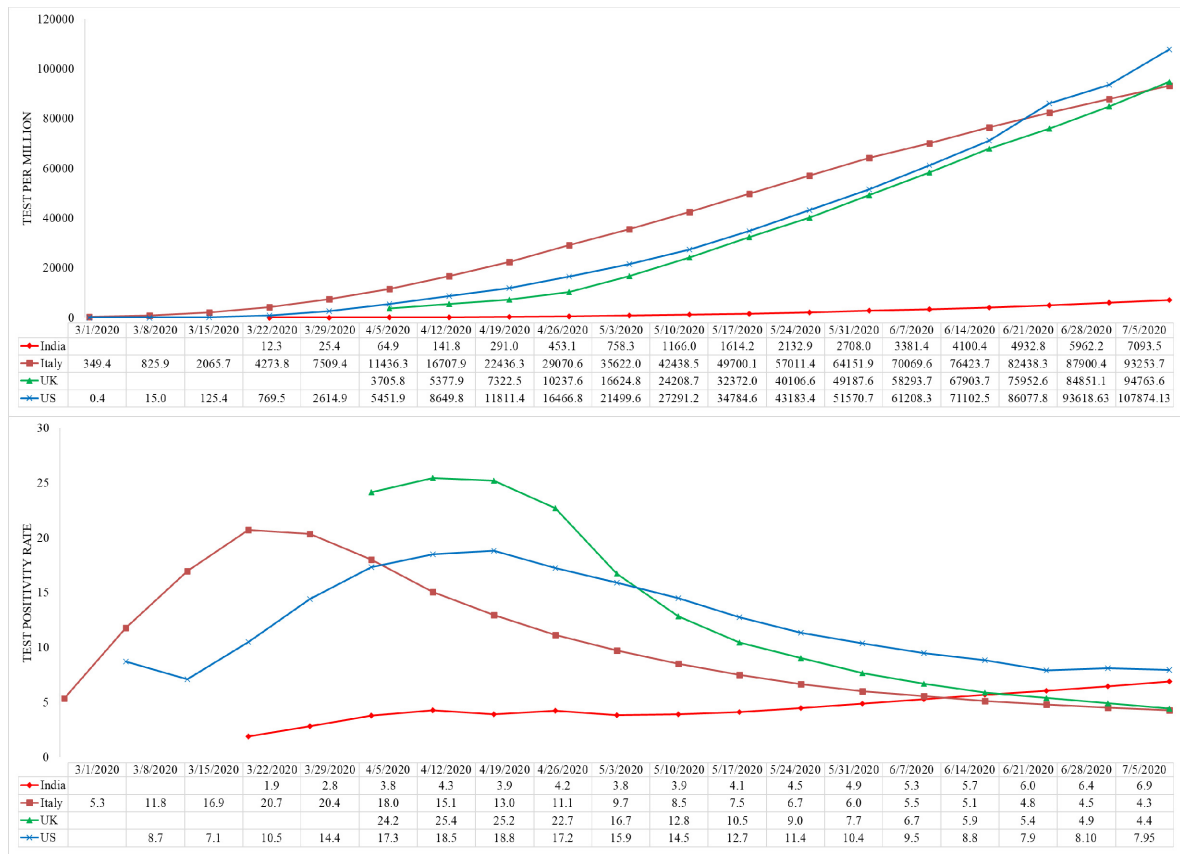


Figure 3: Trends of the rates of testing and test positivity rates for the COVID-19

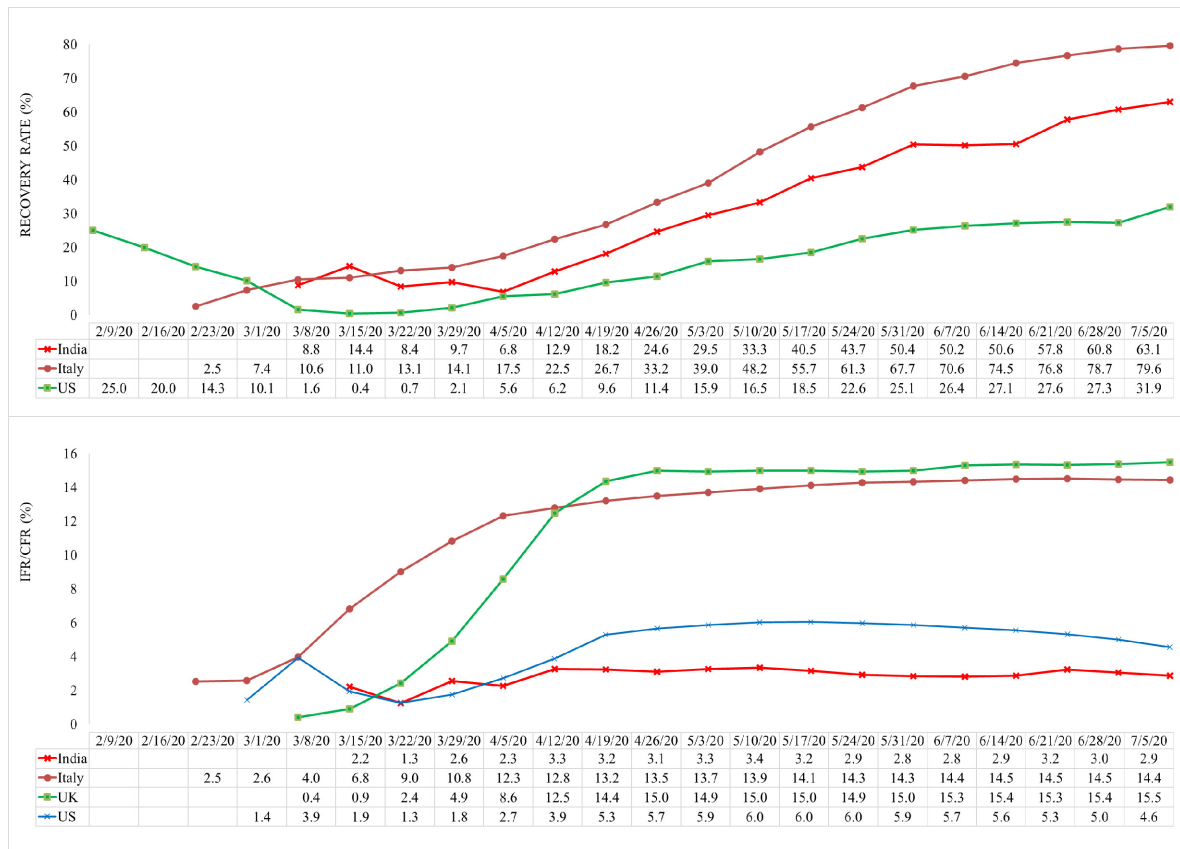


Figure 4: Trends of the rates of outcomes (fatality and recovery) of COVID-19 cases

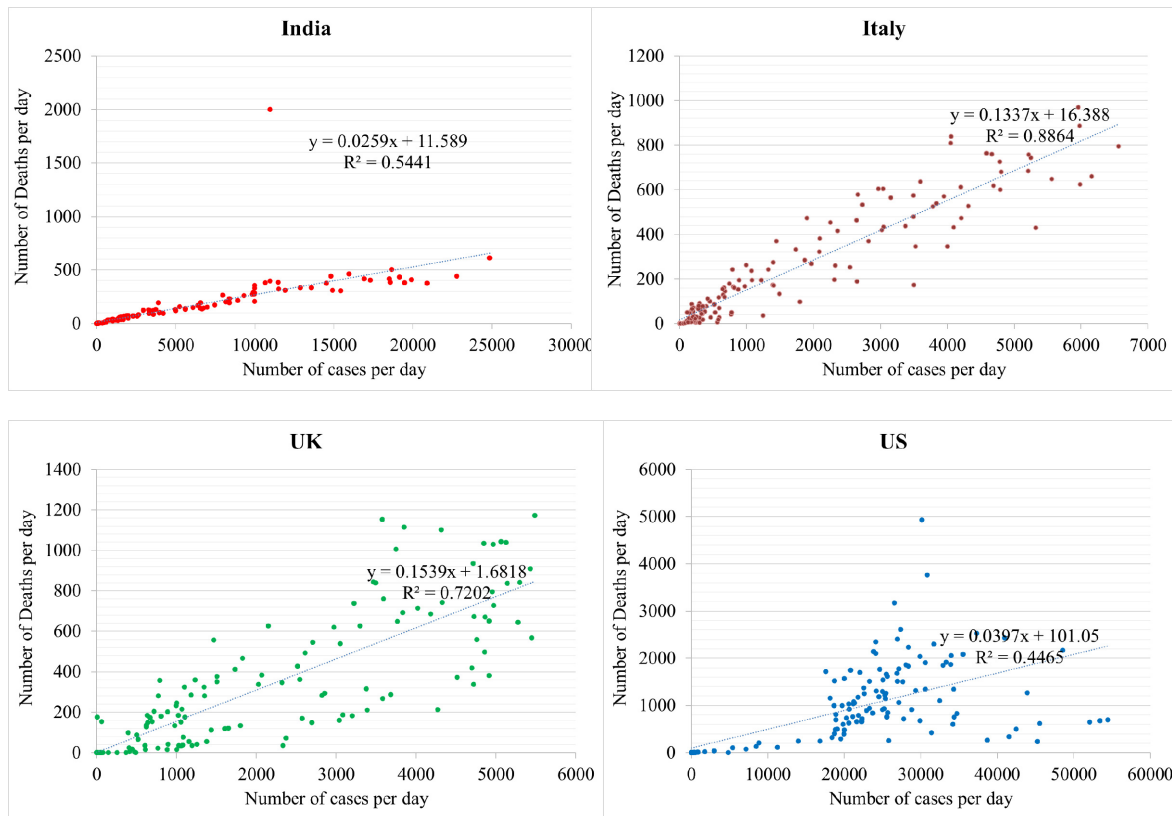


Figure 5: Linear regression model for the estimation of fatalities of COVID-19 cases

Table 1: Regression models to assess the effects of testing on the prediction of the fatalities due to COVID-19

| Country | Dependent variable | Model 1 | | Model 2 | |
|---------|--------------------|---------------------|----------------|-----------------------|----------------|
| | | β (95%CI) | R ² | β (95%CI) | R ² |
| India | Cases per day | 0.026 (0.022-0.030) | 0.544 | 0.009 (-0.010-0.027) | 0.481 |
| | Tests per day | | | 0.002 (0.000-0.003) | |
| Italy | Cases per day | 0.134 (0.126-0.141) | 0.886 | 0.137 (0.129-0.145) | 0.896 |
| | Tests per day | | | 0.002 (0.001-0.003) | |
| UK | Cases per day | 0.154 (0.139-0.169) | 0.72 | 0.122 (0.086-0.157) | 0.662 |
| | Tests per day | | | -0.002 (-0.004-0.000) | |
| US | Cases per day | 0.040 (0.033-0.047) | 0.447 | 0.045 (0.033-0.056) | 0.323 |
| | Tests per day | | | -0.001 (-0.001-0.000) | |

India has remained far behind than the other three countries in terms of its number of tests per million populations ($p < 0.05$). The trend of test positivity rate has also been significantly different in India as compared to the other three countries. In the initial phase of the pandemic, the test positivity rate of India was quite lower and did not have any peak. But this rate was continuously increasing with time and has overtaken Italy and UK in the first week of June. About 6 to 7 COVID-19 tests turned positive per 100 individuals tested in India in the first week of July. Though the test positivity rate in US is declining, yet it is higher as compared to India. (Figure 3)

The recovery rates in India, Italy and US have been progressive with significantly ($p < 0.05$) different trends. India has always reported a higher recovery rate than US and lower than Italy. The trend of CFR

was also significantly different in India as compared to the other three countries. In Italy and UK, CFRs increased rapidly in the initial phase of the pandemic, but have now achieved a plateau. In US it is found to be gradually declining, while it has remained almost constant in India throughout the pandemic. (Fig 4)

The linear regression model for the estimation of fatalities since the report of the first death from COVID-19 was constructed for all the four countries (Figure 5, Table 1). The beta coefficient for the countries depicted the slope parameter- i.e., the increment in the number of deaths with a rise in the number of COVID-19 cases. It was found that the number of tests was a significant covariate in influencing this relationship. The slope parameters of the countries were found to be significantly ($p < 0.05$) different from each other.

DISCUSSION

This descriptive analysis has tried to scientifically compare the trends of COVID-19 pandemic in India with Italy, UK and US through the use of appropriate epidemiological indicators. Data sets for this analysis were retrieved from available sources that may have quality issues. To have a proper insight in these comparisons, population structures and risk factor profiles of these countries are shown in table 2.

The present analysis has revealed that a direct comparison of the number of COVID-19 cases between the countries with varied demography and health system could be misleading. To provide an objective understanding to the general public, the total cases and active cases per million populations should be used. Total cases per million populations represent the comparable disease burden in the country, and active cases reflect the current caseload on the system. To fully understand this data, a comparison of the trends of average growth rates of cases per week in these four countries was performed. These comparisons using objective indicators suggest that India had a slower epidemic growth as compared to Italy, UK and US in the initial phase of the pandemic. But, a trend of constantly lesser doubling time of COVID-19 cases in India as compared to other countries creates confusion with respect to the interpretation of the growth rate of cases in India. This can be appreciated by the fact that, though these four countries reported the first case of COVID-19 within a 10-days' timeframe, the trajectory has differed for India. In US, the first case of COVID-19 was recorded on January 21st; in India it was January 30th, while in UK and Italy it was on January 31st, 2020. Comparatively, India's rate of spread of COVID-19 infection has been slow and it took comparatively longer to reach the 1,00,000-case mark. The variations in the cases per million populations between these countries may be determined by the median age of the population, the prevalence of smokers and the proportion of old age people in the country.

Considering India's dense and diverse population, this slow initial growth of the epidemic appears to be driven by the mass reduction in population mobility during national lockdown which was announced on 23rd March 2020 and was the largest such event in the history of pandemic response by any country.

The prompt and strict response by the Indian government is also reflected by the average stringency index of the country in the early phase of the epidemic, which illustrated the strictness of the country's interventions with respect to the stage of the spread of COVID-19.³⁰ Despite this slow initial growth, now the growth of cases is at a fast pace in India. It may be attributed to the relaxations in lockdown announced by the government of India, which led to the mixing of infected individuals.³¹

For objective comparisons, it was also crucial to take into account the testing capacity of the countries, because it is usually reasoned that the number of cases also depends on the number of tests conducted per million people in a country. Therefore, trends of tests conducted per million populations and positivity rates were compared. Though due to the large population size, the average tests conducted per million populations for India have been lesser than other countries, yet the test positivity rate in India has remained quite appreciable. But this can be argued based on the varying testing criteria or aggressiveness of testing in different countries.

The comparisons were incomplete without taking into consideration of the outcomes of the cases such as fatalities and recoveries. The data suggests that the recovery rate in India has remained poor than Italy, but has always been in a better position as compared to US. India reached an important milestone on 29th May 2020, when the total number of recovered patients (82627) crossed the number of active cases (78466). Italy achieved this milestone on 6th May 2020, while US has not achieved it yet. If these trajectories continue in the recovery rate, the gap between total and active cases per million is likely to widen in the coming days. This is quite remarkable considering the total population and available resources (Surge capacity and GDP per capita) in the country.

The major eye-catching factor during this pandemic in India has been its low CFR. A relatively younger population might be one of the reasons for the lower CFR in India since the risk of a fatal outcome is more among elderly people due to associated comorbidities such as cardiovascular diseases and diabetes.^{32,33} India's CFR of COVID-19 is also lower than the global CFR of 5.41% (as on 15th June 2020).¹⁶

Table 2: Comparison of population-level indicators of India, Italy, UK and US

| Parameters | India | Italy | UK | US |
|---|-------------------------|-------------------------|-------------------------|------------------------|
| Population | 1380004385 | 60461828 | 67886004 | 331002647 |
| Population Density | 382/sq km ¹⁵ | 206/sq km ¹⁶ | 281/sq km ¹⁶ | 36/sq km ¹⁶ |
| Median Age (years) | 28.4 ¹⁷ | 47.3 ¹⁶ | 40.5 ¹⁶ | 38.3 ¹⁶ |
| Geriatric Population (60+) ¹⁸ | 9.8 | 29.4 | 24.5 | 22.5 |
| Diabetes prevalence | 8.9% ¹⁹ | 8.3% ¹⁹ | 6% ²⁰ | 10.2% ²¹ |
| Smoking Prevalence | 10.7% ²² | 21.4% ²³ | 14.7% ²⁴ | 13.7% ²⁵ |
| Hospital beds per thousand ²⁶ | 0.53 | 3.18 | 2.54 | 2.77 |
| Average Stringency Index (SD) ¹³ | 60.1 (17.3) | 59.6 (25.4) | 45.7 (26.9) | 47.7 (29.2) |
| GDP per capita ²⁷ | 2009.98 | 34488.64 | 42962.41 | 62886.84 |
| Extreme Poverty ^{28,29} | 13.4% | 2.0% | 0.2% | 1.2% |

In Italy and UK, the CFR had increased rapidly in the initial phase of the pandemic. Although CFR has remained low in US as compared to Italy and UK, to date it is the worst-hit country due to COVID-19 as far as the number of total deaths is concerned. The proportion of geriatric people and prevalence of diabetes in the country can be an important predictor for the increment in CFR, which has been reported by scientific literature highlighting effect of diabetes on COVID-19 outcome.³⁴ Tests conducted per million populations, was found to significantly influence the prediction of fatalities in the present study.

CONCLUSION

The trends of all the epidemiological indicators of COVID-19 have been significantly different in India as compared to the other three countries. India had a slower epidemic growth in the initial phase of the pandemic as compared to Italy, UK and US. Though the trend of tests conducted per million populations in India has been low than the other three countries, the trend of test positivity rate has remained quite appreciable. The trend of recovery rate in India has remained better than US but poor than Italy. Throughout the pandemic, the trend of CFR has remained significantly at the lower side in India. Testing was a significant covariate in predicting the fatalities.

With this analysis, it can be concluded that, though all four countries have been hit hard by this pandemic, yet India was able to manage the initial phase of the COVID-19 pandemic due to early and strict government interventions and strong public health response. While unfortunately, the epidemiological indicators progressed at a fast pace in Italy, UK and US during the initial phase. Based on the findings, this study emphasizes the importance of early and aggressive public health measures as compared to the relatively delayed or relaxed approach in the containment of the spread of an epidemic or pandemic. But the battle against COVID-19 has not finished yet and there is a need for further improvements, as the epidemic curve is still rising in India and US, while Italy and UK could manage to bend it.

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