ORIGINAL ARTICLE

ESTIMATING THE POSSIBLE ROLE OF TESTING CAPACITY AND SOCIAL DISTANCING IN PREDICTING THE GROWTH RATE OF DAILY COVID-19 CASES

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Background: The purpose of this study was to estimate the effect of social distancing (days since the imposition of a lock-down) and the number of daily tests conducted per million population on the daily growth rate of COVID-19 cases. **Methods:** After excluding the first 30 days since the announcement of an index case in a country, relevant data for the next forty days was collected from four countries: Belgium, Italy, South Korea and United Kingdom. Two online databases: Our World in Data and worldometer were used for the collection of data which included the number of new COVID-19 cases and the number of tests conducted on a given day. The acquired figures were transformed into per million population of the given country. The growth rate of daily COVID-19 cases was derived and was used as the regress and in a multiple linear regression with the number of tests per million population per day and the number of days since a lock-down was imposed as the regressors. **Results:** It was found that the growth rate of daily COVID-19 cases decreased by .051% when the number of daily tests conducted per million population increased by 1. A .532% decrease in the growth rate of daily COVID-19 cases was observed with each passing day of a lock-down, which essentially represented the most effective form of social distancing. A significant regression was calculated ($F(2, 155) = 35.191$, $p=.014$), with an R^2 of .054. Neither the daily number of tests conducted per million population nor the number of days of maintaining social distancing (lock-down) was individually significant contributors to the prediction of the growth rate of daily COVID-19 cases ($p=.267$ and $p=.554$ respectively). **Conclusion:** An extensive and rapid increase in the daily number of testing capacity and maintaining social distancing can decrease the growth rate of daily COVID-19 cases. Depending on the availability of the required resources, timely implementation of these measures can lead to better outcomes for a given population.

Keywords: COVID-19; SARS; Social distancing; Testing; Pandemic; Growth rate; Curve; Corona; Virus

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INTRODUCTION

The first identified case of the severe acute respiratory distress syndrome coronavirus 2 (SARS-CoV-2) was reported in the city of Wuhan, China in December, 2019.[1] The virus quickly spread to the rest of the world leading to an ongoing global pandemic that caused almost 50,000 deaths by the start of April, 2020.[2] Initial studies revealed the virus having an incubation period of 2–14 days with human to human transmission via respiratory droplets, contaminated objects and surfaces. Preventive measures suggested by the WHO include regular hand hygiene, social distancing and increasing testing capacity.[3]

Globally, various initiatives were set in place, to avoid the further spread of the virus while the world continued to struggle for finding a solution.

In an effort to contain the COVID-19 pandemic, China imposed its first lockdown in the city of Wuhan on January 23, 2020. Shortly after Wuhan, the lock-down was extended to other cities of the Hubei province restricting the free movement of millions of people. Besides extensive testing, strict social distancing and thermal screening measures were being imposed throughout the country.[4] By the end of March 2020, the lock-down had been eased and life had started to return to normal in the majority of the China including the epicentre Wuhan. However, preventive measures still remained in place to avert resurgence.[5] WHO praised China's approach to the problem and suggested it as a model to be followed by the rest of the world in combating the COVID-19 pandemic.

Italy reported its first two imported cases of COVID-19 on January 31, 2020. On the same day, The Italian government suspended all flight operations with China and announced a state of emergency for the next 6 months.[6] Nevertheless, the number of cases kept growing over the coming days. Striving to contain the local spread, the Italian government implemented

further stricter measures and divided its national territory into three zones on March 1, 2020: red, yellow and the rest of the national territory.[7] However the numbers kept rising and a nationwide lock-down had to be implemented on March 10, 2020, to hopefully blunt the rising curve of new cases.[8] There had been reports that the efforts were not timely and extensive movement of the population before the lock-down may had been a reason for the massive death toll and spread of the virus in Italy.[9] After almost a month of the lock-down, it seemed to had been effective as the number of new cases kept declining.[10] During the time period of forty days from March 1, 2020 to April 9, 2020, Italy conducted daily an average of 345.138 tests per million population and the average growth rate of daily COVID-19 cases remained at 11.922% per day as shown in Figure 1.

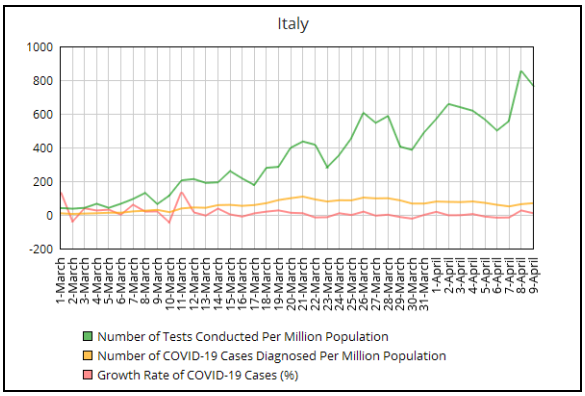

Figure-1: Line graph depicting then of tests conducted and COVID-19 cases per million population along with the growth rate of COVID-19 cases in Italy form March 1, 2020 to April 9, 2020 (mean number of daily tests conducted per million population = 345.138, mean number of daily COVID-19 cases diagnosed per million population= 58.921, mean growth rate of daily COVID-19 cases=11.922%)

South Korea announced its first confirmed COVID-19 case on January 20, 2020.[11] South Korea mainly focused on early testing and extensive thermal screening along with educating its population on social distancing. To ensure that suspected contacts properly followed quarantine guidelines and did not become the possible sources of transmission in the community, modern technologies like GPS tracing were employed.[12] Whilst most of the businesses were running as usual, South Koreans continued to follow social distancing and the transmission rate remained at its minimum. Many observers including the WHO applauded South Korea for its ability to keep the human and economic impact of the COVID-19 pandemic to its minimum.[13] From February 20, 2020 to March 29, 2020, South Korea conducted daily an average of 191.898 tests per million population and the average growth rate of daily COVID-19 cases remained at 25.455% as illustrated in Figure 2.

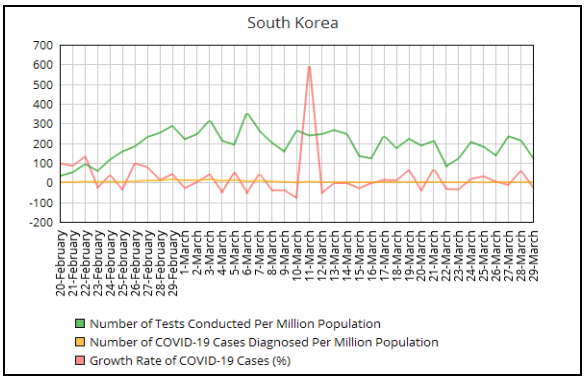

Figure-2: Line graph depicting the number of tests conducted and COVID-19 cases per million population along with the growth rate of COVID-19 cases in South Korea form March February 20, 2020 to March 29, 2020 (Mean number of daily tests conducted per million population = 191.898, Mean Number of COVID-19 cases diagnosed per million population= 4.658, mean growth Rate of COVID-19 Cases= 25.455%)

The index case of COVID-19 in Belgium was announced on February 4, 2020. Belgium went into a lock-down on March 18, 2020.[16,17] From March 5, 2020 to April 13, 2020, Belgium conducted an average daily of 269.081 tests per million population and the average daily growth rate of daily COVID-19 cases remained at 21.899% as depicted in Figure 3.

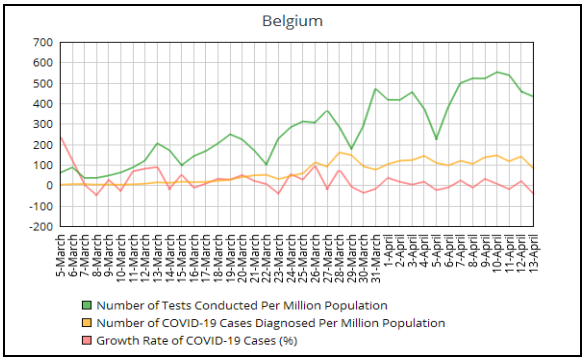

Figure-3: Line graph depicting the number of tests conducted and COVID-19 cases per million population along with the growth rate of COVID-19 Cases in Belgium form March 5, 2020 to April 13, 2020 (Mean number of daily tests conducted per million population = 269.081, mean number of COVID-19 cases diagnosed per million population= 65.934, mean growth rate of COVID-19 cases= 21.899%)

United Kingdom had its first case of COVID-19 on January 31, 2020. The United Kingdom announced a lock-down on March 23, 2020.[17,20] During the time period from March 1, 2020 to April 9, 2020, an average of 85.779 tests per million population per day were conducted and the average daily growth rate of COVID-19 cases was observed to be 36.404% as shown in Figure 4.

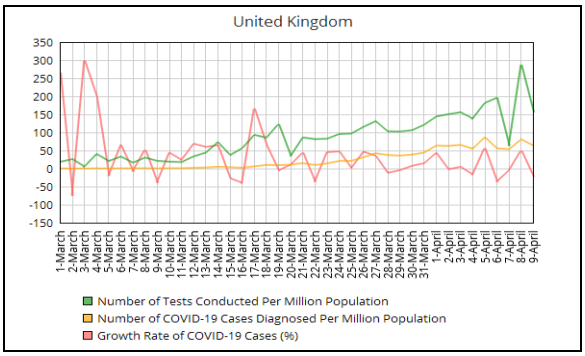

Figure-4: Line graph depicting the number of tests conducted and COVID-19 cases per million population along with the growth rate of COVID-19 cases in United Kingdom form March 1, 2020 to April 9, 2020 (mean number of daily tests conducted per million population = 85.779, mean number of COVID-19 cases diagnosed per million population= 23.953, mean growth rate of COVID-19 cases= 36.404%)

The purpose of this study was to provide a statistical basis for the effects of social distancing and testing capacity on the growth rate of daily COVID-19 cases and to help establish the base for future guidelines on tackling the emerging challenge of containing highly communicable microbial infections.

MATERIAL AND METHODS

Figures regarding the number of tests conducted and new confirmed cases of COVID-19 on a particular day were collected from two online database sources: Our World in Data and worldometer.[14,15] Countries for which adequate and reliable data regarding the number of tests and cases was available were chosen to be incorporated in the analysis. After thorough probing of the mentioned sources, Belgium, Italy, South Korea and the United Kingdom were found to fulfil the criteria and were included in the study. To select appropriate data, the time range for the collection of data was defined as the next forty days after excluding the first thirty days since the announcement of the index case in a country. The first thirty days were excluded assuming unreliability and inadequacy of the information. Collected data have been depicted in the form of line graphs in Figure 1–4.

All the necessary figures were shifted to an excel file and were transformed into per million population of the given country by dividing the figure by total population and then multiplying it by one million. The growth rate of daily COVID-19 cases was calculated using the equation {(final value - initial value)/initial value} *100. where "(final value - initial value)" represented the difference between the values of the variable on any two consecutive days with the initial value being the value on the previous day. Growth rates of daily COVID-19 cases for Italy, South Korea, Belgium and the United Kingdom have been illustrated in Figure 1–4.

Two independent scale variables were created, one represented the number of daily tests conducted per million population and the other accounting for the number of days since a lock-down was announced, with all days before a lock-down was imposed being assigned the value of zero. A scale variable constituting the growth rate of daily COVID-19 cases was taken as the dependent variable. A multiple linear regression was calculated using IBM SPSS Statistics for Windows, Version 16.0.

RESULTS

All the assumptions of linear regression were tested for and are reported in Table 1.

Table-1: Assumption of multiple linear regression

Assumption	Criteria	Model
Linearity	Scatter plot inspection	Satisfied
Multicollinearity	Tolerance < 0.02, VIF < 3	Satisfied
Autocorrelation	Durbin Watson value 1.5-2.5	2.080
Homoscedasticity	Scatter plot inspection	Satisfied
Normality of residuals	Normal Probability Plot (p-p plot)	Satisfied
Influential case bias	Cook's values < 1	Satisfied

A multiple linear regression was calculated to project the growth rate of daily COVID-19 cases based on the number of tests conducted daily per million population along with social distancing defined by "0" before lock-down and the number of days as "1, 2, 3, n" after a lock-down. A significant regression was found ($F(2, 155) = 4.387$, $p = .014$), with an R^2 of .054. The predicted growth rate of daily COVID-19 cases in percentage was equal to 35.191 - .532 (social distancing) -.051 (number of tests conducted per day per million population), where social distancing is measured as "0" = before lock-down, "1, 2, 3, n" = number of days after lock-down. The growth rate of daily COVID-19 cases decreased by .051% when the number of tests conducted per day per million population increased by 1. The growth rate of COVID-19 cases decreased by .532% per day when social distancing was in place. Neither social distancing (lock-down) nor the number of tests conducted daily per million population was found

to be significant individually (*p*- .554 and *p*= .267 respectively). Following is a tabulation constituting coefficients of the independent study variables.

Table-2: Coefficients table of the multiple linear regression analysis

	Study Model				
	Growth rate of daily COVID-19 cases				
	B	**SE B**	**β**	**T**	***p***
Number of daily tests conducted per million population	-.051	.046	-.157	-1.113	.267
Social distancing (number of days of lock-down)	-.532	.897	-.084	-.593	.554

DISCUSSION

Belgium announced its index case of COVID-19 on February 4, 2020, and went into a lock-down on March 18, 2020.[16,17] Average daily number of tests conducted per million population and the growth rate of daily COVID-19 cases in Belgium from March 5, 2020 to March 24, 2020 (first 20 days of the study) were noted to be 138.715 and 35.878% respectively. A decrease of 27.958% in the average growth rate of daily COVID-19 cases from 35.878% to 7.920% was then observed from March 25, 2020 to April 13, 2020 (last 20 days of the study).[14,18] Italy confirmed its first case of COVID-19 on January 31, 2020, and announced a nation-wide lock-down on March 9, 2020.[6,8] Average daily number of tests per million population and the growth rate of daily COVID-19 cases in Italy from March 1, 2020 to March 20, 2020, remained at 155.656 and 24.750% respectively. During the next twenty days, from March 21, 2020 to April 9, 2020, the average growth rate of daily COVID-19 cases dropped 25.657% from 24.750% to -0.906%.[10,14] South Korea had its index case of COVID-19 on January 20, 2020.[11] South Korea never went into a lockdown. The average daily number of tests per million population and the average growth rate of daily COVID-19 cases in South Korea from February 19, 2020 to March 9, 2020 (first 20 days of the study) were observed to be 182.715 and 152.541% respectively. Over the time period of the next twenty days (from March 10, 2020 to March 29, 2020) the average growth rate of daily COVID-19 cases showed a decrease of 125.444% by dropping from 152.541% to 27.097%.[14,19] United Kingdom announced its first case of COVID-19 on January 31, 2020, and went into a lock-down on March 23, 2020.[17,20] The average daily number of tests per million population and the average growth rate of daily COVID-19 cases in the United Kingdom from March 1, 2020 to March 20, 2020 were 41.609 and 59.251% respectively. A decrease of 45.694% in the average growth rate of daily COVID-19 cases was noted over the next 20 days (from March 21, 2020 to April 9, 2020) indicated by a drop in the average growth factor of daily COVID-19 cases from 59.251% to 13.556%.[14,21] Overall, our multiple regression analysis indicated a .051% decrease in the growth rate of daily COVID-19 cases when the daily number of tests conducted per million population increased by 1. In a similar study, Fiore VG and et al. found that a daily testing capacity between 0.7 to 3.6 was required to contain the disease provided that contact tracing and testing efficacy remained above 60%.[22] In our study we noted a 0.532% decrease in the growth rate of daily COVID-19 cases with each passing day when a lock-down was in place. Similar findings were observed by Vopham T *et al*. in their study of the effect of social distancing on COVID-19 incidence and mortality in the US. The study found a 29% decrease in COVID-19 incidence (adjusted IRR 0.71; 95% CI 0.57–0.87) and a 35% reduction in COVID-19 mortality (adjusted IRR 0.65; 95% CI 0.55–0.76) after implementation of stay-at-home orders.[23] Cobb JS and Seale MA in their study found that the compound growth rate of COVID-19 cases lowered by 6.6% and 7.8% after the presidential recommendation of limiting gatherings to less than 10 people and implementing shelter-in-place (SIP) orders respectively.[24] As to what is the best approach to deal with the COVID-19 pandemic remains a matter that merits an immense amount of analysis and discussion and though each having its own merits and demerits, no single approach can ever be sufficient. Populations around the world need to design their policies in agreement with their resources. Our study model suggests that social distancing combined with a rapid massive increase in testing capacity to identify and isolate the infected portion of the population, can prove a cost-effective approach to eventually decreasing the number of daily COVID-19 cases in a given population. Constant re-evaluation of facts and figures is indispensable to deciding, designing and modifying the best strategy to counter the ongoing pandemic.

LIMITATIONS

Data from some of the other worst-hit countries could have been very valuable but unfortunately, due to the unavailability of reliable testing figures, they could not be included in the analysis. The mentioned online databases sometimes modify their previous figures in light of new information. The data used in our analysis was the one that was displayed at the time of access. With the ongoing nature of the pandemic, continuous re-evaluation of figures is crucial to the fact that considerable changes might be observed in the coming days.

CONCLUSION

This study aimed to provide a statistical basis for the role of testing and social distancing in predicting the course of the COVID-19 pandemic defined by the change in the growth rate of daily COVID-19 cases. Data from four countries: Belgium, Italy, South Korea and the United

Kingdom were analyzed statistically. Depending on the point a population was in the course of the pandemic, social distancing and a sustained increase in the number of tests conducted per day was found to decrease the growth rate of daily COVID-19 cases. The earlier these measures are employed after the index case, the better the outcomes are expected to be.

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