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Original Research Article

Concurrent impact evaluation of lockdown measures on COVID-19 positivity in three states of India

Lincoln Priyadarshi Choudhury[1]*, G. R. Jammy[2], Rashmi Pant[2]

[1]Krashapana Consultancy Private Limited, Hyderabad, Telangana, India
[2]SHARE India, Hyderabad, Telangana, India

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***Correspondence:**
Dr. Lincoln Priyadarshi Choudhury,
E-mail: lincolnchoudhury@ gmail.com

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ABSTRACT

Background: In response to the COVID pandemic, many preventive steps have been undertaken in the India, including lockdown measures. The objective of the study was to analyze the impact of lockdown on COVID-19 epidemic.
Methods: We used quasi-experimental interrupted time series analysis using reported data from 17 March 2020 to 14 April 2020 with effective time interruption on 3 April 2020. We used publicly available data from three states to calculate the pre and post lockdown period COVID-19 test positivity.
Results: The lockdown was able to reduce the infections cases in all three states. The trend of positivity changed to negative for Tamil Nadu and Odisha and accelerated upward in Kerala. The trend changes for positivity were statistically significant for two states (Tamil Nadu and Odisha). In comparison to counterfactual, on 13 April 2020, the predicted relative change in COVID-19 positivity was maximum for the state of Odisha (108%), followed by Tamil Nadu (85%) and Kerala (78%) respectively.
Conclusions: The lockdown measurements were observed to be effective in the three states studied. However, the quantity of change varied from state to state. Policymakers and public health scientists can consider these findings ad methodology for future action.

Keywords: India, Interrupted time series, COVID-19

INTRODUCTION

The novel corona virus 2019 (COVID-19) transmission in India is ongoing. The first case was reported on 30 January 2020, the same day World Health Organization (WHO) declared the disease as a public health emergency of international concern.[1,2] As on 06 April 2020, there are more than ten thousand five hundred people actively infected, nearly 1500 have been discharged after treatment and 414 have died of the virus.[3] During this period the government of India and state governments have taken multiple steps to address the spread of the virus. This includes making COVID-19 a notifiable disease, screening of passengers for high-risk countries at the port of entry, banning travel from the high-risk countries, banning travel from outside the country, restricting movement inside the country, and invoking Public Health Emergency Act.[4] The complete lockdown of the country from 25 March 2020 to 14 April 2020 (which was extended to 03 May 2020) is focused on containing the spread of the disease with a focus on social distancing.[5,6]

Many studies have claimed the impact of social distancing measures, most of them showing positive outcome.[7-10] There are few publications that contradicts these claims.[11,12] There are many indicators to understand the movement of epidemic i.e. number of new cases, doubling time and percentage of people found positive. We

considered a single parameter i.e. number of people tested positive for COVID-19 or positivity to examine the impact of lockdown measures on positivity of the current COVID-19 epidemic in India. The objective of the study was to analyze the impact of lockdown on COVID-19 epidemic.

METHODS

Study design

The impact evaluation methods include both randomize trials and quasi experimental methods. As lock down was a nation-wide intervention, finding a suitable control was not feasible. Among the quasi experimental methods of difference in difference, regression discontinuity analysis, propensity score matching and interrupted time series analysis the last one was found to be suitable for the current analysis.[13-15] The decision for choosing this method was based on two factors: firstly, the lockdown measures were universal, which means there is a lack of appropriate control/comparison groups, thus, randomization was not possible, indicating the need for a quasi-randomized model, and secondly, availability of time series data before and during lockdown measures were available in the public domain.

Data collection

We collected the state-specific information from the COVID-19 daily bulletin provided by the respective state government websites. We cross checked the figures with the information provided by the government of India daily bulletin.

Selection of states

The states were selected on the basis of adequacy of data available in the state specific websites by the respective health departments. Adequate information was available in required details for three states of Kerala, Tamil Nadu and Odisha.[16-18] The required data for other states were either not available in the public domain or other publicly available information sources were available but not relevant, and were not chosen for analysis.

Data analysis

The duration of 17 March 2020 to 14 April 2020 was chosen for analysis. These dates represent the day the test results were announced not the days the samples were collected. The usual time gap between sample collection testing and availability of result was assumed as three days. The public announcement of lockdown was made on 24 March 2020 night. Considering the incubation period of COVID-19 (i.e. 7 days), time required for information percolation to the local levels and the time taken for sample testing, an average of three days, it was expected that the impact of the lockdown decision would be seen after ten days of announcement of lock down i.e. 04 April 2020. The end timeline for the analysis was 14 April 2020. Thus, the analysis considered two windows of time. The first one was before the effect of lockdown was felt (i.e. 17th March to 3rd April 2020) and second was during the period when the lockdown was observed (i.e. 4th to 14th April 2020).

We used ordinary least squares method to undertake the preliminary regression analysis of the data for the three states. Further analysis was undertaken for auto co-relation and partial autocorrelation functions to identify and include the auto regression or moving average processes in the final model with time interruption on 03 April 2020. The final model used generalized least square model fit by maximum likelihood method. This provided two linear lines. One that considered data till the 03 April 2020 and the other one that provided trend from 04 April 2020 till 14 April 2020. Both the lines are indicated in the Figure 1 as red and blue colour lines, respectively. Using the same fit, the trend before the lockdown was extended using the same fit (doted red lines) to create the comparison or counter factual, which provided the scenario of the trend of positivity in the absence of lockdown. "Further understanding of the detailed method of analysis is available elsewhere".[19] Data were analyzed using R software version 3.6.3 (holding the Windsock) for Windows.[20] The detailed code and data are available in the supplement.

RESULTS

Figure 1 depicts the level and trend of the COVID-19 positivity. The positivity is shown as solid red line for before the lockdown period and solid blue line for during the lockdown period. This shows overall varying levels of COVID positivity in the three states showing a declining trend during the lockdown. The dashed red line indicates the counterfactual scenario, i.e. if the conditions before the lock down would have continued further. The gradual decline in positivity in Kerala was found to be declining further both in level and trend after the lockdown (Table 1). The first day is calendar day 17 March 2020. The assumed date when the effect of lockdown was realized is 04 April 2020 onwards. The last day was 14 April 2020.

Table 1: Output values of analysis.

State	Coefficients	Value	p-value
Kerala	Time	-0.10	0.55
	Level	-1.55	0.61
	Trend	-0.10	0.81
Tamil Nadu	Time	1.07	0.00
	Level	3.85	0.41
	Trend	-2.68	0.00
Odisha	Time	0.00	0.99
	Level	2.91	0.03
	Trend	-0.38	0.02

The inceptions indicate the positivity level on the first day of analysis. The time indicate the trend of the positivity before the lock down. Which indicate that the detected

positivity was in declining phase for Kerala, increasing for Tamil Nadu and stable for Odisha. This suggests that in the absence of interventions/lockdown the positivity would have continued to decline in Kerala, increase in Tamil Nadu and remain stable in Odisha respectively. The level (Table 1) indicate the situation on the first day of the lockdown effect, in comparison to the previous day. This indicates that while Kerala would have lower positivity to start with, both Tamil Nadu and Odisha had a higher level than the previous day. The trend between the first day of lockdown effect and last day of the analysis shows negative trend for all the states irrespective of the positivity that they started with. However, statistically significant change was noted for the state of Tamil Nadu (-2.68, p value <0.01), and Odisha (-0.38, p value <0.05).

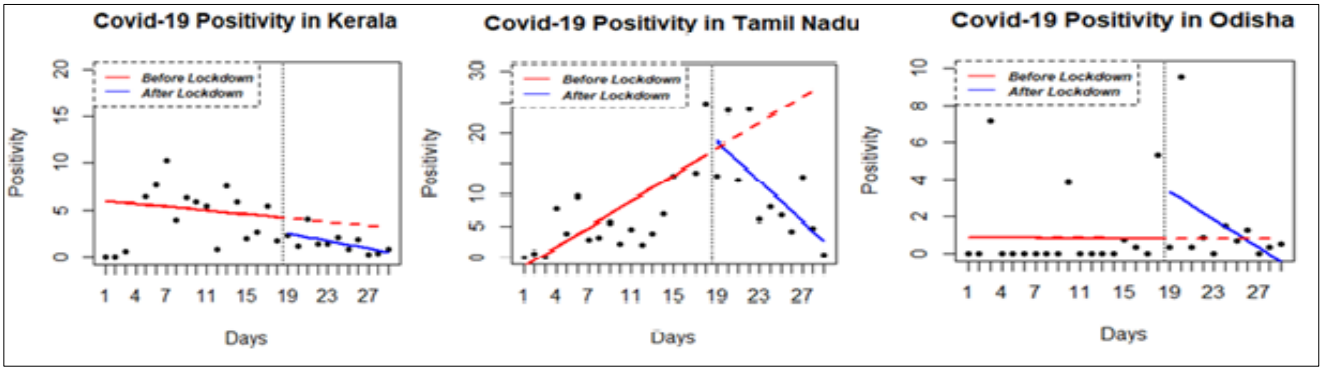

Figure 1: COVID-19 positivity in Kerala, Tamil Nadu and Odisha: interrupted time series.

In order to quantify the difference between the counterfactual and actual recorded positivity, we analyzed the absolute and relative change on 13 April 2020. The absolute change was the positivity on the given day and the estimation through counterfactual. The relative change was the proportion of the absolute change with respect to counterfactual (Table 2). The results show that all the changes are in negative count indicating the positive impact of lockdown in bringing down the COVID-19 positivity. The absolute change will be maximum for the state of Tamil Nadu, followed by Kerala and Odisha respectively. While maximum relative change is observed in Odisha with 108%, followed by 84.7% for Tamil Nadu and Kerala 78%.

Table 2: Calculated decline after four weeks of lockdown.

State	Absolute Change	Relative change
Kerala	-2.519951	-0.7887064
Tamil Nadu	-22.95942	-0.8470451
Odisha	-0.879809	-1.085416

DISCUSSION

All the three states in the analysis showed positive results because of the lockdown. The effect of lockdown was matching with the level of positivity. Higher the level of positivity before the lockdown period, greater the reduction of positivity during the lockdown.

Preventive measures and different epidemics

The spread of any infectious disease can be understood by finding the index case. It is not exactly clear when the epidemic of COVID-19 started in India, other than the first case detected in late January 2020. However, over the period of time it is clear that the epidemic in these states were different from each other, in terms of the first case detection, spread and influence of mobility. The first reported COVID-19 case varied from state to state. Kerala reported first case in the month of January, while both Tamil Nadu and Odisha reported the same in the early week of March 2020. By The first reported COVID-19 case varied from state to state. Kerala reported first case in the month of January, while both Tamil Nadu and Odisha reported the same in the early week of March 2020, several measures were taken by the state and the national authorities including setting up systems of disease detection, isolation, and treatment. In last week of March, the country adopted total lockdown measures. The increase in levels for the state of Tamil Nadu and Odisha are explainable. The rapid increase in positivity can be attributed to a large single-source outbreak reported with nearly 17% of the contacts testing positive. It led to ninety per cent of the state's disease burden.[21] The baseline daily identification of positives in the state of Odisha was low, other than a few spikes of positivity.

Quantifying prevention

Quarantine and isolation have been age-old practice to contain the spread of disease, the lockdown of the whole country, as large-scale quarantine and isolation, has perhaps happened for the first time. Though general observations are powerful tools for understanding the effect of lockdown, scientific measurement of the effect is important. Especially, when the assumptions are used, instead of scientific evidence, to predict various scenarios and presented to authorities to take appropriate action.[8,22-26]

Local facts for local measurements

The population of India is heterogeneous so also the health systems and their capacity to respond to a pandemic varies.[27-30] To improve the understanding of these measures this analysis was undertaken. The population of India is heterogeneous so also the health systems.[31] Thus the state-wise analysis is important and the same is reflected in the results. This also suggests that one needs to be cautious while making assumptions on the impact of any such large-scale interventions. Limitation of publicly available data restricted the analysis to the three states. During the lockdown period all the public health measures were also included like, travel ban, hand washing promotion. It was not possible to segregate those measure policy decisions while undertaking the analysis. The tools and methods are available on request for interested institutions or individuals to take the study forward.

CONCLUSION

This study shows that the country-wide lockdown measures in India had a positive impact on the COVID-19 pandemic by reducing the daily COVID-19 positivity in the three selected states. While most of the other studies assume level of changes due to lockdown this study provides quantitative information on degree of changes on COVID-19 positivity thus adding value to the body of existing scientific evidences to address the pandemic. This can be replicated in other states to generate state-specific information, to inform policy and further actions for containment.

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