Effectiveness of Granular Lockdown as an Epidemic Control Strategy in Kerala, India

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Abstract

Background: Lockdown is a time-tested methodology to cease infectious disease spread. The national and subnational lockdown effectively reduced the spread of COVID-19 in many countries, including India. The current article documents the effectiveness of lockdown at a more granular level, that is, the local self-government (LSG), the lowest administrative unit, in Kerala, a south Indian state.

Methods: We extracted all data pertaining to this study: the distribution of containment zones and the incidence of COVID-19 cases from official data sources of the Government of Kerala. As part of the study, we followed the progression of all LSGs as containment zones over the study period of 10 weeks (7/5/2020-15/7/2020). We created survival distributions characterizing the time to enter lockdown and the time to remain in lockdown for all the districts and the state. Finally, we conducted an interdistrict comparison of the cumulative incidence of COVID-19 per population for 6 months after the period of LSG containment was over to ascertain its effectiveness.

Results: Four northern districts of Kerala state had implemented lockdown strategy more rigorously both in the proportion of LSGs that has become a containment zone and in the period of containment compared to the rest of Kerala. As a result, the growth of COVID-19 cases in these 4 districts was less (7.5 times) than in the other districts (37 times) during the study period. However, the reduction in the disease incidence was not instantaneous; at the same time, it was not short-living as the difference continued to exist for 6 more months past lockdown.

Conclusion: Implementing granular lockdown strategies can effectively control the spread of disease only if it encompasses a sufficient area for an adequate period. We believe our research could help governments provide insights into the years-long and never-ending battle with the pandemic.

Keywords

Lockdown in COVID-19, containment zones, granular lockdown, COVID-19 in Kerala, effectiveness of containment, COVID-19 in India
curtailment strategies and lockdown enforced by the Indian government during the initial days have effectively reduced the transmission parameters, including reproduction numbers and growth rate. The national lockdown was later followed by phased relaxations, including decentralization of the unit of lockdown to state, district, and finally to the local self-government (LSG) level to improve regional acceptability and effectiveness through community involvement and to boost economic activity across the nation.

The LSGs are the grassroots level of administration in India, which gained constitutional validity vide the 73rd and 74th amendments. When it comes closer to the people, the onus of deciding whether to lock down an area will improve its acceptability among them. Though not as efficacious as a large area lockdown like a nation or a state, concentrating on smaller geographical domains will ease its administration and will not hamper the economic activity considerably. In this article, we attempt to explore the effectiveness of regional containment in curtailing the COVID-19 transmission by comparing the district-wide cumulative incidence of the pandemic.

Materials and Methods

Since the concept of containment zone came into effect on May 7, 2020, vide orders of the Ministry of Home Affairs, we included all relevant data after that, till July 15, 2020, for our analysis. During the above specified period, the unit of containment was LSG. A containment zone is a geopolitical area bounded by LSG where the diagnosed coronavirus patients or their contacts are more than an explicit threshold, according to the prevailing transmission pattern within that district. Declaration of LSG as a containment zone was made by the state but only upon the recommendation of the respective district administration. Hence, the criteria for selecting an LSG as a containment zone varies between districts and also with time. However, the extent of restrictions within a containment zone was governed by state guidelines and hence was the same across all zones at any given point in time. Since the declaration of containment primarily reflects the policy adopted by the respective district to which the LSG belongs, we conducted an interdistrict comparison of the containment strategy. We assume no difference in the intensity of containment between LSGs once they are marked as containment zones, as the guidelines to follow were the same across the state.

We explored and followed the progression of all containment zones from their date of declaration till the date of dropout during the study period. We created survival distributions, characterizing the time to lockdown and the other under lockdown for the 14 districts and the state. We used a composite indicator to categorize districts based on the below 3 components:

1. Median proportion of LSGs contained per day out of the total
2. Median number of days that the LSGs remain under lockdown
3. Median number of days to enter lockdown

A district is assumed to have followed a stricter containment strategy if at least 1 of the following holds:

1. A higher median proportion of LSGs contained than the state average
2. Median days under containment is more than the state average
3. Median days to enter containment is lesser than the state average

They have been categorized into group 1 districts. All remaining districts fell into group 2. We then made a group-wise comparison of the effectiveness of containment as a curtailment strategy on disease transmission by comparing the population-adjusted cumulative incidence of COVID-19 of these 2 district groups. We extracted all relevant data regarding containment zones and the daily number of incident COVID-19 cases within the state from the daily communications of the Kerala State Disaster Management Authority and the Director of Health Services using a checklist. We resorted to Kaplan-Meier survival analysis to construct the respective survival distributions for the time under lock down and the time to enter lock down for the LSGs. We used R (version 3.6.3) to conduct all statistical analyses.

Results

During the 10 weeks our study spans across, the LSGs ever contained were 434, including 374 grama panchayats, 54 municipalities, and all municipal corporations (n = 6).

District-Wise Distribution of Containment Zones and Rigorousness of Containment

The distribution of the proportion of LSGs contained per day in every district during the study period is depicted in Figure 1. On average, 10.8% (median = 10.8% [interquartile range {IQR}: 4.8-12.2]) of the LSGs of the entire state were locked down on a single day during the period. Kasargod, Kannur, Palakkad, and Wayanad, the 4 northern districts, had an exceptionally high proportion of LSGs locked down during our study period, which is more than the state average.

We constructed 2 survival distributions for all the 14 districts using Kaplan-Meier survival analysis, one for the time to lockdown (event of interest is the declaration of LSG lockdown) and the other for the time under lockdown (event of interest is the release from lockdown). The survival distributions for the state yielded a median of 41.9 days (IQR: 36.8-49.2) days to declare an LSG as a containment zone and 17.9 days (IQR: 17.1-19.8) that they remain in containment. The 4 northern districts (Kasargod, Kannur, Wayanad, and Palakkad) were characterized by a median time under containment of more than 17.9 days and a time to enter containment of fewer than 41.9 days. Hence, the LSGs of...
these 4 districts were characterized by an early and a prolonged lockdown.

We consider the 4 districts (Kasargod, Kannur, Wayanad, and Palakkad) as effectively contained districts (group 1 districts). These districts had 79.4% of all LSGs earmarked as containment zones anytime during our study period, and they accounted for a cumulative 4,759 containment zone-days (Table 1).

The median days of lockdown are 22 (IQR: 12-33) days. The remaining 10 districts (group 2) had only 30% of their LSGs as containment zones and could reckon only 2,577 containment zone-days with a median of 9 days (IQR: 5-13.3) in lockdown. The group 1 districts have 25 days (IQR: 20-30) as the median number of days to enter lockdown, whereas the rest have 54 days (IQR: 48-60). Hence, in addition to a higher proportion of locked-down LSGs, the group 1 districts were put under early and prolonged containment (Figures 2 and 3). We did a log-rank test to compare the survival distributions representing both district groups, and they came out to be significantly different (for the time under containment $\chi^2 = 11.6, P = .001$ and time to enter containment, $\chi^2 = 54.4, P < .001$).

**Effectiveness of Containment**

Over the 10 weeks of granular lockdown, the number of cases developed within the state is 270.94/million. However, after the strategic withdrawal of the LSG lockdown to move on to a more micro level, the state reported 4,148.3 cases per million over 10 weeks. Therefore, we did a pre- and postcomparison of the population-adjusted cumulated incidence at the district level using a Wilcoxon signed rank
Figure 2. Survival Distributions of the Time Under Containment.

Note: There are 155 LSGs that did not report the event (release from lockdown) during our study period.

Figure 3. Survival Distributions of the Time to Enter Containment.

Note: All LSGs had reported the event (lockdown).
momentum in the second group. Over 10 weeks, the disease has grown by 8.60 times in the group 1 districts, while in the second group, where the containment was less intense, the cumulative COVID-19 caseload has become 37 times. Two weeks past the official denouement of our analysis, the cumulative COVID-19 incidence of both district groups became equal at 680 cases/million of population (Figure 4).

We followed the progression of the disease for 6 more months (Table 2), where the difference in the cumulative incidence became 8,181 cases per million. Finally, we compared the population-adjusted daily case additions of COVID-19 between the 2 district groups using a Friedman’s test to ascertain whether the stringency of lockdown as measured by the proportion of LSGs underwent lockdown, the time under lockdown, and the time to enter lockdown, has become effective or not, which yielded a statistically significant difference ($\chi^2(1) = 145.95, P < .001$).

**Discussion**

The coronavirus disease has pressurized many health systems worldwide, regardless of how much they spent on health care.9,10 The Omicron has contributed to the crisis due to its extreme contagiousness, fast spread, and immune escape properties.11-13 Though we have a handful of vaccines

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**Table 2. Comparing the Cumulative Incidence of COVID-19 Between Group 1 and Group 2 Districts.**

| Date             | Group 1   | Group 2   |
|------------------|-----------|-----------|
| May 7, 2020      | 42.2      | 7.1       |
| June 7, 2020     | 115.9     | 40.3      |
| June 15, 2021    | 363.9     | 263.4     |
| One month        | 1,264     | 1,289     |
| Two months       | 3,044     | 3,520     |
| Three months     | 7,929     | 9,940     |
| Four months      | 12,153    | 16,707    |
| Five months      | 15,549    | 21,599    |
| Six months       | 18,672    | 26,853    |
available, there is severe inequity in the distribution, as the low-income countries could fetch only a minuscule proportion of it.\textsuperscript{14,15} The limited access to vaccination by most of the underdeveloped world had escalated the importance of nonpharmacological disease control measures like imposing movement restrictions, observance of hand hygiene, physical distancing, and wearing of masks.\textsuperscript{3,16,17}

Lockdown is a time-tested and highly efficacious preventive measure as it averts all sorts of interpersonal interactions.\textsuperscript{18} At times of containment, the number of contacts sufficient to transmit the pathogen reduces significantly, hence the effective reproduction number. Many of the countries had benefited from complete lockdown at some point in time during the pandemic.\textsuperscript{19-22} The combination of preventive strategies like school closures, travel restrictions, and physical distancing has been shown to have reduced the incidence of COVID-19 by a more considerable extent than individual measures alone.\textsuperscript{16,23-25} However, lockdown is not a sustainable remedy for disease control with no adverse effects. There are reports on how the restrictions on movement-measures badly affected the major economies of the world.\textsuperscript{26,27} Many authors report that there would be an impact on the agricultural sector and food security across the globe, jeopardizing the completion of many Sustainable Development Goals.\textsuperscript{28,29}

This article established the effectiveness of granular lockdown if appropriately implemented as a transmission intercepting measure. Since the area under lockdown is not as large as in the case of a nation-wide or a state-wide lockdown, the toll on the economy would be lesser, making it a more sustainable alternative than the former. Furthermore, enforcing restrictions would be easier over smaller geographic domains with more involvement of the people’s representatives. Since the early days of implementing the 3-tier system of decentralization, the concept of governments coming closer to the people has resulted in decentralized planning, ensuring overall development in many key sectors, including education and health care. However, there must be a minimum area to affect movement restrictions to reduce transmission effectively.\textsuperscript{30} Our findings show that implementing movement restrictions early enough and for a sufficient period to prevent disease transmission while ensuring that sensitive inclusion criteria are in place to recruit the smaller geopolitical regions, can be rewarding for a much longer period. There is a similar evidence to support that lifting off the stricter containment strategy to a more microlevel later in the course of the pandemic would result in exponential growth, as in our case.\textsuperscript{31}

Though lockdown is not the only answer to curb communicable disease spread, it can be regarded as a litmus to the prowess of the system, which undertakes early case detection, contact tracing, and implementation of other preventive directives over a broad jurisdiction. However, as pointed out earlier, lockdown is not a perpetual solution but one to be used judiciously along with other pharmacological and nonpharmacological options like wearing masks and implementing universal vaccinations.

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