Title:
Phase-wise Impact Analysis of the Indian National Lockdown against COVID-19 Outcomes

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Authors:
Vishwali Mhasawade MS\textsuperscript{1,2}, Siddhesh Zadey BSMS MSc-GH\textsuperscript{1,3}, and Aatmika Nair MBBS\textsuperscript{1,4}

Affiliations:
\textsuperscript{1} Association for Socially Applicable Research (ASAR), Pune, Maharashtra, India.
\textsuperscript{2} New York University, New York, United States
\textsuperscript{3} Department of Surgery, Duke University School of Medicine, Durham, North Carolina, United States
\textsuperscript{4} Mumbai District TB Control Society, Mumbai, Maharashtra, India.

Conflicts of Interest:
None

Background:
India was one of the most vulnerable countries to COVID-19 pandemic considering the high transmissibility of the virus, exploding population, and fragile healthcare infrastructure. As an early counter, India implemented a country-wide lockdown in 4 phases starting from March 25 to May 31, 2020. While effectiveness of lockdowns at national level have been assessed, sub-national differences remain elusive. We aimed to study the impact of the 4 lockdown phases and the 2 unlock (re-opening) phases on four outcomes at the national and sub-national levels using two analytical methods.

Methods:
In order to assess the phase-wise impact, we used projected data for multiple outcomes for India available from the Institute for Health Metrics and Evaluation (IHME). We assessed the impact of 4 lockdown and 2 unlock phases on 1) case growth defined as \( C(t) = \log(c(t)) - \log(c(t - 1)) \) where \( c \) is confirmed infections on day \( t \), 2) death rate in region \( s \), \( D(t) \) defined as \( D(t) = d(t)/\text{population in region} \ s \times 100000 \) where \( d(t) \) denotes the deaths observed on day \( t \), 3) effective reproductive number \( R_t \) which was modeled using the EpiNow2 R package, and 4) composite mobility index (mobility). With the interrupted time series regression (ITR) model we assessed the impact using percentage changes in the coefficients representing slope and intercept in consecutive phases. In Bayesian causal impact analysis (BCIA) we assessed the impact using the absolute effect sizes.
Findings:
We observe that the effects are heterogeneous across outcomes and phases. For example, ITR, the national-level changes in intercept & slope for lockdown phase 3 for D(t) were 0.020 and 0.919, C(t) were -116 and -400, R(t) were -296 and -196.70, while those for mobility were -58.90 and -30.78. BCIA revealed effect sizes of 9.223 for phase 1, 38.156 for phase 2, 28.231 for phase 3, 24.975 for phase 4 of lockdown, 24.571 and -1.057 for unlock phase 1 & 2 for mobility. At the state-level, Maharashtra benefited from the lockdown in comparison to Tripura. Effects of lockdown phases 3 and 4 on D(t) were correlated (R=0.70, p<0.05) depicting 'extended impact' of phase-wise interventions.

Interpretation:
We observe the highest impact on mobility followed by effective reproduction number, case growth, and death rate. For optimal impact, lockdown needs to be implemented at the sub-national level. Furthermore, findings can be compared to countries that didn’t have lockdowns during the same time period to understand causal effects.

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