Heterogeneous Interventions Reduce the Spread of COVID-19 in Simulations on Real Mobility Data

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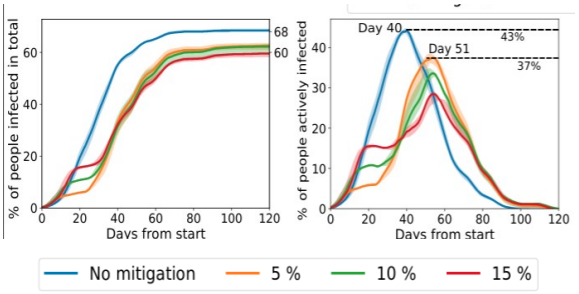
Major interventions introduced worldwide have slowed the spread of the SARS-CoV-2 virus. But large scale lockdowns come at a cost of significantly limited societal functions. We find that interventions focused on most mobile individuals and popular venues reduce both the peak infection rate and the total infected population while retaining high social activity levels. We observe these trends consistently in simulations with real human mobility data of different scales, resolutions, and modalities from multiple cities across the world. The observation implies that compared to broad sweeping interventions, more heterogeneous strategies that are targeted based on the network effects in human mobility provide a better balance between pandemic control and regular social activities.

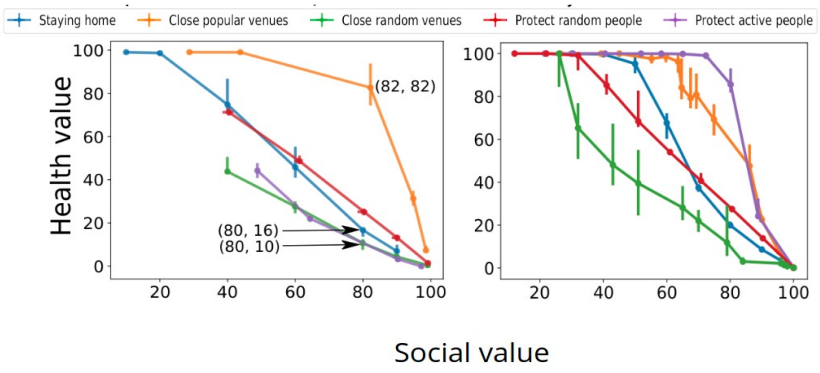
Method: We use a SEIR based multi-agent model to simulate the disease spread and use real mobility traces to get contact patterns between individuals. The study involves three datasets of two types of contacts. i) person to person meetings at an University campus and personal mobility using bikes; ii) check-ins at Foursquare venues. In type (i), the simulated disease is spread from a person to another through meetings, and via venue in the check-in data in type (ii). The disease simulation parameters are inheritted from the Covid-19 statistics.

Main Results:

Baseline uniform lockdown. We model stay-at-home order as a partial lockdown by randomly removing x% of mobility with limited duration (15 days). The peak of the infection is lowered and delayed, but this strategy alone does not significantly reduce the total number of infections when applied for a limited duration.



Heterogeneous interventions. We found that the most active individuals are infected significantly earlier and with higher proportion than the average population. Following these findings, heterogeneous intervention schemes put a higher level of protection on the most active agents and most popular venues to reduce their contribution to spreading the virus. The figure on the left shows this using two mobility datasets.



The social value is the fraction of social events preserved under the intervention. The health value of an intervention is measured as the fraction of agents who escape infection due to the intervention (but would have been infected otherwise).

We have further results on interventions by dividing the population into cohorts and only allowing people to meet within cohorts. This results in reduction in the spread, but found that it is more effective in small populations, and the effectiveness is often dataset specific. We also found that disease simulation on a complex network built from dynamic mobility data produces similar result in terms of epidemic statistics.

Full paper: https://www.nature.com/articles/s41598-021-87034-z