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(G*) Quantifying Density Hotspots and Potential Superspreading Events During COVID-19

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Social distancing measures have been the main non-pharmaceutical intervention (NPI) against the COVID-19 pandemic. Numerous large-scale analyses have studied how these measures have affected human movement, finding sizeable drops in average mobility. Yet comparatively little attention has been paid to higher-order effects such as "superspreading events"which are known to be outsized drivers of pandemics. Networks with heterogeneous (high variance) distributions of contacts can dramatically accelerate spreading processes, even if the average number of contacts is low. This stresses the need to quantify higher-order effects, and the (in)ability of existing NPI to reduce them.

Here we assess this by applying tools of statistical physics to approximately 12 billion anonymized mobile phone traces from 2.33 million devices in the Chicago metropolitan area, from Jan.1 to Jun.30, 2020, covering the first wave of state- and city-level social distancing measures in the pandemic. To identify potential super-spreading events, we grid these data at a fine spatial and temporal resolution, revealing large, transient co-localizations of people which we term hotspot events. We then ask about the spatiotemporal distribution of these events and the mobility statistics of the people participating in them–both before and after the implementation of social distancing measures.
Encouragingly, we find that distancing policies heralded a dramatic rarefaction of people, reflected in an increase in the entropy of their spatial distribution. As a result, we observe a concomitant drop in hotspot event frequency, with the largest reduction occurring in the urban core. This, however, belies a more worrisome trend: though we observe a large average reduction in the amount people travel (as measured by individual radius of gyration), this fails to be true for the subset of users participating in hotspot events. These users display higher-than-average baseline mobility, which persists (and even increases) during the post-lockdown period.

Our findings indicate that though social distancing policies may succeed in reducing average mobility, their effectiveness in reducing the key driver of spreading processes on networks (the second moment of the degree distribution) may be more limited. This in turn suggests the need for additional NPI specifically targeted at "super-spreading events".

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