# Geospatial digital monitoring of COVID-19 cases at high spatiotemporal resolution

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The novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has impacted our societies on an unprecedented scale. Worldwide, lockdowns and quarantines have been implemented to contain the spread of the virus, and are currently in place for more than 50% of the global population. These restrictive physical distancing measures raise many concerns regarding their adverse impact on our societies, economies, and health-care systems.

SARS-CoV-2 spreads via close contact during daily activities, forming clusters of cases mainly in households and workplaces. A crucial challenge to contain the spread lies in the early detection of these outbreak clusters, and the localisation and isolation of infected people. Modern geospatial tools leveraging the precise location of residence of patients with COVID-19 are key digital instruments that have great potential from a prevention perspective.[1] These methods, by allowing early identification of clusters and monitoring of local spread of disease across space and time,[2] can support strategies that dynamically inform epidemiologists and decision makers, to ultimately enable targeted interventions at a local scale.

Here, we present spatiotemporal diffusion dynamics of SARS-CoV-2 clustering, based on RT-PCR test results of 2877 georeferenced, confirmed positive cases among 12 918 individuals tested in the canton of Geneva, Switzerland, between Feb 26 and April 16, 2020 (51 days). On identification of a positive case, the approach consisted of tracing and testing close contacts of the case. Neighbours of positive cases were not contacted for testing. The Virology Laboratory at Geneva University Hospitals, as the reference laboratory for the canton of Geneva, did the tests and provided anonymised data. The addresses included in the analysis were geomasked with a random permutation technique within a radius of 200 m before geovisualisation to ensure patient privacy. We used the address of residence of individuals testing positive for SARS-CoV-2 and disease spatial clustering techniques (modified space–time density-based spatial clustering of applications with noise algorithm)[3] to highlight the diffusion dynamics. Our video, available online, shows the daily clustering dynamics of the 2877 COVID-19 confirmed cases and gradually characterises the respective behaviour of clusters (eg, emergence and reduction).

High-resolution spatiotemporal data analysis has been preferred over space-time kernel density estimation because the use of precise geoinformation facilitates the description and interpretation of disease cluster evolution in the presence of slight changes and complex cluster distributions.[3] Such an ongoing description of the geographical clustering of positive cases across space and time combined with an effective testing strategy has potential to 1) inform on the origin of the disease outbreak by identifying the first emerging clusters; 2) rapidly identify current spreading zones; and 3) enable accurate prevention and containment measures and timely resource allocation to mitigate any re-emergence of the epidemic.[4] The video shows that no clusters form within the first 8 days of detection of the first positive patient, indicating that if adequate containment measures are taken in the first affected neighbourhoods, there is considerable potential to curb the spread of the epidemic. Our analysis shows that the first clusters emerged in areas of high population density. These areas are inhabited by populations with the highest number of persons per room in the canton, suggesting an increased transmission due to residential overcrowding, which can make physical distancing challenging.[5] Further insight on the causes of diffusion is urgently needed to elaborate models to predict COVID-19 risk areas and will require robust analyses via mixed research methods, including spatial cluster detection combined with geographical context and sociodemographic and environmental factors.[6] This line of work should coincide with research characterising the spatial scales of SARS-CoV-2 spread.

As of April 20, more than 27 000 positive cases have been identified in Switzerland, with more than 4500 in the canton of Geneva. After several weeks of exponential growth, the rate of growth dynamics of the epidemic has reduced in Switzerland. These improvements are prompting the government to devise a plan for ending the national lockdown. However, dispersion of the virus will probably remain a reality until a vaccine is developed

See Online for video

and until appropriate levels of immunity are reached in the population. Meanwhile, the risk of a resurgence of the epidemic and of a second wave will remain. Digital contact tracing (DCT), a set of technologies enabling targeted isolation of people who have been in contact with positive cases, could be decisive during this challenging stage and is currently at the centre of discussions in various countries. However, DCT raises privacy, stigmatisation, and human rights concerns. We believe that the simple use of the precise address of residence coupled with geospatial methods constitute valuable tools for precision quarantines that can be mobilised immediately. Regarding potential privacy issues with the use of high-resolution spatiotemporal data, a large toolset has been developed in the past decade to address this challenge.[7] Geospatial approaches will be of best use as part of a multifaceted strategy that combines the advances offered by modern methods and technologies. In particular, when an acceptable contact tracing solution is developed and implemented, the data generated by DCT initiatives, such as the Swiss-led Bluetooth application, DP-3T,[8] will provide new avenues for analysis combined with geospatial analysis.

Beyond the monitoring of test results, one of the challenges is the necessary development of a virological surveillance system. In some countries, including China, Israel, Italy, Spain, the UK, and the USA, researchers have already developed enhanced COVID-19 epidemiological surveillance via daily cohort surveys that monitor citizens' symptoms while collecting personal and geographic information, yet at a lowered spatial resolution.[9] We aim to adapt such an approach locally by offering a participatory tool for population-wide rapid reporting of COVID-19-related symptoms,[10] guided by the advice of local policy makers and experts.

Leveraging precise geospatial information is part of the digital revolution of health care that is required to strengthen our disease prevention systems.[1] We call for cities and regions to develop geospatial strategies locally that use the data collected from their testing plan or population surveys.

We declare no competing interests. The presented study was approved by the Cantonal Research Ethics Commission of Geneva, Switzerland (2020–01081). SJ, LK, and IG contributed equally to this work. The dataset analysed during the current study are available from the corresponding author on reasonable request.



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