COVID-19

CONFRONTING VIRAL RESURGENCES: ARE LOCKDOWNS THE ONLY SOLUTION?

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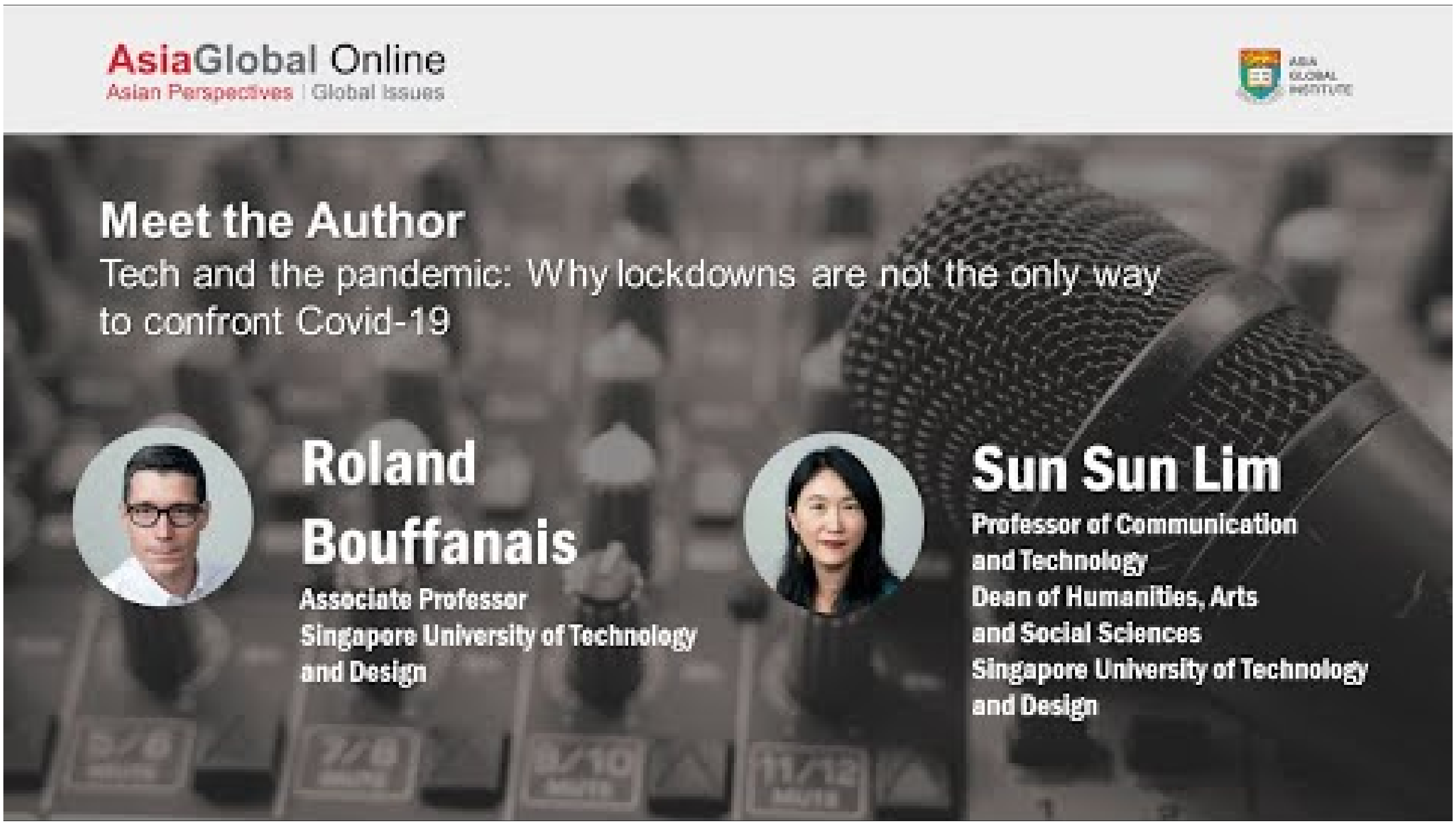
Much as combating the scourge of Covid-19 is a global priority, lockdowns are a bitter pill to swallow, given their harsh side effects, Roland Bouffanais and Sun Sun Lim of the Singapore University of Technology and Design argue. They need not be the only solution, and a more calibrated containment strategy can and should be developed using insights gleaned from big data.

Anti-lockdown, anti-mask protest, London, August 29: A blanket quarantine drastically reduces social interaction and leads to crippled enterprises, lost livelihoods and battered economies (Credit: Jessica Girvan / Shutterstock.com)

In what is a much rehearsed trope, cities that once had Covid-19 under control are reverting to lockdown conditions. Following a fierce, renewed surge in infections, Melbourne declared a state of disaster, subjecting its residents to nightly curfews and confining them to within five kilometers of their homes. Seoul has fallen short of imposing a full lockdown but further tightened restrictions in view of a recent viral resurgence. This includes closing schools, private tuition centers, health clubs and entertainment venues. After months of being free from the virus, New Zealand imposed lockdown across the country and a more stringent quarantine in Auckland, where a new cluster of infections had emerged.



By keeping people indoors as much as possible, such measures drastically reduce social interaction, thereby containing the virus. But they also lead to growing isolation, crippled enterprises, lost livelihoods and anemic economies. To achieve containment of the virus, without the associated economic collapse, a targeted risk-assessment approach that specifically identifies so-called "super-spreader" locations and vulnerable communities is more sustainable, particularly one based on a model of disease transmission that integrates data about human mobility, human co-presence within social networks and epidemic spread. Ideally, robust data must be systematically gathered among different communities and for a diversity of locales, including kindergartens, college campuses, convention centers, museums and other cultural institutions, nursing homes, and hospitals.

Big data analysis can help determine priorities in a pandemic – Should beaches stay open while gyms stay shut? (Credit: Adulwit Natheetavesak / Shutterstock.com)

The decisions to be made on restrictions and partial lockdowns often involve multiple data points and competing priorities. Can beaches remain open while gyms stay shut? Should schools proceed with lessons but adopt staggered arrival and dismissal times? If factories continue to operate, what safety protocols should be introduced? Can cruise ships and theme parks return to business and if so, with what modifications? How can cities thus strike a balance between maximizing public health and minimizing economic decline?

To answer such questions, public-health specialists and municipal government officials need to develop and refine the disease-transmission model to give them the capacity to pinpoint establishments that must be closed or safely reconfigured, businesses that can remain operational but with certain precautions, and population profiles that require closer management and heightened care. This is by no means a trivial exercise, given the incomplete knowledge about Covid-19 transmission pathways. But it is worth the effort rather than relying on the blanket lockdown approach.

The mystery of SARS-CoV-2 transmission

Although significant progress has been made in understanding the specifics of the SARS-CoV-2 virus behind the Covid-19 pandemic – its genetics, protein structure and medical effects on infected individuals – much less is known about how it actually spreads from human to human in different environments. That explains why super-spreading events have attracted so much attention: Why does the same virus in some cases not infect direct family members, while in some cases a single human carrier can infect scores of individuals?

For instance, an infected individual from the city of Yongin in Korea was found to have visited at least five nightclubs in Seoul's entertainment district of Itaewon on the night of May 1-2. He subsequently headed to other districts in the capital and neighboring provinces before testing positive for Covid-19 four days later. Alarmingly, contact tracing for this super-spreader connected him to a staggering 1,300 individuals. This notorious example clearly demonstrates the amplifying effect that some places might have in spreading disease.

Super-spreading events, however, should not be linked just to particular individuals with specific traits or behaviors, but must also be connected to local characteristics directly related to patterns of human movement, physical proximity and interaction. Contrast, for example, transient contact among many shoppers in a hypermarket with a few nursing home residents and staff in close, sustained interaction. These patterns are remarkably complex, especially in bustling, dynamic cities. Nevertheless, there are many components that can be employed to build this model to a reasonable level of applicability.

The multiple data streams we generate already provide valuable insights into the movement of people, objects and therefore, disease. Tracking human mobility patterns is especially critical because people transit in and through cities, potentially carrying and spreading disease to geographically disparate areas. As early as December 31, 2019, the Canadian health-monitoring platform BlueDot notified its customers about a new coronavirus outbreak. The company's proprietary disease surveillance program applies natural language processing and machine learning techniques to analyze news reports in 65 languages, together with airline data and reports of animal disease outbreaks. Its access to global airline ticketing data helped forecast travel patterns of infected individuals and its algorithm correctly predicted that the then-unnamed virus would propagate to Bangkok, Seoul, Taipei and Tokyo after its initial appearance in Wuhan.

Besides air travel information, ground-transport data have become significantly richer with the growing prevalence of ride-sharing services that collate detailed records of every journey. Such statistics can complement public-transport trip data already being tracked by bus, subway and train operators. Cities such as Paris, Singapore and Taipei have made some of their human-mobility data publicly available, but more granular information will facilitate constructing human-flow networks with the required spatiotemporal resolution – tracking human flows down to precise locations and to the hour or even minute. Similarly, smartphone apps for scheduling, navigation, payment, health and communication offer detailed and diverse information, presenting a composite picture of people's daily activities and interactions.

Integration is key to understanding data

Integrating such human-mobility and activity data with known factors of Covid-19 transmission can help model disease spread in a metropolitan area and help us pinpoint super-spreader locations and vulnerable groups. As more granular data is collected, the model should also afford greater precision over time. This endeavor requires a coordinated, large-scale multidisciplinary effort in three largely distinct domains:

Contact tracing app in Singapore: Smartphone data can present a detailed picture of people's daily lives and interactions (Credit: kandl stock / Shutterstock.com)

City-wide human movement network analysis A map may be built from data gathered about how – and how many – people travel between key sites such as schools, shopping malls, train stations or hospitals. This might be based on anonymized cell-phone data or information about journeys taken on public transport. Flows of people should be weighted according to the relative number of individuals moving from one location to the next. Inward and outward flows can be estimated at some key locations within a city using mobility data. Mixing of human flows at transport hubs, airports, museum exhibitions and similar gathering or meeting points may also be included. This can be executed using more granular indoor localization techniques such as Wi-Fi fingerprinting (movement is tracked through signal transmissions from people's devices to wireless internet hotspots), which is already in use in some shopping centers and airports for commercial purposes. Locations can then be ranked according to the intensity of incoming and outgoing flows and the diversity of journey origins and destinations. The ability to rank super-spreader locales using informed methods is ultimately dependent on the availability of data, which unfortunately remains inaccessible to scientists in many instances.

Analysis of human co-presence patterns at key locations The main features of flows of people and their interactions are known from prior studies of malls, train stations, hospitals, schools and parks, among other locations. Some expected patterns emerge: intense and peak flows in transport hubs on weekdays, and sustained flows at weekends in commercial centers, for example. Such distinct temporal patterns greatly influence the path of disease spread. More accurate data are needed for a wider range of venues at the heart of cities such as stadiums, bars, nightclubs and theaters.

Epidemiology tied to individuals This should include all known factors affecting disease transmission and knowledge about the disease in question. Particular demographic groups such as the elderly and immune-compromised are especially vulnerable. Insights into apparently risky social behaviors such as close contact in nightclubs and restaurants, as well as environmental factors pertaining to indoor versus outdoor settings, should be incorporated. In the case of SARS-CoV-2, such knowledge is evolving rapidly but the knowledge about other viral diseases with the same transmission mode – rubella or German measles, SARS, pertussis, smallpox and influenza, for example – can be harnessed to make initial headway.

How to better measure risk

By developing such an all-encompassing modelling framework, governments will then have the urgently needed tools to predict where the riskiest spots might be. They can then optimize finite resources that are fast depleting in the face of economic decline. Targeted measures are also vital for avoiding “virus fatigue”, which after more than eight months into the pandemic is wearing out communities and causing people to lower their guard and take more risks. As the pandemic rages on, blanket lockdowns are simply too blunt and wreak tremendous collateral damage to the economy. They should not - and need not – be the only solution to viral resurgences.

Further reading:

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Swarm Dynamics (Springer, 2016). He received his PhD in computational science from École polytechnique fédérale de Lausanne (EPFL) in Switzerland, for which he was awarded the ERCOFTAC (European Research Community On Flow, Turbulence and Combustion) Da Vinci Award Silver Medal in 2007 and the IBM Research Prize in Computational Sciences the following year.

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