Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Shut down and reboot—preparing to minimise infection in a post-COVID-19 era

Earlier this month, the European Commission gave its support to exit strategies using mobile phone data, recommending a pan-European approach for the adoption of contact-tracing mobile apps using anonymised and aggregated mobile location data. The endorsement is timely with a number of European countries, for example Italy and Germany, taking tentative steps towards lifting COVID-19 lockdowns.

Some countries have been using contact-tracing apps for a few months, while others are now developing them to aid the lifting of a lockdown.

Further afield in Asia, the city of Wuhan, China, where the pandemic began, recently lifted mass lockdown. With the eyes of the world watching, the city is effectively re-booting the social, cultural, and working lives of its inhabitants in the first example of a city's resurrection post-pandemic shut down. But wherever their location, cities and countries planning or implementing their so-called exit strategy are faced with a similar issue: how to protect citizens from a second wave of coronavirus infections. It is here that the judicious use of digital technology, including contact-tracing apps on smart phones, has a key role to play.

Jon Crowcroft from The Alan Turing Institute, UK, co-developed the FluPhone app that measured and modelled the spread of flu in 2011. "[Mobile phone] apps should help us reboot society and run in a steady state so that we effectively immunise society without having to [biologically] immunise everyone. Vaccines will come later", he asserts referring to COVID-19, speaking to *The Lancet Digital Health*.

Contact-tracing apps work either by logging a memory of proximity contacts comprised of time, duration, and distance via Bluetooth signalling between phones. Some apps also require the recording of the global positioning system (GPS) or location tracking position of phones that come within 2 m of each other. Different apps vary in the details recorded but effectively, if an app owner is diagnosed with COVID-19, their app immediately and anonymously notifies contacts of positive cases, who are advised via a message to self-isolate. With some other apps, government health officials are alerted and manually track down contacts.

Crowcroft explains that as the curve of confirmed new cases starts to flatten over time and the lifting of lockdown is considered, the threat of a mass resurgence of infection looms. Contact-tracing apps might be used in combination with a test—whether for a coronavirus antigen or for an antibody to help mitigate this challenge. "But these tests won't be 100% accurate. We'll need to trace and isolate infected individuals, which can be done if the rate of new cases is low enough." He says that this is broadly the model behind the novel UK government app being developed by NHSX, the UK health system's digital transformation arm.

The Singapore Government has been heralded for its success at controlling their COVID-19 outbreak early in March. Part of this success was put down to a Bluetooth-operated contact-tracing app, TraceTogether, that logs all proximity contacts made between phones over a 21-day period.

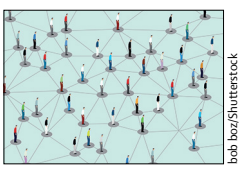
According to Singapore's GovTech official website, TraceTogether uses Bluetooth technology to exchange connections with nearby devices that have the app. The app only has the ability to show connections between devices, and not their locations. Furthermore, the logs stay in the user's phone. Should the Ministry of Health need the logs for contact tracing, they will seek the user's consent to share the logs with them.

Jason Bay, Senior Director of Government Digital Services at GovTech, developed the app with the Singapore Ministry of Health. He explained that transmission of the virus from an infectious patient can be determined using Bluetooth technology that measures duration and distance from others, rather than using location data. "It [GPS] fared poorly in indoor and highly urbanised settings. If you are one floor down in a building, your GPS location could look the same as someone in the floor above", he said. "You could argue that the virus doesn't care *where* transmission happens; it's only interested in whether there is a hospitable host in close contact."

If diagnosed with COVID-19, a TraceTogether user uploads their data to the Ministry of Health, and after decryption, officials use this information to contact other TraceTogether users who were in close contact with the COVID-19 patient. Unlike some other apps in development, including that of NHSX, TraceTogether works alongside conventional manual tracing where a health-care professional notifies contacts identified by the patient.

An app in China uses smartphone data on user movement and coronavirus diagnosis and, via a message on an individual's app, displays a green, amber, or red code to indicate their health status and instructs users to relax or enforce restriction. In a blog post, Bay stresses that "if you ask me whether any Bluetooth contact-tracing system deployed or under development, anywhere in the world, is ready to replace manual contact tracing, I will say without qualification that the answer is, No."

Christophe Fraser, an epidemiologist from the University of Oxford, UK, is



bob boz/Shutterstock

Published **Online**
April 28, 2020
https://doi.org/10.1016/S2589-7500(20)30103-5

For more on the **pan-European approach for the adoption of contact-tracing mobile apps** see https://ec.europa.eu/commission/presscorner/detail/en/ip_20_626 correct?

For more on **epidemic control with digital contact-tracing** see https://science.sciencemag.org/content/early/2020/04/09/science.abb6936

For more on **contact-tracing app TraceTogether** see https://www.tech.gov.sg/media/technews/geeky-myth-busting-facts-you-need-to-know-about-tracetogether

For more on **the contact-tracing app developed in China** see http://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html

For more on **privacy-preserving contact tracing platform TCN coalition** see https://www.tcn-coalition.org/

providing scientific advice to NHSX on the development of their new contact-tracing app. "As people start moving again, returning to work, then accurate and timely digital notification of contacts of new cases can target quarantine requests to those at highest risk of infection, and of transmitting infection to others." Fraser asserts. "If enough people across the population use the app [at least 60% needed], this could contribute to enabling most people to resume their livelihoods whilst minimising the number of people in quarantine and social distancing at any one point in time," Fraser tells *The Lancet Digital Health*. He adds that given the specific features of this virus, and that up to half of transmissions occur early in infection during the asymptomatic phase, traditional manual contact tracing would not keep up with the pace of this pandemic.

China, Germany, Singapore, Italy, Israel, and Spain are just a few of the countries that have already implemented contact-tracing apps. Communications manager at Vodafone, Steve Shepperson-Smith told *The Lancet Digital Health* that they had used aggregated mobile phone data—not individual level data—to aid the Italian Government in mapping out the movements of people during lockdown in Lombardy, the centre of the outbreak in Italy. "These data helped the authorities to understand how life changed [with respect to social distancing and movement of people] upon lockdown. In Lombardy, movement reduced by around 60% but they actually wanted more." Vodafone is now doing similar movement tracing in Greece, Spain, and Portugal.

Este Geraghty is Chief Medical Officer at California-based Esri, a company that builds mapping and spatial analytics software using geographic information system data for gathering and analysing data. She believes aggregated data drawn from various mobile phone companies can support our understanding of the effectiveness of social distancing. In partnership with Unacast, a US-based data aggregator, Esri facilitates the visualisation of transportation patterns during the pandemic through a social distancing score comparing current travel to a pre-COVID-19 time period, explains Geraghty. Esri illustrate this on a spatial data map, which could provide a foundation for public policy decisions across the USA.

But microbes, as SARS-CoV-2 has shown spectacularly, do not respect borders and likewise any contact-tracing apps need to work internationally. The recently launched Pan-European Privacy Preserving Proximity Tracing (PEPP-PT) organisation has developed a platform providing a common denominator for contact-tracing app development and implementation. "If we don't connect the datasets then opening the borders will be impossible", explains Hans-Christian Boos, a founding member of PEPP-PT. Boos also highlights the data privacy issue that goes hand in hand with contact-tracing app development. "In Europe we adhere to principles around data privacy that exist in democratic constitutions. It is possible to implement these apps without destroying privacy." As lockdown lifts, Boos points out that countries could go back to the containment phase—limiting spread by asking those people infected with COVID-19 to self-isolate, but it would have to be implemented much more effectively than the conventional manual way without a digital tool. "We might have to deal with this epidemic for a long time, so if we can manage by having only a few people staying home for a couple of weeks then this is feasible."

Other privacy-preserving contact-tracing platforms include Europe's DP3T, and the global TCN Coalition, which use temporary contact numbers and anonymous keys that maintain user privacy.

In the USA, researchers from the Massachusetts Institute of Technology have developed options for automated contact tracing through an app called SafePaths. Apple and Google are co-developing a cross-platform contact-tracing app via Bluetooth technology. In a press release they highlight that, "user privacy and security [are] central to the design". In May, the companies will release application programming interfaces (APIs) and operating system-level technology to assist in enabling contact tracing.

COVID Watch is a non-profit based in Stanford, CA, USA, which is developing privacy-first digital contact tracing. Spokesman, Rhys Fenwick, explains that should legal and cultural concerns around privacy be overcome in Western liberal democracies, privacy-preserving systems are preferable. "We feel the best way to do this is through the TCN protocol we're using, or the DP3T work being done in Europe. Given the support by Apple and Google for this method, it can likely achieve a high uptake rate."

Looking into the future when testing might become more commonplace, another app in development in the UK aims to be used alongside testing (of either a coronavirus antigen or antibody to demonstrate immunity), says Crowcroft. It relies on widescale testing including sampling people who are asymptomatic. "[This] might involve a communication to the individual to give them the all-clear or authorise a certificate of immunity or similar", he adds. "But this might only be valid for so long because we don't yet know how long immunity to COVID-19 lasts", he says, highlighting yet another unknown with this virus. "Again, this is about rebooting society and enabling people who are clear of COVID-19, or are immune, to go out as long as we can stop new infections and limit another outbreak early on."

Becky McCall