



## Perspective

### Contact Tracing for Covid-19 — A Digital Inoculation against Future Pandemics

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**O**utbreaks of coronavirus disease 2019 (Covid-19) emerged in the United States and in European countries in February 2020. Urgent action was called for, since experts

estimated that 30 to 70% of people in these Western countries could become infected — a frightening projection at a time when the Covid-19 mortality rate was estimated to be substantially higher than we now know it to be. In March 2020, Michael Ryan, executive director of the Health Emergencies Program of the World Health Organization (WHO), implored countries to act, noting that when it comes to epidemic response, “speed trumps perfection” but “the greatest error is not to move.” At the time, the only tools for containing Covid-19 were social distancing, testing, case isolation, and contact tracing.

Contact tracing is a crucial public health practice that has been a part of epidemic responses for

centuries. From the bubonic plague, to smallpox and tuberculosis, to HIV, the fate of public health has relied on our ability to identify people who have been in contact with infected people. In the case of Covid-19, however, the short time between symptom onset in the infector and that in the infected and the virus's propensity for asymptomatic transmission posed challenges for contact tracing. Recall bias, the inability to identify contacts who are unknown to the infected person, and a shortage of trained contact tracers were additional challenges. There was an urgent need to augment the scale and rapidity of contact tracing to identify everyone who had been exposed to Covid-19.

Twenty-first-century digital technology had the potential to enable this escalation. Modeling studies suggested that if digital contact-tracing apps were combined with other mitigation measures, Covid-19 epidemics could be slowed and theoretically even ended.<sup>1</sup> Lessons can be learned from the deployment of digital technologies to augment contact tracing during this pandemic.

The most basic measures of the effectiveness of a pandemic response are case numbers and deaths. By these measures, South Korea's response during its first wave of Covid-19 was highly successful. Having experienced the Middle East respiratory syndrome (MERS) in 2015, the South Korean people and their political leaders understood the need for early recognition of the pandemic threat and a corresponding robust response. They successfully integrated a rapidly scaled diagnostic capacity and contact-tracing system

with effective isolation and quarantine measures.

A key part of the South Korean contact-tracing system was digital contact-tracing technology. Legislative changes in South Korea arising from the MERS outbreak gave health authorities a legal foundation for using geolocation data for contact tracing from the very outset of their epidemic. Global positioning system (GPS) data from cell phones were used to create a centralized database of the movements of people with Covid-19 that was accessible online. The Corona 100m app used these data to warn users when they were near a location visited by an infected person. This intervention interfered with the privacy, data protection, and civil liberties of infected people, but it aimed to disrupt transmission chains to protect society's most vulnerable members.

In most Western countries, no such effort to enhance contact tracing using automation was implemented early in the epidemic. Without prior experience in responding to epidemics in this way, many leaders and citizens found it inconceivable that personal privacy and data protection rights could be ceded to health protection. Yet the fact that many people in Western countries already permit collection of geolocation data by other apps that provide little personal benefit suggests that the resistance to doing so for health protection, while well intended, may have been misguided.<sup>2</sup>

Automation using geolocation tracking allowed teams of epidemiologic investigators in South Korea to trace not only contacts but also the setting in which contact occurred up to 14 days be-

fore symptom onset or diagnosis. This information allowed them to gain a greater understanding of the settings in which SARS-CoV-2 transmission was occurring and to implement more targeted health protection measures in response. In contrast, traditional contact-tracing systems in most Western countries had the capacity to identify and notify only people who had come into contact with an infected person within 48 hours before symptom onset or diagnosis. This digital limitation perhaps contributed to the first wave of Covid-19 in Western countries that outpaced the epidemic in South Korea. By the end of their first epidemic wave in April 2020, South Korea had reported 10,423 infections and only 204 deaths — a remarkable achievement given the population size of just over 50 million. In contrast, European countries saw more than 2.1 million cases and 180,000 deaths by the end of their first wave in June.

Digital contact tracing is not a perfect intervention, given the risks to privacy, personal data, and false positive or false negative characterization of contact status. However, as in a Swiss cheese model, imperfect interventions can work together to curb epidemics. South Korea's deployment of digital technology to augment contact tracing was an example of speed trumping perfection, whereas Europe made the greatest error described by Ryan of the WHO: not to move. Having learned from this experience, Europeans may be much more amenable to sharing location data for contact tracing in health emergencies.<sup>3</sup> It should help in combating the next pandemic that the balance between preserv-

ing privacy and preserving life has changed during this pandemic.

As the first epidemic wave came to an end and the imminent threat of further loss of life eased, geolocation-based digital contact-tracing systems and their interference with personal privacy and data protection rights became less palatable. They became the subject of intense scrutiny in countries that used them, including South Korea and also Norway and Israel. In a pandemic that had the potential to last several years, many Western countries recognized the need for trustworthy, transparent, privacy-preserving digital contact-tracing technologies that were acceptable to Western populations.

Following the example of Singapore's Bluetooth Low Energy (BLE) digital contact-tracing app TraceTogether, Germany, Ireland, and the United Kingdom, among others, set out to develop their own systems, which had varying uptake by target populations (see table).<sup>4</sup> Western countries tended to favor a decentralized, privacy-preserving protocol for contact tracing — meaning that rather than being sent to central government servers, the data collected stay on the user's device, are encrypted, and are automatically deleted after 14 days.<sup>4</sup> By the end of 2020, there were at least 65 BLE-enabled digital contact-tracing systems worldwide, including 26 in the United States.<sup>4</sup>

Although it was never believed that these systems alone would end Covid-19 epidemics,<sup>1</sup> evidence is emerging that they have been beneficial in identifying higher numbers of contacts per case than has traditional contact tracing, increasing the number of people with Covid-19 who have entered

| A Selection of Digital Contact-Tracing Systems in the United States and Europe |                           |                                                             |                                              |
|--------------------------------------------------------------------------------|---------------------------|-------------------------------------------------------------|----------------------------------------------|
| Jurisdiction                                                                   | System                    | No. of Users<br>(Reported on or before<br>January 25, 2021) | Penetration<br>(Percentage<br>of Population) |
| <b>United States</b>                                                           |                           |                                                             |                                              |
| Colorado                                                                       | CO Exposure Notifications | 1,000,000                                                   | 17.36                                        |
| Connecticut                                                                    | COVID Alert CT            | 660,000                                                     | 18.51                                        |
| Maryland                                                                       | MD COVID Alert            | 1,075,000                                                   | 17.78                                        |
| New York                                                                       | COVID Alert NY            | 1,100,000                                                   | 5.66                                         |
| Pennsylvania                                                                   | COVID Alert PA            | 555,000                                                     | 4.34                                         |
| Virginia                                                                       | COVIDWISE                 | 826,000                                                     | 9.68                                         |
| Washington                                                                     | WA Notify                 | 1,125,000                                                   | 14.77                                        |
| Wisconsin                                                                      | WI Exposure Notification  | 1,000,000                                                   | 17.18                                        |
| <b>Europe</b>                                                                  |                           |                                                             |                                              |
| Austria                                                                        | Stopp Corona              | 600,000                                                     | 6.77                                         |
| Denmark                                                                        | Smittestop                | 619,000                                                     | 10.69                                        |
| Finland                                                                        | Koronavilkku              | 2,500,000                                                   | 45.31                                        |
| Germany                                                                        | Corona-Warn-App           | 18,000,000                                                  | 21.68                                        |
| Ireland                                                                        | COVID Tracker             | 1,300,000                                                   | 26.33                                        |
| Italy                                                                          | Immuni                    | 9,769,449                                                   | 16.19                                        |
| Norway                                                                         | Smittestopp               | 158,000                                                     | 2.94                                         |
| Switzerland                                                                    | SwissCovid                | 1,600,000                                                   | 18.67                                        |
| United Kingdom                                                                 | NHS COVID-19 App          | 19,000,000                                                  | 28.51                                        |

quarantine, shortening the time to quarantine by 1 to 2 days, and possibly preventing large numbers of infections thanks to downstream effects of augmented contact tracing.<sup>5</sup>

Challenges remain, however. Integration of digital contact-tracing technologies with existing test-and-trace systems appears to be an important determinant of their utility.<sup>5</sup> More importantly, digital contact-tracing technologies must be made accessible,

particularly to people with limited access to smartphone technology, those with limited digital health literacy, speakers of languages other than a country's primary language, and migrant communities. Increasing accessibility is important not only for maximizing uptake, but also for ensuring that all members of society can benefit equitably from digital advances in contact tracing. If these challenges can be overcome, Western countries will have

gained a trustworthy, privacy-preserving, accessible tool to use during the next pandemic to enhance contact-tracing capacity and control disease spread until elimination is achieved.

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