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Contact tracing for COVID-19: New considerations for its practical application

As lockdowns lift, talk is turning to whether and how to track those infected with COVID-19, as well as those they might have had contact with prior to testing positive. Here's how contact tracing works—and some of its benefits and limitations.

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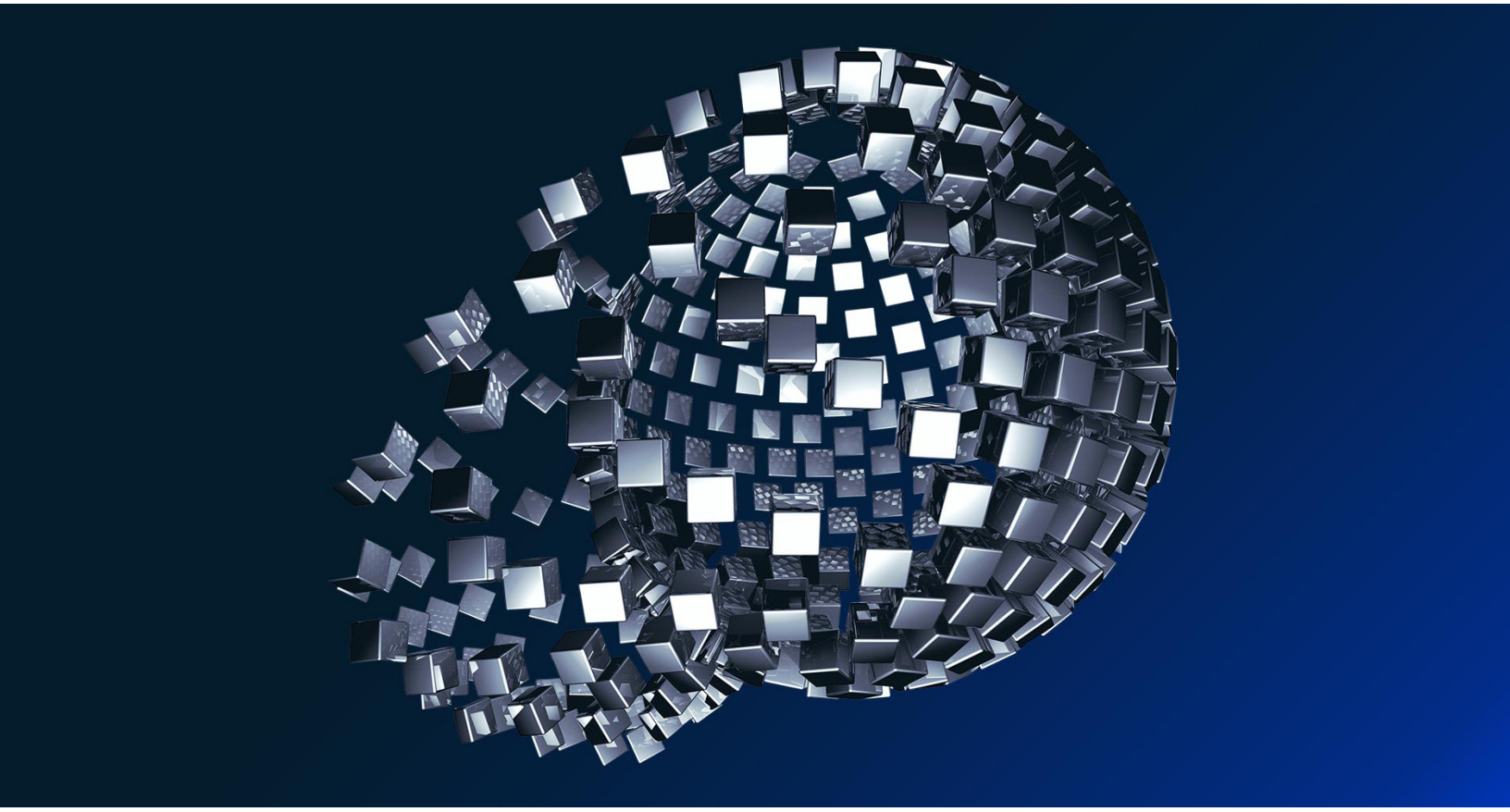

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Contact tracing is a decades-old tool for helping control the spread of infectious diseases. It has been used successfully in efforts to contain Ebola, SARS, MERS, tuberculosis, and other disease outbreaks.[1] It is now a critical part of the fight against COVID-19. In practice, contact tracing begins with those who test positive for COVID-19. Those with whom they have had close contact are then identified, as they may have been infected too. These contacts are notified and supported through a period of quarantine—until they develop symptoms, pass the window of risk, or are proven not to have been exposed. Widespread testing enables optimally effective contact tracing (Exhibit 1).

A cost-effective alternative to blanket lockdowns

Contact tracing enables a targeted approach: rather than imposing a blanket society-wide lockdown, authorities are able to isolate those potentially infected. Lockdowns are necessarily applied where the authorities do not know who has COVID-19. A highly effective program of testing, tracing, isolation of cases, and quarantining contacts can achieve similar benefits as a lockdown while allowing the vast majority of the population the freedom to conduct day-to-day activities. In a world where herd immunity and a vaccine are still far off, even a moderately effective contact-tracing program is an important tool for enabling countries to reopen society.

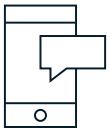
Exhibit 1

Contact tracing identifies and supports in quarantine the contacts of those who have tested positive for COVID-19.

How contact tracing works

Testing
Contact tracing begins with those who have tested positive for COVID-19. The method is most effective when integrally linked to widespread testing.

Identification
Contacts are identified and listed: those who have had meaningful exposure to the diagnosed individual during the period of potential transmission, which begins before the onset of symptoms.



Notification
Contacts are notified of their status, and informed of implications and next steps, such as how to find care. Depending on local public health guidance, quarantine or isolation could be required for high-risk contacts.

Follow-up, monitoring, and support
Contacts are monitored regularly for symptoms and tested for infection. Results of monitoring help determine the most appropriate intervention, including quarantine.

Approaches to contact tracing share basic elements but can differ in terms of technology: traditional contact tracing uses telephone and in-person contact; newer approaches use mobile apps and data. Governments need to evaluate the implications of alternative approaches to tracking and tracing for privacy and individual liberties.

Source: World Health Organization

[1] SARS, or severe acute respiratory syndrome, is caused by the SARS-associated coronavirus (SARS-CoV); MERS, or Middle East respiratory syndrome, is caused by the MERS coronavirus (MERS-CoV).

The cost of an effective contact-tracing program can be substantial. For the United States, for example, a recent cost estimate for one proposal was $3.6 billion. The relative societal cost of a full lockdown, however, is far greater.

The cost of an effective contact-tracing program can be substantial. For the United States, for example, a recent cost estimate for one proposal was $3.6 billion.[2] The relative societal cost of a full lockdown, however, is far greater. Contact tracing is most effective when it is supported by widespread testing and advanced isolation and quarantine approaches, but it can have significant impact on its own in limiting the spread of the disease.

Many countries seen as having had the most successful responses to COVID-19, such as South Korea and Iceland, made contact tracing a pillar of their approach. Most countries with high case counts, including the United States and Germany, have made contact tracing a priority for the reopening phase of their response. The case for a program of testing, tracing, isolation, and quarantine has been included in the strategies of the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), and other public-health organizations.

New programs, new considerations

For countries and organizations now developing contact-tracing programs, several important new considerations have emerged. First, nonsymptomatic cases make contact-tracing for COVID-19 more difficult, though still valuable. Second, some countries and localities are far behind others in their contact-tracing efforts. A further consideration is that the private sector will play a major role in the effort in many locations. Finally, effectiveness can be greatly enhanced by technological enablers, such as contact-tracing mobile apps, but these raise important questions about privacy.

Nonsymptomatic cases make contact tracing harder

Contact tracing is simplest and most effective when two conditions are met: a) all cases are symptomatic, and b) the presence of symptoms is perfectly correlated with the risk of transmitting to others. These conditions are approximately (though not perfectly) true of Ebola, which makes contact tracing an especially potent tool in fighting that disease. However, things are more complicated with COVID-19 because we know that the disease can be transmitted by people *who will never develop symptoms* (asymptomatic transmission) and by those *who have not yet developed symptoms* (presymptomatic transmission).

Of these, presymptomatic transmission is easier for a contact-tracing program to manage. When a person is diagnosed with COVID-19, identification of their close contacts should include those potentially infected in the days prior to the onset of

[2] "'Army' of contact tracers will be needed in coronavirus fight," NBC News, April 17, 2020, nbcnews.com.

symptoms. This condition increases the importance of rapid identification and isolation of cases and quarantining of contacts. It does not prevent the usefulness of contact tracing as long as programs move fast. In contrast, asymptomatic cases may never come to medical attention, making it harder to trace chains of transmission.

An influential paper recently estimated that 85 percent of transmission events originate from patients who have or will develop symptoms, compared to 15 percent from asymptomatic and environmental transmission.[3] Since that paper appeared in March 2020, serological surveys appeared suggesting that the rate of asymptomatic disease is higher than originally recognized. Exhibit 2 summarizes the uncertainty surrounding the question of asymptomatic transmission.

More research is needed, but early modeling suggests that transmission can be reduced by tracing and isolating symptomatic carriers without significant delay, in a process potentially enabled by technology.[4] In the meantime, many countries are concluding that the disproportionate weight of symptomatic cases in driving transmission makes the aggressive pursuit of contact tracing well worth the effort.

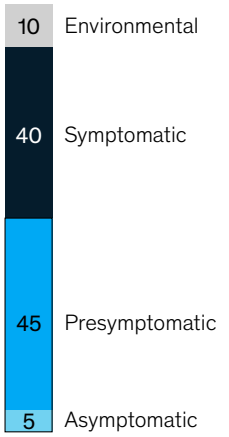
Many countries and jurisdictions are starting late

Contact-tracing programs begin with confirmed cases, from which chains of disease transmission

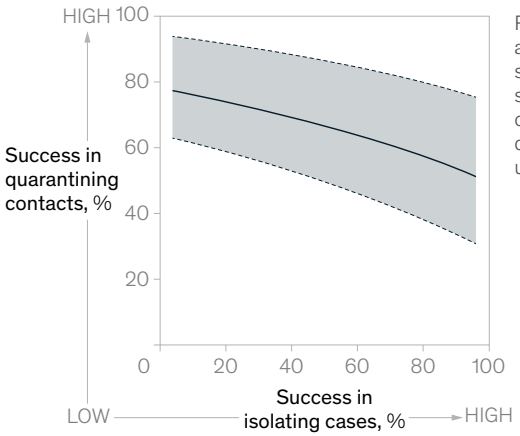
Exhibit 2

Research suggests that contact tracing can likely be successful for COVID-19, even with nonsymptomatic carriers.

Approximate distribution of COVID-19 transmission, %[1]



Intervention model



Potential reduction in R, assuming 1 day to isolate symptomatic patients; solid line is the threshold of epidemic control (R=0); dotted line represents uncertainties

Concerns about the efficacy of contact tracing for COVID-19 arise from the high proportion of nonsymptomatic carriers

Up to 85% of COVID-19 transmission comes from those who have or will develop symptoms

According to one modeling study, isolating and tracing symptomatic patients without delay can effectively reduce transmission of the virus

Early modeling suggests contact tracing requires speed, efficiency, and scale to counter nonsymptomatic carriers

[1] Consolidated from several studies.

Source: *Eurosurveillance; Lancet;* medRxiv; *Science*

[3] Luca Ferretti et al., "Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing," *Science*, March 31, 2020, science.sciencemag.org.

[4] Joel Hellewell et al., "Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts," *Lancet*, April 1, 2020, thelancet.com.

are mapped and contacts are supported in quarantine. The process works best where cases are relatively few in number.[5] Most countries that have deployed contact tracing successfully during this epidemic have maintained relatively low case counts. Some countries have in-depth experience with contact tracing from SARS, MERS, Ebola, tuberculosis, and other infectious diseases that disproportionately affect lower-income populations. Other countries have no such experience. Either way, however, to begin a contact-tracing program in an environment defined by hundreds or thousands of daily confirmed cases is a daunting proposition—especially since known cases represent only a fraction of the total.

We can, however, draw on the experience of the West Africa Ebola outbreak of 2014–16, which was the largest Ebola epidemic in history. Initial contact-tracing efforts could not cope with the scale of the challenge. Eventually, programs were built out and became a key factor in ending the outbreak. The number of cases of COVID-19 is more than 100 times that of the Ebola outbreak, but many of the countries worst affected by COVID-19 have far more resources than do Guinea, Liberia, and Sierra Leone, where Ebola was most concentrated.

The experiences in low-income settings are highly instructive. One important lesson is that the perfect must not be allowed to become the enemy of the good. A minimum scale is required for contact tracing to be effective, but a program need not identify and isolate every contact to slow transmission. COVID-19 will unfortunately be with us for many months to come, so countries should think of contact tracing as a medium-term investment. They will strengthen and improve their program over time, as one important tool in the overall set of solutions. The more effective the program, the fewer the sick, and the greater the level of economic freedom society will enjoy.

The private sector will play a bigger role than in prior contact-tracing efforts

Public-health institutions have led contact-tracing efforts in most past disease outbreaks. The global scale of the COVID-19 pandemic makes it a unique crisis with many parts. It has, for example, expanded into domains where the private sector plays a more prominent role in healthcare. To address the sheer number of cases in particular areas, authorities are assembling many partners, including from the private sector, in contact-tracing efforts. The use of technological enhancements is also drawing in companies with an array of specialized capabilities. Private healthcare organizations and employers are playing an important role in both testing and tracing. The complexity of those invested in controlling this pandemic creates both challenges and opportunities for contact tracing (Exhibit 3).

In the United States, contact-tracing efforts under way in Massachusetts and California are supported to varying degrees by private-sector companies, including private healthcare institutions.

In Massachusetts, a more centralized statewide effort is being rolled out, in which private and public partners have come together. Participants include the state's COVID-19 Response Command Center, Executive Office of Health and Human Services, Department of Public Health, Commonwealth Health Insurance Connector Authority (CCA), Partners In Health (a nonprofit with global contact-tracing experience), Salesforce, local health departments, and others. The Massachusetts League of Community Health Centers, Blue Cross Blue Shield, and other groups are starting to support the contact-tracing plan directly.

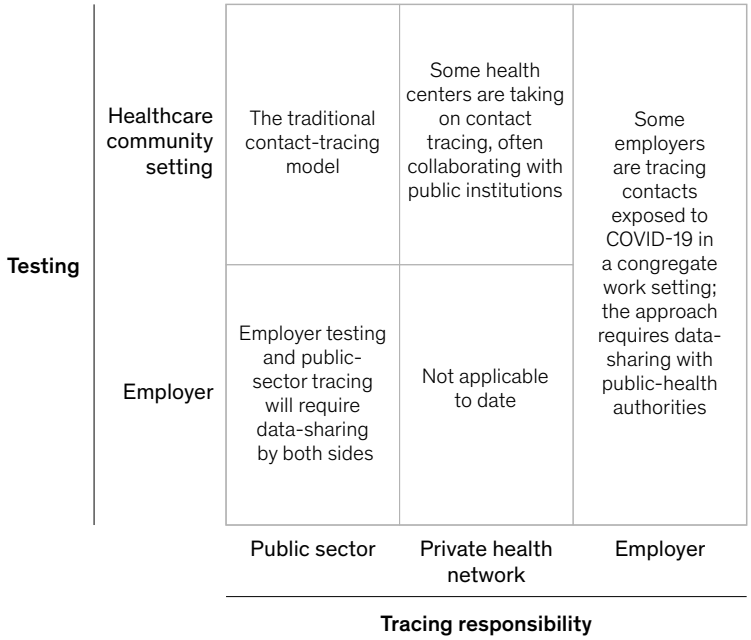
In California, statewide tracing efforts were just announced, but around the state, collaborative efforts have already begun. On the testing side, the governor announced the creation of 80 to 100 high-throughput testing sites, working in partnership with OptumServe and other organizations. Also announced was a program to train up to 10,000 contact tracers. Kaiser Permanente, a managed-care consortium, and other private healthcare institutions are establishing facilities to process 10,000 daily tests. This capability will become a critical link in high-efficiency contact-tracing programs.

[5] Ibid.

Exhibit 3

Contact-tracing efforts are usually led by the public sector, but lately employers and private-health networks are taking part.

Illustrative tracing methods



The availability of technology and the role that private health networks and employers are playing in some countries add complexity to the contact-tracing landscape

Health networks, academics, and affiliates have contributed, by undertaking contact tracing, providing technical guidance and training, and collaborating with public sector organizations

Contact-tracing efforts must always comply with local regulations and guidelines of health authorities, given privacy and risk concerns

Prior to broader announcements, counties and cities in California began to act. In San Francisco, a number of organizations and institutions, public and private, have come together to support tracing, including the city health department, the University of California at San Francisco, and Dimagi, a tech company. Participants in these collaborative efforts are providing diverse support, including testing, tracing, training, technical guidance, and technology.

Globally, employers can be seen taking a more proactive approach to testing and contact tracing, to ensure the protection of their own workforces. This approach has been taken mainly by organizations and institutions with significant resources, such as Fortune 500 companies, those that must operate in congregate settings, such as universities or nursing homes, and those that operate essential services, such as pharmaceutical manufacturers or healthcare providers.

These efforts usually include HR or a central health team that encourages employees to self-report if they have symptoms or a positive test. The team swings into action in the event of a confirmed or presumptive case. It identifies and notifies other employees (and sometimes contractors, customers, or visitors) who may have been in proximity, making recommendations for isolation or quarantine. Some employers are considering treating employee families and even local communities. For employers designing such programs, they should consider

how their efforts would best fit with the broader public-health effort against COVID-19. Other considerations include privacy concerns, legal constraints, and local regulatory compliance. On a practical level, planners would have to determine the data, technology, and people needed for identification, notification, and follow-up monitoring and support.

The promise and challenges of technology

In the context of contact tracing, technological solutions can increase productivity, limit exposure of the workforce, and lower costs. They can also increase the speed of response, which modeling shows to be critical to the overall success of contact tracing. In South Korea, for example, automated tracing helped reduce the amount of time spent on each case from one day to ten minutes. However, the technology has also raised privacy and civil-liberty concerns.

Around the world, technology is being deployed in all parts of the contact-tracing process, in identifying and notifying contacts, providing follow-up monitoring and support, and even alerting contacts when the status has changed. The following examples are simply descriptions of how technology is being used; we make no endorsements of particular uses, tools, or approaches.

— *Identification.* Those afflicted with COVID-19 and their supporters are using technology to identify contacts, entering names into lists or using digital data to create such lists. Massachusetts uses a back-end system to enter and keep track of contacts. In Nigeria, surveillance officers and others are using a system developed for the contact-tracing of polio. On the higher end of the technology spectrum, some countries are using digital data in applications that help automatically identify contacts by GPS or Bluetooth technology. In some of these countries, like Iceland, the backbone of the response was still manual contact tracing. By the time the application was rolled out, up to half of the diagnosed cases had already been in quarantine, a good illustration of how digital and manual contact-tracing solutions can support one another. (Iceland is also supporting isolation cases digitally with an AI-powered remote-care app.) Apple and Google's collaboration on a Bluetooth-based contact-tracing application program interface (API), to be released in May, will likely increase the attractiveness of more tech-enabled approaches to supplement current efforts.

— *Notification.* Technology is also being used to notify contacts and to generate anonymized mapping to notify the public of high-risk areas. (This helps reach those without access to mobile apps.) Often the contact notification is directly built into the identification system, so those who are identified are automatically notified. Some technologies offer both notification and mapping functions, such as MIT's Safe Paths. The MIT solution comprises both a smartphone application (COVID Safe Paths) and a web application (Safe Places). Digital contact tracing uses overlapped GPS and Bluetooth trails, which allow an individual to check if they have crossed paths with someone who was later diagnosed with the virus. On Safe Places, public-health officials can redact location trails and broadcast location information, with privacy protection for carriers.

— *Monitoring and support.* A number of technological solutions are being used for monitoring and support. Some allow daily digital check-ins or compliance monitoring. Healthy Together, a support application used in the US state of Utah, allows individuals to input symptoms and can direct people to testing locations as well as share test results.

Among country-level responses, South Korea and China deployed high-tech solutions within centralized data systems, alongside significant human resources.

— *In South Korea,* at-scale testing has been followed by rigorous tracing. The Korea Centers for Disease Control and Prevention, in collaboration with other government agencies, telecommunications, and credit-card companies, launched a COVID-19 data platform. Once a

case is confirmed, officials work out the patient's movements and contacts in great detail, through interviews, mobile-phone data, CCTV recordings, credit-card records, and other sources. The government shares major locations through text-messaging and making location data public, to help people avoid places where the virus is spreading. Millions have downloaded privately developed apps to help them view this location data, including Corona Maps and Corona 100m, which alerts users when they come within 100 meters of a location where an infected person has been.[6] South Korea has also launched self-quarantine applications to monitor and support contacts under mandatory quarantine.

— *In China,* the government introduced an app-driven access system to help ensure adherence to local regulations. This is the green-amber-red health-code system hosted by Alibaba's mobile payments app and Tencent's messaging app WeChat. Using both self-reported data, and data from authorities, the app segments users into three color codes: green (healthy), amber (contact with infected individual), and red (symptomatic or tested positive). Those with green classifications can travel freely, whereas those with amber or red classifications may face travel restrictions and quarantine or isolation requirements.

Some technology-driven approaches have raised privacy and civil-liberty concerns. Some applications will be generally noncontroversial, while others will raise concerns. Worth noting is that some privacy and civil-liberty considerations can be addressed through the design of technologies and the approaches through which they are deployed.

Organizations will have to think through the means by which they will identify individuals and gather, share, manage, and retain data. Bias reduction must be a priority, with due consideration given to disadvantaged groups, including those that may be disproportionately underrepresented or misrepresented by the technology used.

Consent can be an integral part of the process for identification and enrollment. Organizations can indicate directly what data will be collected and how it will be used. Developing data-sharing guidelines, minimizing data collection, and anonymizing and encrypting data can all be done in order to support privacy rights. Clear conditions can furthermore be established on how and when data will be deleted. With these considerations in mind, organizations can aim to use technology to enable a safer, more efficient, and faster response that could support reopening. It will be important to watch how these solutions evolve.

Many public-health assessments and much practical experience indicate that contact tracing has been an essential part of the most effective strategies to control COVID-19. As World Health Organization guidelines make clear, contact tracing is one of three backbone elements to its response to epidemics, along with widespread testing, isolation, and quarantining. There is more to learn as contact tracing is rolled out in additional locations, so leaders should build learning and improvement into their processes from the start. As localities develop and improve their own responses, they must negotiate a delicate path between the urgency of controlling the pandemic, the need for societies to reopen safely, and the privacy concerns that technological solutions continue to provoke.

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[6] Details on the use of information and communications technology (ICT) in Korea's pandemic response are presented in *Flattening the curve on COVID-19: How Korea responded to a pandemic using ICT*, Government of the Republic of Korea, April 15, 2020, undp.org.