USING DIGITAL CONTACT TRACING TOOLS TO REDUCE THE SPREAD OF COVID-19

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This note outlines key considerations to develop and deploy digital contact tracing[1] tools based on a review of initiatives launched to date to address COVID-19 in various countries and the information available on early lessons. We primarily focus on digital tools that can identify potential COVID-19 cases based on geographic proximity to a known case. We briefly touch on case management functionality and tools, which can be used by health and government officials to manage, track, encourage, and educate individuals who have tested positive for COVID-19.

Note: In many contexts, digital proximity-tracking tools will be insufficient, especially to reach rural and low-income communities. These tools will need to be deployed and integrated with more traditional contact tracing approaches to capture all segments of the population. Combining all modes of contract tracing with integrated case management will also be critical to stopping the spread of COVID-19. For further information please contact Heather Lanthorn at heather.lanthorn@idinsight.org.

RECOMMENDATIONS

Essential complementary measures

- Digital contact tracing tools must be combined with increased testing and isolation measures.
- Deploying a contact tracing digital application should be accompanied by clear communication to the public about how the information collected will be used and why.
- To encourage adoption of digital tools, governments should emphasize the individual and public benefits of their widespread use, and be transparent about how data is collected, shared, and used.
- Proximity tracking tools using location data will likely not capture large, potentially vulnerable segments of the population (including rural, elderly, and poor populations); alternative tools should be considered to target these populations.
- When combined with widespread, contact tracing, and isolation can help to contain the spread of the virus, and could thus ease movement restrictions. But hospital capacity to manage and treat the disease will still be required.

Important considerations for tool selection and design

- Governments need to recognize the trade-off between data accessibility and privacy features, and incorporate this into the selection and design of the tool to be used.
- Contact tracing applications must be easy to use, especially by populations with low-literacy and across language groups.
- Application developers and governments should maximize the ease of data sharing and use, both by the public and government actors involved in contact tracing.

CONTEXT

Contact tracing consists of a) identifying individuals who may have come into contact with persons infected with a disease and b) collecting information and alerting individuals who infected persons have come in contact with. Health officials can use this mechanism to alert and direct these contacts to be tested and/or isolate, as well as offering other instructions, advice, and encouragement. These measures reduce the risk of onward contamination to more individuals. Contact tracing is used in relation to a variety of communicable diseases including measles, Ebola, tuberculosis, sexually transmitted infections, blood-borne infections, SARS-CoV-1, and most recently SARS-CoV-2 (the virus causing COVID-19).

[1] Contact tracing identifies and monitors those who have come in contact with infected people.

Contact tracing has been widely used by governments to contain the spread of the COVID-19 pandemic, including through the creation of contact tracing centers[2]. When carried out effectively for COVID-19, this strategy can identify potentially infected individuals before symptoms appear; alert them and offer diagnosis, counselling and instruction; and prevent their transmission of the disease by minimizing their contact with others[3]. If combined with systematic testing of suspected cases and isolation of positive (or suspected) cases, effective contact tracing could help to mitigate spread. This may allow governments to ease movement restrictions earlier or in a more targeted manner than would otherwise be possible. Further, the data collected can help governments and researchers learn more about the virus and its effects in different countries, across ages, social patterns, and prevalence of comorbidities.

TOOLS FOR CONTACT TRACING

THREE KEY STEPS TO CONTACT TRACING

The contact tracing process, as defined by the WHO, can be broken up into three steps: 1) contact identification, 2) contact listing, and 3) contact follow-up[4].

- *Contact identification*: filling a case investigation form for each positive case based on information provided by the patient or other sources, and systematically listing and prioritizing potential contacts (persons who lived with or visited the patient, all health facility staff having interacted with the patient, etc.) based on risk factors and type of exposure in a contact listing form.
- *Contact listing*: informing each contact via phone or in-person of their risk and providing them with preventive information and guidance (*i.e.*, on self-isolation, limiting contacts).
- *Contact follow-up*: conducting regular follow-up calls or visits to interview each contact and assessing the presence of symptoms, and filling out a report on the findings from the follow-up; these individual reports are then consolidated and new cases are reported. Contacts are the subject of these case management activities until the end of the appropriate follow-up period.

DIGITAL VS TRADITIONAL TOOLS AND PROCESSES

Traditional tools involve human resources for health (HRH) filling out forms on paper or spreadsheets for each step of the process[5]. Contacts could be traced in person, over the phone, and possibly through other means of communication.

The process of collecting and manually entering contact tracing information, as described, has several challenges: i) labor- and time-intensive, ii) human errors, iii) duplicative efforts, and iv) privacy concerns given how data are collected and stored.

COVID-19 PRESENTS A DIFFICULT CASE FOR CONTACT TRACING

Contact tracing is particularly useful when the disease has three features: infection can be asymptomatic, the definition of a risky contact is clear, and when the rate of transmission is slow[6,7]. While COVID-19 can have asymptomatic infection and transmission, the other conditions are not clearly met. First, COVID-19 may spread in various ways (physical contact with infected persons, indirect contact with surfaces or objects used on the infected person, airborne transmission). Second, COVID-19 spreads at a very rapid rate. These features

2 Coronavirus COVID-19 Public Health Advice, "COVID-19 Contact Tracing Centres (CTCs) Frequently Asked Questions (FAQs)", Health Protection Surveillance Centre, April 7, 2020, https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/guidance/contacttracingguidance/Frequently%20Asked%20Questions%20-%20CTCs.pdf

3 Keeling, Matt J., T. Deirdre Hollingsworth, and Jonathan M. Read. "The Efficacy of Contact Tracing for the Containment of the 2019 Novel Coronavirus (COVID-19)." medRxiv (2020), https://www.medrxiv.org/content/10.1101/2020.02.14.20023036v1

4 WHO, 2020, https://www.who.int/news-room/q-a-detail/contact-tracing

5 WHO, "Contact tracing during an outbreak of Ebola virus disease", WHO (2014). https://www.who.int/csr/resources/publications/ebola/contact-tracing-during-outbreak-of-ebola.pdf

6 Hogben, Matthew, Dayne Collins, Brooke Hoots, and Kevin O'Connor. "Partner services in STD prevention programs: a review." Sexually transmitted diseases 43, no. 0 0 1 (2016): S53, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4717997/

7 Keeling, Matt J., T. Deirdre Hollingsworth, and Jonathan M. Read. "The Efficacy of Contact Tracing for the Containment of the 2019 Novel Coronavirus (COVID-19)." medRxiv (2020), https://www.medrxiv.org/content/10.1101/2020.02.14.20023036v1

complicate contact tracing, and may thus necessitate different or adapted tools. Because of these shortcomings, even the most effective contact tracing application will not sufficiently stop the spread, it must be done in tandem with widespread diagnosis and medical treatment.

TYPES OF DIGITAL TOOLS, DRAWBACKS AND BENEFITS

Digital tools have emerged to mitigate the challenges associated with traditional contact tracing tools; they have functionalities that can cut across the different steps in the contact tracing process. While useful, the effectiveness of these digital tools depends critically on the purpose for which they are used, how widely and well they are used, and the broader government response that they are intended to support.

There are several drawbacks important to note with digital tools: (1) they won't work in low-connectivity environments (2) they can't track populations without access to technology; this is especially problematic if those communities are high-risk, *e.g.* low-income or marginalized groups (3) they can require high levels of digital literacy to operate effectively.

Digital tools do have significant benefits. They vary in their purpose, features and complexity, but can facilitate improvements relative to traditional tools by[8]:

- **Improving the efficiency and accuracy** of data management and follow-ups through task automation.
- **Reducing the burden of data collection on human resources for health** by allowing electronic self-reporting by individuals found to be infected and their contacts.
- **Identifying a wider net of contacts**, including those unknown to infected individuals[9] using location data to look at possible exposure.

Digital tools for contact tracing can help to achieve these improvements through two main types of functionalities: (1) case management and (2) proximity tracking[10]. Some digital tools are also used for (3) surveillance. Different tools can include more than one of these functionalities.

Case management functionality allows for entry and review of data on cases, contacts, and their progress. Digital tools built for case management may also have additional capabilities including:

- Automated notification to cases and contacts (to test, isolate, check for symptoms, as well as provide information and encouragement)[11].
- Enabling users to report symptoms and contacts.
- Enable data input from multiple sources including data that users enter directly, data imported or shared from other systems, such as data systems from health authorities that may make use of in-person or phone interviews to trace contacts.

Proximity tracking functionality uses Bluetooth or GPS to track an individual's exposure to cases by capturing spatial proximity to known or suspected cases. Most tools with this function use Bluetooth Low Energy (BLE) transmissions. Once the tool (an application or 'app') is installed on a smartphone, it broadcasts a signal from the phone (in the form of a string of numbers and letters unique to that device and anonymous). These broadcasts are detectable by other phones with the same application installed within Bluetooth range (about 9 meters). Users can report if they have tested positive, and the app makes it possible to track which other phone users with that application installed were within range of the person tested positive in the last 14 days, and thus at risk of contamination; these at-risk users receive an alert. Apple and Google have jointly introduced a unifying update to their Bluetooth short-range wireless protocols to provide, which will make it easier for

8 Centers for Disease Control and Prevention, "Digital Contract Tracing Tools for COVID-19", CDC (2020), https://www.cdc.gov/coronavirus/2019-ncov/downloads/digital-contact-tracing.pdf

9 This is particularly useful for tracing contamination between strangers, as there is no other information channel, unlike with family members or friends.

10 Centers for Disease Control and Prevention, "Digital Contract Tracing Tools for COVID-19", CDC (2020), https://www.cdc.gov/coronavirus/2019-ncov/downloads/digital-contact-tracing.pdf

11 Tom-Aba, Daniel, Patrick Mboya Nguku, Chinedu Chukwujekwu Arinze, and Gerard Krause. "Assessing the concepts and designs of 58 mobile apps for the management of the 2014-2015 West Africa Ebola outbreak: systematic review." JMIR public health and surveillance 4, no. 4 (2018): e68. https://publichealth.jmir.org/2018/4/e68/pdf

developers to build a contact tracing application that works without modification on both Apple and Google platforms. The software for applications being built in various countries (including Germany, Great Britain, Ireland, and the United States) are being rewritten to take advantage of this new arrangement[12].

Many proximity tracking tools can include case management functionality for the set of cases and contacts with the app. These can include: identification of at-risk users' contacts; automated aggregation of proximity or user-reported data to facilitate use by health authorities; alerts to users to test, isolate, self-diagnose or provide symptoms and other information; and sharing of guidance or information with users.

While tools that have a primarily case management function can pull data from across sources, tools built around proximity tracking can only perform case management through use of the app. This has important implications for the segments of the population that can or can't be captured in the contact tracing process with each type of tool.

***Surveillance** tools* are also used to monitor compliance with self-isolation directives. In some countries, including Taiwan and Hong Kong, digital tools track locations of individuals instructed to self-isolate using geofencing technology[13]. In Taiwan, the system monitors phone signals and trigger an alert to alert police and local officials if individuals instructed to quarantine move away from their home or turn off their phones, officials then are to call within 15 minutes of an alert, as well as twice a day to ensure individuals don't avoid tracking by leaving their phones at home[14]. In Hong Kong, travelers returning from abroad are given a wristband with a QR code scanned to pair the wristband with the *StayHomeSafe* application. Authorities are alerted when an individual instructed to quarantine leaves their home; these individuals can reportedly be subject to a fine and time in prison[15].

Many digital contact tracing tools — with one or more of the functionalities described above — have recently been deployed in a variety of countries, including China, Czech Republic, Ghana, Hong Kong, Iceland, Peru, Singapore, South Korea, Taiwan and Vietnam. Other countries currently developing one or planning to do so include Morocco, France, Germany, Great Britain, Ireland and the United States. Further information on the digital tools introduced in these countries is available in the *Annex*.

LIMITATIONS

While digital tools can facilitate contact tracing, they have important limitations to be considered when setting expectations for what they can help to achieve, and to plan for complementary – and ideally well-integrated – measures and tools for contact tracing.

ENABLING ENVIRONMENT IS REQUIRED

Reliance on widely available testing: these tools will only be effective if users know, and thus can report through the application, if they are carriers, including the potentially large proportion[16,17] of individuals who

12 The Economist, "App-based contact tracing may help countries get out of lockdown", The Economist, April 16, 2020, https://www.economist.com/science-and-technology/2020/04/15/app-based-contact-tracing-may-help-end-coronavirus-lockdowns?fsrc=newsletter&utm_campaign=the-economist-today&utm_medium=newsletter&utm_source=salesforce-marketing-cloud&utm_term=2020-04-15&utm_content=article-link-1

13 An algorithm on the application samples signals (such a s WiFi, Bluetooth and cellular networks nearby); as the user moves walks around their home, the application creates a virtual perimeter for the corresponding real-word geographic area correspond home. The application can be programmed to generate an alert if the user's mobile device leaves or enters the area.

14 Yimou Lee, "Taiwan's new 'electronic fence' for quarantines leads wave of virus monitoring", Reuters, March 20, 2020, https://www.reuters.com/article/us-health-coronavirus-taiwan-surveillanc/taiwans-new-electronic-fence-for-quarantines-leads-wave-of-virus-monitoring-idUSKBN2170SK

15 Mary Hui, "Hong Kong is using tracker wristbands to geofence people under coronavirus quarantine", Quartz, March 20, 2020, https://qz.com/1822215/hong-kong-uses-tracking-wristbands-for-coronavirus-quarantine/

16 While there is no consensus on the proportion of infected people who do not show symptoms or fall ill, Anthony Fauci, director of the National Institute of Allergy and Infectious Disease, estimated that this could range from 25% to 50%. Reference: The New York Times, "White House Adviser Warned of Risks of Pandemic; Trump Misleads on Testing", The New York Times, April 6, 2020, https://www.nytimes.com/2020/04/06/world/coronavirus-live-news-updates.html

17 Lavezzo, E. et al, "Suppression of COVID-19 outbreak in the municipality of Vo, Italy." medRxiv (2020), https://www.medrxiv.org/content/10.1101/2020.04.17.20053157v1

are asymptomatic and can still spread the virus. This will then allow the application to provide information to all users about who may be spreading the virus. This requires testing to be widely and consistently available, affordable, and acceptable to the public so that each person identified in the contact tracing chain can be tested. In the absence of widespread testing, applications can only collect and share data on reported symptoms, which will fail to provide confirmation that individuals with symptoms are in fact infected and to capture asymptomatic cases. It is possible to reach out to asymptomatic contacts and instruct them to act as if they have been infected, but this would require significant trust and buy-in from the public for individuals to comply.

Usefulness dependent on effective isolation measures: users instructed to self-isolate through these digital tools must follow these instructions in order to reduce the risk of onward transmission. This requires clear guidelines for self-isolation being issued, and for the public to understand and adhere to these guidelines.

BARRIERS TO WIDESPREAD USE

Low and unequal adoption: automated contact tracing becomes increasingly effective as more people adopt it. Initial epidemiological research suggests that a coverage of at least 60% of the population would be needed for effectiveness for a contact tracing application to be effective[18]. Adoption rates observed across countries have thus far been much lower, with the *Rakning C-19* application in Iceland reported to have among the highest rates at 40%[19].

Adoption is also likely to be unequal, as the application can only be downloaded by individuals with smartphones, and is more likely to be used by younger people, who are more familiar with digital applications. Adoption will be low in low-connectivity and low-resource environments (including places with low digital capacity). The type of BLE chips required to detect proximity between devices without draining the phone's battery is absent from an estimated 25% of the 3.5 billion smartphones estimated to be in active use globally; an estimated 1.5 billion more phones currently in use cannot run the operating systems used by contact tracing applications[20].

Concerns over data privacy: Contact tracing involving Bluetooth or GPS data relies on individual location data, thus raising concerns over how this data will be used. Most applications rolled out to date provide features to ensure data privacy, such that the signal transmitted by the phone device will be a regularly updated anonymous key (string of numbers and letters), in order to prevent the phone user to be identified. However, concerns over transparency on who can access the data and how remain, and in some countries data privacy measures are limited. Most notably, in South Korea, individuals were traced prior to diagnosis using GPS locations, surveillance cameras, and credit card records. When a person gets diagnosed with the virus, this information is used to trace all the people who may have come into contact with, and authorities publish personal details of the infections hoping that residents will determine if they might have been in contact with the infected individual[21].

Further, some privacy features may lessen the effectiveness of the applications; the French government has publicly asked for Apple and Google's privacy protections around digital contact tracing to be weakened, as they currently set strict limits on what data collected can be shared with public health authorities[22].

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18 The Economist, "App-based contact tracing may help countries get out of lockdown", The Economist, April 16, 2020, https://www.economist.com/science-and-technology/2020/04/15/app-based-contact-tracing-may-help-end-coronavirus-lockdowns?fsrc=newsletter&utm_campaign=the-economist-today&utm_medium=newsletter&utm_source=salesforce-marketing-cloud&utm_term=2020-04-15&utm_content=article-link-1

19 ibid

20 Tim Bradshaw, "2bn phones cannot use Google and Apple contact-tracing tech", The Financial Times, April 19, 2020, https://www.ft.com/content/271c7739-af14-4e77-a2a1-0842cf61a90f

21 This approach was enabled by changes to South Korean laws on managing and publicly sharing information on patients of infectious diseases introduced after the MERS outbreak in 2015. "Coronavirus privacy: Are South Korea's alerts too revealing?", BBC, March 5, 2020, https://www.bbc.com/news/world-asia-51733145

22 Helene Fouquet, "France Says Apple Bluetooth Policy Is Blocking Virus Tracker", Bloomberg, April 20, 2020, https://www.bloomberg.com/news/articles/2020-04-20/france-says-apple-s-bluetooth-policy-is-blocking-virus-tracker?srnd=prognosis

TECHNICAL LIMITATIONS

False positives: many tools still lack the precision to differentiate between individuals who are actually sharing a space or are located in adjacent rooms. Such issues could lead to notifications being incorrectly sent out to individuals who were not actually in close contact with a person tested positive. This in turn could lead to lower confidence in the application instructions, and thus lower overall adherence to testing or isolation measures.

Failure to capture nuanced information: relative to traditional tools, most digital tools capture fewer nuances such as the period of exposure, and could thus result in giving the same treatment to individuals who cross paths and individuals that shared physical space for a longer time. To the extent that testing and treatment resources are limited, data collected through digital tools may not facilitate prioritization of cases as effectively as traditional tools.

RECOMMENDATIONS

ESSENTIAL COMPLEMENTARY MEASURES

Digital contact tracing tools must be combined with increased testing and isolation measures. A contact tracing application will only be effective if testing is widely available, and if confirmed cases are effectively isolated. Deploying such a tool in the absence of mass testing capacity could undermine momentum for its use, and prevent reaching the adoption rate required for effectiveness. To facilitate mass testing, testing facilities could be set up outside of hospitals to reduce the burden on hospital resources and the risk of nosocomial transmission to other patients and healthcare workers[23], though there should be mechanisms in place to ensure effective follow-up with patients, given the time required between the administration of the test and the delivery of results, and hygiene and social distancing standards should be followed.

Similarly, identifying contacts at risk of being infected will only be useful to contain onward transmission if these contacts are effectively isolated. Setting up a well-functioning isolation measures infrastructure is thus an essential complement to contact tracing.

A communication strategy should be designed to encourage the public to use digital tools. No contact tracing application to date has been reported to reach 60% of the population, the estimated requirement for its effectiveness. Widespread adoption requires multiple conditions:

- *People must feel like they are contributing to a common good*. It may be appealing to require or mandate people to install the application, but this may undermine people's willingness to use it and report any test results or symptoms, a necessary condition for effectiveness. **Communication around the application should emphasize the individual and public benefits of widespread use**.
- *Transparency is required to build trust that data will not be mis-used*. In countries including Singapore, Israel, and Czech Republic, making the code "open source", as has been done in order to allow experts to assess data privacy and ensure adherence by the public[24]. **Governments should provide as much transparency as possible on how the application works, and how data is collected, shared and used**. This could be achieved by including information and answers to frequently asked questions in the application itself, setting up a hot-line for people to ask questions and report concerns, or sharing information in the media.

Proximity tracking tools using location data are likely not to capture large, potentially vulnerable segments of the population (including rural, elderly and poor populations); alternative tools should be considered to target these populations. Digital case management tools (such as Dimagi's *CommCare*) can achieve some

[23] Salathé Marcel et al, "COVID-19 epidemic in Switzerland: on the importance of testing, contact tracing and isolation", Swiss Medical Weekly, March 19, 2020, https://smw.ch/article/doi/smw.2020.20225?fbclid=IwAR2MDart-7WJ1IotWGBszlmHl6JCSgqVQexw2iPqOlnMvZQ1XSpjsV1PNaY
[24] Omar El Hyani, "Covid-19 : L'application de tracking des Marocains doit être open source", Medias24, April 16,2020, https://www.medias24.com/covid-19-l-application-de-tracking-des-marocains-doit-etre-open-source-9498.html

efficiency gains relative to traditional contact tracing tools and be deployed to reach more vulnerable populations, though they still require significant human and technical resources.

While widespread testing, contact tracing and isolation can help to contain the spread of the virus, and could thus facilitate the easing of movement restrictions, they are not sufficient, and the risks of additional waves of contaminations remain, including due to imported cases, as the examples of Singapore and South Korea illustrate[25]. In addition to setting up an effective "test, trace, isolate" infrastructure, governments should continue to ensure that sufficient resources for hospitalization and treatment are available.

IMPORTANT CONSIDERATIONS FOR TOOL SELECTION AND DESIGN

Governments need to recognize the trade-off between data availability and privacy features, and incorporate this into the selection and design of the tool to be used. How this trade-off is managed will influence the willingness of the public to use the application, and shape risks for possible mis-uses of the data collected.

Contact tracing applications must be easy to use. Ease of use is important to encourage consistent and adequate use of the application, and to ensure that alerts and information communicated are correctly understood. The tool should be adapted to reach populations who have low literacy levels and across diverse languages spoken by the intended users; adding visual cues (checkboxes, red and green colors, icons/images) may help with user understanding and engagement[26]. Reminders to users to enter and consult data in the application should also be considered. The application developed could be tested for ease of use through focus groups with targeted users, especially those with low levels of digital literacy.

Application developers and governments should maximize the ease of data sharing and use, both by the public and government actors involved in contact tracing. Contact tracing should not rely fully on automation, and consideration should be given to which human actors will use the information and how, and tailor the application to these uses. Functionalities for visualization of relevant data, access to telemedicine for remote diagnostics, and information sharing (such as a checklist of symptoms or frequently asked questions) could help to increase the probability that the information collected will be used to effectively contain the virus[27]. Further, developers should pay attention to interoperability of the application across platforms[28].

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25 Liza Lin & Joyu Wang, "Singapore, Taiwan and Hong Kong Face Second Wave of Coronavirus Cases", https://www.wsj.com/articles/singapore-taiwan-and-hong-kong-face-second-wave-of-coronavirus-cases-11584445836

26 Dimagi, "3 Lessons from Contact Tracing During the Ebola Outbreak", Dimagi, March 7, 2016, https://www.dimagi.com/blog/contact-tracing-during-the-ebola-outbreak-notes-from-the-field/

27 The Economist, "App-based contact tracing may help countries get out of lockdown", The Economist, April 16, 2020, https://www.economist.com/science-and-technology/2020/04/15/app-based-contact-tracing-may-help-end-coronavirus-lockdowns?fsrc=newsletter&utm_campaign=the-economist-today&utm_medium=newsletter&utm_source=salesforce-marketing-cloud&utm_term=2020-04-15&utm_content=article-link-1

28 For instance, by taking advantage of Apple and Google's a unifying update to their Bluetooth short-range wireless protocol mentioned earlier in the note.

ANNEX: OVERVIEW OF CONTACT TRACING APPLICATIONS USED ACROSS COUNTRIES

Country	Application Description	Adoption	Data Privacy	Functionality
China[29,30]	*Alipay Health Code* Runs on platforms developed by Alipay and WeChat for the Chinese government. It relies on self-reporting by the user and government information (medical records, their travel history and contact with someone diagnosed with COVID-19). Users are assigned color codes based on their risks: green code allows free travel, yellow code indicates home isolation, and red code indicates that the user is a confirmed COVID-19 patient who should be in quarantine.	Mandatory	There have been concerns with the lack of transparency over how the app works and security of data storage.	Surveillance; Case management
Czech Republic[31]	*eRouška (eFacemask)* Uses Bluetooth to track user movements. If a user tests positive for COVID-19, the user sends an anonymous list to the Apps sanitary station worker of e-mask users (App users) they were in contact with and are at risk of being infected. People in the list are then contacted via phone.	Voluntary	App does not collect location information, anonymously detects users who have come into close contact with an infected user. Only health staff know identity of infected users.	Proximity tracking; Case management
Ghana[32]	*COVID-19 tracker* Use telephone-related mobile data (telephone records and locations) to trace frequent contact of individuals, target health service provision, identify individuals who should be quarantined based on their exposure to the virus and notify them through an SMS message. The application also provides a checklist of symptoms, frequently asked questions, and digital assistance. It is also intended to monitor the compliance of self-isolation measures.	Voluntary	App does not collect personal information (collects phone numbers and locations).	Proximity tracking; Surveillance
Hong Kong[33]	*StayHomeSafe* Uses geofencing technology to track user movement. At the airport (or those in contact with a confirmed case), all arrivals are given a wristband, each with a unique QR code. The user then downloads the app on their phone and scans the QR code to pair the wristband with the app. Breaching of quarantine triggers a warning and alerts the government. After initial challenges[34], the government has developed improved wristbands that track user location and alerts officials in the event of loss of connectivity or atypical behavior.	Mandatory for all individuals arriving from abroad	App does not track exact location of users but merely signals to deduce whether the user is inside or outside of the home.	Surveillance; Case management

29 Helen Davidson, "China's coronavirus health code apps raise concerns over privacy", The Guardian, April 1, 2020, https://www.theguardian.com/world/2020/apr/01/chinas-coronavirus-health-code-apps-raise-concerns-over-privacy
30 Nectar Gan and David Culver, "China is fighting the coronavirus with a digital QR code. Here's how it works", CNN, April 16, 2020, https://www.cnn.com/2020/04/15/asia/china-coronavirus-qr-code-intl-hnk/index.html
31 eRouska, 2020, https://erouska.cz/
32 ITU News, "Ghana launches COVID-19 Tracker App", April 1, 2020, https://news.itu.int/ghana-launches-covid-19-tracker-app/
33 Mary Hui, "Hong Kong is using tracker wristbands to geofence people under coronavirus quarantine", Quartz, March 20, 2020, https://qz.com/1822215/hong-kong-uses-tracking-wristbands-for-coronavirus-quarantine/
34 Only 2 out of 3 of wristbands distributed by 20 March reportedly worked (see reference above).

Country	Application Description	Adoption	Data Privacy	Type
Iceland[35,36]	*Rakning C-19 (Tracking C-19)* Uses phone location data and saves the data several times per hour. If a user is diagnosed with COVID-19, the Department of Civil Protection and Emergency Management's Contact Tracing Team sends a request through the app, for the user to share their data with them. Once a user agrees to share the information, data will be sent securely to the Contact Tracing Team's database who use the location data (and other information shared by user) to identify the individuals and places that have potentially been exposed to the virus.	Voluntary (40% of population have reportedly downloaded the application)	Data is only stored for 14 days on the smartphone. Consent is required by app users to share collected information.	Proximity tracking; Case management
Israel[37,38,39]	*HaMagen' (The Shield)* Tracks user whereabouts and compares to known movements of diagnosed COVID-19 patients (available from Health Ministry), to check if paths crossed within 14 days prior to diagnosis. If the app finds a match, it links the smartphone owner to the Health Ministry website (for information on what to do next, and how to register as going into self-quarantine) and gives the user the option of reporting their exposure to the Health Ministry by filling out a form.	Voluntary (17% of population have reportedly downloaded the application)	Personal and location data are only stored on the device and not available to others (including operators). Users decide whether to report their exposure to the virus to the ministry.	Proximity tracking; Case management
Peru[40,41]	*PeruEnTusManos (Peru In Your Hands)* Uses Bluetooth and GPS functions to trace the movements of confirmed cases for the 14 days prior to infection and identify users who came into contact with them. A probabilistic model calculates the risk of other users being contaminated based on the length of exposure and juxtaposition; individuals above a certain threshold are instructed to get tested or self-assess symptoms. Carriers can share their locations for care and preventative guidance. The data collected can allow the government to identify blocks with a high concentration of cases and provide targeted assistance to individuals tested positive or waiting for their results.	Voluntary	Data privacy of app users is upheld and information is shared only with approval from users.	Proximity tracking; Case management

35 Directorate of Health and The Department of Civil Protection and Emergency Management, 2020, https://www.covid.is/app/en

36 The Economist, "App-based contact tracing may help countries get out of lockdown", The Economist, April 16, 2020, https://www.economist.com/science-and-technology/2020/04/15/app-based-contact-tracing-may-help-end-coronavirus-lockdowns?fsrc=newsletter&utm_campaign=the-economist-today&utm_medium=newsletter&utm_source=salesforce-marketing-cloud&utm_term=2020-04-15&utm_content=article-link-1

37 Tova Cohen, "1.5 million Israelis using voluntary coronavirus monitoring app", Reuters, April 1, 2020, https://www.reuters.com/article/us-health-coronavirus-israel-apps/1-5-million-israelis-using-voluntary-coronavirus-monitoring-app-idUSKBN21J5L5

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Country	Application Description	Adoption	Data Privacy	Type
Singapore[42,43,44]	*TraceTogether* Uses Bluetooth to track and notify people who have come into contact with confirmed COVID-19 cases. People with confirmed infections allow contact tracers access to app's anonymized geo-info to trace potential infections. This app is complemented by a service to send daily updates on COVID-19 via WhatsApp. The Ministry of Manpower and Immigration and Checkpoints Agency launched a tool to send out SMS at random hours to check in on quarantined residents. Participants had to click on a unique link provided in the SMS to report their current location through a web app.	Voluntary (17% of the population have downloaded the application)	Collected data is anonymized and only accessible with prior approval from app users. However, infected individuals can be compelled to release their data, and the government can access a list of their contacts.	Proximity tracking; Case management
South Korea[45,46,47]	*Self-quarantine safety protection* Uses GPS and location tracking safety measure to monitor movements of users in quarantine and allows them to stay in contact with case workers and report on their progress. People using the app carry out a self-diagnosing twice a day for 14 days. It was initially set up for people who had recently entered the country or contacts of anyone suspected COVID-19 cases; It is now available to all Koreans and long staying foreign nationals.	Voluntary	Legal amendments have given the Ministry of Health the legal authority to collect private data, without a warrant, from both already confirmed and potential patients.[48]	Proximity tracking; Case management
Taiwan[49,50,51]	Rather than asking users to download an application, the government is using existing phone signals to track the location of individuals returning from abroad the country and instructed to quarantine for 14 days. The location of the phone owner relative to nearby cell towers is triangulated; movements too far from their home triggers an alert system, and calls and messages are sent to determine the location of the individual instructed to quarantine. Turning the phone off for more than 15 minutes will also trigger an alert, and officials call users up to twice a day to check that they have their phone and to ask about their health. Breaching quarantine is punishable by a fine of up to $33,000.	Mandatory for all individuals arriving from abroad (55,000 people were reportedly being monitored as of 1 April)	There are concerns and fears of surveillance about the government digitally tracking phone locations without a warrant, and the lack of public information about how the technology works and how the data is used.	Surveillance; Case management

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Country	Application Description	Adoption	Data Privacy	Type
United Kingdom[52] (being developed)	NHSX is leading UK efforts to develop an app similar to Singapore's, using Bluetooth to log users' proximity and notify them should people be exposed to an infected individual.	Voluntary	Consent is required for collection of private data.	Proximity tracking; Case management
Vietnam[53,54]	*NCOVI* Allows the public to declare their health status on a daily basis. Users provide personal, family information and contact details, take a disease survey, and self-assess their personal health status. Health workers then use the data to identify those in need of medical support.	Voluntary	Data is only accessible by certain government bodies.	Case management
Other	*Dimagi's CommCare*[55] Predesigned platform adapted to government or private client COVID-19 needs. It can be used to 1) quickly identify people infected by COVID-19 through customized screening and triage protocols, 2) track patients via mobile case management features and trace each case's contacts, 3) disseminate information to frontline workers, and 4) track the status of tests and enable field-based responders to manage logistics for medical supplies on their mobile phone. It has been adopted by state governments, including Alaska (United States) and Ogun (Nigeria).	Voluntary - Targeted at government and private actors	Data enters CommCare via mobile submissions, APIs, and direct upload via the website. Only authorized users have access to data or user information stored by Dimagi. Software allows partners to de-identify data prior to export from the servers[56].	Case management
	Safe Paths (still in development)[57,58] Uses overlapped GPS and Bluetooth trails allowing users to check if they crossed paths with a confirmed COVID-19 patient. It will enable users to match the personal diary of location data on their smartphone with anonymized, redacted, and blurred location history of infected patients. Users who came into contact with diagnosed patient are notified. The app will allow health officials to draw location trails of diagnosed subjects and broadcast location information with privacy protection for both diagnosed patients and local businesses.	Voluntary	Individuals' location trail only required to be provided to health officials for the last 28 days; health officials redact personally identifiable information from the location trail released.	Proximity tracking; Case management

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