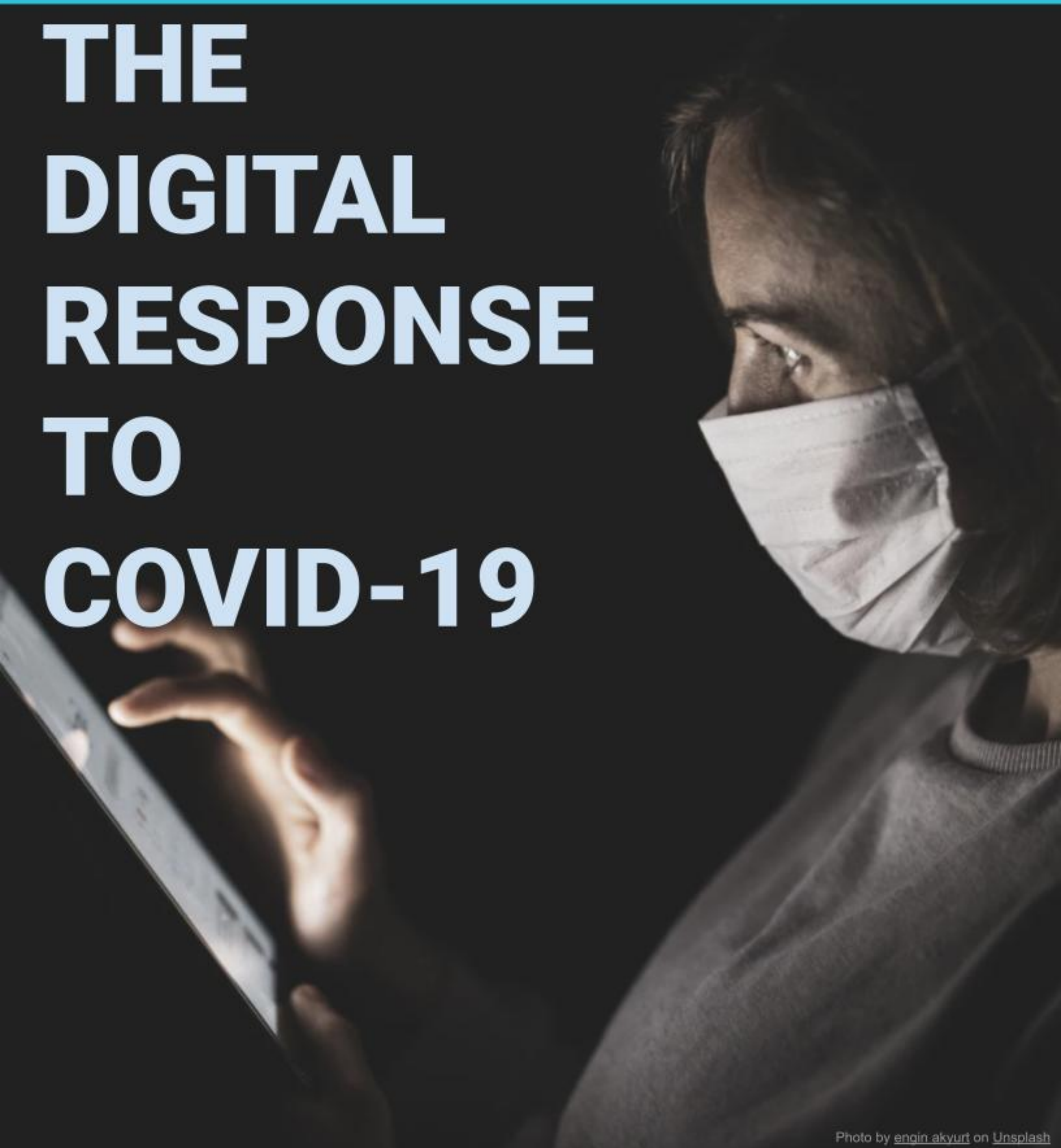
Digital Global Health & Humanitarianism Lab

THE DIGITAL RESPONSE TO COVID-19



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ABOUT OUR LAB

Our research aims to shed insight into the different ways digital technologies are used in disasters and emergencies, the challenges and risks, and benefits and opportunities associated with digital technology use. We seek to provide strategies for guidance, and support efficacy-focused, ethical, low-risk interventions around the world. Our research adopts systems and complex networked perspectives, where we creating understanding through interconnectivity. We engage experts and organizations, both academic and practitioner, across disciplines to evolve research at the intersection of systems to enhance context-driven understanding.

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Digital Contact Tracing

Jennie Phillips, Rebecca Babcock,
Soumiya Suresh, Ariana Fathi, Gautham Krishnaraj

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1.1. The Digital Response to COVID-19 Study: An Introduction

The ongoing COVID-19 pandemic requires global clinical public health mitigation interventions. These are designed to identify, contain, control, and prevent outbreaks of COVID-19 infection. These mitigation interventions include isolation of active COVID-19 cases; social distancing practices ranging from 'lock-down' to limited social interaction in 'bubbles' of varying size; rapid individual or population testing for the presence of COVID-19; and contact tracing to identify and limit the further transmission of the virus.[1] The rapid spread of COVID-19 coupled with inadequate or insufficient public health resources and tools to identify, contain, mitigate and control the pandemic, has sparked the need to find innovative ways of using digital technologies to assist with the response. In turn, a digital response to the COVID-19 pandemic has emerged, where we are both observers of, and participants in (willingly or unwillingly), a global surge of digital innovations being used to identify, track, and mitigate the spread of COVID-19. While the digital response has been highly distributed with many novel solutions, these are typically ad-hoc, vary widely in their utility and in their proactive adherence to security, privacy and human rights protections. Early research of the media coverage offers a piece-meal attempt to generate an understanding of this digital response. Furthermore, little research exists that attempts to capture the digital response's nature, scale, scope, and wider implications.

This research study aims to fill this gap with three modules that describe the landscape of the Digital Response to COVID-19. These modules provide a *descriptive overview* of digital technologies used in COVID-19 in terms of 1) Digital Contact Tracing, or tracking viral spread; 2) Social Behavior Monitoring Communications, which is designed to influence or control social behavior, and 3) Public Communications alongside Remote Diagnostics & Treatment. Technologies assessed include mobile devices (SMS, apps, data), web platforms, drones, telemedicine, and Artificial Intelligence (AI). This study was conducted through meta-analysis of peer-reviewed and grey literature including media reports, blog posts, and social media data along the three research themes identified above.

The three modules (plus an Executive Summary) of the *Digital Response to COVID-19 Study* are:

Executive Summary
Module 1. Digital Response Overview: Digital Contact Tracing
Module 2. Digital Response Overview: Social Behaviour Monitoring
Module 3. Digital Response Overview: Public Communications, and Remote Diagnostics & Treatment

Note: *As this field is rapidly emerging, and the scale of innovation around the world is vast, this study is by no means comprehensive. It is meant to provide a rapid overview of the different initiatives in use around the world from the start of the pandemic to the end of June 2020. A brief examination was conducted in*

[1] S Hsiang, et al., The effect of large-scale anti-contagion policies on the COVID-19 pandemic, Nature, 584, 262–267 (2020).)

August 2020 to update any clearly outdated information, yet it is out of the scope to evaluate the impact, viability, and sustainability of all the tools identified.

1.2. Introduction to Module 1

This module of the *Digital Response to COVID-19 Study* focuses specifically on digital measures used to track the spread of the virus (**digital contact tracing**) during the COVID-19 pandemic. Digital contact tracing (D-CT) is introduced by explaining the concept of contact tracing, how D-CT differs from in-person or manual contact tracing (M-CT), and then how D-CT works through description of the various digital technologies in use. Applications of D-CT interventions are described through three main approaches: centralized tracing - enforced, centralized tracing - voluntary, and decentralized tracing - involuntary.

1.3. Digital Contact Tracing (D-CT)

1.3.1. Introduction

1.3.1.1. What is contact tracing?

Contact tracing is the process of identifying, assessing, and managing people who have been exposed to a disease to prevent onward transmission.[2] Contact tracing identifies and tracks the spread of a virus by mapping the movements and interactions of people that have tested positive for the virus in order to identify individuals who have been exposed or infected with a virus.[3] Through communicating with the infected individual about who they have been in contact with and where they have been, the social and physical pathways of contact can be identified. This enables the identification of persons who *definitely* have been in contact with the infected individual as well as a second tier of individuals that *may* have intersected paths with the infected individual. Ideally, these individuals are notified, appropriate public health mitigation measures are implemented (Isolation), and may be subsequently tested for the virus.[4] If any of these contacts of the initial infected persons test positive, the contact tracing cascades to include their social contacts and physical movement pathways.[5] The cycle continues until the pathway leads to individuals that have not been infected.[6] When systematically applied to a transmissible disease, contact tracing can be used to identify transmission pathways, and is an essential public health tool for identifying, containing, controlling, and preventing the spread of a disease causing agent like COVID-19.[7]

[2] Partners in Health. (2014, Oct 11). *How Contact Tracing Works.* [Video]. Youtube. Retrieved from https://www.youtube.com/watch?v=hlHCLXv2HQs
[3] WHO. (2017, May 9). *Contact Tracing.* WHO. Retrieved from https://www.who.int/news-room/q-a-detail/contact-tracing
[4] Ibid.
[5] Partners in Health. (2014, Oct 11). *How Contact Tracing Works.* [Video]. Youtube. Retrieved from https://www.youtube.com/watch?v=hlHCLXv2HQs
[6] Ibid.
[7] WHO. (2020). *Rolling Updates on coronoavirus disease.* WHO. Retrieved from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen

1.3.1.2. How is contact tracing traditionally performed?

During the 1854 cholera outbreak in Soho London, UK, the efforts of physician John Snow mark the earliest known instance of contact tracing.[8] In an attempt to identify where the sickness was originating from and how it spread, Snow mapped the locations of individuals showing signs of illness and interviewed them to trace their behaviours and interactions.[9] Combining these findings, he was able to isolate the source of the outbreak: the Broad Street water pump where locals collected drinking water.[10] Using his findings, Snow lobbied the local Board of Guardians to remove the public pump handle to prevent people from getting water from this source and to boil water. Despite not knowing the exact mechanism of transmission, this intervention effectively stopped the outbreak, and pointed to the possibility of a physical vector of disease (contrary to "foul air" theory of the time).[11]

Since John Snow, and the subsequent advent of germ theory, contact tracing has become an epidemiological procedure that is standard practice in responding to outbreaks. Typically, it is performed through in-person interviews to identify an infected person's movements and interactions with others.[12] Although the approach is time-consuming and labour-intensive, contact tracing is a highly effective measure to understand and control the spread of disease.[13] In fact, according to the WHO, contact tracing is "one of the most effective outbreak containment measures" and has been widely promoted by the WHO as a principal means to effectively control Ebola virus outbreaks in Africa.[14]

1.3.1.3. What is digital contact tracing (D-CT)?

Due to the number of infected COVID-19 cases exceeding resources and time available to leverage traditional contact tracing measures – alongside the implementation of physical distancing measures which actively encourage the separation between patient and health provider – the need emerged to find alternate ways of conducting contact tracing that are more remote and automated. This need triggered a surge of innovation and research around the use of digital technologies to perform contact tracing measures. Given the rate at which the virus spreads, many experts argue that these digital contact tracing (D-CT) interventions must be deployed with a sense of urgency. For example, Professor Christophe Fraser from Oxford University's Big Data Institute, Nuffield Department of Medicine, explains:

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[8] Rogers, S. (2013, Mar 15). John Snow's data journalism: the cholera map that changed the world. *The Guardian.* Retrieved from https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map

[9] Ibid.

[10] Rogers, S. (2013, Mar 15). John Snow's data journalism: the cholera map that changed the world. *The Guardian.* Retrieved from https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map; Smith, J. (2020, April 7). The science behind contact tracing, and the limitations to US implementation. *Medium.* Retrieved from https://medium.com/swlh/the-science-behind-contact-tracing-and-the-limitations-to-us-implementation-94c5c1a71186

[11] Rogers, S. (2013, Mar 15). John Snow's data journalism: the cholera map that changed the world. *The Guardian.* Retrieved from https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map; Chodosh, S. (2019). You know nothing. Meet the real John Snow. Forget the mother of dragons. This is the father of epidemiology. *Popular Science*. Retrieved from https://www.popsci.com/real-john-snow/

[12] Smith, J. (2020, April 7). The science behind contact tracing, and the limitations to US implementation. *Medium.* Retrieved from https://medium.com/swlh/the-science-behind-contact-tracing-and-the-limitations-to-us-implementation-94c5c1a71186

[13] Ibid.

[14] WHO Africa. (2014). *Contact tracing during an outbreak of ebola virus disease.* World Health Organization Africa. Retrieved from https://www.who.int/csr/resources/publications/ebola/contact-tracing-during-outbreak-of-ebola.pdf; WHO. (2015). Implementation and management of contact tracing for Ebola virus disease. *World Health Organization & Centers for Disease Control and Prevention.* Retrieved from https://www.who.int/csr/resources/publications/ebola/contact-tracing/en/

> *"[the] Coronavirus is unlike previous epidemics and requires multiple inter-dependent containment strategies. Our analysis suggests that almost half of coronavirus transmissions occur in the very early phase of infection, before symptoms appear, so we need a fast and effective mobile application for alerting people who have been exposed. Our mathematical modelling suggests that traditional public health contact tracing methods are too slow to keep up with this virus."*[15]

This urgency is being felt around the world and countries from Singapore to Switzerland are in the process of innovating their own solutions.

D-CT tools, as described by Anglemyer *et al.* (2020), can be grouped into three areas: 1) outbreak response; 2) proximity tracing; and 3) symptom tracking.[16] Outbreak response tools "relate to the management of cases and their contacts through electronic data entry of case and contact information."[17] Proximity tracing tools "focus on tracing the movements of individuals to identify people who may have been exposed to an infected person."[18] Meanwhile, symptom tracking tools "typically rely on routinely collecting self-reported signs and symptoms to assess the prevalence of the disease by time and place that can help inform contact tracing processes."[19] Examples of these types of D-CT tools will be identified below.

1.3.1.4. How is digital contract tracing (D-CT) being done during COVID-19?

Research on D-CT methods reveals similar but varied approaches as to how technology is being used around the world for this contact tracing purpose. There are a series of low-tech solutions that seem to fall under the outbreak response category. For instance, the Mayo Clinic in the USA developed an intervention that evolved traditional contact tracing measures by linking human resource systems together (such as health and employer systems) to build a list of contacts that are informed via a 24/7 call centre in the event an infected individual is identified.[20] Dimagi, an organization from Nigeria, developed the *CommCare Template* App which was accessed by more than 200 organizations in the first 24 hours of its release.[21] The app is a decision support system that guides the app's users through the traditional contact tracing process.[22] Nigeria also implemented an open source software app called *Surveillance*

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[15] Oxford University. (2020, March 17). Oxford University infection disease experts provide evidence for coronavirus mobile applicationfor instant contact tracing. *University of Oxford*. Retrieved from http://www.ox.ac.uk/news/2020-03-17-oxford-university-infectious-disease-experts-provide-evidence-coronavirus-mobile-app

[16] Anglemyer A, Moore THM, Parker L, Chambers T, Grady A, Chiu K, Parry M, Wilczynska M, Flemyng E, Bero L. (2020). Digital contact tracing technologies in epidemics: a rapid review. *Cochrane Database of Systematic Reviews*, Issue 8. Art. No.: CD013699. Retrieved from https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD013699/epdf/full

[17] Ibid.

[18] Ibid.

[19] Ibid.

[20] Orrick, D. (2020, April 19). Contact tracing 2.0: Mayo Clinic Method saves time in 'race against close'. *Twin Cities Pioneer Press*. Retrieved from https://www.twincities.com/2020/04/19/coronavirus-contact-tracing-2-0-mayo-clinic-method-saves-time-in-race-against-clock/

[21] Vota, W. (2020, March 25). Three Early Digital Health COVID-19 Response Success Stories. *ICTworks*. Retrieved from https://www.ictworks.org/digital-health-covid-response-success-stories/#.XsU6-xNKg3j

[22] Dimagi. (2020). *COVID-19 Template App: WHO FFX Protocol*. Dimagi. Retrieved from https://confluence.dimagi.com/display/commcarepublic/COVID-19+Template+App%3A+WHO+FFX+Protocol

Outbreak Response Management and Analysis System (SORMAS). This web and mobile app allow states to digitize disease surveillance data in real-time, share information, and engage in rapid decision-making.[23]

Most interventions however, use mobile phones' GPS (Global Positioning System) and/or Bluetooth capabilities to enable location-based tracking and/or proximity tracing, the second category identified in Section 3.1.3. Proximity tracing typically works by measuring interactions based on distance (individuals that are within 6 feet/2 meters of one another) and time (individuals are in contact for 10-15 minutes). In the event that both of these criteria are met, contract tracing apps may use a Bluetooth low energy approach (which measures the power of the Bluetooth signal received to gauge distance) or leverage Bluetooth pairing ability to perform a 'Bluetooth handshake' where both phones exchange short codes over Bluetooth. A log of these codes is encrypted and stored on the user's mobile phone. In the event someone tests positive for COVID-19 and uses the app to upload their diagnosis, all individuals that possess that code on their phone receive an exposure alert and instructions on next steps. Data is typically stored for approximately two weeks depending on the app and geographical location. Another form of proximity tracing is location-based tracking which uses a phone's Global Position System (GPS) to track people and where they are traveling to in order to identify when, and where there could be a transmission of the virus and who could have been exposed.

Interventions implemented early in the pandemic are characterized by location-based tracking methods. Conversely, proximity tracking methods have picked up more traction in recent months. Innovators from academic institutions, governments, and private institutions are developing, or have developed, Bluetooth-based apps that can execute proximity tracing (i.e. identifying contact between individuals through the proximity of two mobile phones). In comparison to the GPS-driven location-based tracking that typically collects and shares identifiable information as well as stores this information on a central server, Bluetooth is being touted as the privacy-friendly D-CT method.[24] Using Bluetooth capabilities, like pairing functionality or key exchange method, simultaneously enable the collection and storage of de-identified human interaction data as well as the ability to anonymously identify and notify individuals that may have come into contact with an infected person. Examples of these types of proximity-focused digital tools will be identified in the following sections.

D-CT tools that facilitate symptom tracking are slightly more uncommon than the above categories. In this study, there was only one example of an online platform specifically designed to only track symptoms. In other cases, symptom tracking components were integrated into proximity tracking tools as an additional feature. Furthermore, this study found that symptom tracking tools were often designed for an individual to understand what next medical steps to take and these solutions will be discussed in Module 3.

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[23] XinhuaNet. (2020, August 17). Nigeria uses digital surveillance tool to report COVID-19 cases. *XinhuaNet.* Retrieved from http://www.xinhuanet.com/english/2020-08/17/c_139297572.htm

[24] O'Neill, P.H., Ryan-Mosley, T., Johnson, B. (2020, May 7). A flood of coronavirus apps are tracking us. Now it's time to keep track of them. *Technology Review.* Retrieved from https://www.technologyreview.com/2020/05/07/1000961/launching-mittr-covid-tracing-tracker/

Finally, it should be noted that across these three categories of D-CT tools, there is a wide range of technologies being used to conduct D-CT beyond those mentioned above, such as credit card information, CCTV cameras, mobile data, amongst others. These various technologies will be identified in the following sections.

The surge of D-CT measures does not come without its share of ethical concerns, which is currently outside the scope of this study. Despite these challenges, the opportunities associated with D-CT is widely perceived to outweigh the risks. Many countries around the world have adopted (or are in the process of developing) D-CT techniques to track and control the spread of the coronavirus. Moreover, public interest in adopting these tools continues to rise, especially when framed as an effective mechanism for lifting social distancing measures and opening the economy.[25]

Within this risk-benefit framework and across the three categories of D-CT tools, countries are leveraging technology to perform D-CT through three main approaches: 1) centralized tracing – enforced participation, 2) centralized tracing – voluntary/consensual participation, and 3) decentralized tracing – voluntary. Centralized implies data is stored on central servers operated by institutions such as governments or health authorities, whereas decentralized implies data is stored on the user's end (e.g. on a mobile app). Centralized approaches span enforced monitoring to voluntary and/or consensual monitoring while decentralized is considered voluntary. Each approach will be described in the following sections.

1.3.2. Centralized Tracing - Enforced Participation

In many regions around the world, health authorities argue that D-CT is most effective if data is centralized and participation is enforced. In these circumstances, national and state governments may adopt community-wide monitoring and surveillance approaches to track the spread of the virus. In many cases, these measures are implemented without public consent. The COVID-19 pandemic is not the first instance in which this type of centralized, enforced participation has occurred. For instance, call detail records were used in Haiti after the 2010 earthquake to analyze the spread of cholera and there was a "media storm" in 2015 over the "(non)use" of call detail records to assist in the tracking of Ebola, with media outlets and organizations arguing that the benefits of using this data outweighed the privay concerns associated with this data.[26] While the authors argue that it is not as easy as it seems to make the claim that the benefits of these digital tools outweigh the risks and that explicit action must be taken to mitigate the risks and amplify the benefits to ensure these tools are beneficial in a crisis, this is outside the scope of the study.

During the COVID-19 pandemic, **China** has been one of the countries most widely recognized for its invasive approaches. During the COVID-19 outbreak, the Chinese government has been collecting

[25] Coss, J. (2020, June 3). The key to re-opening our economy and communities: Contact tracing. *Thomson-Reuters.* Retrieved from https://blogs.thomsonreuters.com/answerson/thomson-reuters-contact-tracing/'; Alberta. (2020). *ABTraceTogether.* Government of Alberta. Retrieved from https://www.alberta.ca/ab-trace-together.aspx

[26] Taylor, L. (2016) The Ethics of Big Data as a Public Good: Which Public? Whose Good? Available at SSRN: http://ssrn.com/abstract=2820580

everything from people's movements to facial scans to digital wallet activity in an effort to trace the spread of the virus.[27] The government also partnered with major tech companies, like Alibaba Group Holding Ltd. and Tencent Holdings Ltd., to tie people's health data into their tracing efforts[28]

Other countries that have adopted similarly invasive measures include **Israel**. Framed by some as using counter-terrorism tech to combat the virus, Israel sanctioned the use of phone tracking (location data with phone metadata) to trace the movements of infected individuals to identify those potentially exposed to the virus.[29] In April, Israel's Supreme Court banned their local intelligence agency from its 'lawless tracing measures' until legislation had passed and is reported by the BBC to have stated that: "the state's choice to use its preventative security service for monitoring those who wish it no harm, without their consent, raises great difficulties and a suitable alternative… must be found."[30] Four weeks later, the Israeli parliament passed a bill presented by the government that permitted the use of "The Tool" to continue this invasive tracking.[31]

In other situations, individuals may be forcibly (and sometimes unknowingly) monitored. In February, 240 Uber accounts in **Mexico** were suspended after the Mexican health authorities reached out to the company regarding an individual with COVID-19 that had used Uber services.[32] Using rider histories, the accounts of two drivers that had come in contact with the infected passenger alongside the accounts of 240 other users who had made contact with the drivers were identified and suspended.[33] This is not however, the extent of **Mexico**'s contact tracing efforts. As a part of the Government of Mexico City's comprehensive Detection, Protection and Safeguard program that includes SMS, testing, early care protocols and other services, there also is a D-CT component developed by tech company Avaya.[34] It is currently uncertain as to whether this effort is voluntary or compulsory, centralized or decentralized.

Other countries are using QR codes to track visitors to public services and businesses. **Singapore** developed the *Safe Entry App* which is mandated in public spaces like supermarkets and workplaces. Marketed as a visitor management service to fight COVID-19, the *Safe Entry App* is a national digital check-in app (that is now compatible with Singapore's D-CT app *TraceTogether* – discussed in Section 3.4)

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[27] Kluth, A. (2020, April 22). If we must build a surveillance state, let's do it properly. *Bloomberg.* Retrieved from https://www.bloomberg.com/opinion/articles/2020-04-22/taiwan-offers-the-best-model-for-coronavirus-data-tracking

[28] De Vynck, G. (2020, April 30). The World Embraces Contact-Tracing Technology to Fight Covid-19. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2020-04-30/the-world-embraces-contact-tracing-technology-to-fight-covid-19

[29] Halbfinger, D., Kershner, I., Bergman, R. (2020, March 18). To Track Coronavirus, Israel Moves to Tap Secret Trove of Cellphone Data. *The New York Times.* Retrieved from https://www.nytimes.com/2020/03/16/world/middleeast/israel-coronavirus-cellphone-tracking.html

[30] BBC. (2020, April 27). Coronavirus: Israeli court bans lawless contact tracing. *BBC News*. Retrieved from https://www.bbc.com/news/technology-52439145

[31] Schwartz Altshuler, T., Aridor Hershkowitz, R. (2020, July 6). How Israel's COVID-19 mass surveillance operation works. *The Brookings Institution.* Retrieved from https://www.brookings.edu/techstream/how-israels-covid-19-mass-surveillance-operation-works/

[32] Hawkins, A.J. (2020, February 3). Uber temporarily suspends 240 accounts in Mexico over coronavirus fears. *The Verge.* Retrieved from https://www.theverge.com/2020/2/3/21120643/uber-coronavirus-mexico-accounts-suspension

[33] Hawkins, A.J. (2020, February 3). Uber temporarily suspends 240 accounts in Mexico over coronavirus fears. *The Verge.* Retrieved from https://www.theverge.com/2020/2/3/21120643/uber-coronavirus-mexico-accounts-suspension

[34] BusinessWire. (2020, July 13). Government of Mexico City Implements Avaya Contact Center Solutions for Contact Tracing, Conducting 2,700 Tests Daily Across 117 Health Centers. *BusinessWire.* Retrieved from https://www.businesswire.com/news/home/20200713005035/en/Government-Mexico-City-Implements-Avaya-Contact-Center

used for D-CT and data verification using QR codes. Specifically, customer and employee visits to hotspots and essential services locations are logged through the scanning of QR codes. Upon scanning a QR code, users are required to provide information including their name, mobile number, and National Registration Identity Card (NRIC) number.[35] Despite the invasive nature of these measures, government surveys show that more than three-quarters of the population support Singapore's handling of their personal data (at least prior to the pandemic).[36] More recent reports however, show that there is some backlash as Singapore continues to implement digital solutions (discussed in Section 3.4).[37] **Spain** is also using QR codes with travelers passing through its airports to help facilitate D-CT. Travelers must fill out a digital health form that, once completed, provides the traveler with a QR code that is scanned once the traveler arrives in Spain. If a COVID-19 case were to be confirmed, this health form and QR code system would improve contact tracing efforts as authorities would have travelers' contact information, flight information, destinations to be visited, etc.[38]

Meanwhile, **South Korea** is perceived to have one of the most successful digital responses to the outbreak. They did so however, without the use of D-CT apps. Instead, they used a nation-wide testing strategy combined with a network of contact tracers and digital information collection measures – including CCTV camera footage, satellite-based phone tracking, and credit card transactions – to track the movements of potential carriers.[39] When someone tests positive, government health authorities send text alerts to the citizens within the infected person's region to: 1) inform them that someone within their region has the disease; and 2) share details about the infected person including their age, gender, and places they have visited.[40] Earlier reports however, show that the government was also publishing movements of people before they were diagnosed with the virus.[41] Despite this, polls show that South Koreans possess high public trust in, and support, these measures despite the measures being enforced and involuntary.[42]

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[35] NDI{api}. (2020). *Safe Entry*. NDI Developer and Partner Portal. Retrieved from https://www.ndi-api.gov.sg/safeentry

[36] PDPC Singapore. (2020). *2019 Consumer Survey on the Personal Data Protection Act (PDPA).* PDPC, Singapore Government. Retrieved from https://www.pdpc.gov.sg/-/media/Files/PDPC/PDF-Files/Resource-for-General/Consumer-Survey-2019.pdf

[37] Asher, S. (2020, July 4). Coronavirus: Why Singapore turned to wearable contact-tracing tech. *BBC News.* Retrieved from https://www.bbc.com/news/technology-53146360

[38] Stockhouse. (2020, August 20). The Spanish Ministry of Health and AENA choose Atos to manage the health control form process for all passengers flying to Spain. *Stockhouse.* Retrieved from https://stockhouse.com/news/press-releases/2020/08/20/the-spanish-ministry-of-health-and-aena-choose-atos-to-manage-the-health

[39] Kluth, A. (2020, April 22). If we must build a surveillance state, let's do it properly. *Bloomberg.* Retrieved from https://www.bloomberg.com/opinion/articles/2020-04-22/taiwan-offers-the-best-model-for-coronavirus-data-tracking; Nature. (2020 April 29). Show evidence that apps for COID-19 are secure and effective. *Nature.* Retrieved from https://www.nature.com/articles/d41586-020-01264-1

[40] Gaffrey, S. (2020, April 22). What the US can learn from other countries using phones to track COVID-19. *Vox.* Retrieved from https://www.vox.com/recode/2020/4/18/21224178/covid-19-tech-tracking-phones-china-singapore-taiwan-korea-google-apple-contact-tracing-digital

[41] Kim, MJ, Denyer, S. (2020, March 13). A 'travel log' of the times in South Korea: Mapping the movement of coronavirus carriers. *The Washington Post.* Retrieved from https://www.washingtonpost.com/world/asia_pacific/coronavirus-south-korea-tracking-apps/2020/03/13/2bed568e-5fac-11ea-ac50-18701e14e06d_story.html

[42] Fisher, M., Sang-Hun, C. (2020, March 23). How South Korea flattened the curve. *The New York Times.* Retrieved from https://www.nytimes.com/2020/03/23/world/asia/coronavirus-south-korea-flatten-curve.html?auth=login-facebook; Thompson, D. (2020, May 6). What's behind South Korea's COVID-19 Exceptionalism? *The Atlantic.* Retrieved from https://www.theatlantic.com/ideas/archive/2020/05/whats-south-koreas-secret/611215/

1.3.3. Centralized Tracing - Voluntary Participation

In contrast to the above examples, other areas of the world strongly advocate for the centralized collection and storage of D-CT data yet argue that tracing should be voluntary. In **India**, their *Aarogya Setu* D-CT app has been voluntarily downloaded by more than 160 million users.[43] In saying that, this app also has been made mandatory to download for employees in certain sectors as well as residents of specific suburbs.[44] The app registers the user's name, age, gender, health status, and recent travel history data on centralized servers. It captures GPS location data to track individual travel and contact history as well as measures and monitors the user's health status via a series of diagnostic questions aimed at identifying individuals that may be infected with COVID-19. Each individual is assigned a unique digital identity with their perceived COVID-19 status (low risk, high risk, positive, and negative).[45] In **Bahrain**, the *BeAware App* is being used to assist with contact tracing.[46] The app notifies individuals if they are approaching a location where an active case has been detected or whether they are in close proximity of an active confirmed case.[47] The government of Bahrain states that downloading the app is entirely by choice and that although data is stored centrally it will be kept confidential and protected.[48] Despite this, the government has been reported to have published sensitive personal information of suspected COVID-19 cases.[49] In addition to the app, the government of Bahrain has implemented more invasive digital measures (i.e. geo-fencing and eBracelets) to ensure people stay home if placed under quarantine; the monitoring and surveillance measures for quarantine purposes will be explored further in Module 2.[50] Some states in the **United States**, including Utah and North and South Dakota, also have adopted centralized D-CT apps.[51] North Dakota however, is said to also be in the process of developing a voluntary decentralized D-CT app based on the Apple-Google model (to be discussed in Section 3.4).[52]

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[43] Hariharan, S. (2020, September 25). Aarogya Setu downloads drops 90% since launch - Times of India. The Times of India. Retrieved from https://timesofindia.indiatimes.com/business/india-business/aarogya-setu-downloads-drops-90-since-launch/articleshow/78304259.cmshttps://timesofindia.indiatimes.com/business/india-business/aarogya-setu-downloads-drops-90-since-launch/articleshow/78304259.cms

[44] Clarance, A. (2020, May 14). Aarogya setu: Why India's Covid-19 contact tracing applicationis controversial. *BBC.* Retrieved from https://www.bbc.com/news/world-asia-india-52659520#:~:text=The%20app%20%2D%20Aarogya%20Setu%2C%20which,raises%20huge%20data%20security%20concerns.; Singh, P. (2020, July 16). India's Aarogya Setu becomes world's most downloaded contact-tracing application. *WION.* Retrieved from https://www.wionews.com/india-news/indias-aarogya-setu-becomes-worlds-most-downloaded-contact-tracing-app-313748

[45] Das, S. (2020, April 30). [BigDataSur-COVID] Surveillance in the Time of Coronavirus: The Case of the Indian contact tracing applicationAarogya Setu. *DataActive.* Retrieved from https://data-activism.net/2020/04/bigdatasur-covid-surveillance-in-the-time-of-coronavirus-the-case-of-the-indian-contact-tracing-app-aarogya-setu/

[46] Kingdom of Bahrain. 2020. *BeAware Bahrain.* Kingdom of Bahrain. Retrieved from https://apps.bahrain.bh/CMSWebApplication/action/ShowAppDetailsAction?selectedAppID=321&appLanguage=en

[47] Kingdom of Bahrain. 2020. *BeAware Bahrain.* Kingdom of Bahrain. Retrieved from https://apps.bahrain.bh/CMSWebApplication/action/ShowAppDetailsAction?selectedAppID=321&appLanguage=en

[48] TradeArabia. (2020, March 21). Bahrain launches virus contact tracing app. *Zawya*. Retrieved from https://www.zawya.com/mena/en/business/story/Bahrain_launches_virus_contact_tracing_app-SNG_170728250/

[49] Amnesty International. (2020, June 16). Bahrain, Kuwait and Norway contact tracing apps among most dangerous for privacy. *Amnesty International.* Retrieved from https://www.amnesty.org/en/latest/news/2020/06/bahrain-kuwait-norway-contact-tracing-apps-danger-for-privacy/

[50] Toumi, H. (2020, April 6). Bahrain uses technology to track home quarantine COVID-10 patients. *GulfNews.com.* Retrieved from https://gulfnews.com/world/gulf/bahrain/bahrain-uses-technology-to-track-home-quarantine-covid-19-patients-1.70838518

[51] Zestrow, M. (2020, May 12). Coronavirus contact-tracing apps: can they slow the spread of COVID-19? *Nature.* Retrieved from https://www.nature.com/articles/d41586-020-01514-2

[52] Brodwin, Erin. (20202, June 24). An applicationfor football fans became a digital contact tracing tool — and could be a litmus test for Covid-19 technology. *Stat News.* Retrieved from https://www.statnews.com/2020/06/24/digital-contact-tracing-north-dakota/

Europe initially approached D-CT by focusing on cross-border privacy protocol development. Eight European countries (and over 180 researchers) came together on April 1 2020 to commence the Pan-European Privacy Preserving Proximity Tracing (PEPP-PT) initiative. Led by Germany, this open-source initiative advocated Bluetooth-based proximity tracing measures for D-CT. It also promoted a centralized approach for storing data collected during contract tracing that can work across borders and is in full compliance with General Data Protection Regulations (GDPR) (the privacy rule book established by the EU).[53] The **United Kingdom** was one of the first (and few) countries involved in the initiative to develop a D-CT app, the NHS D-CT app, that used centralized data storage.[54] Yet, the app was surrounded by controversy concerning privacy; this controversy is most emphasized by the leaking of the report on the UK government ministers' plans to de-anonymize user data collected from the app.[55] Due to this controversy – alongside the pressure from other countries in Europe for cross-compatibility, the app's poor ability to recognize iPhones, amongst other obstacles – the UK ditched their centralized D-CT app and opted for the Apple and Google model (explained in Section 3.4) that is advocated by many other countries.[56] **France** also pursued centralized data storage options for their D-CT app. The app, *TousAntiCovid*, was launched on June 2 and uses Bluetooth proximity tracing technology but centralizes user data.[57] As a result of this development, there exists significant contention with Google and Apple's model which also will be explored in the following section.[58]

Other centralized measures that encourage voluntary opt-in span QR codes to online platforms. **New Zealand** is taking a similar approach as Singapore by using a centralized QR code approach to D-CT – the significant difference is that it is voluntary. Every business in the country is given a unique QR code. Users of the app, *NZ COVID Tracer*, scan the QR codes of places they visit upon entry and exiting. At the time of the first scan, users are prompted for personal details including name, date of birth, residential address, demographic information, and email. The phone number and date of birth however, are the only two pieces of information that are recommended to be filled out.[59] According to the New Zealand government, personal data and contact details collected are shared with the NCCS (National Close

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[53] Busvine, D. (2020, April 1). Europe to launch coronavirus contact tracing applicationinitiative. *Reuters.* Retrieved from https://www.reuters.com/article/health-coronavirus-europe-tech/europe-to-launch-coronavirus-contact-tracing-app-initiative-idUSL8N2BP1N0; PEPP-PT. (2020). *Pan-European privacy-preserving proximity tracing.* PEPP-PT.org. Retrieved from https://www.pepp-pt.org

[54] McCarthy, K. (20202, May 5). UK finds itself almost alone with centralized virus contact-tracing applicationthat probably won't work well, asks for your location, may be illegal. *The Register.* Retrieved from https://www.theregister.co.uk/2020/05/05/uk_coronavirus_app/

[55] Pegg, D., Lewis, P. (2020, April 13). NHS Coronavirus app: memo discussed giving minister's power to 'de-anonymise' users. *The Guardian.* Retrieved from https://www.theguardian.com/world/2020/apr/13/nhs-coronavirus-app-memo-discussed-giving-ministers-power-to-de-anonymise-users

[56]Zestrow, M. (2020, May 12). Coronavirus contact-tracing apps: can they slow the spread of COVID-19? *Nature.* Retrieved from https://www.nature.com/articles/d41586-020-01514-2; Kelion, L. (2020, June 18). UK virus-tracing applicationswitches to Apple-Google model. *BBC.* Retrieved from https://www.bbc.com/news/technology-53095336

[57] Dillet, R. (2020, June 2). France releases contact-tracing applicationStopCovid. *TechCrunch.* Retrieved from https://www.nytimes.com/2020/03/16/world/middleeast/israel-coronavirus-cellphone-tracking.html; Fisher, T. (2021, January 15). TousAntiCovid is stalling and "is not possible to slow the spread of the epidemic", says Cedric O. Inside Wales Sport. Retrieved from https://www.insidewalessport.co.uk/tousanticovid-is-stalling-and-is-not-possible-to-slow-the-spread-of-the-epidemic-says-cedric-o/

[58] Asher Hamilton, I. (2020, May 6). France attached Apple for net helping to build its contact-tracing app. *Business Insider*. Retrieved from https://www.businessinsider.com/france-attacks-apple-contact-tracing-app-2020-5

[59] Daalder, M. (2020, May 19). Government releases contact tracing app. *Newsroom.* Retrieved from https://www.newsroom.co.nz/2020/05/19/1180137/government-releases-contact-tracing-application

Contact Service) to quickly get in touch with users if they are identified to have made close contact with someone infected with COVID-19.[60] Meanwhile, **Portugal** developed an alternate approach called *Covidografia*, an online platform that allows people to update their symptoms (or lack thereof) as well as see the states of health and behaviours of individuals in their area; this information is shared with health authorities to inform decision-making about the response to COVID-19.[61]

1.3.4. Decentralized Tracing - Voluntary Participation

Given widespread privacy and human rights concerns linked with many of the existing and proposed measures for D-CT, decentralized monitoring is advocated as a means to avoid the risk of redefining the state's relationship with surveilling its citizens.[62] Worldwide, it is the approach most democratic nations support the most.

In Europe, the Google Apple Exposure Notification (GAEN) Application Programming Interface (API) has taken priority in D-CT app developments rather than the PEPP-PT initiative described in the previous section. The PEPP-PT (described earlier) lost considerable traction given its primary focus on centralized data storage. Countries, like Switzerland, claim the initiative is not transparent enough, i.e. the centralized systems storing data do not respect personal privacy.[63] As a result, Spain, Germany, and others pulled out of these efforts and simply turned their attention to the GAEN API.[64] Google and Apple have been working together to promote a decentralized approach to D-CT by developing an API that allows D-CT apps to run on their operating systems in the background as well as iOS/Android interoperability. They limit one app per country to encourage streamlined implementation.

Countries like France (who, reported earlier, are using a centralized approach) initially provided strong support for Google and Apple's venture to open up their operating system. Yet, France eventually refused the digital solutions in development by Google and Apple due to issues of privacy, compatibility with their health system, and friction around responsibility – i.e. fighting the coronavirus was the responsibility of the state, not a "US digital giant" (according to Cedric O, the French minister for digital technologies).[65] Similarly, while the UK was said earlier to have moved towards using the GAEN API infrastructure, reports then suggested that the UK has "stepped almost entirely away" from D-CT apps after the GAEN API failed

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[60] Ministry of Health. (2020). *NZ COVID tracer app.* Ministry of Health, New Zealand. Retrieved from https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-health-advice-general-public/contact-tracing-covid-19/nz-covid-tracer-app#privacy

[61] Covidgrafia. (2020). *The platform that takes an instant photograph of the symptoms of the Portuguese.* Covidgrafia. Retrieved from https://covidografia.pt/

[62] Busvine, D, Rinke, A. (2020, April 26). Germany flips to Apple-Google approach on smartphone contact tracing. *Reuters*. Retrieved from https://www.reuters.com/article/us-health-coronavirus-europe-tech/germany-flips-on-smartphone-contact-tracing-backs-apple-and-google-idUSKCN22807J

[63] Swissinfo.ch. (2020, May 1). Contact tracing applicationready this month, says expert. *Swissinfo.ch.* Retrieved from https://www.swissinfo.ch/eng/digital-solution_contact-tracing-app-could-be-launched-in-switzerland-within-weeks/45706296

[64] Lomas, N. (2020, April 17). Europe's PEPP-PT COVID-19 contacts tracing standard push could be squaring a fight with Apple and Google. *TechCrunch.* Retrieved from https://techcrunch.com/2020/04/17/europes-pepp-pt-covid-19-contacts-tracing-standard-push-could-be-squaring-up-for-a-fight-with-apple-and-google/

[65] Thompson, R. (2020, May 05). StopCOVID: France's controversial tracing applicationready by June, government says. *Euronews.* Retrieved from https://www.euronews.com/2020/04/29/coronavirus-french-mps-approve-covid-19-tracing-app-despite-privacy-concerns

to meet experts' standards.[66] After months of back and forth, the UK did release the NHS app based on the GAEN API.[67]

Many other European countries however, remain in support of Google and Apple's development. **Germany,** for example, originally planned to evolve Singapore's *TraceTogether* app but shifted towards using Google and Apple's infrastructure.[68] **Portugal** has also developed a voluntary, decentralized D-CT app using the GAEN API.[69] After leaving the PEPP-PT initiative, **Switzerland** started working on their DP-3T (decentralized privacy-preserving proximity tracing) protocol and once Google and Apple announced their plans to release a privacy preserving API, the country and two tech giants worked closely together to ensure compatibility between the app and the API.[70] In fact, it was recently claimed that Switzerland developed and implemented the first app in Europe using the GAEN API – only once "parliament passed a legal amendment to govern its use and data protection."[71] Using Bluetooth low energy functionality, the app enables D-CT without the need for a centralized server to store the personal data (all data stays on the user's phone).[72] It was created by a "core team of over 25 scientists and academic researchers from across Europe."[73] Meanwhile, **Northern Ireland** is the first region in the United Kingdom to implement a D-CT app using the GAEN infrastructure. Taking a human-centered approach that sought feedback from the public, this app was developed by the Northern Ireland Department of Health, design consultants Big Motive, software developers NearForm, quality services consultancy Expleo, and various government bodies.[74] It is also compatible with the D-cT app in use in the Republic of Ireland.[75] Outside of Europe, Virginia and Alabama in the **United States** released a statewide app and a pilot version of a D-CT app, respectively, based on the GAEN API technology.[76] Furthermore, while Alberta, **Canada** launched its *TraceTogether* app in May based off of Singapore's *TraceTogether* app (described below), the **Canadian** Government used the GAEN API to develop a nation-wide privacy-centric, voluntary app – *COVID Alert* – which was implemented a few months later at the end of July.[77] For a descriptive and critical analysis of

[66] Lomas, N. (2020, August 6). UK reported to be ditching coronavirus contacts tracing in favor of 'risk rating' app. *Tech Crunch.* Retrieved from https://techcrunch.com/2020/08/06/uk-reported-to-be-ditching-coronavirus-contacts-tracing-in-favor-of-risk-rating-app/

[67] Mageit, S. (2020, November 2). NHS COVID-19 contact tracing app fails to ask users to self-isolate. Healthcare IT News. Retrieved from https://www.healthcareitnews.com/news/emea/nhs-covid-19-contact-tracing-app-fails-ask-users-self-isolate

[68] Thompson, R. (2020, May 05). StopCOVID: France's controversial tracing applicationready by June, government says. *Euronews.* Retrieved from https://www.euronews.com/2020/04/29/coronavirus-french-mps-approve-covid-19-tracing-app-despite-privacy-concerns

[69] STAYAWAY. (2020). *STAYAWAY COVID.* STAYAWAY. Retrieved from https://stayaway.inesctec.pt/en/

[70] Leprince-Ringuet, D. (2020, May 28). The world's first contact-tracing applicationusing Google and Apple's API goes live. *ZDNet.* Retrieved from https://www.zdnet.com/article/the-worlds-first-contact-tracing-app-using-google-and-apples-api-goes-live/

[71] Swissinfo.ch. (2020, June 25). Switzerland launches SwissCovid tracing applicationfor residents. *Swissinfo.ch.* Retrieved from https://www.swissinfo.ch/eng/switzerland-launches-swisscovid-contact-tracing-app-for-residents/45859778

[72] Ibid.

[73] Troncoso, C, et al. (2020, April 12). Decentralized Privacy-Preserving Proximity Tracing. *Github.* Retrieved from https://github.com/DP-3T/documents/raw/master/DP3T%20White%20Paper.pdf

[74] Downey, A. (2020, August 6). Northern Ireland launches UKs first Covid-19 contact-tracing app. *Digital Health.* Retrieved from https://www.digitalhealth.net/2020/08/northern-ireland-launches-uks-first-covid-19-contact-tracing-app/

[75] Ibid.

[76] Timber, C., Hendrix, S., Kim, M.J. (2020, August 18). Cellphone apps designed to track covid-19 spread struggle worldwide amid privacy concerns. *Washington Post.* Retrieved from https://www.washingtonpost.com/technology/2020/08/17/covid-tracking-apps-cellphones/

[77] Government of Canada. (2020).How the COVID Alert applicationworks. Government of Canada. Retrieved from https://www.canada.ca/en/public-health/services/video/covid-alert.html

COVID Alert, please see the DGHH Lab's two-part blog post series here and here. The DGHH Lab will also be releasing a case study analysis of Canada's *COVID Alert* in May 2021.

Singapore also has been widely recognized for its D-CT app: *TraceTogether*. The app is built on the BlueTrace protocol designed by the Government Digital Services team at the Government Technology Agency of Singapore.[78] Developers of the app report that identities are anonymized and the app stores only the user's mobile number and a randomized userID. Furthermore, the app does not track user location and the information collected is stored on the user's phone unless the user is confirmed to have COVID-19 and agrees to share personal data to a central server. Use of the app is voluntary but is marked as a social responsibility, like handwashing. In an effort to assist the elderly who may not have smartphones, **Singapore** also developed and implemented a wearable device called *TraceTogether Tokens*. This effort has since been expanded to the general public, but not without some backlash regarding privacy (which is rare in Singapore).[79]

The *TraceTogether* app has been mimicked around the world. Alberta, **Canada's** *TraceTogether* App and **Poland**'s *ProteGO Safe* app also used Singapore's *TraceTogether* as its foundation and was set to be the foundation of **Germany's** D-CT app prior to moving to the GAEN API. **Australia** also developed the *COVIDSafe* app based on *TraceTogether*. It functions similar to Singapore's app – data is stored on the individual's phone and upon testing positive, data is uploaded on an Amazon Web Services server based in Australia with the consent of the individual. Some concerns have been raised over this data being stored with Amazon, but Australia passed legislation to prevent data from the app being moved offshore, how long data will be retained and when data will be deleted, as well as how data could be used and by whom.[80]

Meanwhile, **Iceland** developed *Rakning C-19*, a voluntary, GPS-driven contact-tracing app. Many academic institutions also have developed (or are in the process of developing) privacy-centric D-CT apps. Major contenders include: Stanford University and the University of Waterloo's *Covid Watch* app, MIT's Safe Paths, and Oxford University's modelling to help configure D-CT apps.

Methods also have been devised to use QR codes in an entirely decentralized fashion. California, **USA** has developed the *TrackCOVID* app that uses QR codes to create checkpoints in public gathering points. The first user of the app registers a public space as a checkpoint and is given a quick response code. Others join the checkpoint by scanning the QR code and as people gather over time, interactions connect anonymously. Once an individual is infected, they can report their status anonymously through the app

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78 Tan, A. (2020, March 24). Singapore government to open source contact-tracing protocol. *ComputerWeekly.com.* Retrieved from https://www.computerweekly.com/news/252480501/Singapore-government-to-open-source-contact-tracing-protocol

79 Asher, S. (2020, July 4). Coronavirus: Why Singapore turned to wearable contact-tracing tech. *BBC News.* Retrieved from https://www.bbc.com/news/technology-53146360

80 Taylor, J. (2020, May 15). Covidsafe app: how Australia's coronavirus contact tracing applicationworks, what it does, downloads and problems. *The Guardian*. Retrieved from https://www.theguardian.com/australia-news/2020/may/15/covid-safe-app-australia-how-download-does-it-work-australian-government-covidsafe-covid19-tracking-downloads; Goldenfein, J. (2020, July 27). The Political Life of COVIDSafe Contact Tracing in Australia. *Blogdroiteuropeen.* Retrieved from https://blogdroiteuropeen.com/2020/07/27/the-political-life-of-covidsafe-contact-tracing-in-australia-by-jake-goldenfein/.

and users with a history of interaction with this person will receive a notification for elevated risk of exposure.[81]

1.4. Conclusions

This module describes **digital contact tracing** to help build understanding of the digital response to COVID-19. Discussion begins by introducing the concept of contact tracing, distinguishing between manual and digital contact tracing, and explaining how D-CT works and the different digital technologies in use. Applications of D-CT are described through three main approaches observed worldwide: centralized tracing - enforced, centralized tracing - voluntary, and decentralized tracing - voluntary.

[81] Irvine, BB. (2020, April 16). TrackCOVID is a free, open-source smartphone applicationthat permits contact tracing for potential coronavirus infections while preserving privacy. *Futurity*. Retrieved from https://www.futurity.org/trackcovid-coronavirus-tracking-app-2338902-2/

DIGITAL RESPONSE OVERVIEW

MODULE 2.
Social Behaviour Monitoring

Jennie Phillips, Rebecca Babcock,
Soumiya Suresh, Ariana Fathi, Gautham Krishnaraj

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Photo by Goh Rhy Yan on Unsplash

2.1. The Digital Response to COVID-19 Study: An Introduction

The ongoing COVID-19 pandemic requires global clinical public health mitigation interventions. These are designed to identify, contain, control, and prevent outbreaks of COVID-19 infection. These mitigation interventions include isolation of active COVID-19 cases; social distancing practices ranging from 'lock-down' to limited social interaction in 'bubbles' of varying size; rapid individual or population testing for the presence of COVID-19; and contact tracing to identify and limit the further transmission of the virus.[82] The rapid spread of COVID-19 coupled with inadequate or insufficient public health resources and tools to identify, contain, mitigate and control the pandemic, has sparked the need to find innovative ways of using digital technologies to assist with the response. In turn, a digital response to the COVID-19 pandemic has emerged, where we are both observers of, and participants in (willingly or unwillingly), a global surge of digital innovations being used to identify, track, and mitigate the spread of COVID-19. While the digital response has been highly distributed with many novel solutions, these are typically ad-hoc, vary widely in their utility and in their proactive adherence to security, privacy and human rights protections. Early research of the media coverage offers a piece-meal attempt to generate an understanding of this digital response. Furthermore, little research exists that attempts to capture the digital response's nature, scale, scope, and wider implications.

This research study aims to fill this gap with three modules that describe the landscape of the Digital Response to COVID-19. These modules provide a *descriptive overview* of digital technologies used in COVID-19 in terms of 1) Digital Contact Tracing, or tracking viral spread; 2) Social Behavior Monitoring Communications, which is designed to influence or control social behavior, and 3) Public Communications alongside Remote Diagnostics & Treatment. Technologies assessed include mobile devices (SMS, apps, data), web platforms, drones, telemedicine, and Artificial Intelligence (AI). This study was conducted through meta-analysis of peer-reviewed and grey literature including media reports, blog posts, and social media data along the three research themes identified above.

The three modules (plus an Executive Summary) of the *Digital Response to COVID-19 Study* are:

Executive Summary
Module 1. Digital Response Overview: Digital Contact Tracing
Module 2. Digital Response Overview: Social Behaviour Monitoring
Module 3. Digital Response Overview: Public Communications, and Remote Diagnostics & Treatment

Note: *As this field is rapidly emerging, and the scale of innovation around the world is vast, this study is by no means comprehensive. It is meant to provide a rapid overview of the different initiatives in use around the world from the start of the pandemic to the end of June 2020. A brief examination was conducted in*

[82] S Hsiang, et al., The effect of large-scale anti-contagion policies on the COVID-19 pandemic, Nature, 584, 262–267 (2020).)

August 2020 to update any clearly outdated information, yet it is out of the scope to evaluate the impact, viability, and sustainability of all the tools identified.

2.2. Introduction to Module 2

This module of the *Digital Response to COVID-19 Study* focuses specifically on digital measures used to **monitor and control social behaviours during the coronavirus outbreak** during the COVID-19 pandemic. Social behaviour monitoring is introduced by explaining the concept as applied to COVID-19, and the need for digital intervention. Applications of social behaviour monitoring are described through three main approaches: quarantine monitoring, social distancing and other public health measures enforcement, and informing future planning & policy.

2.3. Social Behaviour Monitoring

2.3.1. Introduction

2.3.1.1. What is social behaviour monitoring?

Social behaviour monitoring can be described as when a system or person observes behaviours and analyzes patterns in those behaviours; the focus is not on the behaviour itself but the patterns related to the behaviour.[83] This is not the same as social behaviour surveillance, which is the close inspection of social behaviours with the aim of controlling or managing those behaviours; the focus is on the behaviour itself.[84] Ultimately, there is a small but important difference between social behaviour monitoring and surveillance.

An example of social behaviour monitoring in day-to-day life is the surveying and analysis of society's use of public transit. One potential goal is to monitor the use of public transit to identify patterns – such as peak public transiting times – in order to improve the public transit system. In comparison, an example of social behaviour surveillance could be the use of security cameras at airports to scrutinize specific individuals' behaviours. The existence of security cameras alone will have an impact on behaviour and control behaviour to some degree.[85] The examination of behaviour by those behind the security camera may lead to actions meant to further control or manage unwanted behaviour, such as authority intervention.

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[83] Young, C. S. (2015). Chapter 8—Electronic Terrorism Threats, Risk, and Risk Mitigation. In C. S. Young (Ed.), *The Science and Technology of Counterterrorism* (pp. 221–281). Butterworth-Heinemann. Retrieved from https://doi.org/10.1016/B978-0-12-420056-2.00008-7

[84] Marx, G. T. (2004). Surveillance and Society. In G. Ritzer (Ed.), *Encyclopedia of Social Theory* (Vol. 1–2). Sage Publications Inc. Retrieved from https://web.mit.edu/gtmarx/www/surandsoc.html; Young, C. S. (2015). Chapter 8—Electronic Terrorism Threats, Risk, and Risk Mitigation. In C. S. Young (Ed.), *The Science and Technology of Counterterrorism* (pp. 221–281). Butterworth-Heinemann. Retrieved from https://doi.org/10.1016/B978-0-12-420056-2.00008-7

[85] Mazerolle, L., Hurley, D., & Chamlin, M. (2002). Social Behavior in Public Space: An Analysis of Behavioral Adaptations to CCTV. *Security Journal*, 15, 59–75. Retrieved from https://doi.org/10.1057/palgrave.sj.8340118

Social behaviour monitoring and surveillance can occur using a variety of technologies for a wide range of purposes. On one end of the spectrum, video surveillance technology – such as car dash, police body, security, and stoplight cameras – are used to monitor and surveil social behaviour (often for legal purposes). On the other end of the spectrum, there is the location tracking component of food delivery service applications to ensure food is delivered to the appropriate location. Further examples include the monitoring of: 1) sensors, cameras, and smartphone data to show traffic congestion on web and mobile map applications (like Google Maps); 2) search engine entry history to provide targeted advertisements on social media platforms; and 3) health and fitness behaviours – such as sleep or exercise patterns – through smart and/or wearable technology and mobile applications (these applications often collect the data to share or sell with third parties for various purposes). How social behaviour monitoring and surveillance technologies are situated in the context of COVID-19 will be thoroughly explained in the following section.

An important point to note is that this analysis of the digital response to social behaviour monitoring and surveillance during the COVID-19 pandemic encompasses the concepts of surveillance and monitoring and does not attempt to make a distinction as to whether individual digital responses fall under monitoring or surveillance. Doing so requires a deep understanding of the political environment, legal considerations, and social/cultural values in each country where a specific technology is being used – it is subsequently considered outside the scope of this report.

2.3.1.2. COVID-19 Social Behaviour Monitoring & Surveillance

The COVID-19 pandemic is unique because social behaviours are strongly correlated with an individual's risk of contracting and/or spreading the virus once infected. For example, the use of public services and spaces can have an impact on one's health (i.e. contracting COVID-19) and public health in general (i.e. the overall spreading of the disease). In this situation, monitoring social behaviours – a task that is traditionally outside the scope of the healthcare field (although there are a few exceptions) – has become a critical piece of the COVID-19 response. Around the world, teams, individuals, and businesses have responded to this need by developing or adapting technology to monitor COVID-19 associated social behaviours in public and/or private spaces. For instance, tracking technology initially designed to look at travel patterns was adapted in March to monitor population movement and determine the effectiveness of lockdown procedures in Austria and Italy.[86] Public transit monitoring methods also are being used to determine whether social distancing measures are being followed and how effective these measures are in many communities across the world.[87] In the examples below, the extent of technology being used to monitor and surveil social behaviour for health purposes during the COVID-19 pandemic comes to full light.

Our research revealed that there are three main approaches to social behaviour monitoring and surveillance during the pandemic: 1) Quarantine-Monitoring and Surveillance, 2) Social Distancing and

[86] Bodoni, S. (2020, March 20). EU Privacy Chiefs Say Data Laws Don't Hinder Virus Fight. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2020-03-20/eu-privacy-chiefs-say-data-laws-don-t-hinder-virus-fight
[87] Google. (2020). *COVID-19 Community Mobility Report*. Google. Retrieved from https://www.google.com/covid19/mobility?hl=en

Other Public Health Measures Enforcement, and 3) Next-Step Planning. Each of these approaches is described in the following sections.

2.3.2. Quarantine-Monitoring and Surveillance

This category of social behaviour monitoring is used to ensure people who are quarantined stay in quarantine and do not violate quarantine protocols. The Government of **Singapore** is using text messaging and GPS technology to check if the people who are required to quarantine at home for 14 days are at home.[88] Individuals receive a text message at various times each day and must then share their phone's GPS location via a unique link provided in the text message within one hour of receiving the text.[89] Authorities also complete random house visits or phone calls to ensure compliance with quarantine protocols; those who receive a phone call are required to take a photo of their whereabouts.[90] A similar approach is being taken in **Poland** where quarantined persons are required to send geo-located selfies through a mobile application.[91] In Moscow, **Russia,** those who have tested positive for COVID-19 or are suspected of having COVID must install *Social Monitoring*, a smartphone application that sends notifications every two hours to upload a selfie to ensure people in quarantine are staying home; it also uses GPS to track these persons.[92]

The use of mobile applications to check quarantine compliance also has become quite common. **Turkey** is using a mobile application that leverages mobile device location data to pinpoint the location of those in quarantine.[93] Similarly, upon arrival in **Thailand**, all travelers who have traveled to/from high-risk countries are provided with SIM cards and required to download the *AoT Airports* mobile application which tracks these persons for 14 days to ensure they remain in quarantine.[94] **Ecuador**, on the other hand, is tracking mobile phones through GPS but without the use of a specific mobile application.[95] Interestingly, in

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[88] Mahmud, A.H. (2020, May 12). More than 7,000 Stay-Home Notices issued for COVID-19; checks done through GPS, photos: ICA. *CNA*. Retrieved from https://www.channelnewsasia.com/news/singapore/covid-19-coronavirus-ica-7000-stay-home-notice-enforcement-gps-12530060; Lee, Y. (2020, March 20). Taiwan's new "electronic fence" for quarantines leads wave of virus monitoring. *Reuters*. Retrieved from https://www.reuters.com/article/us-health-coronavirus-taiwan-surveillanc-idUSKBN2170SK

[89] Mahmud, A.H. (2020, May 12). More than 7,000 Stay-Home Notices issued for COVID-19; checks done through GPS, photos: ICA. *CNA*. Retrieved from https://www.channelnewsasia.com/news/singapore/covid-19-coronavirus-ica-7000-stay-home-notice-enforcement-gps-12530060

[90] Ibid.

[91] Hamilton, I. A. (2020, March 23). Poland made an app that forces coronavirus patients to take regular selfies to prove they're indoors or face a police visit. *Business Insider*. Retrieved from https://www.businessinsider.com/poland-app-coronavirus-patients-mandaotory-selfie-2020-3; Privacy International. (2020, March 19). Poland: App helps police monitor home quarantine. *Privacy International.* Retrieved from https://www.privacyinternational.org/examples/3473/poland-app-helps-police-monitor-home-quarantine

[92] Luxmoore, M. (2020, June 11). As Russia Lifts Lockdowns, Expanded Surveillance Network May Remain. R*adioFreeEurope RadioLiberty*. Retrieved from https://www.rferl.org/a/as-russia-lifts-lockdowns-expanded-surveillance-network-may-remain/30665176.html

[93] Bayar, G. (2020, April 9). Turkey launches COVID-19 isolation tracking project. *Anadolu Agency*. Retrieved from https://www.aa.com.tr/en/latest-on-coronavirus-outbreak/turkey-launches-covid-19-isolation-tracking-project/1797961; Hürriyet Daily News. (2020, April 9). Turkey to use mobile data to track isolation—Turkey News. *Hürriyet Daily News*. Retrieved from http://www.hurriyetdailynews.com/turkey-to-use-mobile-data-to-track-isolation-15369

[94] The Nation Thailand. (2020, March 17). Movement of visitors from high-risk areas to be tracked with mandatory sim and app. *The Nation Thailand.* Retrieved from https://www.nationthailand.com/news/30384226?utm_source=category&utm_medium=internal_referral

[95] EcuadorTV. (2020, March 17). Government authorizes satellite tracking to improve epidemiological surveillance. *EcuadorTV*. Retrieved from https://www.ecuadortv.ec/noticias/covid-19/romo-vigilancia-epidemiologico-covid19-?

Argentina, it is only those caught breaking quarantine that are forced to download an application that tracks the person's location.[96]

Taiwan, praised for having one of the best responses to the pandemic to-date, is believed to be the first country to use mobile data for the purpose of enforcing quarantine.[97] While largely using a self-surveillance approach where the country's citizens voluntarily partnered with the government to create a bottom-up and top-down flow of information, Taiwan also is using an 'electronic fence' approach which uses location tracking to ensure people under quarantine stay home.[98] If people move away from their address or turn off their phones, the police and local authorities are notified and either contact or visit those who trigger the alert within 15 minutes.[99] In addition to tracking mobile location data, local police call twice a day to ensure people are not leaving their phones at home to avoid tracking.[100] Facing the same tracking evasion issues with their mobile application that uses GPS to pinpoint the location of those in quarantine, **South Korea** is resorting to the use of electronic wristbands – that connect to the mobile application via Bluetooth – to monitor those who avoided tracking by leaving their phones at home and subsequently broke quarantine.[101]

Many countries have combined GPS tracking capability with electronic wristbands to further enforce compliance with quarantine measures. **Bahrain**, for example, is using its *BeAware App* (explained earlier in Module 1) to track the movement of active home quarantine cases over the 14-day quarantine period alongside eBracelets that connect to the application via Bluetooth to ensure accuracy.[102] Similarly, **Hong Kong** implemented the mandatory wearing of electronic wristbands that are connected to its smartphone application, *StayHomeSafe*, for incoming travellers to ensure they remain at home.[103]

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[96] Gershgorn, D. (2020, April 9). We Mapped How the Coronavirus Is Driving New Surveillance Programs Around the World. *OneZero*. Retrieved from https://onezero.medium.com/the-pandemic-is-a-trojan-horse-for-surveillance-programs-around-the-world-887fa6f12ec9

[97] Lee, Y. (2020, March 20). Taiwan's new "electronic fence" for quarantines leads wave of virus monitoring. *Reuters*. Retrieved from https://www.reuters.com/article/us-health-coronavirus-taiwan-surveillanc-idUSKBN2170SK

[98] Kluth, A. (2020, April 22). If we must build a surveillance state, let's do it properly. *Bloomberg*. Retrieved from https://www.bloomberg.com/opinion/articles/2020-04-22/taiwan-offers-the-best-model-for-coronavirus-data-tracking; Lee, Y. (2020, March 20). Taiwan's new "electronic fence" for quarantines leads wave of virus monitoring. *Reuters*. Retrieved from https://www.reuters.com/article/us-health-coronavirus-taiwan-surveillanc-idUSKBN2170SK

[99] Lee, Y. (2020, March 20). Taiwan's new "electronic fence" for quarantines leads wave of virus monitoring. *Reuters*. Retrieved from https://www.reuters.com/article/us-health-coronavirus-taiwan-surveillanc-idUSKBN2170SK

[100] Ibid.

[101] Kim, M. S. (2020, March 6). South Korea is watching quarantined citizens with a smartphone app. *MIT Technology Review*. Retrieved from https://www.technologyreview.com/2020/03/06/905459/coronavirus-south-korea-smartphone-app-quarantine/; Bostock, B. (2020, April 11). South Korea launched wristbands for those breaking quarantine because people were leaving their phones at home to trick government tracking apps. *Business Insider*. Retrieved from https://www.businessinsider.com/south-korea-wristbands-coronavirus-catch-people-dodging-tracking-app-2020-4

[102] Kingdom of Bahrain. 2020. *BeAware Bahrain*. Kingdom of Bahrain. Retrieved from https://apps.bahrain.bh/CMSWebApplication/action/ShowAppDetailsAction?selectedAppID=321&appLanguage=en; Bahrain News Agency. (2020, April 17). BeAware App now sending contact tracing notifications. *Bahrain News Agency*. Retrieved from https://www.bna.bh/en/iGABeAwareAppnowsendingcontacttracingnotifications.aspx?cms=q8FmFJgiscL2fwIzON1%2BDrMlRMF0AjEnBlu8qoVX6M0%3D; Arabian Business. (2020, April 5). Bahrain distributing bracelets to track active cases of coronavirus. *Arabian Business*. Retrieved from https://www.arabianbusiness.com/healthcare/444361-bahrain-distributing-bracelets-to-track-active-cases-of-coronavirus

[103] Saiidi, U. (2020, March 18). Hong Kong is putting electronic wristbands on arriving passengers to enforce coronavirus quarantine. *CNBC*. Retrieved from https://www.cnbc.com/2020/03/18/hong-kong-uses-electronic-wristbands-to-enforce-coronavirus-quarantine.html

In addition to the use of mobile data and applications to enforce quarantine, **Russia** is also using a network of over 100,000 cameras equipped with facial recognition technology to enforce quarantine in Moscow.[104] **China**, on the other hand, is installing CCTV security cameras outside (or inside) quarantined persons' residences to ensure they do not leave home.[105] Furthermore, upon lifting lockdown orders, **China** integrated a QR health code approach (the '*Alipay Health Code*') dictating who can access public spaces and who should stay home.[106] Combining national identity number or passport numbers, phone numbers, and completed questionnaires about travel history and current symptoms, all information is verified and individuals are assigned a colour-coded QR code.[107] Codes range from green (COVID-19 free), yellow (COVID-19 risk), or red (COVID-19 positive). A green code implies free movement, enabling people to roam freely in public (like entering malls or using subways), while yellow or red codes force individuals to stay home.[108] Upon trying to enter a location, users of the app must scan the QR code and have their temperature taken before being approved to enter.[109]

Sri Lanka's surveillance strategy also is particularly unique in comparison to the other examples seen above. Within two days of Sri Lanka's first suspected case of COVID-19, the country had built a tracker for COVID-19 surveillance using *DHIS2* (an "open-source, web-based health management information system (HMIS) platform" used around the globe).[110] The focus of this surveillance strategy is to register and track "incoming travelers from areas with high risk of COVID-19 infection" for 14 days.[111] The process involves three stages of contact with the individual: 1) the initial 'registration' phrase at the port of entry (i.e. airport); 2) the follow-up within 14 days of registration; and 3) the follow-up at the end of 14 days.[112] Inspired by Sri Lanka's innovation, the *DHIS2* team developed a digital data package to "accelerate case detection, situation reporting, active surveillance, and response for COVID19;" this digital data package is currently operational in 19 countries and in the development stage in 27 countries.[113]

In the majority of these contexts, if authorities are notified of individuals breaking quarantine rules then there are various subsequent actions taken to control the behaviour and enforce quarantine further - from

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[104] Ilyushina, M. (2020, March 29). How Russia is using authoritarian tech to curb coronavirus. *CNN.* Retrieved from https://www.cnn.com/2020/03/29/europe/russia-coronavirus-authoritarian-tech-intl/index.html

[105] Kharpal, A. (2020, March 26). Use of surveillance to fight coronavirus raises concerns about government power after pandemic ends. *CNBC.* Retrieved from https://www.cnbc.com/2020/03/27/coronavirus-surveillance-used-by-governments-to-fight-pandemic-privacy-concerns.html; Gan, N. (2020, April 28). China is installing surveillance cameras outside people's front doors ... and sometimes inside their homes. *CNN.* Retrieved from https://www.cnn.com/2020/04/27/asia/cctv-cameras-china-hnk-intl/index.html

[106] Mozur, P., Zhong, R.,Krolik, A. (2020, March 1). In Coronavirus Fight, China Gives Citizens a Color Code, With Red Flags. *The New York Times.* Retrieved from https://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html

[107] Tangermann, V. (2020, April 16). In China, This Coronavirus App Pretty Much Controls Your Life. *Futurism.* Retrieved from https://futurism.com/contact-tracing-apps-china-coronavirus

[108] Ibid.

[109] Mozur, P., Zhong, R.,Krolik, A. (2020, March 1). In Coronavirus Fight, China Gives Citizens a Color Code, With Red Flags. *The New York Times.* Retrieved from https://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html

[110] DHIS2. (2020). *About DHIS2.* DHIS2. Retrieved from https://www.dhis2.org/about; DHIS2. (2020). *Innovating DHIS2 Tracker and Apps for COVID-19 Surveillance in Sri Lanka.* DHIS2. Retrieved from https://www.dhis2.org/sri-lanka-covid-surveillance

[111] DHIS2. (2020). *Innovating DHIS2 Tracker and Apps for COVID-19 Surveillance in Sri Lanka*. DHIS2. Retrieved from https://www.dhis2.org/sri-lanka-covid-surveillance

[112] Amarakoon, Pamod. (2020, Feb 26). DHIS2 for COVID-19 Surveillance: Sri Lankan use case. *DHIS2Community.* Retrieved from https://community.dhis2.org/t/dhis2-for-covid-19-surveillance-sri-lankan-use-case/38516

[113] DHIS2. (2020). *COVID-19 Surveillance Digital Data Package.* DHIS2. Retrieved from https://www.dhis2.org/covid-19

sending a text alert to the individual to return home to having authorities handle the incident in-person to facing legal penalties such as imprisonment or fines.[114]

2.3.3. Social Distancing and Other Public Health Measures Enforcement

Digital technologies also are being used to monitor and surveil social behaviours connected to the enforcement of social distancing measures. This can be observed in **Hungary** and **Italy** where both countries are using drones to monitor and enforce social distancing practices.[115] A particularly prominent approach to facilitate this second task however, is the use of AI-based video analytics technology. For instance, L&T Smart World & Communication is using AI-based video analytics to alert authorities on crowd gathering in cities across **India**.[116] Similarly, Landing AI and Camio – both based in California, **United States** – have developed for its customers AI-driven software that can be integrated into security cameras to analyze video streams and detect whether people are standing 6-feet apart.[117] More specifically, Camio's program turns 2D camera footage into a "virtual 3D floor-plane grid" to provide insights about whether people are standing 6 feet apart; the program also analyzes whether individuals are wearing masks.[118] In New Brunswick, **Canada,** an application (*2metre*) that helps companies maintain physical distancing between employees by tracking and enforcing building capacity limits has been deployed.[119]

Dubai is taking a different surveillance approach to enforce residents to stay home (not for quarantine purposes). On March 26 2020, the UAE implemented the "National Sterilization Programme" which required residents to stay home between 8 pm and 6 am to facilitate the "complete sterilisation of all public utilities and public transport."[120] Outside of these times, residents were permitted to leave home

[114] Hamilton, I. A. (2020, March 23). Poland made an app that forces coronavirus patients to take regular selfies to prove they're indoors or face a police visit. *Business Insider*. Retrieved from https://www.businessinsider.com/poland-app-coronavirus-patients-mandaotory-selfie-2020-3; Hürriyet Daily News. (2020, April 9). Turkey to use mobile data to track isolation—Turkey News. *Hürriyet Daily News.* Retrieved from http://www.hurriyetdailynews.com/turkey-to-use-mobile-data-to-track-isolation-15369; Arabian Business. (2020, April 5). Bahrain distributing bracelets to track active cases of coronavirus. *Arabian Business.* Retrieved From https://www.arabianbusiness.com/healthcare/444361-bahrain-distributing-bracelets-to-track-active-cases-of-coronavirus; Saiidi, U. (2020, March 18). Hong Kong is putting electronic wristbands on arriving passengers to enforce coronavirus quarantine. *CNBC*. Retrieved from https://www.cnbc.com/2020/03/18/hong-kong-uses-electronic-wristbands-to-enforce-coronavirus-quarantine.html

[115] Holroyd, M. (2020, March 23). Coronavirus: Italy approves use of drones to monitor social distancing. *Euronews.* Retrieved from https://www.euronews.com/2020/03/23/coronavirus-italy-approves-use-of-drones-to-monitor-social-distancing; Roth, A., Kirchgaessner, S., Boffey, D., Holmes, O., & Davidson, H. (2020, April 14). Growth in surveillance may be hard to scale back after pandemic, experts say. *The Guardian*. Retrieved from https://www.theguardian.com/world/2020/apr/14/growth-in-surveillance-may-be-hard-to-scale-back-after-coronavirus-pandemic-experts-say

[116] Larsen & Toubro. (2020). *Technology to fight COVID19*. Larsen & Toubro. Retrieved from https://www.larsentoubro.com/corporate/about-lt-group/technology-for-growth/technology-to-fight-covid19/

[117] Landing AI. (2020, April 16). *Landing AI Creates an AI Tool to Help Customers Monitor Social Distancing in the Workplace.* Landing AI. Retrieved from https://landing.ai/landing-ai-creates-an-ai-tool-to-help-customers-monitor-social-distancing-in-the-workplace/; Camio. (2020). *Camio*. Camio. Retrieved from https://camio.com/covid-19

[118] Camio. (2020). *Camio*. Camio. Retrieved from https://camio.com/covid-19

[119] Yamoah, M. (2020, August 14). Fredericton-based company launches COVID-19 contact tracing app 2metre. *Global News.* Retrieved from https://globalnews.ca/news/7275120/coronavirus-fredericton-contact-tracing-app-2metre/

[120] Omar, A. A. (2020, April 17). Dubai Extends 24-Hour Movement Restrictions for Another Week. *Bloomberg.* Retrieved from https://www.bloomberg.com/news/articles/2020-04-17/dubai-extends-24-hour-movement-restrictions-for-another-week; Time Out Dubai. (2020, May 18). UAE announces new timings for National Sterilisation Programme ahead of Eid al-Fitr 2020. *Time Out Dubai.*

only for essential services.[121] On April 5 2020, this restriction in movement was extended to 24-hours a day and residents were allowed to leave the home for essential services but required permits to leave the home.[122] The requirements changed ahead of Ramadan and continue to change based on the number of COVID-19 cases.[123] For the period of time this programme and its movement restrictions remain in place, speed radars "controlled by systems using artificial intelligence" are being used to track vehicles to determine whether travel is for essential purposes.[124] For instance, the system can determine whom the vehicle belongs to and if that person is an essential worker travelling to their workplace.[125] Alternatively, the system can determine whether the vehicle has a movement permit and in either case, will determine the route of the vehicle in order to decide whether the person was running an essential errand, such as grocery shopping, before issuing a fine.[126] In addition to speed radars, it is said that the city's network of AI-powered surveillance cameras are not only watching people but also checking temperatures of those passing by as well as making sure people are maintaining proper physical distance.[127]

Another city is innovatively monitoring residents through QR codes. Nizhny Novgorod in **Russia**, is implementing a QR code pass system to allow citizens to leave their homes for various purposes – walking the dog, getting groceries, taking out the garbage, etc. – while also tracking individuals and enforcing the city's lockdown measures.[128] Authorities in Nizhny Novogrod also have made it mandatory for service providers (beauty salons, barbers, etc.) to install surveillance cameras at their own expense as a condition to reopen the city after the lockdown; these cameras will be connected to a central database.[129]

2.3.4. Informing Future Planning & Policy

In this category, technologies are used to monitor social behaviour and subsequently collect and/or analyze social behaviour data to help governments and organizations (such as healthcare facilities and non-profits) determine how to deploy resources and decide which next steps to take to combat the virus.

Retrieved from https://www.timeoutdubai.com/news/441062-uae-announces-new-timings-for-national-sterilisation-programme-ahead-of-eid-al-fitr-2020

[121] Ibid.

[122] Ibid.

[123] Ibid.

[124] Al Shouk, A. (2020, April 6). COVID-19 precaution: Dubai Police using AI to find out if your trip was essential. *Gulf News.* Retrieved from https://gulfnews.com/uae/covid-19-precaution-dubai-police-using-ai-to-find-out-if-your-trip-was-essential-1.70829268

[125] Ibid.

[126] Ibid.

[127] Gambrell, J. (2020, July 9). Virus projects renew questions about UAE's mass surveillance. *CTV News.* Retrieved from https://www.ctvnews.ca/world/virus-projects-renew-questions-about-uae-s-mass-surveillance-1.5016922

[128] Khurshudyan,I. (2020, April 5). Coronavirus is testing the limits of Russia's surveillance state. *The Washington Post.* Retrieved from https://www.washingtonpost.com/world/europe/coronavirus-russia-surveillance-tracking/2020/04/04/0798f4dc-7519-11ea-ad9b-254ec99993bc_story.html; The Moscow Times. (2020, April 2). Russia's Nizhny Novgorod Unveils Digital Passes to Enforce Virus Lockdown. *The Moscow Times.* Retrieved from https://www.themoscowtimes.com/2020/04/02/russias-nizhny-novgorod-unveils-digital-passes-to-enforce-virus-lockdown-a69845

[129] Luxmoore, M. (2020, June 11). As Russia Lifts Lockdowns, Expanded Surveillance Network May Remain. R*adioFreeEurope RadioLiberty.* Retrieved from https://www.rferl.org/a/as-russia-lifts-lockdowns-expanded-surveillance-network-may-remain/30665176.html

Many nations are leveraging mobile phone capabilities to gain insight into the effectiveness of social distancing and lockdown or quarantine measures. A tech company in **Brazil**, Inloco, launched a platform to determine how lockdown protocols and related measures to combat the disease are being followed.[130] InLoco provides reports to relevant authorities, who use the data to determine where further action is needed – such as where resources should be located to most effectively enforce social distancing.[131] **Germany** is using a voluntary mobile application that connects to smartwatches to monitor vital signs to determine whether an individual is symptomatic.[132] While this seems like a screening/diagnostic tool or even may be useful for contact tracing, one of the objectives is to "to draw conclusions on how infections are spreading and whether containment measures are working."[133] Telekom, a cell phone company in **Germany**, announced that its affiliate Motionlogic is sharing anonymized data with the Robert Koch Institute (Germany's public health agency group, similar to the CDC) to determine if public health measures are working and to decide on next steps that are effective and targeted.[134]

Meanwhile, **Belgium's** Data Against COVID-19 task force was reported to have analyzed anonymized and aggregated data provided by mobile companies (Proximus, Orange, and Telenet) to determine the effectiveness of measures and decide on future steps.[135] In **Austria**, A1 Telekom Austria is providing the government with results from a "motion analysis application developed by Invenium, a spin-off from the Graz University of Technology" to analyze population/individual movements and determine the effectiveness of the COVID-19 restriction measures.[136] Vodafone is producing an "aggregated and anonymous heat map for the Lombardy region in **Italy** to help the authorities to better understand movements in order to help thwart the spread of COVID-19."[137] **Switzerland** is taking a different approach, using SIM card geolocation data to specifically inform authorities about gatherings of more

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[130] Mari, A. (2020, March 27). Brazil introduces surveillance tech to slow the spread of coronavirus. *ZDnet*. Retrieved from https://www.zdnet.com/article/brazil-introduces-surveillance-tech-to-slow-the-spread-of-coronavirus/; Inloco. (2020). *Location data to control COVID-19 while respecting individual privacy*. Inloco. Retrieved from https://www.inloco.ai/covid-19?hsCtaTracking=f0be6e1c-cfdb-4a99-bcdb-8de048835500%7Cbdd18bed-4478-4302-9d95-3b7211a58696
[131] Ibid.
[132] Busvine, D. (2020, April 7). Germany launches smartwatch app to monitor coronavirus spread. *The Guardian*. Retrieved from https://www.theguardian.pe.ca/business/reuters/germany-launches-smartwatch-app-to-monitor-coronavirus-spread-434738/
[133] Ibid.
[134] Schmidt, N. (2020, March 20). Mit Schwarmdaten gegen Ansteckung. *Telekom*. Retrieved from https://www.telekom.com/de/blog/konzern/artikel/mit-schwarmdaten-gegen-ansteckung-597374
[135] Zaimova, Rosita. (2020, March 31). How data can help fight a health crisis like the coronavirus. *World Economic Forum*. Retrieved from https://www.weforum.org/agenda/2020/03/role-data-fight-coronavirus-epidemic/; Telenet. (2020). *COVID-19: Belgium analyses telecom data to measure the impact of confinement*. Telenet. Retrieved from https://press.telenet.be/covid-19-belgium-analyses-telecom-data-to-measure-the-impact-of-confinement; Proximus. *Data taskforce against corona*. Proximus. Retrieved from https://www.proximus.be/en/id_b_cl_data_against_corona_taskforce/companies-and-public-sector/blog/news-blog/innovate/data-against-corona-taskforce.html
[136] Tirone, J., Seal, T., & Drozdiak, N. (2020, March 18). Location Data to Gauge Lockdowns Tests Europe's Love of Privacy. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2020-03-18/austria-italy-join-push-to-use-mobile-data-to-gauge-lockdown; Pollina, E., Busvine, D. (2020, March 18). European mobile operators share data for coronavirus fight. *Reuters*. Retrieved from https://www.reuters.com/article/us-health-coronavirus-europe-telecoms/european-mobile-operators-share-data-for-coronavirus-fight-idUSKBN2152C2; Invenium. (2020). *Helping in the COVID Crisis*. Invenium. Retrieved from https://www.invenium.io/en/
[137] Vodafone. (2020, March 18). *Vodafone launches five-point plan to help counter the impacts of the COVID-19 outbreak*. Vodafone. Retrieved from https://www.vodafone.com/news-and-media/vodafone-group-releases/news/vodafone-launches-five-point-plan-to-help-counter-the-impacts-of-the-covid-19-outbreak

than 20 people in an area of 100x100 meters.[138] Interestingly, the authorities will not be notified in real-time for the purpose of enforcing social distancing measures quickly.[139] Instead, the aim is to determine where gatherings in public areas take place for multiple days in a row and then subsequently "take measures to disperse them."[140]

A final example of utilizing mobile data to inform COVID-19 measures is in **France** where Inserm – a public health organization – is analyzing aggregated mobile data provided by telecom company Orange to: 1) understand the impact of confinement on the course of the pandemic; 2) "evaluate how it is respected by the population;" 3) predict "how the virus will spread by taking into account mobility;" 4) identify regions at risk, and 5) model "the impact on the healthcare system."[141] This data is described as important to "better advise public decision-makers on how to allocate healthcare sources and to inform them of the most vulnerable regions."[142]

AI also is prominently used for 'next-step planning' in a variety of ways. BlueDot (a **Canadian** AI company) is "starting to produce metrics that allow the [Canadian] government to understand where social distancing has been effective, if people are following public health advice and where to deploy valuable resources."[143] A team at the University of Texas's Health Science Center in the **United States** developed an AI-driven model that looks at varying degrees of interventions and when interventions should be implemented to ultimately see how COVID-19 would spread (specifically within the Greater Houston area) depending on those factors.[144] Similarly, a team at Stanford Woods Institute for the Environment used computing software to model the effectiveness of different non-pharmaceutical interventions for COVID-19 within the **United States** to assist U.S. decision-makers.[145] Another approach has been taken by AI startup DatakaLab who have created a mask detection software program that can be integrated into security cameras; it is now being used in the Paris metro system to detect whether people are wearing masks to gather data on mask adoption in **France**.[146] The **China**-based AI company, Baidu, also has released an AI model that detects whether individuals in crowded areas are wearing masks to provide an

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[138] Seydtaghia, A. (2020, March 25). Swisscom aidera la Confédération à détecter les attroupements via les téléphones. *Le Temps.* Retrieved from https://www.letemps.ch/economie/swisscom-aidera-confederation-detecter-attroupements-via-telephones

[139] Ibid.

[140] Ibid.

[141] Inserm. (2020, March 27). *Deploying Cellphone Data to Fight COVID-19*. Inserm. Retrieved from https://presse.inserm.fr/en/deploying-cellphone-data-to-fight-covid-19/38831/

[142] Ibid.

[143] BlueDot. (2020). *BlueDot: Outbreak Risk Software*. BlueDot. Retrieved from https://bluedot.global/; Vendeville, G. (2020, March 27). U of T infectious disease expert's AI firm now part of Canada's COVID-19 arsenal. *University of Toronto News*. Retrieved from https://www.utoronto.ca/news/u-t-infectious-disease-expert-s-ai-firm-now-part-canada-s-covid-19-arsenal

[144] Lake, D. M. (2020, March 25). Stricter, immediate intervention critical for keeping COVID-19 cases manageable for health care facilities, according to UTHealth modeling. *UTHealth News*. Retrieved from https://www.uth.edu/news/story.htm?id=53b9ba63-b0e5-46c5-8293-92ecd5a6575c

[145] Jordan, R. (2020, March 30). Modeling social distancing's impact. *Stanford News.* Retrieved from https://news.stanford.edu/2020/03/30/modeling-social-distancings-impact/; Mordecai, E., Childs, M., Kain, M., Nova, N., Ritchie, J., Harris, M. (2020). Potential Long-Term Intervention Strategies for COVID-19. *Stanford.* Retrieved from https://covid-measures.stanford.edu/

[146] Vincent, J. (2020, May 7). France is using AI to check whether people are wearing masks on public transport. *The Verge.* Retrieved from https://www.theverge.com/2020/5/7/21250357/france-masks-public-transport-mandatory-ai-surveillance-camera-software

indicator of the "population's view and response to the coronavirus, by gauging the public's adoption of safe health procedures like wearing face masks and regularly washing hands."[147] Finally, **Argentina** was trialing **Israel**-based SparkBeyond's predictive analytics AI platform to look "at how the country can allow citizens to return to work and minimize economic impact."[148]

Indeed, some social behaviour monitoring and surveillance initiatives for 'next step planning' have a more global scope. For instance, the COVID-19 Mobility Data Network – a global network of infectious disease epidemiologists working with technology companies around the world – uses anonymized, aggregated data sets from mobile location data to "provide daily updates to decision-makers at the state and local levels on how well social distancing interventions are working."[149] Google also uses data from mobile devices to develop and provide "COVID-19 Community Mobility Reports" to 131 countries for the purpose of helping public health officials "make critical decisions about COVID-19."[150] Similarly, Facebook's Data for Good program is using aggregated data to provide maps of population movement to help researchers and nonprofits understand the COVID-19 crisis and effectively respond to the virus.[151]

2.4. Conclusions

This module describes **social behaviour monitoring and surveillance** to help build understanding of how digital technologies have been used to understand and influence social behaviours during COVID-19. Discussion begins by introducing the concept of social behaviour monitoring, how it is usually performed and how applications are different during COVID-19. Applications are described through three main approaches observed worldwide: Quarantine-Monitoring and Surveillance, Social Distancing Enforcement, and Informing Future Planning & Policy.

[147] Baidu Research. (2020, March 12). *How Baidu is harnessing the power of AI in the battle against coronavirus.* Baidu Research. Retrieved from http://research.baidu.com/Blog/index-view?id=133

[148] SparkBeyond. (2020, April 8). *How SparkBeyond is powering a global response to COVID-19.* SparkBeyond. Retrieved from https://www.sparkbeyond.com/blog/covid19/; Earley, K. (2020, April 7). Argentina may use AI to make decisions about Covid-19 restrictions. *Silicon Republic.* Retrieved from https://www.siliconrepublic.com/start-ups/argentina-ai-covid-19-coronavirus-restrictions?utm_source=Website%20Link

[149] COVID-19 Mobility Data Network. (2020, May 15). *COVID-19 Mobility Data Network*. COVID-19 Mobility Data Network. Retrieved from https://www.covid19mobility.org/

[150] Google. (2020). *COVID-19 Community Mobility Report*. Google. Retrieved from https://www.google.com/covid19/mobility?hl=en

[151] Jin, K. (2020, April 6). Data for Good: New Tools to Help Health Researchers Track and Combat COVID-19. *About Facebook*. Retrieved from https://about.fb.com/news/2020/04/data-for-good/

DIGITAL RESPONSE OVERVIEW

MODULE 3.
Public Communications, and Remote Diagnostics & Treatment

Jennie Phillips, Rebecca Babcock,
Soumiya Suresh, Ariana Fathi, Gautham Krishnaraj

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Photo by Syed Ali on Unsplash

3.1. The Digital Response to COVID-19 Study: An Introduction

The ongoing COVID-19 pandemic requires global clinical public health mitigation interventions. These are designed to identify, contain, control, and prevent outbreaks of COVID-19 infection. These mitigation interventions include isolation of active COVID-19 cases; social distancing practices ranging from 'lock-down' to limited social interaction in 'bubbles' of varying size; rapid individual or population testing for the presence of COVID-19; and contact tracing to identify and limit the further transmission of the virus.[152] The rapid spread of COVID-19 coupled with inadequate or insufficient public health resources and tools to identify, contain, mitigate and control the pandemic, has sparked the need to find innovative ways of using digital technologies to assist with the response. In turn, a digital response to the COVID-19 pandemic has emerged, where we are both observers of, and participants in (willingly or unwillingly), a global surge of digital innovations being used to identify, track, and mitigate the spread of COVID-19. While the digital response has been highly distributed with many novel solutions, these are typically ad-hoc, vary widely in their utility and in their proactive adherence to security, privacy and human rights protections. Early research of the media coverage offers a piece-meal attempt to generate an understanding of this digital response. Furthermore, little research exists that attempts to capture the digital response's nature, scale, scope, and wider implications.

This research study aims to fill this gap with three modules that describe the landscape of the Digital Response to COVID-19. These modules provide a *descriptive overview* of digital technologies used in COVID-19 in terms of 1) Digital Contact Tracing, or tracking viral spread; 2) Social Behavior Monitoring Communications, which is designed to influence or control social behavior, and 3) Public Communications alongside Remote Diagnostics & Treatment. Technologies assessed include mobile devices (SMS, apps, data), web platforms, drones, telemedicine, and Artificial Intelligence (AI). This study was conducted through meta-analysis of peer-reviewed and grey literature including media reports, blog posts, and social media data along the three research themes identified above.

The three modules (plus an Executive Summary) of the *Digital Response to COVID-19 Study* are:

Executive Summary
Module 1. Digital Response Overview: Digital Contact Tracing
Module 2. Digital Response Overview: Social Behaviour Monitoring
Module 3. Digital Response Overview: Public Communications, and Remote Diagnostics & Treatment

Note: *As this field is rapidly emerging, and the scale of innovation around the world is vast, this study is by no means comprehensive. It is meant to provide a rapid overview of the different initiatives in use around the world from the start of the pandemic to the end of June 2020. A brief examination was conducted in*

[152] S Hsiang, et al., The effect of large-scale anti-contagion policies on the COVID-19 pandemic, Nature, 584, 262–267 (2020).)

August 2020 to update any clearly outdated information, yet it is out of the scope to evaluate the impact, viability, and sustainability of all the tools identified.

3.2. Introduction to Module 3

This module of the *Digital Response to COVID-19 Study* focuses specifically on digital measures used to enable **public communications as well as remote diagnostics and treatment** during the COVID-19 pandemic**.** Public communications are introduced through a comparison of traditional and emergent forms of communications. Applications of digital technology use for public communications are explained through two main approaches: one-way and two-way communications. Remote diagnostics and treatment tools are introduced by explaining both concepts and distinguishing how diagnosis and treatment are typically performed from how they have been performed during the pandemic. Applications of remote diagnostics and treatment tools are described through three main approaches: screening and assessment, healthcare delivery, and decision-making and research support.

3.3. Public Communications (One-Way and Two-Way)

3.3.1. Introduction

3.3.1.1. What is public communications? How is public communications usually performed? How is this situation different? What is the need for a new approach?

Public communications encapsulates the act and process of sharing of information with the general population - a broad audience without specific subject matter expertise. Traditional mediums for public communications include radio, newspaper, and television. While these mediums are still in use, more modern public communications strategies leverage tools such as social media, text messaging, artificial intelligence (AI)-driven solutions (i.e. chatbots), and web and mobile platforms.

Public communications can be conducted via one-way and two-way communication methods. One-way implies information dissemination to an audience where there is no mechanism for a response. Historically speaking, King George VI announced war on Germany on September 3 1939 via radio broadcast for example.[153] A current application of one-way technology is the use of an emergency system text notification (i.e. an Amber Alert in Canada that notifies residents of child abductions or the *KATWARN* tool in Germany that notifies residents of disasters and dangerous situations) that goes out to all cell phones. In both situations, there is no ability to directly respond to the sender of the message.

Alternatively, two-way communication implies the exchange of information between two parties and typically involves a smaller audience (i.e. a specific group of people or an individual). This form of communication can be facilitated in two ways: manually and automated. In this context, as defined by the DGHH lab, manual communication is human-to-human interaction. While this form of interaction typically

[153] BBC Archive. (1939, September 3). King George VI addresses the nation. BBC Archive. Retrieved from https://www.bbc.co.uk/archive/king-george-vi-addresses-the-nation/zky9f4j

occurs face-to-face (i.e. a patient's visit to their doctor), it can be facilitated through digital means. For instance, the use of Morse code is a historical example of a pseudo-digital technology that facilitates the sharing of information between two parties. A more relevant example is the use of telemedicine where various technologies (SMS, video conferencing, web chat, etc.) can be leveraged to facilitate a medical assessment between a patient and a medical professional. While this is a form of two-way communication, in our study we consider this tool to be more accurately described as a form of remote diagnosis and treatment; thus, these types of medical communication solutions will be described in more detail in Section 4.4. Automated two-way communication, as defined by the DGHH lab, refers to human-to-robot interactions and is typically facilitated through the use of AI and machine learning. Such communications have been integrated into various facets of daily life; for example, the interaction between a person and an assistance chatbot on a shopping website. The user is not speaking to a real person, but is interacting with a program that is designed to answer common questions and share information. These automated two-way communications have also been applied for use in crises, where applications can range from automated self-diagnostics to myth-busting. While automated two-way communication is relatively new in comparison to the aforementioned traditional and one-way communication methods, it has been used widely in the COVID-19 response. These uses will be explored in greater depth in the coming sections.

Each type of communication has its benefits. One-way communication is particularly useful for the mass broadcasting of information to a large audience, and two-way communication allows for tailored messaging to be delivered based on individual or group needs. The automation of public communications specifically enables a greater number of queries to be addressed and a greater number of people to receive information. Each of these attributes are valuable to different aspects of responding to a crisis situation, particularly when working with limited resources to communicate vital information to large groups, and responding directly to the concerns of individuals and smaller communities. In order to respond to these needs, innovators have been developing or repurposing interventions that leverage digital technologies to facilitate multi-faceted and cohesive public communication initiatives that respond to COVID-19. The following section will outline how digital technologies are being used to conduct one-way and two-way automated communication during the pandemic.

3.3.2. One-Way Communication

During the COVID-19 pandemic, many governments and organizations have been using automated one-way methods of public communications to connect with their respective populations. Emergency alert systems have been used in nations such as Canada, New Zealand, United Kingdom, Denmark, The Netherlands, France, and Romania to keep their citizens informed during the pandemic.[154] Oftentimes, these alerts are used to update populations on changing social distancing, quarantine, or lock-down measures.[155] For instance, Ontario, **Canada's** mass notification system that is typically used for natural disasters and amber alerts is being used for COVID-19.[156] In one instance, a mass notification was sent to

[154] Radio World. (2020, March 25). COVID-19 and Emergency Alerting Best Practices. *Radio World.* Retrieved from https://www.radioworld.com/news-and-business/news-makers/covid19-eas-best-practices
[155] Ibid.
[156] Rocca, R. (2020, April 04). Coronavirus: Ontario issues 2nd COVID-19 emergency alert. *Global News.* Retrieved from https://globalnews.ca/news/6779038/ontario-coronavirus-emergency-alert/

all Ontario citizens to inform and reinforce the 14-day quarantine that travelers are supposed to immediately observe upon returning to the province. Similarly, **Germany** is using its public warning apps, such as *KATWARN* and *NINA*, to provide citizens with information relating to COVID-19 as well as any new instructions to follow (i.e. changes to social distancing measures).[157]

Meanwhile, Vodafone is aiding all governments to facilitate the dissemination of critical information via text alerts.[158] The company also has stated its interest in assisting with targeted text messaging, such as focused campaigns for residents in a particularly affected area.[159] This is a clear example of whole population and targeted-population communications. Another example of leveraging text messaging capabilities can be seen in *Safiri Smart*, an automated text service used in **Kenya** that alerts Safaricom subscribers of COVID-19 updates via USSD.[160] [161] Also in use in **Kenya** are various interventions put in place by BRCK, a company that focuses on making the internet accessible to everyone in Africa. BRCK designed a COVID-19 specific channel through their web app to connect Kenyans to COVID-19 information.[162] BRCK also built a platform through Public Service Announcements (PSAs) that sends COVID-19 related messages directly to smartphones.[163] These messages can be sent in different languages and formats to make sure that Kenyans receive helpful suggestions and reminders, such as proper social distancing protocols and effective hygiene practices, during the pandemic. Similarly, Viamo – a **Canadian** company focused on leveraging mobile technology to share vital information to isolated populations in **Africa** - has a 3-2-1 hotline and targeted mass messaging services that provide critical COVID-19 information through audio messages, SMS, social media, chatbots, and telephone calls.[164] These messages can be recorded in local languages and are in use in countries such as **Haiti, Nepal, Mozambique, Democratic Republic of Congo**, and **Indonesia**.[165] Meanwhile, the Ministry of Health and Population in **Nepal** launched a mobile app alongside a web portal to keep the public updated on COVID-19 news and alerts.[166]

In other countries, drones also are being used to deliver public messages. In New Jersey, **USA**, drones are reminding people to practice correct social distancing procedures through automated voice messages.[167]

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[157] EENA. (2020, April 20). *Data and strategies on emergency calls & public warning during COVID-19 outbreak.* EENA. Retrieved from https://eena.org/data-strategies-emergency-calls-public-warning-covid19/

[158] Vodafone Group. (2020, March 18). *Vodafone launches five-point plan to help counter the impacts of the COVID-19 outbreak.* Vodafone. Retrieved from https://www.vodafone.com/news-and-media/vodafone-group-releases/news/vodafone-launches-five-point-plan-to-help-counter-the-impacts-of-the-covid-19-outbreak

[159] Ibid.

[160] USSD stands for Unstructured Supplementary Service Data, it is a series of quick/feature codes used for a communication protocol by Global System for Mobile cellular telephones to communicate with their mobile network operator's computers

[161] Vota, W. (2020, March 25). Three Early Digital Health COVID-19 Response Success Stories. ICTworks. Retrieved from https://www.ictworks.org/digital-health-covid-response-success-stories/#.XsU6-xNKg3j

[162] Moja Discover. (2020). Coronavirus disease (COVID-19) Pandemic. *BRCK.* Retrieved from https://covid19.brck.com/

[163] Boma COVID-19 Summit. (2020). A global conversation on how we act. *Boma.* Retrieved from https://s3.amazonaws.com/media.boma.global/uploads/documents/f3df2c6b8bcb69f451ac7abc02b0d755819eff1d.pdf

[164] Viamo. (2020). *A global social enterprise improving lives via mobile.* Viamo. Retrieved from https://viamo.io/

[165] Ibid.

[166] Nepali Telecom. (2020, April 03). CoronaVirus mobile apps and website launched in Nepal. *Nepali Telecom.* Retrieved from https://www.nepalitelecom.com/2020/03/mobile-apps-covid-19-portal-nepal.html

[167] Krauth, D. (2020, April 15). Coronavirus News: Pandemic drones to monitor fever, crowds from above. *ABC News.* Retrieved from https://abc7ny.com/coronavirus-drones-covid-19-pandemic-nj/6102905/?fbclid=IwAR3VIVm1oWAY1U6buZLaFIOeZXfc7sNgxVNmEv06tBQtkIjl6Cgtl4_yVYk

Similarly, drones in **China** are approaching citizens to warn them about following social distancing protocols and using PPE (personal protective equipment) in order to prevent the spread of the virus.[168] In **India**, drones are warning individuals in high disease prevalence areas to practice proper hygiene and social distancing communication.[169] Ultimately, through the use of these drones, these governments are educating the public about the proper measures that need to be taken to combat the virus. Drones also are being used as a resource to capture information around the world; reporters are working around social distancing measures by flying drones from their homes to capture footage around the city.[170] While these drones are not being used directly for one-way public communications, this footage has the potential to be used as public communications content through a different method (television, social media, etc.) by other non-governmental organizations and businesses.

3.3.3. Two-Way Communication (Human to Robot)

Many countries and health agencies have leveraged SMS, mobile apps, web app services, AI, and drones to facilitate two-way, human-to-robot communication methods to share information.

WhatsApp, the widely used messaging app, has been repurposed specifically for COVID-19 purposes. *HealthAlert*, for example, is an **international** WhatsApp based helpline released by the WHO that uses AI technology to respond to users.[171] Through machine learning algorithms, it can accept incoming questions from users and respond using automated answers. This tool provides information on topics including symptoms, updated news on the pandemic, myths versus facts, and protection measures. Currently, this service is offered in Arabic, English, French, Hindi, Italian, Spanish, and Portuguese (in the regions where the app is available). The government in **New Zealand** was leveraging WhatsApp in similar ways. They launched a WhatsApp channel that automatically messages people every morning to ask how they are feeling.[172] This algorithm gathered whether a user displays any of the listed symptoms for the virus and sends this information to the Ministry of Health to respond accordingly. It also was a source for people to obtain trustworthy information but it was decommissioned on June 7, 2020 when New Zealand was reporting multiple days of zero COVID-19 cases and the need for immediate information dramatically reduced.[173]

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[168] D'Amore, R. (2020, February 11). 'Yes, this drone is speaking to you': How China is reportedly enforcing coronavirus rules. *Global News.* Retrieved from https://globalnews.ca/news/6535353/china-coronavirus-drones-quarantine/

[169] The Economic Times. (2020, April 12). Drones for sanitising, robots in isolation wards, special stethoscope--innovations to fight corona. *The Economic Times.* Retrieved 2020, from https://economictimes.indiatimes.com/news/science/drones-for-sanitising-robots-in-isolation-wards-special-stethoscope-innovations-to-fight-corona/articleshow/75105576.cms?utm_source=contentofinterest

[170] Celine, T. (2020, April 15). Drone Technology: A New Friend Could Fight Against COVID-19. *Tech times* Retrieved from https://www.techtimes.com/articles/248861/20200415/video-coronavirus-are-drones-on-their-way-to-fight-covid-19.htm?fbclid=IwAR0ZcshFf2ERXn2JTiSgXdWIoefpbUdLZgJj6gV8YDvNMSZry6zMsP2AV78

[171] WHO. (2020, May 05). *WHO Health Alert brings COVID-19 facts to billions via WhatsApp.* World Health Organization. Retrieved from https://www.who.int/news-room/feature-stories/detail/who-health-alert-brings-covid-19-facts-to-billions-via-whatsapp

[172] Daalder, M. (2020, May 06). Govt app quietly rolls out daily health check-ins. *Newsroom.* Retrieved from https://www.newsroom.co.nz/technology/2020/05/01/1151690/govt-app-quietly-rolls-out-daily-health-check-ins

[173] Digital.Govt.nz. (2020, April 3). *COVID-19 response strengthened with Govt.nz WhatsApp service.* Digital.Govt.nz. Retrieved from https://www.digital.govt.nz/news/covid-19-response-strengthened-with-govt-nz-whatsapp-service/; Forrester, G. (2020, Aug 31). Coronavirus: Was the Government's WhatsApp channel worth the $672,000 price tag? *Stuff.* Retrieved from https://www.stuff.co.nz/national/health/coronavirus/122565173/coronavirus-was-the-governments-whatsapp-channel-worth-the-672000-price-tag

Beyond Whats-App, other countries have developed other types of AI-driven chatbots for information sharing purposes. The **Lithuanian** government started using the AI-powered digital robot called *ViLTė* for two-way automated communication.[174] The AI's primary function is to answer questions from the Lithuanian public about the coronavirus, restrictions for travel, and the support provided by the government for entrepreneurs, unemployment, and education. This automated system can also answer questions about access to basic needs, services, the status of various religious and cultural places, civil services, waste management, police, and more, thereby ensuring that the Lithuanian public has access to any information they may need during the pandemic. Similarly, *askNivi* is a free interactive messaging service driven by AI that is offered through the Facebook messaging feature in **Kenya** and **India**.[175] It shares news and statistics about COVID-19 as well as information about best practices during the pandemic, such as how to practice good hygiene. MILA, based in Quebec, **Canada** is partnering with Dialogue and Nuance Communications to develop an AI-driven question system that will help take the burden off of the Quebec government's helplines.[176] Stallion.AI, also based in **Canada,** has built a multilingual virtual healthcare agent through AI capabilities.[177] While one of the main components of this agent is to facilitate a remote self-screening process (an approach to remote diagnosis that will be discussed further in Section 4.4.2), it is also able to answer questions about COVID-19, recommend protection measures, and provide clear guidelines.

One of the largest communication problems faced during this pandemic has been managing the spread of fake news and misinformation pertaining to the virus. In response to this challenge, innovators and emergency response organizations have been developing creative ways for AI to identify misinformation and stop its spread. This form of communication is considered two-way because it involves automated monitoring and flagging of misinformation shared and the automated control and response information, like pushing misinformation alerts with social media posts deemed questionable. *CoronaCheck* is one such example of a tool developed to control the spread of misinformation. It is an AI-driven fact checker that was created through an **international** partnership between Eurocom, **Canada** and Cornell University, **USA**.[178] This app uses John Hopkins University's (**USA**) daily collection of data on COVID-19 as its data source to verify whether a claim is true or false. Other companies like Facebook (**USA**) are implementing algorithm controls to locate and block these posts spreading misinformation.[179] The Facebook algorithm is able to locate fake information through: 1) the use of natural-language models which helps better analyze the meaning of a post, and 2) evaluating content that consists of images and text combined.

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[174] Korona Stop. (2020). *Lietuvos Respublikos Vyriausybė*. Korona Stop. Retrieved from https://koronastop.lrv.lt/; ViLTė. (2020). *Official state virtual agent working 24/7.* ViLTė. Retrieved from https://viltebot.com/

[175] Goyal, S., Bellows, B., & Green, E. (2020). Hi, I'm Nivi. How can I help you? *Nivi.io.* Retrieved from https://www.nivi.io/

[176] MILA. (2020, April 02). *Mila and its partners rally the scientific community to develop novel data-driven solutions to assist with COVID-19 outbreak.* MILA. Retrieved from https://mila.quebec/en/mila-and-its-partners-rally-the-scientific-community-to-develop-novel-data-driven-solutions-to-assist-with-covid-19-outbreak/

[177] Obeidat, S. (2020, March 30). How Artificial Intelligence Is Helping Fight The COVID-19 Pandemic. *Entrepreneur* Retrieved from https://www.entrepreneur.com/article/348368

[178] CoronaCheck. (2020). *Computational Fact Checking for Statistical Coronavirus Claims.* CoronaCheck. Retrieved from https://coronacheck.eurecom.fr/en

[179] Hao, K. (2020, May 12). Facebook's AI is still largely baffled by covid misinformation. *MIT Technology Review.* Retrieved from https://www.technologyreview.com/2020/05/12/1001633/ai-is-still-largely-baffled-by-covid-misinformation/

Google (**USA**) is also using an algorithm that identifies searches relating to COVID-19 and ensures that top entries are from trusted local and national sources in order to promote accurate information; it even creates a COVID-19 alert sidebar that summarizes information and statistics regarding COVID-19 that is relevant to the user's area.[180]

3.4. Remote Diagnostics & Treatment

3.4.1. Introduction

3.4.1.1. What is diagnosis and treatment? How are diagnosis and treatment usually performed? How is this situation different? What is the need for a new approach?

Diagnosis and treatment – the identification of a condition that ails an individual and the subsequent therapeutic approach taken to manage the condition, respectively – are the foundation of healthcare. In a non-pandemic situation, diagnosis and treatment are accomplished by patients visiting healthcare institutions, such as medical clinics or hospitals, where relevant histories are taken and referrals for appropriate tests made. Once results are obtained, treatment is administered if needed and the relevant public health authorities are informed should the patient be diagnosed with a disease that is of public health concern. These steps are traditionally performed in-person where precautions are taken if needed, albeit not to the extent seen in this pandemic.

Given the highly infectious nature of COVID-19, the actions taken to diagnose and treat individuals must be balanced with protecting healthcare workers, other patients, and members of the community as well as preventing the overburden of the healthcare system. These considerations become further complicated by additional pressures, such as shortages in personnel and personal protective equipment.[181] Yet, accurate diagnosis and effective treatment remain essential for the proper control and management of COVID-19. Therefore, this situation warrants the use of Information Communications Technologies (ICTs) to facilitate *remote* diagnosis and treatment so that COVID-19 diagnosis and treatment processes can be done from a distance (i.e. the medical professional and the patient are not in physical contact with one another). This shift has resulted in a surge of digital solutions development, as well as steps taken to repurpose existing digital tools, to facilitate remote diagnosis and treatment. In the context of COVID-19, remote diagnosis and treatment is conducted via three approaches: screening and assessment, healthcare delivery, and decision-making and research support.

[180] Chadwick, J. (2020, March 27). Google launches 'SOS Alert' for coronavirus in search results. *The Daily Mail.* Retrieved from https://www.dailymail.co.uk/sciencetech/article-7951707/Google-launches-SOS-Alert-coronavirus-search-results.html
[181] Pole, A. (2020, April 6). Anxieties over COVID-19 and possible PPE shortages prompting some health care workers to draft wills. *CBC.* Retrieved from https://www.cbc.ca/news/canada/covid-doctors-wills-equipment-shortages-1.5523357

3.4.2. Screening & Assessment

The diagnosis process briefly described above includes screening and assessment components. In the COVID-19 pandemic context, the screening phase entails identifying the potential of an individual having the virus, while the assessment stage includes taking steps to confirm a COVID-19 diagnosis and determine a treatment pathway. To respond to this need for remote diagnosis during the pandemic, digital tools that facilitate screening and assessment have been developed and implemented. These tools fall under two categories: self-screening and physiological monitoring.

Self-screening

In the context of COVID-19, self-screening tools encompass digital solutions that enable individuals to: 1) facilitate a self-report/review for coronavirus-related symptoms; 2) share this information with a program or person for analysis; and 3) receive information about the likelihood of having COVID-19 and instructions regarding next steps (i.e. whether the person requires additional care in a healthcare facility or is able to manage these symptoms at home). These screenings and two-way sharing of information can be completed in isolation which prevents unnecessary exposure and transmission of the virus in public areas.

Numerous national, state, and local governments have implemented mobile and web apps to facilitate this remote self-screening process. For instance, the Community of Madrid, **Spain** released an app allowing users to enter their contact information, answer evaluation questions, and receive instructions and recommendations for further steps.[182] Similar apps and questionnaires have been developed by the Community of Catalonia in **Spain**; Andrija.ai in **Croatia**; the Ministry of Health and Population in **Nepal**; Apple, Microsoft, Ipsoft-Sharecare-NTT Data, and Partners Healthcare System in the **USA**; Diagnostic Robotics in **Israel**; and the global health technology company Ada and Stallion.ai in **Canada**. AI algorithms process the entered information to provide standard risk evaluations and recommendations based on national or WHO guidelines. These platforms often emphasize that their questionnaires are not to be seen as a conclusive diagnosis of COVID-19.[183] **Cambodia's** *115 Hotline* (established in 2015 for the community to report any disease outbreaks via public reporting) has been enhanced by the Cambodia Ministry of Health for the COVID-19 pandemic to help screen callers and provide them with appropriate referrals to response and contact tracing teams.[184] In this situation, a person, rather than a program, manually analyzes the answers provided by the caller to determine next steps.

Physiological Monitoring

Another means of facilitating the screening and assessment components of the COVID-19 diagnosis process is through *remote physiological monitoring*. Physiological monitoring is the monitoring of a wide range of a person's bodily functions. In the COVID-19 context, numerous devices have been developed to

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[182] Comunidad de Madrid. (2020, March 23). *COVID-19 Self Assessment*. Comunidad Madrid. Retrieved from https://coronavirus.comunidad.madrid/

[183] Lyons, K. (2020, March 21). CDC uses Microsoft healthcare chatbot service to create coronavirus symptom checker. *The Verge*. Retrieved from https://www.theverge.com/2020/3/21/21189227/cdc-microsoft-chatbot-coronavirus-symptom-checker

[184] ICTWorks. (2020, May 6). Cambodia's 115 Hotline: Successful COVID-19 Digital Response. *ICTWorks.org*. Retrieved from https://www.ictworks.org/cambodia-115-hotline-digital-response/#.Xr25XxNKjfY

detect fevers, measure the frequency of symptoms, monitor vital signs, and record lung sounds in an effort to screen, assess, and diagnose an individual. There has been significant development of fever-detection digital solutions that seem to be designed to screen individuals for the purpose of detecting those that may need further assessment. For instance, companies such as Amorph Systems (**Germany**) and INESA (**China**) are using digital software developed by VANTIQ (**USA**) to explore the potential of detecting high temperatures in high-volume areas (i.e. airports and elevators) in **China**.[185] Similar AI-driven programs have been created by SenseTime and Sunell for the possible detection of individuals with fevers in crowded areas in **China**.[186] Drones with thermal cameras have also been identified as a potential digital intervention to detect high temperatures in crowded areas and were found to be used in the Suba district in **Colombia**.[187] It is not yet clear however, as to how the data being obtained by the drones is used, although one report by the CBC claims it was used to detect persons breaking quarantine rules.[188] Finally, as mentioned in Section 4.2.3, the **UAE** is using its extensive surveillance network to monitor temperature of passersby and are even trying to equip police with helmets that monitor temperature as well.[189]

Other digital tools focus less on the screening component and more on the assessment component of diagnosis and even venture into the monitoring component of healthcare (healthcare delivery will be further discussed in Section 4.4.3). *BioSticker*, created by **US**-based BioIntelliSense and provided FDA clearance in January 2020, is a wearable sensor that has the potential to continuously monitor a patient's vitals for up to 30 days, send this data to a healthcare team for accurate and timely diagnosis of COVID-19, and appropriately monitor COVID-19 patients or frontline staff.[190] VitalConnect, **USA**, also was granted Emergency Use Authorization from the FDA to use *VitalPatch*, a wearable biosensor that can monitor physiological vitals for COVID-19 patients undergoing drug treatment for COVID-19.[191] Similar diagnosis and monitoring claims have been made for devices created by AMC Health, Current Health, Bifourmis, and PMD Healthcare – all of which are created by companies based in the **USA** or **Europe -** although

[185] VANTIQ. (2020). *INESA Case Study: Real-Time Smart Cities at Scale*. VANTIQ. Retrieved from https://vantiq.com/customer-stories/inesa/

[186] SenseTime. (2020, February 10). SenseTime Joins Fight Against Novel Coronavirus Outbreak. *Sensetime Newsroom*. Retrieved from https://www.sensetime.com/en/news/view/id/140.html; Heilweil, R. (2020, Feb 27). Coronavirus is the first big test for futuristic tech that can prevent pandemics. *Vox.* Retrieved from https://www.vox.com/recode/2020/2/27/21156358/surveillance-tech-coronavirus-china-facial-recognition

[187] CBC News. (2020, May 20). Police in Colombia using drones to detect people flouting coronavirus quarantine. *CBC News.* Retrieved from https://www.cbc.ca/news/world/drones-colombia-bogota-coronavirus-quarantine-1.5577395

[188] CBC. (2020, May). Police in Colombia using drones to detect people flouting quarantine rules. *CBC.* Retrieved from https://www.cbc.ca/player/play/1740532291973

[189] Gambrell, J. (2020, July 9). Virus projects renew questions about UAE's mass surveillance. *CTV News.* Retrieved from https://www.ctvnews.ca/world/virus-projects-renew-questions-about-uae-s-mass-surveillance-1.5016922

[190] MDDI. (2020, April 11). Several Telemedicine and Remote-Patient Monitoring Solutions Cutting Through the COVID-19 Clutter. *Medical Device and Diagnostic Industry*. Retrieved from https://www.mddionline.com/several-telemedicine-solutions-cutting-through-covid-19-clutter; Lawrence, S. (2020, July 9). Philips, Biointellisense partner on at-home patient wearable to monitor COVID, chronic disease. *BioWorld.* Retrieved from https://www.bioworld.com/articles/436355-philips-biointellisense-partner-on-at-home-patient-wearable-to-monitor-covid-chronic-disease

[191] CISION. (2020, May 5). FDA Grants Emergency Use Authorization to VitalConnect for Cardiac Monitoring in COVID-19 Patients. *Cision.* Retrieved from https://www.prnewswire.com/news-releases/fda-grants-emergency-use-authorization-to-vitalconnect-for-cardiac-monitoring-in-covid-19-patients-301052783.html

Bifourmis' *Biovitals Sentinel* is being used in **Singapore**.[192] Other biosensors include the **Indian** Institute of Technology of Bombay's "digital stethoscope" for the purpose of identifying heart and lung abnormalities in the assessment stage.[193]

Another interesting realm of diagnostic inquiry and development has focused on vocal changes as potential diagnostic markers for COVID-19. Voca.ai (Israel) has partnered with researchers from Carnegie Mellon, **USA** and Vocalis Health (**USA**) has partnered with the **Israeli** government to identify whether an individual has COVID-19 based on voice recordings.[194] Another initiative based out of **Israel** is the adaptation of Cordio Medical's speech analysis AI system *HearO* (which normally detects congestive heart failure) to detect bilateral pneumonia with edema found in COVID-19 patients.[195] Currently under clinical trials at Ramban Medical Center in Israel, the company claims to identify lung changes earlier than patients themselves and aims to identify deterioration within 10-48 hours.[196] One expert however, claims that this technology is likely not going to be useful for monitoring COVID-19 patients.[197] Similar to the efforts put forward by Cordio Medical, the *RESP system* created by Strados Labs in the **USA** records lung sounds to be played back by clinicians and nurses remotely.[198] Though currently only available for investigational use, the company hopes to be able to capture and quantify cough symptoms for the early detection and monitoring of COVID-19.[199] Finally, another **USA**-based initiative (developed through a partnership between MIT researchers, Stanford University researchers, and venture capital fund Atomic) is *Cough for the Cure* which aims to collect cough sounds from individuals with varying symptoms of COVID-19.[200] These sounds will be used to train AI algorithms to detect COVID-19 from audio recordings alone.[201] Ultimately, all of the above voice-based diagnostic tools, if validated, may allow for a completely remote, digital-only diagnostic tool for COVID-19.

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[192] MDDI. (2020, April 11). Several Telemedicine and Remote-Patient Monitoring Solutions Cutting Through the COVID-19 Clutter. *Medical Device and Diagnostic Industry*. Retrieved from https://www.mddionline.com/several-telemedicine-solutions-cutting-through-covid-19-clutter; Lee, G. (2020, July 31). Biofourmis deploys Biovitals Sentinel platform in Singapore. *BioWorld.* Retrieved from https://www.bioworld.com/articles/496399-biofourmis-deploys-biovitals-sentinel-platform-in-singapore

[193] The Economic Times. (2020, April 12). Drones for sanitising, robots in isolation wards, special stethoscope—Innovations to fight corona. *The Economic Times*. Retrieved from https://economictimes.indiatimes.com/news/science/drones-for-sanitising-robots-in-isolation-wards-special-stethoscope-innovations-to-fight-corona/articleshow/75105576.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst\

[194] Wiggers, K. (2020, April 1). Cordio and Rambam Hospital will trial AI that detects coronavirus cases from speech samples. *VentureBeats*. Retrieved from https://venturebeat.com/2020/04/01/cordio-and-rambam-hospital-will-trial-ai-that-detects-coronavirus-cases-from-speech-samples/

[195] Wiggers, K. (2020, April 1). Cordio and Rambam Hospital will trial AI that detects coronavirus cases from speech samples. *VentureBeats*. Retrieved from https://venturebeat.com/2020/04/01/cordio-and-rambam-hospital-will-trial-ai-that-detects-coronavirus-cases-from-speech-samples/

[196] Ibid.

[197] Glatter, R. (2020, June 23). This New App Analyzes Your Voice Quality To Diagnose Congestive Heart Failure: Can It Help With Covid-19? *Forbes.* Retrieved from https://www.forbes.com/sites/robertglatter/2020/06/23/this-new-app-analyzes-your-voice-quality-to-diagnose-congestive-heart-failure-can-it-help-with-covid-19/#674308d3257a

[198] MDDI. (2020, April 11). Several Telemedicine and Remote-Patient Monitoring Solutions Cutting Through the COVID-19 Clutter. *Medical Device and Diagnostic Industry*. Retrieved from https://www.mddionline.com/several-telemedicine-solutions-cutting-through-covid-19-clutter

[199] Ibid.

[200] Cough for the Cure. (2020). *Cough for the Cure*. Cough for the Cure. Retrieved from https://coughforthecure.com/

[201] Ibid.

3.4.3. Healthcare Delivery

While digital approaches can provide useful diagnostic information and assist with diagnosis, it is essential for healthcare workers to be able to connect with patients to provide guidance and care. This goal can be accomplished remotely through the use of telemedicine technologies providing *virtual consultations*. Numerous companies around the world have established platforms for healthcare workers to connect with patients virtually. **Pakistan**, **India**, **Nigeria**, and **Kenya** are using apps and websites – including *Sehat Kahani*, *Intelehealth*, *Afridokta*, *TeleDr4You*, *Baidu*, *DoctHERs*, and *BetterNow* – to remotely connect patients with physicians through video chat. TytoCare, a telehealth company that has partnered with over 100 major health systems in the **USA, Europe, Asia**, and **Israel,** recently was acknowledged for its innovative all-in-one telehealth platform that enables AI-powered, on-demand, remote medical exams that responded specifically to the pandemic.[202] In the **Chinese** provinces of Sichuan and Hubei, a 5G network infrastructure has been established to better facilitate and handle video consultations and has been reported as providing "indispensable" communication support.[203] Yet, the 5G network in **China** also plays a role in supporting technology conducting various tasks discussed through the report: unmanned vehicles (i.e. drones) that are monitoring citizens or broadcasting messages; medical robots that help staff to "conduct consultations, disinfection, cleaning, and deliveries;" and temperature detection.[204] In the above situations, video consultations allow patients to remain physically distant and/or self-isolate while also having their progress monitored. *Virtual consultations* are also being leveraged for the triage process and obtaining information for emergency responders to aid in healthcare delivery. 911 dispatch centers in New Orleans, **USA** have started to use video chatting technologies with users to provide more information to emergency responders as well as improve the triage process for both COVID-19 cases and other medical issues.[205] A similar virtual triage assessment center has been developed in a region of Ontario, **Canada** to provide care to individuals.[206] This system links individuals with a physician or nurse practitioner where phone or video appointments are given, usually within a few hours.[207] Approximately 80% of the calls do not require an in-person visit, thereby preventing overcrowding at hospitals and limiting the possible transmission of the virus.[208]

Medication delivery technologies also have been developed to facilitate healthcare while also maintaining physical distancing recommendations and reducing the risk of viral transmission between healthcare

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[202] Cision. (2020, July 16). Tyto Care Selected as the Winner of the 2020 Extreme Tech Challenge COVID-19 Innovation Award. *Cision*. Retrieved from https://www.prnewswire.com/il/news-releases/tyto-care-selected-as-the-winner-of-the-2020-extreme-tech-challenge-covid-19-innovation-award-301094930.html

[203] Industrial Automation Asia. (2020, April 24). The Future of 5G In The COVID-19 Era. *Industrial Automation Asia*. Retrieved from https://www.iaasiaonline.com/the-future-of-5g-in-the-covid-19-era/

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[205] Descant, S. (2020, May 13). New Tech Aids 911 Centers During COVID-19 Crisis. *Government Technology*. Retrieved from https://www.govtech.com/public-safety/New-Tech-Aids-911-Centers-During-COVID-19-Crisis.html?utm_term=New%20Tech%20Aids%20911%20Centers%20During%20COVID-19%20Crisis&utm_campaign=Iowa%20Governor%20Delays%20Reopening%20as%20Cases%2C%20Deaths%20Rise%20in%20State&utm_content=email&utm_source=Act-On+Software&utm_medium=email

[206] Arsenault, A., & Barr, J. (2020, May 24). House calls, revisited: Mobile medical team provides in-home care to help take pressure off hospitals. *CBC News*. Retrieved from https://www.cbc.ca/news/health/virtual-triage-assessment-centre-renfrew-1.5579197

[207] Ibid.

[208] Ibid.

workers, patients, and the general public. Drones, such as Google's Wing, **USA**, and Drone Delivery **Canada**, have been identified as excellent tools to deliver essentials, including medications.[209] Drone Delivery Canada is currently in talks with the Canadian federal government to work with health systems and implement this contactless delivery approach.[210] In fact, Drone Delivery Canada is confirmed to be transporting COVID supplies to a First Nation community in Ontario.[211] Drone technology also is being considered for the transportation of laboratory materials for COVID-19 testing as well as the transportation of contagious wastes for safe disposal, both of which would help limit infected individuals' contact with public areas.[212] Instead of drones, VANTIQ (**USA**) technology is being utilized by The IVT Group, a regional technology services firm based in **Asia**, to create a *Medical Services Queue Management* app that mitigates the risks of COVID-19 by dispensing medicines without manual input.[213] As seen by the examples above, patients with COVID-19 can be managed and treated entirely through virtual means. Such is the case at Jefferson Health in Philadelphia, **USA**, where patients with COVID-19 have been evaluated and treated without referrals to in-person care.[214]

3.4.4. Decision-Making and Research Support

The final approach to facilitating remote diagnosis and treatment is through supporting decision-making at individual and systemic levels as well as supporting research initiatives. Various technologies also have been deployed to assist frontline healthcare workers with clinical decision-making to best serve patients. InStrat's Global Health Solutions (a company that facilitates improved healthcare delivery in **Africa**) released a COVID-19 app designed to provide front-line healthcare workers with accurate information and screening tools based on the WHO guidelines.[215] An app titled *COVID-19 Triage* also has been developed for healthcare workers in **South Korea** providing guidelines on how to assess a patient's symptoms and epidemiological factors .[216] Similarly, Skymind Holdings has implemented an AI system in a **Malaysian** hospital to support healthcare professionals with diagnoses and early interventions while increasing "medical efficiency."[217]

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[209] De Zeen. (2020, April 15). Google's Wing drones deliver essentials during coronavirus pandemic. *De Zeen*. Retrieved from https://www.dezeen.com/2020/04/15/google-wing-drone-delivery-coronavirus-virginia/?fbclid=IwAR19YpaY3V_GV-iEL31Qr0uwOteScrRk2DRnxljLclb_aVIJs7-OsX1NINA; Drone Delivery Canada. (2020, March 25). Drone Delivery Canada reaches out to healthcare industry for COVID-19 related drone delivery use cases. *Newswire*. Retrieved from https://www.newswire.ca/news-releases/drone-delivery-canada-reaches-out-to-healthcare-industry-for-covid-19-related-drone-delivery-use-cases-839027203.html

[210] Drone Delivery Canada. (2020, March 25). Drone Delivery Canada reaches out to healthcare industry for COVID-19 related drone delivery use cases. *Newswire*. Retrieved from https://www.newswire.ca/news-releases/drone-delivery-canada-reaches-out-to-healthcare-industry-for-covid-19-related-drone-delivery-use-cases-839027203.html

[211] Reagan, J. (2020, August 4). Drone Delivery Canada transporting COVID Supplies to First Nation Community. *Dronelife.* Retrieved from https://dronelife.com/2020/08/04/drone-delivery-canada-transporting-covid-supplies-to-first-nation-community/

[212] Drone Delivery Canada. (2020, March 25). Drone Delivery Canada reaches out to healthcare industry for COVID-19 related drone delivery use cases. *Newswire*. Retrieved from https://www.newswire.ca/news-releases/drone-delivery-canada-reaches-out-to-healthcare-industry-for-covid-19-related-drone-delivery-use-cases-839027203.html

[213] VANTIQ. (2020). *Countering COVID-19.* VANTIQ. Retrieved from https://vantiq.com/vantiq-coronavirus-applications/

[214] Hollander, J. E., & Carr, B. G. (2020). Virtually Perfect? Telemedicine for COVID-19. *The New England Journal of Medicine*, *382*, 1679–1681. Retrieved from https://doi.org/10.1056/NEJMp2003539

[215] Instrat. (2020). *InStrat's Android COVID-19 Application*. Instrat Global Health Solutions. Retrieved from http://instratghs.com/instrats-android-covid-19-application/

[216] COVID-19 Triage. (2020). *Covid-19 Triage.* Covid-19 Triage. Retrieved from http://ncovcheck.com.s3-website.ap-northeast-2.amazonaws.com/index.html?lang=en#/

[217] BioSpectrum Asia Edition. (2020, April 20). Assistive diagnostic AI tool to tackle COVID-19 in Malaysia. *BioSpectrum Asia Edition*. Retrieved from https://www.biospectrumasia.com/news/91/15811/assistive-diagnostic-ai-tool-to-tackle-covid-19-in-malaysia.html

In addition to providing healthcare workers with support on an individual level, numerous technologies are in the process of development, or have been developed and implemented, to assist healthcare systems with planning and handling large influxes of patients. Computer scientists from the University of Copenhagen, **Denmark** collaborated with Rigshospitalet and Bispebjerg Hospital to create an AI system that calculates the risk of a COVID-19 patient requiring intensive care or a ventilator.[218] The Jewish General Hospital in Montreal, **Canada** is using an AI platform to obtain reliable daily projections on the expected number of COVID-19 patients.[219] These two digital solutions help the respective hospitals prevent resource shortages, improve resource allocation (such as PPE and beds required), and maximize efficiency.[220] Meanwhile, researchers from New York University (NYU) have partnered with Wenzhou Central Hospital and Cangnan People's Hospital in **China** to develop an AI tool to predict the severity of COVID-19 cases.[221] In addition to its use as a clinical decision-making aid, this tool may be able to determine which patients are in need of hospital resources and which patients can manage the illness from home.[222] VANTIQ (**USA**) has partnered with **Singapore**-based Personify to develop a risk and quarantine management app for hospitals.[223] The app aims to reduce wait times and exposure to the virus by managing the spread of COVID-19 through efficient patient triage, capacity management, and tracking and routing patients.[224] Similarly, EISOT is collaborating with state governments in **Latin America** to monitor the COVID-19 outbreak by leveraging the VANTIQ system.[225] The objective is to create a system that manages the dispatch of emergency services and optimize treatment regionally. Finally, Qventus is working with healthcare systems in the **USA** to "to improve operations and drive more efficient patient flow" by modelling the spread of COVID-19.[226]

Many research groups around the world are working to develop a treatment for COVID-19 and are leveraging ICTs to support these pursuits, particularly through the use of AI. BenevolentAI and the Imperial College of London, **United Kingdom** have developed an AI algorithm to integrate molecular structure data with biomedical information on receptors and diseases to identify drug targets.[227] Insilico Medicine, **Hong Kong** recently partnered with Arctoris, **United Kingdom** – a company that developed the "world's first fully automated drug discovery platform" – to more effectively identify and evaluate novel small molecules which will assist in discovering, synthesizing, and profiling "a set of inhibitors for

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[222] Ibid.
[223] VANTIQ. (2020). *Countering COVID-19*. VANTIQ. Retrieved from https://vantiq.com/vantiq-coronavirus-applications/
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COVID-19 treatment."[228] Google's DeepMind, **United Kingdom** has developed algorithms to predict protein folding which is an essential step for identifying drug targets.[229] Through their *Alphafold* system, they have worked with researchers around the world to release structure predictions of varied under-studied proteins associated with COVID-19.[230] Alchemy, **USA** has suggested the use of progeny drugs, as determined by AI algorithms, to fight COVID-19 should initial drugs fail.[231] The **Korean** AI company Deargen used their *Molecule Transformer-Drug Target Interaction* model to identify "commercially available drugs" that could be effective against COVID-19.[232] In Montreal, **Canada,** My Intelligent Machines (MIMs) developed an AI platform called *PandemIA* to personalize COVID-19 treatment and vaccination.[233] By identifying population subgroups most at risk and most associated with specific efficacy and toxicity issues, the platform aims to optimize vaccinations and treatment for each patient.[234] Iktos, **France** and SRI International, **USA** collaborated to develop antiviral therapies for COVID-19 using "deep generative models'' of AI.[235] Similar drug discovery and development technologies are also being explored by Gero, **Singapore**, Exscienta, **United Kingdom**, and SenseTime, **Hong Kong**. These technologies can assist researchers with exploring promising leads as well as save considerable amounts of time and resources.

3.5. Conclusions

This module describes **public communications, and remote diagnostics and treatment** to help build understanding of how digital technologies have been used to track and control social behaviour during COVID-19. Discussion begins by introducing the concept of public communications, how it is traditionally performed and how they have been applied during COVID-19. Applications are described through one-way and two-way communications approaches. Remote diagnostics and treatment are also described through traditional versus present approaches, and applications are categorized by focus on screening and assessment, healthcare delivery, and decision-making and research support.

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[235] SRI International. (2020, March 3). Iktos and SRI International Announce Collaboration to Combine Artificial Intelligence and Novel Automated Discovery Platform for Accelerated Development of New Antiviral Therapies. *SRI International*. Retrieved from https://www.sri.com/iktos-and-sri-international-announce-collaboration-to-combine-artificial-intelligence-and-novel-automated-discovery-platform-for-accelerated-development-of-new-anti-viral-therapies/press-release/