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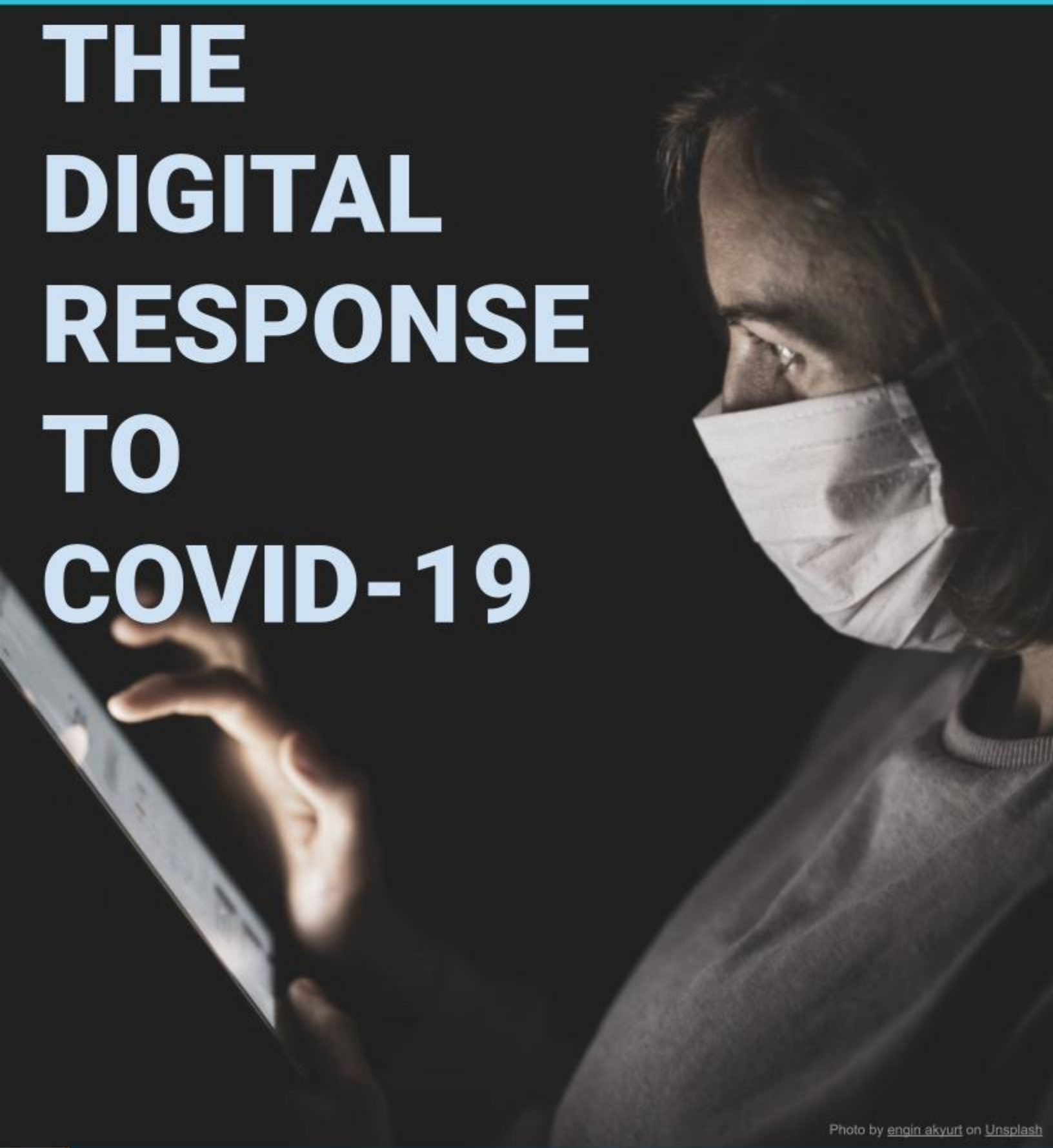
Digital Global Health & Humanitarianism Lab

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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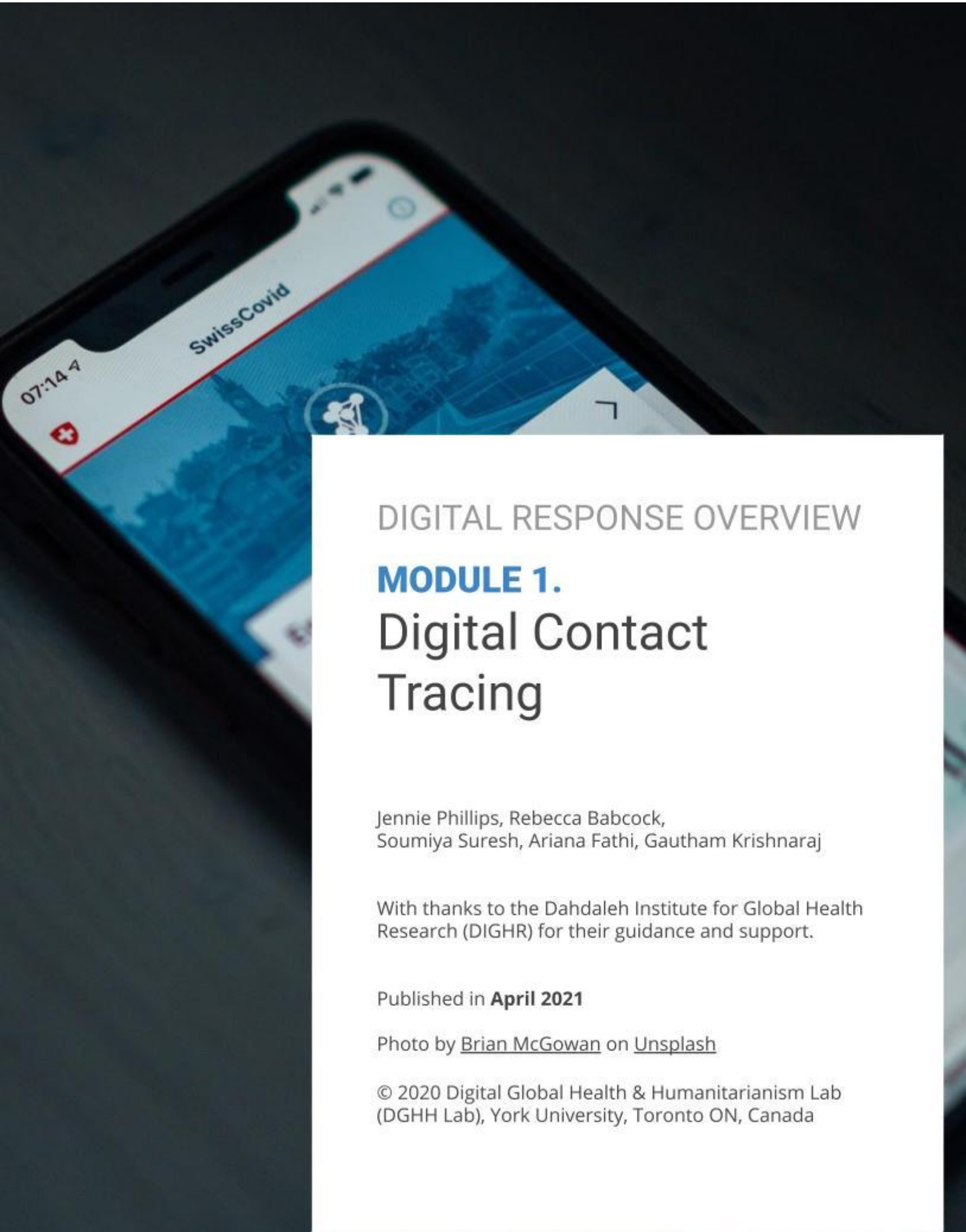

DIGITAL RESPONSE OVERVIEW

MODULE 1.

Digital Contact Tracing

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

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.

3. Digital Contact Tracing (D-CT)

3.1. Introduction

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]

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

[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
[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

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]

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:

> "*[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*

[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/

> *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.

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 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]

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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

[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

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.

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.

[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/

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.

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 everything from people's movements to facial scans to digital wallet activity in an effort to trace the

[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

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) used for D-CT and data verification using QR codes. Specifically, customer and employee visits to hotspots

[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

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/

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

[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]

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

[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

[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]

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.

To continue learning more about the digital response to COVID-19:

Executive Summary.
Module 2. Digital Response Overview: Social Behaviour Monitoring, describes how other types of digital technologies have been used to monitor and control social behaviours, such as the use of eBracelets to ensure that people self-isolate.
Module 3. Digital Response Overview: Public Communications, and Remote Diagnostics & Treatment, explains how digital technologies have been used to diagnose and treat remotely, for example, the use of drones for crowd temperature checking.

[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/