DGHH
Digital Global Health & Humanitarianism Lab

EXPLORING USER-UPTAKE OF DIGITAL CONTACT TRACING (D-CT) APPS

A PRACTITIONER GUIDE

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Dahdaleh Institute for Global Health Research (DIGHR) & Disaster & Emergency Management (DEM)
York University, Toronto ON, Canada

DGHH
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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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Tiana Putric, Rebecca Babcock, Dr. Jennie Phillips

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EXECUTIVE SUMMARY

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Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps
Executive Summary

Background

Since the emergence of COVID-19, societies around the world have experienced significant digital transformation, invention, and innovation and witnessed the rise of digital pandemic response tools to facilitate digital contact tracing (D-CT), social behaviour surveillance and monitoring, public communications, and remote diagnostics and treatment. Although D-CT apps are revolutionizing public health initiatives, particularly at the intersection of manual contact tracing, little research has been conducted on the risks and benefits of these apps from a user perspective. This understanding is vital in successfully rolling out this technological intervention in a manner that mitigates the risks and amplifies the benefits for users across four stages of user engagement 1) uptake (i.e. users downloads the app), 2) use (i.e. users run the app and keeps it updated, 3) report (i.e. users report a positive COVID-19 diagnosis via the app), and 4) react (i.e. users follow necessary next steps upon receiving an exposure notification from the app). As a result, D-CT apps have faced problems such as inconsistent and variable rates of user-uptake and self-reporting across geographical contexts.

Our Study

The Digital Global Health and Humanitarianism Lab's (DGHH Lab) study — "Exploring User-Uptake of Digital Contact Tracing Apps" — aims to gain insight into these problems by identifying and analyzing the individual, community, and system level factors that influence users' engagement with stage one of the user engagement continuum: downloading D-CT apps. The study poses four user-oriented questions:

1. Why is there higher user-uptake of D-CT apps in some countries over others?
2. How does uptake vary across contexts?
3. What factors influence uptake uptake across contexts?
4. How does risk-benefit perception influence uptake?

Ultimately, this study aims to provide D-CT app developers, implementers, and regulators with data-driven strategies for increasing user-uptake while minimizing risk and improving the effectiveness of D-CT apps. As said by the DGHH Lab's Director, Dr. Jennie Phillips, "It is hoped that our findings can help enhance the efficacy of D-CT apps by prioritizing the needs and wants of the individuals expected to use these apps."

To understand D-CT apps through the lens of those using the apps, the DGHH Lab adopted a multiple case study approach, analyzing the context surrounding D-CT app use in Iceland, Cyprus, Ireland, Scotland, and South Africa. These countries were selected because they (1) use voluntary, decentralized D-

CT apps, (2) represent both small and large populations, (3) demonstrate sufficient regional similarity and variation, and (4) reflect the broad range of user-uptake rates that exist globally. For instance, Iceland and Ireland, two developed countries with relatively small populations, have high D-CT uptake at 40% and 43% respectively. Conversely, Scotland's app has seen moderate uptake at 27.5%. Cyprus, a small developed nation, and South Africa, a developing nation with a larger population, both have uptake rates of 1%.

Factors Influencing Uptake

The DGHH Lab's research indicates that user-uptake is influenced by **eight factors**.

1. **Perceptions of Data Collection & Management:** *This individual level factor refers to individual perceptions of data collection and management as well as personal knowledge of privacy and security.*
   Finding: This study found that level of trust in government and private institutions; extent of user input in the development, implementation, and regulation of D-CT apps; the extent and nature of data collected; risk of poor data management; and misunderstandings or misinterpretations that exist in relation to privacy were common themes that influenced user-uptake.

2. **Sense of Community:** *This community-level factor reflects a community's level of shared trust, identity, duty, communitarian values, and connectedness with each other.*
   Finding: Our research indicates that the strong communitarian values can increase user-uptake, while levels of inequality can negatively impact user-uptake.

3. **Communications & Misinformation:** *A community-system level factor that measures the timeliness, transparency, method, and nature of information dissemination as well as the prevalence, spread, and control of misinformation.*
   Finding: Our research indicates that positive and negative narratives, the presence of malicious actors, and the spread of misinformation can influence user-uptake. Transparent and consistent messaging increase uptake while contradictory messaging, fake apps, and social media misinformation negatively impact uptake.

4. **Accessibility & Inclusion:** *A system level factor that considers the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population as well as the level of discrimination and marginalization that results from interventions that fail to meet the principles of universal design.*
   Finding: Across all case studies, digital constraints, app usability, discrimination, digital literacy, and the digital divide impeded uptake of D-CT apps. While some countries took action to increase accessibility & inclusion, there was a general lack of apps that were universally accessible.
5. **Trust in Public/Private Institutions:** *A system level factor considering the citizenry's level of trust and faith in public and private institutions as well as D-CT app developers.*

Finding: The role of government in developing D-CT apps, the role of politics in the country's COVID-19 response, and the D-CT app development approach were common themes identified as potentially influencing user-uptake. Whereas apps that were developed by open source code and non-political, science-driven pandemic responses seemed to increase uptake, low levels of trust in government and/or police seemed to disincentivize users.

6. **Policy & Governance:** *A system level factor that considers the degree to which policies and governance mechanisms regulate D-CT app development, implementation, and use alongside the extent of data collected, the method and length of time data is stored, and when and how data is deleted.*
   Finding: This study found that levels of compliance with existing privacy regulations alongside the intersection of policy transparency and lack of additional safeguards impacted user-uptake. Apps that were at risk of breaching laws saw lower uptake, whereas apps that had transparent policies and/or implemented additional safeguards saw higher uptake.

7. **Response Infrastructure:** *A system level factor that considers the degree to which healthcare and emergency management infrastructure is able to mitigate and respond to COVID-19.*
   Finding: Response experience, response infrastructure capability, and the dynamics between manual and digital contact tracing were seen as influencing user-uptake. Countries experienced with emergencies and had the infrastructure to support the COVID-19 response seemed to contribute to high uptake, whereas infrastructure deficiencies alongside systemic inequality dissuaded uptake.

8. **Digital Capability:** *This system level factor considers the efficacy and efficiency of D-CT apps in serving their purpose and aiding in the management of the COVID-19 pandemic.*
   Finding: Interoperability, poor app functionality in less connected environments, single-purpose functionality, app reliability, and centralized versus decentralized data collection were themes seen to influence user-uptake. App interoperability, offline capacity, and decentralized data collection can incentivized uptake. While low app reliability seemed to serve as a disincentive.

Recommendations

The study identified five cross-case challenges that decreased D-CT uptake and developed recommendations for countering these uptake barriers, as summarized below.

CHALLENGE 1. "Fears of immediate and future surveillance, and alternative uses of personal data."
Across all cases, user-uptake was adversely impacted by fears regarding data harvesting, immediate and future surveillance, and data security.

RECOMMENDATIONS

- ❑ Build open and transparent communication between government officials, citizens, and residents
- ❑ Establish clear data-deletion and D-CT surveillance period end-dates
- ❑ Build and/or leverage trust building relationships
- ❑ Make D-CT apps open-source
- ❑ Employ ethical hacking as a proactive cybersecurity strategy

CHALLENGE 2. "Privacy perceptions may override privacy-by-design principles."Users may have perceptions around app functionality and privacy safeguards that do not reflect the reality of privacy-preserving D-CT apps which will negatively impact user-uptake.

RECOMMENDATIONS

- ❑ Increase data privacy education and awareness
- ❑ Encourage apolitical, science-led response
- ❑ Create a national hotline to report D-CT app misuse/scams
- ❑ Ensure data collection and management processes are open and transparent

Challenge 3. Some communities, such as the elderly, persons with disabilities, or highly surveilled communities, "**are disproportionately affected by and/or excluded from D-CT apps/measures."**

RECOMMENDATIONS

- ❑ Build perceptions of working together and highlighting shared values
- ❑ Understand and prevent/mitigate differential impacts
- ❑ Expand media coverage with more inclusive social media campaigns
- ❑ Build multilingual functionality
- ❑ Ensure compliance with accessibility standards
- ❑ Ensure equal incentives

Challenge 4. "Perceptions of D-CT app effectiveness are poor." While D-CT app effectiveness is dependent on a majority of the public downloading the app, the public is reluctant to download D-CT apps because they believe them to be ineffective.

RECOMMENDATIONS

- ❑ Build, strengthen, and communicate the relationship between manual and digital contact tracing
- ❑ Strive to limit false positives as well as better embed incubation and infection risk into D-CT software
- ❑ Minimize digital glitches
- ❑ Build communication channels between app users and app developers
- ❑ Build app functionality

Challenge 5. "Digital limitations inhibit people from downloading D-CT apps." From owning outdated technology to having limited Internet access to lacking digital literacy, digital limitations (and the digital divide) inhibit people from accessing and downloading D-CT apps.

RECOMMENDATIONS

- ❑ Minimize technical and connectivity requirements
- ❑ Publish short yet instructive app-installation and app-use tutorials
- ❑ Giving individuals free mobile devices or alternative technologies to enable participation

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 1.

Digital Contact Tracing (D-CT) and User-Uptake: **A Primer**

Tiana Putric, Dyllan Goldstein, Jennie Phillips, Rebecca Babcock

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Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 1. A Primer on D-CT and User Uptake

1.1. Study Overview

1.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Section 1.5 below). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have some of the highest rates of countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[1] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with

[1] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

1.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[2] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[3] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 1.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

1.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

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[2] Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/

[3] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

1.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

1.2. Module Overview

This module aims to introduce readers to Digital Contact Tracing (D-CT), D-CT apps, and user-uptake. Discussion begins with providing a detailed background on what D-CT is, why it is a prominent component to the response to COVID-19 globally, and the varied digital approaches to D-CT. Following,

we discuss the opportunities and challenges with D-CT apps, with an emphasis on efficacy and the need to study user-engagement. The next two sections characterize user-engagement with D-CT apps, with a specific focus on user-uptake (phase 1 of the user-engagement process) with D-CT apps across contexts. The last two sections highlight the factors influencing user-uptake in D-CT apps before briefly explaining the study and its methodology.

1.3. Introduction to Digital Contact Tracing (D-CT)

In early 2020, scientists and researchers at China's Viral Disease Prevention and Control Institute determined the existence of a novel coronavirus, later identified as severe acute respiratory syndrome coronavirus or COVID-19. As of January 27, 2021, the virus spread to 219 countries and territories, resulting in approximately 101,210,038 confirmed cases of coronavirus, an estimated 73,130,498 recovered cases, and approximately 2,176,682 deaths.[4]

Throughout the outbreak, the world turned to digital response technologies to reduce and prevent the spread of COVID-19. Digital response technologies harness physical technology (hardware, mobile phones, drones) and soft technology (social media, SMS functionality) to mitigate, prepare for, respond to, and recover from natural, technological, and intentional disasters and emergencies, including public health emergencies. Often, digital response technologies complement and amplify on the ground disaster efforts, as demonstrated by the COVID-19 pandemic.

Prior to the COVID-19 pandemic, Manual Contact Tracing (M-CT) had been a cornerstone public health management tool for infectious disease outbreaks, where the movements and interactions of positive testing patients are tracked by public health agencies.[5] The magnitude of infection brought by COVID-19 helped modernize M-CT into Digital Contact Tracing (D-CT). A more resource-efficient approach to traditional contact tracing systems, D-CT allows epidemiologists to identify potential virus carriers through digital interventions such as mobile apps, QR codes, and tokens. Unlike M-CT, which requires epidemiologists to physically track and trace potential patients and conduct one-on-one interviews, D-CT employs algorithms which run on harvested data (i.e. data that has been extracted from a digital source and analyzed for valuable personal information). D-CT can be used independently or concurrently with M-CT efforts.

D-CT is most frequently implemented in the form of mobile apps. They function through GPS location-based and/or Bluetooth proximity-based tracking and tracing of users. GPS-based D-CT apps record and store users' movements and location data via the device's internal GPS software. Bluetooth-driven D-CT apps use a device's Bluetooth functionality to exchange encrypted keys with other devices that 1) are equipped with the app, and 2) fall within a pre-established radius and duration of time (typically 6 meters

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[4]Worldometer. (2021, January 27. Coronavirus Update (Live): 57,664,343 Cases and 1,372,692 Deaths from COVID-19 Virus Pandemic. Worldometer. Retrieved from https://www.worldometers.info/coronavirus/

[5]Partners In Health. (2014, October 14). *How Contact Tracing Works* [YouTube Video]. Retrieved from https://www.youtube.com/watch?v=hlHCLXv2HQs; WHO Team. (2017, May 9). Contact tracing. World Health Organization. Retrieved from https://www.who.int/news-room/q-a-detail/contact-tracing

for 15 minutes). In both cases, users will be alerted through the phone app if their location logs or Bluetooth caches (in the form of keys) indicate they have come into contact with a user who has tested positive for COVID-19.

D-CT app implementation can take various approaches. Foremost, D-CT can be involuntary in nature (the public is forced to adopt the country's D-CT measures) or accomplished through voluntary participation (individuals have the freedom to choose whether or not they adopt their country's D-CT measures). Both involuntary and voluntary D-CT measures can utilize centralized or decentralized data storage. Centralized data storage involves keeping personal data on central institution-operated servers (generally public health agencies) while decentralized data storage gives users more agency by storing data on the user's end (e.g. on a mobile app). Further, D-CT implementation may take a streamlined or distributed approach. Streamlined D-CT measures embrace cross-border collaboration, with all states or neighbouring nations using the same app or different apps that are compatible with one another. For example, Canada's COVID Alert app can be used by those residing in almost any Canadian province or territory (with the exception of Alberta, British Columbia, Nunavut, and the Yukon).[6] Streamlined approaches to D-CT are beneficial as they allow for interoperability between regions and countries; this is essential as viruses and infectious diseases such as COVID-19 "know[ ] no borders" and therefore necessitate interjurisdictional cooperation.[7] By contrast, distributed D-CT measures emphasize regional independence and delegate "app development to localities or states."[8] The United States, for instance, has taken a distributed approach to D-CT, opting to launch "dozens of apps . . . within small geographic areas, each with its own limits on what other contact tracing apps it can communicate with" but also providing the developer and implementer the freedom to design an app that can respond to its region's specific needs.[9] Third, D-CT apps may also differ in terms of backend development, with some apps operating on the Google Apple Exposure Notification (GAEN) application programming interface (API) and others using custom programming packages produced by academic institutions, non-governmental organizations, or private corporations. Examples of GAEN-based apps include Ireland's *COVID Tracker Ireland*, Scotland's *Protect Scotland*, and South Africa's *COVID Alert SA*. On the other hand, Cyprus' *CovTracer* app operates on the Massachusetts Institute of Technology's (MIT) Safe Paths platform while Iceland's *Rakning C-19* utilizes the Department of Civil Protection and Emergency Management and the Directorate of Health's custom open-source program.[10]

In addition to mobile apps, there are a slate of other digital technologies being used for D-CT like QR codes (China, New Zealand), wearable tokens (Singapore), and eBracelets (South Korea, Bahrain, Hong Kong). QR codes require users to scan barcodes before they use public transportation or enter indoor

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[6] Daigle, T. (2020, October 6). Few provinces still resisting COVID Alert app as new features under consideration. CBC. Retrieved from https://www.cbc.ca/news/technology/covid-alert-app-features-coronavirus-quebec-1.5751497

[7] de Bengy Puyvallée, A., & Kittelsen, S. (2018). "'Disease Knows No Borders": Pandemics and the Politics of Global Health Security. *Pandemics, Publics, and Politics*, 59–73. https://doi.org/10.1007/978-981-13-2802-2_5

[8] Advisory Board. (2020, May 21). How 9 countries are sprinting to launch contact tracing—and 4 ways hospitals can get involved. Retrieved from https://www.advisory.com/blog/2020/05/contact-tracing

[9] Ibid.

[10] Ciric, J. (2020, March 26). Tracking app may assist Iceland with Coronavirus contact tracing. Iceland Review. Retrieved from https://www.icelandreview.com/sci-tech/tracking-app-may-assist-iceland-with-coronavirus-contact-tracing/

locations such as stores and restaurants. eBracelets, which often work alongside mobile D-CT apps, are wireless wearable technologies that track and trace individuals based on the distance from their mobile device. Tokens (an intervention that does not require a mobile phone) are wearable D-CT technologies that employ Bluetooth signals as well as QR codes to create personalized location and contact logs for the wearer. That being said, mobile apps represent the most prevalent and popular D-CT approach, with approximately 49 countries adopting this approach and over 76 mobile D-CT apps released over the course of 2020-21.[11] As such, this study will concentrate on identifying, analyzing, and evaluating mobile D-CT apps across the globe.

1.4. Opportunities & Challenges with D-CT apps

The surge in D-CT apps may be attributed to perceived opportunities, including lower resource demands, more timely transmission tracking, and the ability to track exposure beyond individual social networks. One of the immediate benefits of D-CT is its ability to lower human, financial, and physical resource demands by automating the M-CT process. The M-CT process involves a high degree of human labour, with epidemiologists required to locate COVID-19 carriers, interview them about their whereabouts and interactions, and use this information to identify potential carriers. D-CT lessens the human and financial burdens placed on public health departments by employing algorithms to assume such track and trace responsibilities. As both rapid testing and timely contact tracing are integral to reducing the spread of COVID-19, reducing human labour from the contact tracing equation via D-CT increases the speed at which COVID-19 case investigation, monitoring, and transmission tracking can be carried out. Another perceived benefit of D-CT is its ability to track exposure beyond an individual's known social networks, a capability that is otherwise not possible with M-CT. A final perceived benefit is D-CT's ability to supplement M-CT methods. Whereas epidemiologists were once tasked with identifying, locating, and interviewing infected persons; modelling patient location trails; notifying exposed persons; and conducting follow-up appointments, D-CT apps can now assume these roles and responsibilities. This automation of M-CT is crucial in light of rapid virus multiplication, shrinking "public health departments, the shortage of experienced contact tracing staff, mistrust of government, and lack of cooperation by contacts."[12]

Despite the many opportunities associated with the use of D-CT apps, there are many challenges and risks linked to this innovative approach to contact tracing. These hurdles primarily pertain to privacy and human rights, accessibility and inclusivity, and efficacy. Concerns related to privacy and human rights represent the greatest D-CT barrier, with critics questioning the (1) ethics of involuntary D-CT, (2) the effectiveness of privacy and anonymity safeguards, and (3) the validity of private corporations such as Google and Apple assuming governmental and/or public health roles, among other concerns. In addition, activists and non-governmental organizations such as Human Rights Watch have expressed concerns that D-CT will be used as a trojan horse for mass surveillance, with governments – especially those considered

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[11] Johnson, B. (2020, December 16). The Covid Tracing Tracker: What's happening in coronavirus apps around the world. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/12/16/1014878/covid-tracing-tracker/

[12] Lo, B., & Sim, I. (2020). Ethical Framework for Assessing Manual and Digital Contact Tracing for COVID-19. *Annals of Internal Medicine.* Retrieved from https://doi.org/10.7326/m20-5834

surveillance states – extending control under the "guise of measures for the public's health."[13] Further, it is unclear whether D-CT apps satisfy international human rights standards, follow regulations imposed by governing bodies such as the European Data Protection Supervisor, and fulfill regional and international data protection laws such as the *General Data Protection Regulation* (*GDPR*).

Beyond barriers related to privacy and human rights, D-CT apps may exacerbate accessibility and inclusivity issues because they do not fully embrace universal access nor design. Regarding universal access, uptake of D-CT interventions has been limited by several factors. Most notably, uptake has been hindered by the first-level and second-level digital divide.[14] The first-level digital divide – defined as gaps in physical, material technology access, such as access to the Internet software, and supported devices – is most prominent among high-risk populations such as:

- elderly and low-income individuals, who lack material access to supported technology
- homeless individuals, who do not own mobile devices or "change cell phones and phone numbers frequently"[15]
- migrant workers, who lack device opportunity or do not own devices that support D-CT apps
- people living in refugee camps, where Internet blackouts are a regular occurrence, SIM cards are frequently confiscated, and SIM-card sharing is a common practice[16]

The first-level digital divide is quite possibly the greatest obstacle to D-CT uptake and efficacy, as less than 50% of people own a mobile device and approximately "2 billion mobile phone users worldwide do not own devices that are configured to support Bluetooth-based tracing, a popular version of the technology."[17] Additional universal access issues include limited language options and lack of support for older versions of Android or iOS mobile devices.

Even if the digital divide were overcome, the second-level digital divide – the degree to which people are comfortable with technology and possess relevant Internet and device usage skills – remains a major barrier. The elderly are particularly impacted by the second-level digital divide as many do not possess the knowledge and skills needed to download, set-up, and utilize D-CT apps. In fact, while the elderly are the most vulnerable to COVID-19, they are further disproportionately impacted by the virus because their limited technological knowledge excludes them from gaining the possible benefits from digital solutions aiding to mitigate the spread of the virus. Ultimately, the digital divide further exacerbates the inequities COVID-19 has unearthed.

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[13] Toh, A., & Brown, D. (2020, June 4). How Digital Contact Tracing for COVID-19 Could Worsen Inequality. Human Rights Watch. Retrieved from https://www.hrw.org/news/2020/06/04/how-digital-contact-tracing-covid-19-could-worsen-inequality

[14] van Deursen, A. J., & van Dijk, J. A. (2018). The first-level digital divide shifts from inequalities in physical access to inequalities in material access. *New Media & Society*, 21(2), 354–375. https://doi.org/10.1177/1461444818797082

[15] Toh, A., & Brown, D. (2020, June 4). How Digital Contact Tracing for COVID-19 Could Worsen Inequality. Human Rights Watch. Retrieved from https://www.hrw.org/news/2020/06/04/how-digital-contact-tracing-covid-19-could-worsen-inequality

[16] Ibid.

[17] Ibid.

Beyond digital divide-related issues, many D-CT interventions may not reflect the principles of universal or inclusive design and may not comply with accessibility standards. For instance, the degree to which D-CT apps are amenable to assistive technologies such as large-print options, screen readers, braille and braille embossers, refreshable braille display, video magnifiers, and screen magnification software is unclear.

Closely related to the aforementioned D-CT opportunities and challenges is the question of efficacy - defined as how effective and efficient international D-CT interventions are. Machine failure can hinder effectiveness and efficiency, meaning accurate results are not guaranteed. As many scholars and studies have pointed out, Bluetooth-based apps are likely to produce false positives because Bluetooth signals can travel through walls, meaning two people can be "inside, within six feet but in different apartments or office suites" and still receive an exposure alert.[18] This is especially problematic as the majority of D-CT apps utilize Bluetooth.[19] In addition, D-CT interventions are largely reactive and ad-hoc and have not been sufficiently pretested or red teamed (a cybersecurity technique in which corporations or app developers conduct cyberattack simulations against their own technologies to ensure all security deficiencies are preemptively identified and addressed).[20]

One of the major factors linked to efficacy is user engagement (the primary focus of this study). Preliminary research suggests that better understanding user engagement can provide important insight in understanding the efficacy of D-CT apps. Specifically, the effectiveness and efficiency of D-CT apps is critically dependent on populations downloading and using D-CT apps. By assessing user engagement with D-CT apps specifically from the perspective of risk-benefit, developers, regulators, and implementers can understand how to optimize benefit and mitigate risk for the user which can positively influence user engagement and improve D-CT app efficacy. Yet, preliminary research also shows that the user has not been the focus during the development and implementation of these apps. Subsequently, user-uptake numbers continue to be lacking (see Section 1.6 below for further detail). Consequently, user engagement requires further understanding. As such, this study aims to fill gaps in the research landscape by analyzing how international D-CT efficacy has been positively and negatively influenced by users' perceived and real benefits and risks.

1.5. Characterizing User-Engagement in D-CT Apps

To date, most research and media reports examining user engagement in D-CT apps have largely focused only on uptake, i.e. the number of app downloads. Yet, user engagement cannot be understood by the metrics surrounding the uptake of D-CT apps alone. Instead, an approach which considers all the user engagement stages is necessary in order to provide a more accurate measurement of D-CT app

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[18] Landau, S., Lopez, C., & Moy, L. (2020, May 1). The Importance of Equity in Contact Tracing. Lawfare. Retrieved from https://www.lawfareblog.com/importance-equity-contact-tracing

[19] Leslie, M. (2020). COVID-19 Fight enlists digital technology: Contact tracing apps. *Engineering*, 6(10), 1064–1066. Retrieved from https://doi.org/10.1016/j.eng.2020.09.001

[20] Ibid.

effectiveness. Echoing the research of Thornlow et. al (2020),[21] we identify engagement as a four-stage continuum of engagement (Figure 1.1.0).

Figure 1.1.0 Continuum of User Engagement in Digital Contact Tracing Apps

Each stage is described below:

1. **Uptake** - App users download, install, and register on the app
2. **Use** - App users ensure the app is running and up-to-date on their phone
3. **Report** - App users, identified as positive for COVID-19, report their status in the app so that others they may have had contact with get an exposure alert
4. **React** - App users that have received an exposure notification get tested and/or follow local quarantine protocol

As an emerging public health technology, D-CT requires in-depth research along all stages of the user engagement continuum. In the case studies explored in the following modules, brief descriptions are provided as to what user engagement looks like across all stages of engagement. Yet, because most publicly available data pertains to uptake at this point, this study focuses only on the first of the four stages: user-uptake. Subsequent studies will aim to address the remaining stages of the continuum. As our research goal is to address the larger problem of *why does user-engagement vary across contexts*, this specific study aims to address the question of:

Why is there higher user-uptake of D-CT apps in some countries over others?

Addressing this question involves understanding the following:

1. How does uptake vary across contexts?
2. What factors influence uptake across contexts?
3. How does risk-benefit perception influence uptake?

It should be noted though, that measuring user-uptake is fraught with difficulties arising from a general lack of pre-existing theory to severe data limitations. The following case studies look at uptake through

[21] Thorneloe, R., Epton, T., Fynn, W., Daly, M., Stanulewicz, N., Kassianos, A., Shorter, G. W., Moll, S.-J., Campbell, M., Sodergren, S. C., Chapman, S., Sutherland, L., Armitage, C., Arden, M. A., Chater, A., Byrne-Davis, L., & Hart, J. (2020). *SCOPING REVIEW OF MOBILE PHONE APP UPTAKE AND ENGAGEMENT TO INFORM DIGITAL CONTACT TRACING TOOLS FOR COVID-19.* https://doi.org/10.31234/osf.io/qe9b6

two separate lenses: 1) aggregate app downloads and 2) modified measurements. Ireland's D-CT app, *COVID Tracker Ireland,* will be used as an example to discuss the benefits and challenges with these two user-uptake measurements as more extensive uptake data was revealed through the research process in comparison to the other case studies.

User-uptake is often measured by aggregate downloads. This is a widely available and commonly tracked metric across most D-CT apps. It can provide insight into who is downloading the app and when it is being downloaded. Downloads also provide information on how users react to different events - such as a decrease and subsequent increase in downloads after a major app glitch occurred and was subsequently fixed, as was seen in Ireland when its D-CT app was draining users' phone battery.[22] Yet, aggregate downloads as a sole metric of user-uptake also presents limitations. Foremost, aggregate downloads only measure the total number of times an app has been downloaded and does not provide conclusive insight into whether the app is actually used (i.e. set-up of the app beyond the initial download). Aggregate downloads also do not account for those who uninstall or reinstall the app. Therefore, there may be a considerable discrepancy between app downloads versus usage. This can be illustrated by looking at COVID Tracker Ireland, which has around 1.3 million "active users" but more than 2.1 million "app registrations."[23] If the downloads are used as the metric, the country's uptake rate sits at 40%[24] whereas the registration number means only roughly 28%[25] of the population is actively using the app, highlighting significantly different efficacy rates.

Modified measures of uptake, such as active user measurements, have their own set of benefits and challenges. Modified measures of uptake combine downloads with a variety of other metrics – such as user onboarding (e.g. user registration) or app uninstalls – to provide a more complete picture of user-uptake. For example, Ireland's active users measurement counts those who have completed the app's onboarding process (the minimum amount of action required for the app to function). Metrics such as this cut away large portions of the aggregate download numbers, providing more detailed insight into the rate of users using the app. Despite this increased insight, modified measurements also have some major limitations. First, because the measurements depend on subjective determinations – such as the definition of a user – it remains vulnerable to bias which can ultimately distort the data and the subsequent analysis of the data.[26] Modified metrics also require more data collection which, given prominent privacy concerns, may negatively influence user-uptake. Furthermore, much of the data needed for these calculations is

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[22] Foxe, K. (2020, October 2). Covid-19 app: 150,000 uninstalled app after August battery issue. Irish Examiner. Retrieved from https://www.irishexaminer.com/news/arid-40058456.html

[23] Health Service Executive. (2020). COVID Tracker Ireland [mobile application]. Google Play. Retrieved from https://play.google.com/store/apps/details?id=com.covidtracker.hse&hl=en_US&gl=US

[24] Hawkins, L. (2020, September 25). NearForm's privacy-first contact tracing app has high uptake. Healthcare Global. Retrieved January 27, 2021 from https://www.healthcareglobal.com/telehealth-and-covid-19/nearforms-privacy-first-covid-tracking-app-has-high-uptake

[25] Department of Health. (2020, October 21). Ireland is one of the first countries to link contact tracing apps with other EU Member States. Government of Ireland. Retrieved from https://www.gov.ie/en/press-release/2dc55-ireland-is-one-of-the-first-countries-to-link-contact-tracing-apps-with-other-eu-member-states/

[26] A question which itself does not have a singular or clear answer.

either not available or not collected. Further exploration of issues relating to user-uptake measurements are described in Module 9.

To compensate for issues raised with measuring uptake identified above, our research will take a systems-based approach (described in Section 1.7) to analyze in-depth the factors identified in preliminary research (described in Section 1.6) as well as further identify factors that may impact uptake.

1.6. Factors influencing User-Uptake in D-CT apps

Between countries, and in some cases, within countries, there is great deal of variation in app-uptake. Singapore's *TraceTogether*, with 3.2 downloads, has almost a 74% uptake rate.[27] As if September 2, 2020, New Zealand's *NZ COVID Tracer* has 2.1 million downloads which is a 43% uptake rate.[28] Only 16% of Canada's population has downloaded *COVID Alert*[29] and 18% of France's population has downloaded *TousAntiCovid*.[30] Meanwhile. Iran's *AC19* has an even lower uptake rate with roughly 5%.[31] Meanwhile, Denmark (24%);[32] Australia (24%);[33] Switzerland (29%);[34] England and Wales (29%);[35] and Germany (22%)[36] hover in the middle of the uptake spectrum. While only having a 12% uptake-rate, India has over 160 million downloads.[37] Finally, within the case studies explored in this study, Iceland and Ireland have both seen high levels of user-uptake with 40% and 43%. This is in stark contrast to Cyprus and South Africa with uptake rates barely exceeding 1% of its population. Finally, Scotland is in the middle of the uptake spectrum with 27.5%.

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[27] Government of Singapore. (2020). TraceTogether. Retrieved from https://www.tracetogether.gov.sg/

[28] Blake-Persen, N. (2020, September 2). Covid19 coronavirus: 2.1 million download Covid Tracer app, but who is signing in?. New Zealand Herald. Retrieved from https://www.nzherald.co.nz/nz/covid-19-coronavirus-21-million-download-covid-tracer-app-but-who-is-signing-in/THLDEG6224FS3F4YCE3UM3WRXE/

[29]Government of Canada. (2020). Download COVID Alert Today. Retrieved from https://www.canada.ca/en/public-health/services/diseases/coronavirus-disease-covid-19/covid-alert.html

[30] 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/

[31] Udin, E. (2020, March 11). Coronavirus: Google Deletes Detection App after 4 million Downloads. GizChina. Retrieved from: https://www.gizchina.com/2020/03/11/coronavirus-google-deletes-detection-app-after-4-million-downloads/

[32] The Local. (2020, December 18). Smittestop: Denmark launches English version of Covid-19 contact tracing app. Retrieved from https://www.thelocal.dk/20201218/smittestop-denmark-launches-english-version-of-covid-19-contact-tracing-app

[33] Meizner, S. (2020, June 1). How many people have downloaded the COVIDSafe app and how central has it been to Australia's coronavirus response? ABC News. Retrieved from https://www.abc.net.au/news/2020-06-02/coronavirus-covid19-covidsafe-app-how-many-downloads-greg-hunt/12295130

[34]Künzi, M. (2020, October 29). How 80% of the Swiss population will download the COVID-App. Enigma. Retrieved from https://enigma.swiss/en/blog/how-80-of-the-swiss-population-will-download-the-covid-app/

[35] Langford, E. The NHS Covid-19 App Has Only Had Half the Downloads NHS Advisors Say It Needs to Help Stop the Coronavirus Pandemic. Politics Home. Retrieved from https://www.politicshome.com/news/article/nhs-covid19-app-users-downloads-coronavirus-pandemic-40-80

[36] Oltermann, P. (2020, September 23). Glitches dent German enthusiasm for Covid contact-tracing app. The Guardian. Retrieved from https://www.theguardian.com/world/2020/sep/23/glitches-dent-german-enthusiasm-for-covid-contact-tracing-app

[37] Johari, A. (2020, November 17). Aarogya Setu: Has the world's most downloaded contact-tracing app actually been effective?. Scroll. Retrieved from https://scroll.in/article/978309/aarogya-setu-has-the-worlds-most-downloaded-contact-tracing-app-actually-been-effective

Inquiry into why there is such widespread variation in uptake around the world is complex. Given that the currently available D-CT apps have all been released at different times, in different contexts, and with different capabilities, case comparison can be difficult. Therefore, such comparative analysis requires one to measure across time, look at different variations of uptake, and to identify factors that apply across differing contexts that may influence one's willingness to download a D-CT app. Preliminary examination of existing literature highlights a number of factors that may positively or negatively impact uptake. These varied factors, as presented below, are by no means exclusive of each other. At the margins, there is overlap and multi-directional influence between each factor and those around it.

Many of the factors impacting uptake are best seen through a risk-benefit lens, meaning an analysis focused on how people view the app in relation to themselves. Overall, willingness to use an app will increase when perceived benefits outweigh potential current and future risks. Some of the factors influencing this are: user incentives,[38] trust,[39] and privacy.[40] User incentives may range from entertainment to security to financial outcomes that help increase perceptions of an app's benefit and increase motivation to engage.[41] Meanwhile, notions of low trust in relation to collection and management of personal data may increase the perception of risk. For instance, trust can refer to trust towards the government and often is tied to concerns surrounding privacy, such as whether the government will sell D-CT user data to private third parties.[42] Decisions surrounding participation status (involuntary vs voluntary), data collection methods (centralized vs decentralized), and software type (open source vs closed source) influence trust and subsequently, user-uptake. Moreover, these factors also directly influence app-uptake. For instance, involuntary D-CT interventions, such as Qatar's[43] enforced contact tracing app or China's contact tracing system,[44] report greater engagement than voluntary apps because the former have widespread adoption while the latter experience much lower uptake thresholds.

The proliferation and spread of misinformation[45] also can influence uptake. As has become commonplace in the daily torrent of online interactions and will be highlighted in the case studies, claims have been

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[38] Soltani, A., Calo, R., Bergstrom, C. (2020, April 27). Contact-tracing apps are not a solution to the COVID-19 crisis. Brookings. Retrieved from https://www.brookings.edu/techstream/inaccurate-and-insecure-why-contact-tracing-apps-could-be-a-disaster/

[39] Trust has been reported in some cases as one of the primary influences of user-uptake. For an example see O'Callaghan, M. E., Buckley, J., Fitzgerald, B., Johnson, K., Laffey, J., McNicholas, B., … Glynn, L. (2020). A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland. *Irish Journal of Medical Science*. https://doi.org/10.1007/s11845-020-02389-y

[40] Rowe F. (2020). Contact tracing apps and values dilemmas: A privacy paradox in a neo-liberal world. *International journal of information management*, *55*, 102178. https://doi.org/10.1016/j.ijinfomgt.2020.102178

[41] Labno, A., Kellar, J., Lawyer, P., Wroblewska, J. (2020, June 12). The Promise and the Perils of Contact Tracing. Boston Consulting Group. Retrieved from https://www.bcg.com/en-ca/publications/2020/pros-and-cons-of-contact-tracing-amid-covid-19

[42] Sur, P. (2020, June 21). Many Indian citizens believe their government is trying to steal and sell their data. Here's why. CNN Business. Retrieved from https://www.cnn.com/2020/06/21/tech/india-privacy-app-hnk-intl/index.html

[43] Amnesty International. (2020, May 26). Qatar: Contact tracing app security flaw exposed sensitive personal details of more than one million. Retrieved from https://www.amnesty.org/en/latest/news/2020/05/qatar-covid19-contact-tracing-app-security-flaw/

[44] Huang, Y., Sun, M., Sui, Y. (2020, April 15). How Digital Contact Tracing Slowed Covid-19 in East Asia. Harvard Business Review. Retrieved from https://hbr.org/2020/04/how-digital-contact-tracing-slowed-covid-19-in-east-asia

[45] Budd J., Miller BS., Manning EM. et al. (2020). Digital technologies in the public-health response to COVID-19. *Nat Med* 26, 1183–1192. https://doi.org/10.1038/s41591-020-1011-4

made about D-CT apps that are entirely devoid of supporting evidence. The claimed "infodemic"[46] occurring during the COVID-19 pandemic can create perverse narratives around D-CT apps which can distort user perspectives or reaffirm user misunderstandings surrounding the app, thereby exacerbating perceived risk.

Finally, the degree to which apps are inclusive and accessible to all is a major factor impacting uptake.[47] Barriers to a D-CT app being accessible range from the digital divide[48] to language comprehension to digital literacy to personal disability. Specific development practices and choices have enforced this, such as operating system limitations that originated from the GAEN API (which will be explored in the following modules). Meanwhile, increasing the amount of language options available in the app's settings or having simple instructional videos on how to use the app can be perceived by those who normally would be excluded from downloading a D-CT app as optimizing benefit. It is important to note that it is traditionally underserved populations who often face the greatest barriers to accessing technology.

Though there is a quickly developing system of thought surrounding the influences of D-CT technologies, there is much work to be done. Additional research is needed to understand: 1) how these factors influence uptake across contexts, 2) if there are additional factors that exist that may influence uptake, 3) the relationship of risk-benefit perceptions and the uptake factors identified around the world, and 4) how these factors impact and influence each other. These gaps in knowledge assisted in defining this study's focus and methodology, described in the following section.

1.7. Proposed Study

As initially identified in Section 1.5, this research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

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[46] WHO. (2020, September 23). Managing the COVID-19 infodemic: Promoting healthy behaviours and mitigating the harm from misinformation and disinformation. Retrieved from https://www.who.int/news/item/23-09-2020-managing-the-covid-19-infodemic-promoting-healthy-behaviours-and-mitigating-the-harm-from-misinformation-and-disinformation

[47] McAuliffe, E. (2020, August 14). Covid-19: Ireland cannot keep relying on volunteers for contact tracing. The Irish Times. Retrieved from https://www.irishtimes.com/opinion/covid-19-ireland-cannot-keep-relying-on-volunteers-for-contact-tracing-1.4329627; Weckler, A. (2020, May 10). Ireland's contact-tracing app may struggle - and not just on privacy. Independent. Retrieved from https://www.independent.ie/business/technology/irelands-contact-tracing-app-may-struggle-and-not-just-on-privacy-39192270.html; Clarke, V. (2020, September 25). Covid-19: Half of Ireland moving in the wrong direction, expert warns. Irish Examiner. Retrieved from https://www.irishexaminer.com/news/arid-40054628.html

[48] Watts, G. (2020). COVID-19 and the digital divide in the UK. *The Lancet Digital Health*, 2(8), e395–e396. https://doi.org/10.1016/s2589-7500(20)30169-2

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[49] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include Iceland, Cyprus, Ireland, Scotland, and South Africa. Besides the criteria described above, these countries were chosen based on: 1) similar populations with at least one other country (e.g. Scotland and Ireland, Cyprus and Iceland); 2) regional similarities (e.g. Ireland and Scotland); 3) regional differences (e.g. developed (Iceland) vs developing (South Africa) countries); and 4) variations in D-CT app-uptake (e.g. Cyprus (1%) vs Iceland (40%). Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[50] This theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels of their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 1.1.4 above) through an introduction to D-CT and user-uptake (Module 1); case study (Modules 2-6); systems analysis of factors identified that influence uptake (Modules 7-8); and recommendations and future research (Module 9). For a more detailed overview of our research approach, the full methodology is available here through our website at www.dghhlab.com.

[49] Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/

[50] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 2.
Case Study. **Iceland**

Laksmiina Balasubramaniam, Rebecca Babcock, Jennie Phillips

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Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 2. Case Study: Iceland

2.1. Study Overview

2.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have some of the highest rates amongst the countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[51] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with

[51] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

2.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[52] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[53] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 2.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

2.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

[52]Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/
[53] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

2.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

2.2. Module Overview

This module aims to explore Digital Contact Tracing (D-CT) developed and implemented in Iceland for the COVID-19 response. Focus is on their D-CT app, *Rakning C-19*, and understanding user-uptake. The case study begins with a brief overview of the country's overall response to COVID-19 and the impact of the

virus on the country. Following, we explain Iceland's app by describing how it emerged, how it is designed and functions, how users engage with the app across the whole user-engagement process, and what user-uptake looks like in the country. The next section describes the main factors that emerged in our research for this country that suggest influencing user-uptake within the country's context. This section ends with a brief conclusion.

2.3. Case Study

2.3.1. COVID-19 in Iceland

Iceland saw the first confirmed case of COVID-19 on 28 February 2020 and as of 28 January 2021, had 6,001 confirmed cases of COVID-19 with 29 deaths.[54] In May 2020, Iceland was reporting more than 500 confirmed cases per 100,000 people – putting it among one of the highest confirmed infection rates in the world.[55] However, their death rate from COVID-19 is among one of the lowest (at 0.05%) as of January 2021.[56] The high case count and the low death rate can be explained by Iceland's proactive pandemic response.

Prior to the first positive case, Iceland had activated the Icelandic Pandemic and Influenza Preparedness Plan (IPIPP) in mid-January 2020.[57] Combined with aggressive testing and contact tracing, Iceland was able to flatten the curve by the end of April 2020 with few new cases. This low case count was maintained throughout the summer months with a slight increase in mid-August 2020. By the end of September 2020, Iceland saw a spike in coronavirus cases which was maintained into the end of October 2020 at which point the number of cases started to decrease. The curve flattened by mid-November and a decreasing trend has been continuing throughout January 2021.

[54] Worldometer. (2020). Iceland Coronavirus Cases. Worldometer. Retrieved October 24, 2020, from https://www.worldometers.info/coronavirus/country/iceland/

[55] Bishop, T. (2020, May 17). COVID-19 lessons from Iceland: How one Nordic country has all but stopped the virus in its track. GeekWire. Retrieved from https://perma.cc/RKS6-LG4G

[56] Johns Hopkins. (2020). Coronavirus Resource Center: Mortality Analyses. Retrieved from https://coronavirus.jhu.edu/data/mortality

[57] Sigurgeirsdóttir, S. (2020, June 11). Policy Responses for Iceland. COVID-19 Health System Response Monitor. Retrieved from https://www.covid19healthsystem.org/countries/iceland/livinghit.aspx?Section=5.%20Governance&Type=Chapter

Isolation and quarantine, by region

	Isolation	Quarantine
Greater Reykjavík	468	632
Suðurnes Peninsula	30	74
South Iceland	56	56
East Iceland	2	
Northeast Iceland	115	131
Northwest Iceland	9	5
West Fjords	3	3
West Iceland	24	77
Unknown	3	11
Abroad		

Figure 2.1.0 COVID-19 Isolation and Quarantine Cases by Region[58]*

2.3.2. Evolution of the Digital Contact Tracing App

To supplement the manual contact tracing efforts of the Contact Tracing Teams,[59] the Icelandic government released their GPS-based, decentralized contact tracing app – Rakning C-19 – on 1 April 2020.[60] Rakning C-19 is open source and created as a joint project of the Department of Civil Protection and Emergency Management and the Directorate of Health.[61] The app was created with the volunteered support of private companies in Iceland including: Aranja, Kolibri, Stokkur, Sensa, Samsyn, Icelandic Genetics, and Syndis.[62]

Iceland is said to be moving towards a Bluetooth-based app using the GAEN interface.[63] This shift is to reduce the workload of the manual contact tracing team as rather than trying to identify people who may have been exposed to COVID-19 by relying on location data, the Bluetooth-based app will create records of individuals who have come into contact with individuals who tested positive for COVID-19. The new app will maintain integration with the manual contact tracing team.

The app is the focus of the government's digital efforts to combat COVID-19, other digital solutions (such as QR codes or health passports) are not currently in use.

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[58] Government of Iceland. (2020). Tracing app Rakning C-19. Retrieved from https://www.covid.is/data

*Data is current cases as of 7 November 2020 (not cumulative).

[59] Ciric, J. (2020, March 26). Tracking app may assist Iceland with Coronavirus contact tracing. Iceland Review. Retrieved from https://www.icelandreview.com/sci-tech/tracking-app-may-assist-iceland-with-coronavirus-contact-tracing/

[60] National Crisis and Coordination Centre. (2020, April 3). *Status report: Coronavirus- COVID-19* [Press release]. Retrieved from https://www.almannavarnir.is/english/pandemic-influenza/influenza-a-h1n1/

[61] Ciric, J. (2020, March 26). Tracking app may assist Iceland with Coronavirus contact tracing. Iceland Review. Retrieved from https://www.icelandreview.com/sci-tech/tracking-app-may-assist-iceland-with-coronavirus-contact-tracing/

[62] COVID-19: Tracing with the help of apps. (2020, April 4). Directorate of Health. Retrieved from https://www.landlaeknir.is/um-embaettid/frettir/frett/item40650/covid-19-smitrakning-med-adstod-apps

[63] Personal communication, October 9, 2020

2.3.3. How the app works/design

Table 2.1.0: *Rakning C-19* App Details

	Iceland
Name of the App	Rakning C-19
Developer(s)	❖ Department of Civil Protection and Emergency Management ❖ the Directorate of Health
Decentralized or Centralized Data Collection	Decentralized
Bluetooth, GPS, Both, Other	GPS-based
Type of App: GAEN or Other	Other: GPS-based, open-source app
Mobile Requirements: e.g. iOS, Android, version	iOS 9.0 and up Android 5.0 and up
Alternate functionality?	❖ chat features for users to speak to public health officials ❖ additional information for tourists
Data Collected (Voluntarily) By App	❖ Location data ❖ telephone number
Data Collected (Voluntarily) By Government	❖ Location data ❖ telephone number
Data Collection permission	Voluntary
Data Deletion period	14 days for data on user's phone 14 days for data uploaded (with consent) to a centralized database

Rakning C-19 is a decentralized, GPS-based contact tracing app that was developed as a joint project of the Department of Civil Protection and Emergency Management and the Directorate of Health.[64] In order to download the app, phones must have Android 5.0 and up or iOS 9.0 or later.[65] When individuals download the app they are asked to enter their phone number which is stored in the app's database stored on secure servers hosted by Sensa.[66] For the app to properly function, the individuals must consent to share their phone's location data at all times. The app collects GPS data and this is stored on the user's own device and deleted after 14 days.

[64] Ciric, J. (2020, March 26). Tracking app may assist Iceland with Coronavirus contact tracing. Iceland Review. Retrieved from https://www.icelandreview.com/sci-tech/tracking-app-may-assist-iceland-with-coronavirus-contact-tracing/

[65] Rakning C-19. (2020). Google Play. Retrieved from Retrieved from https://play.google.com/store/apps/details?id=is.landlaeknir.rakning&hl=en_CA&gl=US; Rakning C-19 (2020). App Store. Retrieved from https://apps.apple.com/ca/app/rakning-c-19/id1504655876

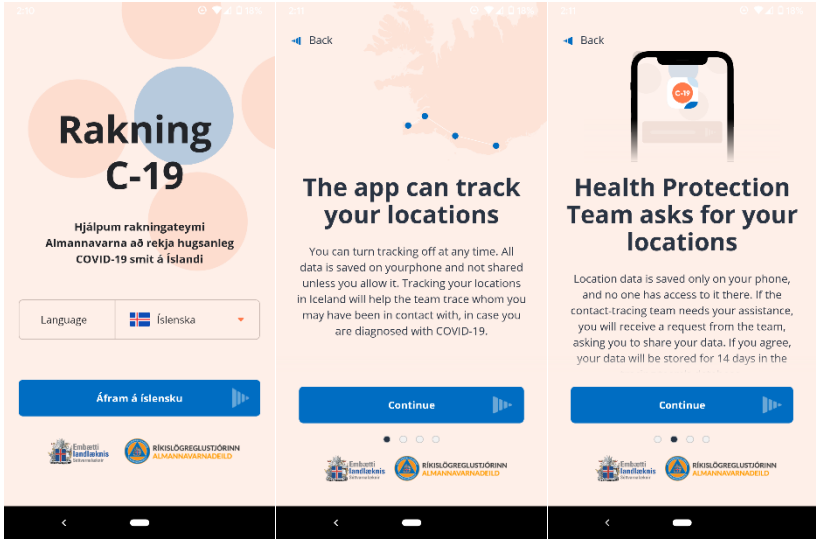
[66] Government of Iceland. (2020). Tracing app Rakning C-19. Retrieved from https://www.covid.is/app/en

If an individual tests positive for COVID-19, they can choose to consent to share their location data with the government's contact tracing team and then their location information will be stored in the team's database for 14 days. This double-opt in design, where individuals must opt to download the app and then opt to share their location data with the contact tracing team if they test positive protects the privacy of users. The app also has chat features for users to speak to public health officials relating to COVID-19 matters as well as contains additional information for tourists.

2.3.3.1. The App Engagement Process

Phase One: Downloading and Setup

Users can download *Rakning C-19* from the Google Play Store or the App Store.[67] When the app is installed, individuals are asked to enter their phone number. Individuals will then receive a text message with a code that must be entered into the app. The user will then be asked whether they consent to giving the app access to their location data.



[67] Ibid.

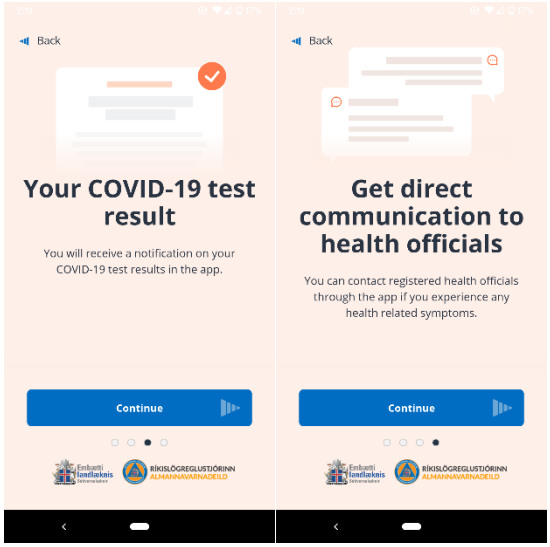


Figure 2.2.0. Initial *Rakning C-19* Set-Up Screen Images[68]

Phase Two: Usage

For the app to function, individuals need to allow the app to have access to location data. *Rakning C-19* works by registering users' GPS data to create a record of where individuals have traveled. The app runs in the background, saving location information several times per hour. The app does not need to be specifically opened in order to work and will run when other apps are being used. The website notes however, it may be a good idea to open the app briefly when departing home as the app may sometimes stop working in the background.

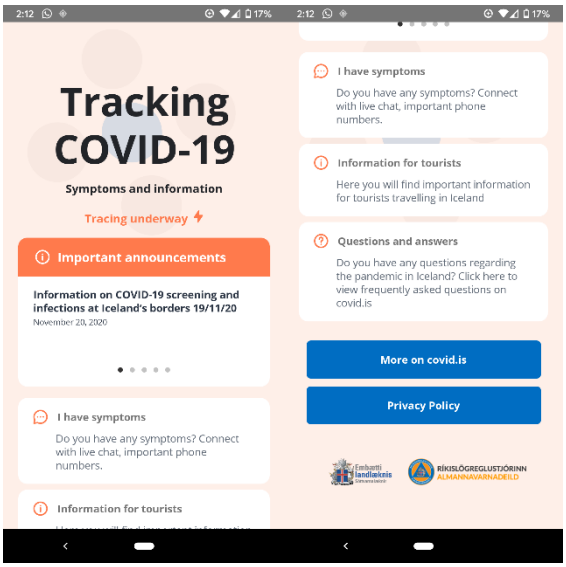


Figure 2.3.0. How *Rakning C-19* Looks Once Downloaded and Tracking is Activated[69]

[68] Rakning C-19. (2020). Google Play. Retrieved from Retrieved from https://play.google.com/store/apps/details?id=is.landlaeknir.rakning&hl=en_CA&gl=US

[69] Rakning C-19. (2020). Google Play. Retrieved from Retrieved from https://play.google.com/store/apps/details?id=is.landlaeknir.rakning&hl=en_CA&gl=US

Phase Three: Reporting

Individuals who have tested positive for COVID-19 and use *Rakning C-19* will receive a request in the app from the Department of Civil Protection and Emergency Management's Contact Tracing Team asking them to share their location data.[70] Individuals can consent by entering their national ID number. Sending location data can help the contact tracing team get a more accurate idea of all the locations the person has visited. This location data can help the contact tracing team identify locations where transmission and potential exposure may have occurred.

Part Four: Reacting

Under the current version of the app, individuals do not receive notifications about potential exposure based on their location data because only data from individuals who test positive for COVID-19 and consent to share their data are available to the contact tracing team. As previously noted, the new app that may be introduced will address this limitation by providing exposure notifications through relying on Bluetooth technology.

2.3.4. App-Uptake

2.3.4.1. Uptake Summary

Table 2.2.0: *Rakning C-19* Uptake Summary

	Iceland
Uptake (#downloads)	~136,000[71]*
Uptake (active users)	Data could not be found
General Uptake (# of downloads general population)	~40%[72]
Age Appropriate Uptake (# of downloads / people over age allowed to download)	Data could not be found
Digital Uptake (# of downloads / connected population)	Data could not be found
Digital Capability Uptake (# of downloads / app-compatible population)	Data could not be found

[70]Government of Iceland. (2020). Tracing app Rakning C-19. Retrieved from https://www.covid.is/app/en

[71] Big brother knows and still Icelanders are happy. (2020, April 23). United Nations Regional Information Centre for Western Europe. Retrieved from https://unric.org/en/big-brother-knows-and-still-icelanders-are-happy/;

*Personal correspondence in October 2020 suggested there has been close to 210,000 downloads of Ranking C-19, but this estimate includes tourists who then delete the app.

[72] Law Library of Congress, Global Legal Research Directorate. (2020, June). Regulating Electronic Means to Fight the Spread of COVID-19. Retrieved from https://www.loc.gov/law/help/coronavirus-apps/iceland.php

2.3.4.2. Uptake Description

With a population of 341,947, roughly 40% of Iceland's population downloaded *Rakning C-19*, reportedly one of the highest penetration of voluntary contact tracing apps in the world.[73] Within the first 24 hours, 75,000 people downloaded the app.[74] Reports of the high levels of download approaching 40% appeared within the first month of the app's release. Based on personal correspondence in October, it is evident that there may be close to 210,000 downloads but this estimate included downloads by tourists who would then delete the app when they leave Iceland.[75] Therefore, while the estimate that 40% of Icelanders downloaded *Rakning C-19* has not been updated since June 2020, it remains the best published estimate of the download rate among the Icelandic population. In terms of other percentages of different groups of uptake as defined in Table 2.2.0, no data could be found. It is important to note that, as mentioned in Module 1, Section 1.5, there are significant issues with determining app success via uptake percentages.

2.4. Uptake Factors

2.4.1. Summary of Uptake Factors

Table 2.3.0: Summary of Uptake Factors in Iceland

Factor	Micro, Meso, and/or Macro	Brief Description
Sense of Community	Meso	The Icelandic government has described their COVID-19 strategy as a "collaborative model" with citizens, residents, and tourists, opting to trust these groups to follow guidelines.
Trust in Public/Private Institutions	Macro	People in Iceland are reported to have high levels of trust in government officials to take appropriate measures to respond to the pandemic.
Policy & Governance	Macro	The privacy policies of the app are publicly available and easily understandable.
Response Infrastructure	Macro	As a nation that regularly faces emergencies (e.g. earthquakes), there is existing infrastructure to manage emergency responses. There were similarly quick and efficient responses to mobilize health infrastructure to respond to the pandemic (e.g. expansion of testing capacity and investment in aggressive manual contact tracing efforts).

[73] Johnson, B. (2020, May 11). Nearly 40% of Icelanders are using a covid app—and it hasn't helped much. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing/; Worldometer. (2020). Iceland Coronavirus Cases. Retrieved October 24, 2020, from https://www.worldometers.info/coronavirus/country/iceland/

[74] National Crisis and Coordination Centre. (2020, April 3). *Status report: Coronavirus- COVID-19* [Press release]. Retrieved from https://www.almannavarnir.is/english/pandemic-influenza/influenza-a-h1n1/

[75] Personal communication, October 9, 2020

2.4.2. Factor Descriptions

2.4.2.1. Sense of Community

Iceland has been described as a country that is socially cohesive with "strong social networks."[76] The government's approach to limiting the spread of COVID-19 has capitalized on this strong sense of community; their approach has been described as a "collaborative model" with citizens, residents, and tourists.[77] They opted to put trust in these groups to follow the guidelines rather than heavily relying on fines and laws. This shared trust between the government and citizens, residents, and tourists allowed Iceland to avoid full national lockdown.[78] Authorities indicated that Icelanders were following social distancing requirements and thus guidelines functioning largely on trust were successful.

Additionally, the website launched by the Iceland government for *Rakning C-19* indicates the more people who download the app, the more useful information analyzed from it will be, and asks people to "be a strong link in the chain."[79] This highlights the strong emphasis placed on every individual doing their part to protect the community from the spread of COVID-19. The existing strong social connections and sense of civic responsibility among Icelanders may have allowed such messaging to strike a chord with citizens, residents, and tourists and contributed to the successful adoption of the app by a significant part of the population. Similarly, high levels of social interaction and trust among the community may increase the responsibility people feel to download and use the app to help safeguard the health of others as they expect others will act this way too.

2.4.2.2. Trust in Public/Private Institutions

People in Iceland are reported to have high levels of trust in government officials, including in the Directorate of Health and the Department of Civil Protection and Emergency Management, both of which were crucial in coordinating the government response to the COVID-19 pandemic.[80] The Icelandic government prioritized good communication during the pandemic response and conducted open and frequent communication to inspire the belief amongst its citizens, residents, and tourists that the government was taking appropriate action.[81] During the height of the pandemic, there were daily press briefings described as just the facts, "no politics and no politicians in the way."[82] In addition, the

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[76] A coronavirus test for anyone? In Iceland, it's happening. (2020, April 8). The Press Democrat. Retrieved from https://www.pressdemocrat.com/article/news/a-coronavirus-test-for-anyone-in-iceland-its-happening/?sba=AAS

[77] Johnson, B. (2020, May 11). Nearly 40% of Icelanders are using a covid app—and it hasn't helped much. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing/

[78] Hjelmgaard, K. (2020, April 10). Iceland has tested more of its population for coronavirus than anywhere else. Here's what it learned. USA Today. Retrieved from https://www.usatoday.com/story/news/world/2020/04/10/coronavirus-covid-19-small-nations-iceland-big-data/2959797001/

[79] Government of Iceland. (2020). Tracing app Rakning C-19. Retrieved from https://www.covid.is/app/en

[80] NPR Weekend Edition Sunday. (2020, May 17). How Iceland handles contact tracing [Audio recording]. Retrieved from https://perma.cc/EBW8-2QQZ

[81] Controlling and preventing infection spread in Iceland. (2020, July 23). Health Europa. Retrieved from https://www.healtheuropa.eu/controlling-and-preventing-infection-spread-in-iceland/101614/

[82] Kolbert, E. (2020, June 1). How Iceland beat the Coronavirus. The New Yorker. Retrieved from https://www.newyorker.com/magazine/2020/06/08/how-iceland-beat-the-coronavirus

government launched a COVID-19 website available in eight languages.[83] The high level of transparency seemed to successfully sustain high levels of trust in government – a Gallup poll reported a 96% approval rate among Icelanders of the response of Icelandic authorities to the pandemic.[84]

Also likely contributing to high approval ratings was the government's response respecting the Icelandic population's high regard for scientific expertise.[85] Reflecting this belief, the government's response has been described as allowing politicians to take a back-seat to medical experts who are leading the response. Science-focused strategic communication that is transparent and expert-driven has been suggested as a factor contributing to public cooperation with contact tracing and containment measures and this may be especially effective when it mirrors beliefs held by the population.[86]

2.4.2.3. Policy & Governance

Transparency and privacy protection are factors that have been suggested to increase the willingness of people to download a contact tracing app.[87] Concern about the storage of data collected and lack of protections against the use of this data for purposes other than contact tracing may serve as barriers to app adoption. *Rakning C-19* has been recognized as one of the least invasive apps from a privacy perspective.[88] By having clearly laid out privacy policies, the *Rakning C-19* website makes the data storage procedures and limitations on data use easily comprehensible. The *Rakning C-19* website indicates "location data are saved only on your phone, and no one has access to them there. If the nation's contact tracing team needs your assistance in tracing contagion, they will send you a request and ask you to send them your data. If you agree, your data will be stored for 14 days in the Tracing Team's Database." Additionally, the app is open source and has been approved by the Icelandic Data Protection Authority.[89] The clearly laid out policies may have contributed to high adoption rates because if people feel confident

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[83]Bishop, T. (2020, May 17). COVID-19 lessons from Iceland: How one Nordic country has all but stopped the virus in its track. GeekWire. Retrieved from https://perma.cc/RKS6-LG4G

[84] Askham, P. (2020, April 21). COVID-19 in Iceland: Tenth death, new government package announced. Grapevine. Retrieved from https://grapevine.is/news/2020/04/21/covid-19-in-iceland-tenth-death-new-government-package-announced/

[85] Hjelmgaard, K. (2020, April 10). Iceland has tested more of its population for coronavirus than anywhere else. Here's what it learned. USA Today. Retrieved from https://www.usatoday.com/story/news/world/2020/04/10/coronavirus-covid-19-small-nations-iceland-big-data/2959797001/

[86] Bhatia, D., Morales-Vazquez, M., Song, K., Roerig, M., Allin, S., & Marchildon, G. (2020). COVID-19 Case and Contact Tracing: Policy Learning from International Comparisons. Toronto: North American Observatory on Health Systems and Policies. Rapid Review (No.25).

[87] von Gratz, P. G. (2020, June 24). Pandemic management – room for improvement at ground control? Mobi Health News. Retrieved from https://www.mobihealthnews.com/news/emea/pandemic-management-room-improvement-ground-control

[88] Law Library of Congress, Global Legal Research Directorate. (2020, June). Regulating Electronic Means to Fight the Spread of COVID-19. Retrieved from https://www.loc.gov/law/help/coronavirus-apps/iceland.php

[89] Boudreaux, B., Denardo, M., Denton, S., Sanchez, R., Fiestel, K., & Dayalani, H. (2020). Data Privacy During Pandemics. RAND. Retrieved from https://www.rand.org/content/dam/rand/pubs/research_reports/RRA300/RRA365-1/RAND_RRA365-1.pdf
Bhatia, D., Morales-Vazquez, M., Song, K., Roerig, M., Allin, S., & Marchildon, G. (2020). COVID-19 Case and Contact Tracing: Policy Learning from International Comparisons. Toronto: North American Observatory on Health Systems and Policies. Rapid Review (No.25).

they understand how data is being collected and the limited purposes their data will be used for (avoiding fears of mission creep), they may be more willing to download and use the app.[90]

2.4.2.4. Response Infrastructure

Iceland's Director of Health, Dr. Alma Möller, described Iceland as "[...] a nation that's used to catastrophes."[91] As a country with an emergency agency that has experience dealing with avalanches and volcanoes, their capabilities to respond to the new emergency of COVID-19 may have been superior to other countries with less experience with emergency response management. Comparatively, Iceland may have had existing legislation and public infrastructure in place allowing a fast and effective government response.[92] For example, the National Commissioner of the Icelandic Police (NCIP) runs the Department of Civil Protection and Emergency Management which oversees a national command centre that operates during emergencies.[93] Furthermore, as stated by Prime Minister Katrín Jakobsdóttir, Iceland began preparing for the pandemic long before the first positive case in Iceland with widespread testing and discussing contact tracing plans.[94]

Iceland's speed of activating its sresponse infrastructure was also reflected in the efficient adaptation of health infrastructure in response to the pandemic. Specifically, the government's collaboration with private biotech company deCODE Genetics based in Iceland allowed Iceland to achieve one of the highest testing rates per capita early on in the pandemic. [95] Widespread testing began prior to the first positive diagnosis and free tests were available to the public. High testing rates meant Iceland was clearly informed of the incidence of the virus and could make informed judgements about restrictions necessary to contain the spread. Furthermore, prior to the introduction of the *Rakning C-19*, the government had invested resources in building a team of manual contact tracers.[96] Manual contact tracing provides nuanced information about interactions not captured by contact tracing apps (for example, if people were wearing masks during interactions). Thus, integrating manual and digital contact tracing efforts can lead to superior outcomes. The earliness and effectiveness of activating response infrastructure allowed

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[90] Hamilton, I. (2020, May 12). Iceland had the most-downloaded contact-tracing app for its population size. Authorities there say it hasn't made much difference. Business Insider. Retrieved from https://www.businessinsider.com/iceland-contact-tracing-not-gamechanger-2020-5

[91] Kolbert, E. (2020, June 1). How Iceland beat the Coronavirus. The New Yorker. Retrieved from https://www.newyorker.com/magazine/2020/06/08/how-iceland-beat-the-coronavirus

[92] Bhatia, D., Morales-Vazquez, M., Song, K., Roerig, M., Allin, S., & Marchildon, G. (2020). COVID-19 Case and Contact Tracing: Policy Learning from International Comparisons. Toronto: North American Observatory on Health Systems and Policies. Rapid Review (No.25).

[93] About the Department of Civil Protection and Emergency Management. (2020). Almannavarnir. Retrieved from https://www.almannavarnir.is/english/about-the-department-of-civil-protection-and-emergency-management/

[94] Kolbert, E. (2020, June 1). How Iceland beat the Coronavirus. The New Yorker. Retrieved from https://www.newyorker.com/magazine/2020/06/08/how-iceland-beat-the-coronavirus; Laurent, L. (2020, May 16). Iceland Is the Perfect Coronavirus Refuge. Bloomberg Opinion. Retrieved from https://www.bnnbloomberg.ca/iceland-is-the-perfect-coronavirus-refuge-1.1437223

[95] Law Library of Congress, Global Legal Research Directorate. (2020, June). Regulating Electronic Means to Fight the Spread of COVID-19. Retrieved from https://www.loc.gov/law/help/coronavirus-apps/iceland.php

[96] Johnson, B. (2020, May 11). Nearly 40% of Icelanders are using a covid app—and it hasn't helped much. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing/

Icelandic officials to make informed decisions which likely contributed to high levels of trust and approval of the government's response as well as likely increased willingness to follow government directives such as downloading the contact tracing app. Furthermore, it has been suggested that contact tracing apps are most effective when part of a broader healthcare response including widespread testing and access to healthcare.[97]

2.5. Conclusion

With one of the highest download rates per capita for a voluntary digital contact tracing app, *Rakning C-19* has been an important part of Iceland's digital response to the pandemic. Within a month of its release, about 40% of the population had downloaded the app. Relying on GPS, the app creates a record of locations a user has traveled to, which can be shared with the contact tracing team if an individual tests positive for COVID-19. Sharing this location data can help the contact tracing team develop a more accurate understanding of locations an individual who tested positive for COVID-19 has traveled to and better pinpoint possible areas of exposure. In this way, *Rakning C-19* has been an important supplement to the manual contact tracing efforts in Iceland. The incorporation of digital contact tracing with manual contact tracing may have led to a more effective contact tracing system.

In general, Icelanders are reported to have high approval rates of effectiveness of the response of Icelandic authorities to the pandemic. This could be because authorities acted quickly to activate its response infrastructure and allowed medical professionals to lead the pandemic response which also sought to capitalize on high levels of a sense of community. Additionally, the government adopted a response that valued transparency and privacy protection which may have facilitated high levels of trust in government institutions. All these factors may have increased the willingness of the population to comply with government directives and download *Rakning C-19*. Advances in technology may allow digital contact tracing to take an increasingly important role in this pandemic, however, to be most effective, digital contact tracing apps cannot function alone, they must be a part of an overall efficient pandemic response plan.

[97] Browne, R. (2020, July 3). Why coronavirus contact-tracing apps aren't yet the 'game changer' authorities hoped they'd be. CNBC. Retrieved from https://www.cnbc.com/2020/07/03/why-coronavirus-contact-tracing-apps-havent-been-a-game-changer.html

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 3.
Case Study. **Cyprus**

Petra Molnar, Tiana Putric, Rebecca Babcock, Jennie Phillips

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DGHH

Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 3. Case Study: Cyprus

3.1. Study Overview

3.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have some of the highest rates of countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[98] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with

[98] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

3.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[99] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[100] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 3.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

3.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

[99] Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/
[100] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

3.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

3.2. Module Overview

This module aims to explore Digital Contact Tracing (D-CT) developed and implemented in Cyprus for the COVID-19 response. Focus is on their D-CT app, *CovTracer*, and understanding user-uptake. The case study begins with a brief overview of the country's overall response to COVID-19 and the impact of the

virus on the country. Following, we explain Cyprus' app by describing how it emerged, how it is designed and functions, how users engage with the app across the whole user-engagement process, and what user-uptake looks like in the country. The next section describes the main factors that emerged in our research for this country that suggest influencing user-uptake within the country's context. This section ends with a brief conclusion.

3.3. Case Study

3.3.1. COVID-19 in Cyprus

On March 9, 2020, the Republic of Cyprus identified its COVID-19 patient zero. As of 21 January 2021, Cyprus has recorded a total of 3,817 coronavirus cases and 25 deaths.[101] The Cypriot government's proactive and evidence-based response to COVID-19 involves strict quarantine measures, international and inter-city travel restrictions, strong government communication, rapid virus monitoring and detection, and large-scale testing (the country is "one of the top 3 per-capita testing countries in Europe").[102] In fact, the country has been deemed the 26th most COVID-19 safe country in the world and was the last country in the European Union to report a case of coronavirus at the beginning of the pandemic.[103]

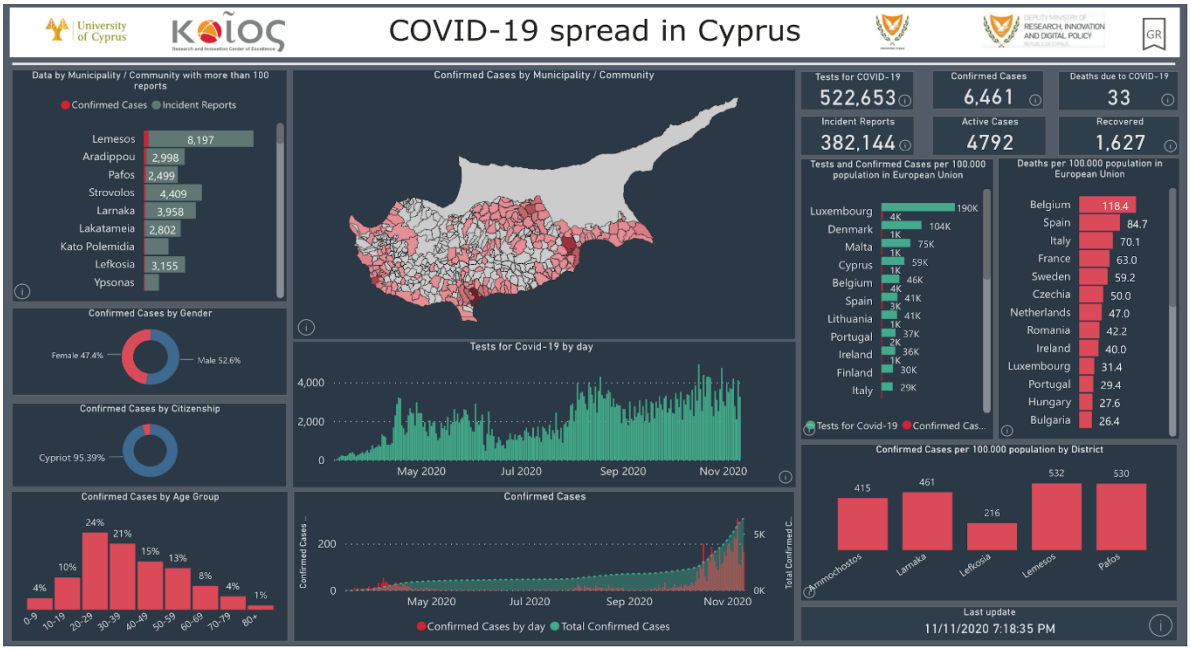

Figure 3.1.0. COVID-19 Spread in Cyprus[104]*

[101] Worldometer. (n.d.). Cyprus Coronavirus: 29,472 Cases and 176 Deaths - Worldometer. Retrieved January 21, 2021, from www.worldometers.info website: https://www.worldometers.info/coronavirus/country/cyprus/

[102] Savva, C. (2020, June 8). Cyprus Ranks Among The Safest Countries During The COVID-19 Pandemic - Coronavirus (COVID-19) - Cyprus. Retrieved from https://www.mondaq.com/cyprus/operational-impacts-and-strategy/948978/cyprus-ranks-among-the-safest-countries-during-the-covid-19-pandemic.

[103] Deep Knowledge Global. (2020). COVID-19 Regional Top-30 Ranking. Deep Knowledge Group. Retrieved from https://www.dkv.global/COVID-REGIONAL-ASSESSMENT

[104] Presidency of the Republic. (2020). Πύλη Πληροφόρησης Πανεπιστημίου Κύπρου για το COVID-19. Covid19. Retrieved from https://covid19.ucy.ac.cy

* as of 11 November 2020

3.3.2. Evolution of the Digital Contact Tracing App

When Cyprus began experiencing a rapid uptick in coronavirus cases and deaths in February 2020, efforts to develop and deploy a COVID-19 contact tracing app began. Cyprus' Deputy Ministry of Research, Innovation and Digital Policy collaborated with the Research and Innovation Centre on Interactive Media, Smart System and Emerging Technologies (RISE UP) to release Cyprus's first and only digital contact tracing (D-CT) app: *CovTracer*.[105] Beyond combating the spread of COVID-19, Cyprus began investing human and financial resources into D-CT because they wanted to contribute to "a coordinated European approach in terms of tracing apps that might improve the management of COVID-19 across the continent, as well as speed up border openings as travel restrictions get lifted."[106] In other words, Cyprus's D-CT efforts were motivated by necessity, public health, economic, political, and international relations imperatives.

The app was initiated by Deputy Minister for Research, Innovation and Digital Policy, Kyriacos Kokkinos, who called for the use of "digital technologies to find quick and innovative ways to fight the COVID19 pandemic."[107] With respect to development, *CovTracer* was developed by RISE UP, who used the Massachusetts Institute of Technology's free, open-source *SafePaths* technology which comprises (1) "a smartphone application, PrivateKit" and (2) "a web application, Safe Places."[108] According to data found on GooglePlay and the App Store, *CovTracer* is being implemented by both RISE UP and the Deputy Ministry for Research, Innovation, and Digital Policy; thus, the app can be characterized as a joint public-private effort.

Since *CovTracer* came into effect, the app's approach has not changed, however the app's target audience has broadened. For instance, the app's pilot version targeted "those on the frontline (e.g. police officers, firefighters, doctors etc.)" while the app's current version (Version 2.0.1) targets the general public, including Cypriot citizens, residents, and tourists.[109] As of 28 October 2020, Cyprus is not employing alternative digital technologies in complement to *CovTracer*.

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[105] Pscheid, J. (2020, May 29). How to Create a COVID-19 Contact Tracing App for Government. EMERGE. Retrieved from https://www.emergeinteractive.com/insights/detail/covid-19-contact-tracing-app-exposure-notification-api/

[106] Hadjicostis, M. (2020, May 2). Cyprus backs voluntary tracking app use to halt virus spread. AP NEWS. Retrieved from https://apnews.com/article/c2063f20458aec53ea4bed6965c62be6

[107] RISE. (2020, April 5). Mobile App to Help Prevent the Spread of COVID19 Developed by RISE Centre of Excellence. Cyens Centre of Excellence. Retrieved from https://www.rise.org.cy/en-gb/media/news/mobile-app-to-help-prevent-the-spread-of-covid19-d/

[108] Massachusetts Institute of Technology [MIT]. (n.d.). Project Overview: Safe Paths. MIT Media Lab. Retrieved from https://www.media.mit.edu/projects/safepaths/overview/

[109] Silva, M. A. (2020, April 23). COVID-19 Apps. European Emergency Number Association. Retrieved from https://eena.org/knowledge-hub/documents/covid-19-apps/

3.3.3. How the app works/design

Table 3.1.0: *CovTracer* Details

	Cyprus
Name of the App	CovTracer
Developer(s)	❖ Cyprus' Deputy Ministry of Research, Innovation and Digital Policy ❖ the Research Centre of Excellence on Information and Communication Technologies in Cyprus ❖ the Massachusetts Institute of Technology ❖ XM.com ❖ Prountzos & Prountzos LLC
Decentralized or Centralized Data Collection	Decentralized
Bluetooth, GPS, Both, Other	Both: GPS and Bluetooth
Type of App: GAEN or Other	Other: MIT's free, open-source SafePaths platform
Mobile Requirements: e.g. iOS, Android, version	iOS 9.0 and up Android 5.0 and up
Alternate functionality?	❖ *symptoms checker* function ❖ news function
Data Collected (Voluntarily) By App	❖ Full Name ❖ Address ❖ Date of Birth ❖ Reason(s) of moving per occasion ❖ Phone number ❖ Email address ❖ Age ❖ Gender ❖ Postal code ❖ Country ❖ Previous medical conditions ❖ Travel history ❖ Existing symptoms ❖ Recent contacts ❖ Phone's location ❖ Phone's memory ❖ Time-stamped location data in five-minute intervals ❖ Information about apps, browsers and devices the user employs in accessing and using the app ❖ User and third-party interactions ❖ Device type ❖ Browser settings Operating system ❖ Network information ❖ IP address ❖ Crash reports ❖ System activity ❖ Cookies
Data Collected (Voluntarily) By Third Parties	❖ According to Section 12 of CovTracer's Privacy Policy, users' personal data will not be shared with third parties unless: ❖ 1. It is with your consent or ❖ 2. The sharing of such information is required and or permitted by law or ❖ 3. To trusted collaborators that they do abide by this privacy policy or ❖ 4. Address fraud, security, or technical issues or ❖ 5. Enforce applicable Terms of Service[110]
Data Collection permission	Voluntary
Data Deletion period	One year

[110] CovTracer. (n.d.). Privacy – CovTracer. Retrieved from https://covid-19.rise.org.cy/RISE_CovTracer_Privacy_Policy_EN.pdf

CovTracer is a voluntary, decentralized mobile digital contact tracing app built using MIT's free, open-source SafePaths platform.[111] Five parties were directly and indirectly involved in the development of *CovTracer*: 1) Cyprus' Deputy Ministry of Research, Innovation and Digital Policy, 2) the Research Centre of Excellence on Information and Communication Technologies in Cyprus, a nonprofit with international partners, 3) the Massachusetts Institute of Technology (MIT), 4) XM.com, and 5) Prountzos & Prountzos LLC. The app uses "overlapped GPS and Bluetooth trails" to contain the spread of COVID-19 by: 1) identifying and alerting individuals "who have come into recent contact with confirmed cases of the SARS-Cov-2 virus" and 2) providing epidemiologists with the information required to implement "timely interventions such as evacuation and disinfection of spaces."[112] *CovTracer* also features a *news* function and a *symptoms checker* function which allows users to determine whether they have symptoms commonly associated with COVID-19. *CovTracer* is compatible with iPhones, iPads, and iPod Touch devices that use iOS 9.0 or later as well as mobile phones that use Android 5.0 and up.[113]

In terms of privacy, *CovTracer* is designed so that users' data – described in Table 3.1.0 – cannot be accessed without the user's explicit consent.[114] In addition, the app preserves and protects users' privacy by allowing users to turn the tracking feature on and off and deleting users' data after one year.[115] No other parties collect users' data, however users' personal information will be shared with third parties, including the Cypriot government, under certain conditions (as identified in Table 3.1.0).[116] Moreover, "[n]on identifiable information may be shared with others in promoting the purpose of the app. This will be in an aggregated statistical fashion, such as with relevant authorities mapping out outbreak areas."[117]

3.3.3.1. The App Engagement Process

Phase One: Downloading and Setup

The user downloads *CovTracer* from either the App Store or Google Play. Upon downloading, the user must specify their preferred working language (Greek or English) as well as their full name, address, and date of birth. A phone number and email address may also be requested for movement tracking, contact, and data verification purposes.

Phase Two: Usage

In order to utilize *CovTracer*, the user must switch on the app's logging by selecting the 'Start/Stop Logging' option. Once in 'Start Logging' mode, the app will track user location information, using GPS, Device Sensor data, IP address Wi-Fi access points, Bluetooth, and cell towers. Users will be asked to specify their "reason(s) of moving per occasion" and location data will be recorded every five minutes in the form of time-stamped data. It is important to note that this data will be stored on the user's device.

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[111] Massachusetts Institute of Technology [MIT]. (n.d.). Project Overview: Safe Paths. MIT Media Lab. Retrieved from https://www.media.mit.edu/projects/safepaths/overview/

[112] CovTracer. (n.d.). CovTracer. Retrieved from https://covid-19.rise.org.cy/en/

[113] Google Play. (n.d.). CovTracer - Apps on Google Play. Retrieved from https://play.google.com/store/apps/details?id=edu.rise.ihnilatis&hl=en&gl=US; App Store. (2020, May 13). CovTracer. App Store. Retrieved from https://apps.apple.com/tt/app/covtracer/id1510330601?ign-mpt=uo%3D2

[114] CovTracer. (n.d.). Privacy – CovTracer. Retrieved from https://covid-19.rise.org.cy/en/privacy/

[115] Ibid.

[116] Ibid.

[117] Ibid.

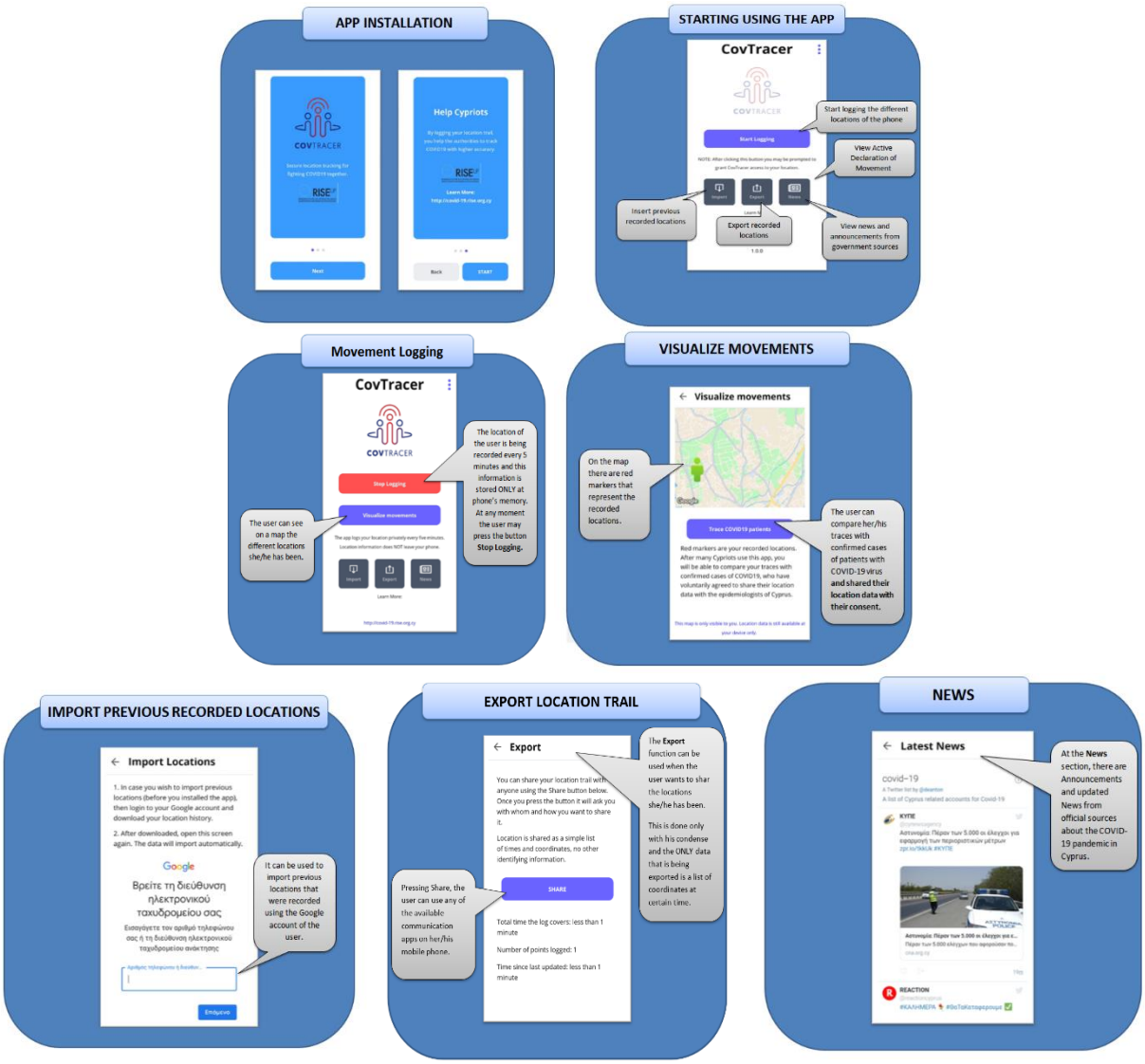

Figure 3.2.0. A Step-by-Step Visualization of *CovTracer* From Installation to Export[118]

Phase Three: Reporting

To report test results and location trails, the user must press *CovTracer's* 'Share' button, thereby consenting to sharing all data recorded by *CovTracer* over the last two weeks, including timestamps, coordinates, geolocation data, and movements. This information will then be sent to an epidemiologist.

Part Four: Reacting

An epidemiologist[119] will review uploaded data and take action such as "evacuate areas [and] perform cleaning [of areas and facilities contaminated with the virus] or . . . inform people who were in close touch with the patient."[120] With user consent, *CovTracer* will anonymize the user's geolocation data and upload it to *CovTracer's* public database for the benefit of other users. According to *CovTracer's* website,

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[118] CovTracer. (n.d.). CovTracer Manual. Retrieved from https://covid-19.rise.org.cy/en/manual/

[119] Please note, it is unclear whether these epidemiologists are employed by the Government of Cyprus or a third party.

[120] CovTracer. (n.d.). Concept – CovTracer. Retrieved from https://covid-19.rise.org.cy/en/concept/

"information about the patient's home and any possible identification traces are removed."[121] The following image depicts the backend tracing tool epidemiologists utilize to track and trace coronavirus-positive users and identify and alert users who may have come into contact with a positive-testing patient.

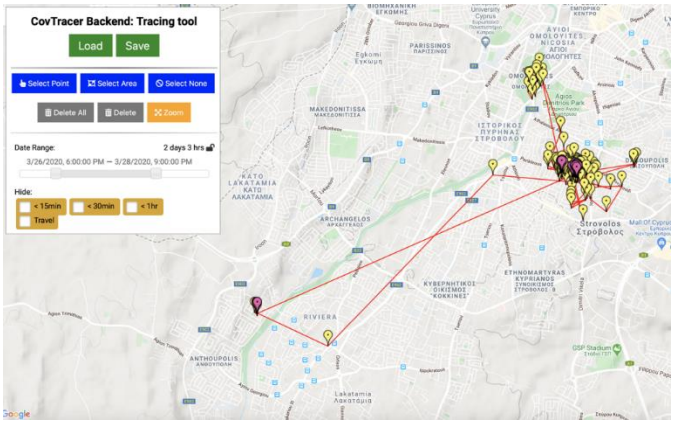

Figure 3.3.0. *CovTracer's* Backend Tracing Tool (used by Epidemiologists for Virus Tracking and Tracing)

3.3.4. App-Uptake

3.3.4.1. Uptake Summary

Table 3.2.0: *CovTracer* Uptake Summary

	Cyprus
Uptake (#downloads)	~8,000 downloads[122]
Uptake (active users)	Data could not be found
General Uptake (# of downloads general population)	~1%
Age Appropriate Uptake (# of downloads / people over age allowed to download)	~1%
Digital Uptake (# of downloads / connected population)	~1%
Digital Capability Uptake (# of downloads / app-compatible population)	~1%

3.3.4.2. Uptake Description

Very little data is available regarding *CovTracer* uptake. However, on 27 April 2020 news outlets reported that the app had approximately 8,000 downloads.[123] Using this data, it is possible to estimate uptake

[121] Ibid.
[122] The National Herald. (2020, April 27). Cyprus Using Tracing App to Follow COVID-19 Pandemic Rath. Retrieved from https://www.thenationalherald.com/cyprus_politics/arthro/cyprus_using_tracing_app_to_follow_covid_19_pandemic_rath-268841/
[123] Euro Cities. (2020, April 16). Nicosia – Tracing corona contacts with an app. https://covidnews.eurocities.eu/?s=Nicosia&orderby=relevance&order=DESC&post_type=post&category_name=limit-the-spread

percentages. As of 2020, Cyprus is home to approximately 1,210,282 people.[124] Therefore, approximately 1% of Cypriots have downloaded CovTracer (general uptake). Regarding age appropriate uptake, approximately 1,067,905 Cypriots meet *CovTracer's* age rating (18+ years old); therefore, age appropriate uptake is 1%. With respect to digital uptake, there were a reported 933.5 thousand mobile internet users in Cyprus as of January 2019, placing digital uptake at roughly 1%.[125] Given that 1,197,240 Android and iOS mobile devices are currently in use in Cyprus, digital capability uptake is estimated to be 1%.[126] It is important to note that, as mentioned in Module 1, Section 1.5, there are significant issues with determining app success via uptake percentages.

3.4. Uptake Factors

3.4.1. Summary of Uptake Factors

Table 3.3.0: Summary of Uptake Factors for Cyprus

Factor	Micro, Meso, and/or Macro	Brief Description
Perceptions of Data Collection & Management	Micro	*CovTracer* is characterized by total transparency and high user control, meaning users are more likely to trust and use the app
Trust in Public/Private Institutions	Macro	People in Cyprus lack trust in the Cypriot government; this may result in lower *CovTracer* uptake as the app is linked to and funded by the government
Policy & Governance	Macro	Cyprus' implementation of *CovTracer* may be at risk of breaching regional and international data protection laws, including a possible contravention of the General Data Protection Regulation (GDPR)
Digital Capability	Macro	The efficacy of *CovTracer* varies between users, with some stating that the app does not work and others reporting positive experiences

3.4.2. Factor Descriptions

3.4.2.1. Perceptions of Data Collection & Management

One of the deciding factors in app-uptake is users' intrinsic perceptions regarding data collection and management, including perceptions of privacy and safety. For instance, research indicates that people's willingness to adopt and engage with apps is influenced by whether the app "seeks user input before delivering personalized services."[127] Apps that consult users before harvesting and mining their personal data are viewed more favourably than apps that do so "covert[ly]" and are more likely to be installed and

[124]Worldometer. (2020). Cyprus Population (2020) - Worldometer. Retrieved from https://www.worldometers.info/world-population/cyprus-population/

[125] Hootsuite. (2019). Digital 2019 Cyprus (January 2019) v01. Retrieved from https://www.slideshare.net/DataReportal/digital-2019-cyprus-january-2019-v01

[126] Stat Counter. (2020). Mobile Operating System Market Share Cyprus. Retrieved from https://gs.statcounter.com/os-market-share/mobile/cyprus/2019

[127] Swayne, M. (2018, April 24). User control and transparency are key to trusting personalized mobile apps. Scienmag. Retrieved from https://scienmag.com/user-control-and-transparency-are-key-to-trusting-personalized-mobile-apps/

less likely to be uninstalled.[128] *CovTracer* employs this privacy-aware design framework and relies on opt-in defaults, explains the purpose of each tracking feature, and consults users at every stage of the data collection process. Such user- and perception-oriented features empower *CovTracer* users and allow them to find "their internal locus of control," meaning users may be more likely to form positive perceptions of the app and trust the app.[129] The more users trust an app, "the greater their involvement in the app and the more positive [their] attitudes."[130] In addition, *CovTracer's* use of opt-in defaults may increase users' perceptions of privacy, decrease perceived security and privacy risks, and increase users' confidence in their self-perceived knowledge of the app.

Moreover, *CovTracer's* high transparency philosophy and design may create incentives for app-uptake and engagement. For instance, the app is run by a nonprofit, avoids using inaccessible jargon in its privacy policy (a move that is thought to decrease real and perceived risk), and runs on open source code, meaning anyone can access and evaluate the app's backend. The latter can be seen as a beneficial feature that increases transparency, accountability, and security. However, open source code can pose a threat to users' privacy and security as it gives all individuals, including black hat hackers,[131] the opportunity to view the app's backend. From a software development perspective however, the risks associated with open source code are offset by the fact that "given enough eyeballs, all security bugs are shallow" (a principle known as Linus's Law).[132] In other words, given a large enough base of open source community members, almost every problem [including security problems] as well as solutions to the problem will be identified.[133] Therefore, the perceived benefits of transparency may represent an uptake incentive for *CovTracer*.

3.4.2.2. Trust in Public/Private Institutions

In Cyprus, trust in government may represent an uptake barrier because Cypriots are largely pessimistic about their country's government, parliament, and political parties. In fact, a recent study found that 66% of Cypriots surveyed "distrust the government," 63% lack trust in parliament, and 87% of Cypriots do not "trust political parties."[134] Lack of trust in the Cypriot government may result in lower *CovTracer* uptake as the app is directly associated with government institutions and bureaucrats. For instance, *CovTracer* is affiliated with Cyprus' Deputy Ministry of Research, Innovation and Digital Policy, was developed by the government-funded RISE UP research centre, and has been recommended by the Cypriot government and key political leaders.

Despite *CovTracer's* ties to the Cypriot government and government-affiliated institutions, the app is also associated with nongovernmental third parties, a detail that may positively influence trust and, in turn, uptake. To elaborate, *CovTracer* is based on MIT's nongovernmental SafePaths platform; is partnered with

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[128] Ibid.

[129] Mesibov, M. (n.d.). The Perception of Control | UX Booth. UX Booth. Retrieved from https://www.uxbooth.com/articles/the-perception-of-control/

[130] Ibid.; Swayne, M. (2018, April 24). User control and transparency are key to trusting personalized mobile apps. Scienmag. Retrieved from https://scienmag.com/user-control-and-transparency-are-key-to-trusting-personalized-mobile-apps/

[131] The term black hat hacker refers to a computer hacker who infiltrates computer systems and networks for malicious reasons such as obtaining and selling peoples' personal information.

[132] Wang, J., Shih, P. C., & Carroll, J. M. (2015). Revisiting Linus's law: Benefits and challenges of open source software peer review. International Journal of Human-Computer Studies, 77, 52–65, p. 59. https://doi.org/10.1016/j.ijhcs.2015.01.005

[133] Raymond, E. S., & Young, B. (2001). *The cathedral and the bazaar: musing on Linux and Open Source by an accidental revolutionary.* Retrieved from https://monoskop.org/images/e/e0/Raymond_Eric_S_The_Cathedral_and_the_Bazaar_rev_ed.pdf

[134] Hadjioannou, B. (2020, February 20). Eurobarometer: Cypriots distrust political parties, tend to trust the army more than other institutions. In-Cyprus. Retrieved from https://in-cyprus.philenews.com/eurobarometer-cypriots-distrust-political-parties-tend-to-trust-the-army-more-than-other-institutions/

Prountzos & Prountzos LLC, a Cyprus-based law firm that specializes in "Digital and GDPR/Data Protection Law;" and is affiliated with XM, a global investment and brokerage firm.[135] Please note, the nature of *CovTracer's* relationship with Prountzos & Prountzos LLC and XM is unclear. While *CovTracer* is associated with non-governmental affiliates, *CovTracer's* government partners will likely have a greater impact on user-uptake as individuals tend to recall and act on negative associations more readily than positive or neutral ones. In this case, app-uptake is more likely to be negatively influenced by Cypriot's low trust in government rather than positively influenced by non-governmental associations affiliated with the app.

3.4.2.2. Policy & Governance

The policy frameworks that surround and govern *CovTracer* represent a barrier to app-uptake. Cyprus' implementation of the *CovTracer* app may be at risk of breaching regional and international data protection laws, including a possible contravention of the General Data Protection Regulation (GDPR), namely the GDPR's laws regarding the storage and processing of location data. Even though the app is presented as "entirely voluntary" to the average user, it is not clear what safeguards are in place to prevent data sharing and function creep – "expanding the utilization of an innovation from the foundation for which it was at first planned to an alternate reason"[136] – from occurring once a person turns on the location sharing data.[137] The European Commission singled out Cyprus as a problematic jurisdiction:

> Location data is not necessary nor recommended for the purpose of contact tracing apps, as their goal is not to follow the movements of individuals or to enforce prescriptions . . . Collecting an individual's movements in the context of contact tracing apps would violate the principle of data minimisation and would create major security and privacy issues.[138]

Not only does *CovTracer* fail to definitively satisfy GDPR requirements, but the app's policy is not clear about what safeguards exist regarding the sharing of location and personal data with third parties. See Section Eight of *CovTracer's* Privacy Policy for the statements in question.[139]

The app may also, on occasion, be relying on algorithmic decision-making which is governed by Article 12 of the GDPR. As such, this app would need to show the necessity of employing automated decision-making as well as clear reasons why):

> The app utilizes a number of technologies such as cookies and local storage to Collect, Process and Store Information. Beyond this information may be used by our automated systems that analyze users' reports- should the user choose to share such reports so as to better improve the app and provide more accurate collated data, as well as algorithms to recognize patterns in these.[140]

Lastly, the security measures in place for *CovTracer* may not stand up to scrutiny of the European Data Protection Supervisor (EDPS) and other compliance bodies, particularly when placing the onus of security

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[135] Prountzos & Prountzos LLC. (n.d.). Our Firm. Retrieved from https://www.pplegal.com.cy/en/our-firm

[136] Safdar, M., Ullah, F., Khan, I., Ullan, F., & Khan, I. (2016). Function Creep in Surveillance Techniques. International Journal of Scientific Research in Science, Engineering and Technology IJSRSET, 2(2), 2394–4099. Retrieved from https://www.academia.edu/25501943/Function_Creep_in_Surveillance_Techniques

[137] CovTracer. (2020). Privacy notice CovTracer-EN. RISE UP. Retrieved from https://covid-19.rise.org.cy/Privacy_notice_CovTracer-EN_v1.pdf

[138] eHealth Network. (2020, April 15). Mobile applications to support contact tracing in the EU's fight against COVID-19. Retrieved from https://ec.europa.eu/health/sites/health/files/ehealth/docs/covid-19_apps_en.pdf

[139] CovTracer. (n.d.). Privacy Policy – CovTracer. Retrieved from https://covid-19.rise.org.cy/RISE_CovTracer_Privacy_Policy_EN.pdf

[140] Ibid.

on the user and employing vague terms such as 'industry standards' without providing more information about what security protocols exist in place, particularly regarding issues around confidentiality, privacy, and security of personal information. See Section 13 of *CovTracer's* Privacy Policy for the measures in question.[141] It is unclear whether users are aware of these threats to security and privacy, however such threats would likely have a negative impact on app-uptake.

3.4.2.4. Digital Capability

According to user reviews found on Google Play, the efficacy of *CovTracer* varies between users, with some stating that the app does not work and requires users to uninstall the app, make updates, and then reinstall the app. Not only does this process take time, but it also results in all data and movement history being lost; this, in turn, causes users to question *CovTracer's* efficacy and reliability. As one user put it, "now all my previous movements are gone and location history from Google cannot be transferred. Not helpful."[142] Users who experience glitches will be less inclined to engage with the app and may uninstall the app altogether. On the other hand, users who have a positive experience will continue using the app and may recommend it to friends, family, colleagues, etc. For instance, one user who gave the app a five-star rating wrote, "A helpful app to keep a diary of movements for two weeks on my phone. Doing all we can to combat covid-19."[143] In the case of *CovTracer*, real and perceived digital capability can serve as both an uptake incentive and uptake barrier.

3.5. Conclusion

While Cyprus' overall COVID-19 response has been effective, the success of the country's voluntary D-CT app, *CovTracer*, has yet to be determined due to gaps in data. As of 27 April 2020, *CovTracer* has been downloaded approximately 8,000 times and has an uptake percentage of 1%. Based on MIT's open-source, privacy-by-design Safe Paths platform, the decentralized *CovTracer* app uses GPS and Bluetooth to track users' location data in five-minute intervals and create location trails. If a user tests positive for COVID-19 and consents to exporting their data, these location trails are shared with epidemiologists, who utilize the app's backend tracing tool to identify and alert users who may have come into contact with the positive-testing patient. Although further research must be conducted to evaluate the effectiveness of *CovTracer*, it is possible that the app is helping Cyprus keep COVID-19 case counts and death rates low. For instance, at the time of writing, Cyprus has reported 40 coronavirus-related deaths over an eight month period.

The fact that *CovTracer* emphasizes privacy, transparency, and data agency may represent an uptake incentive as privacy-oriented approaches have been found to increase individuals' trust in technology, amplify app engagement, and decrease perceived security and privacy risks. On the other hand, uptake may be hindered by low trust in the Cypriot government as well as high level policy and governance issues, including potential contraventions of the GDPR and insufficient security measures as per the EDPS. Finally, an individual's unique user experience due to the digital capabilities of the app is a factor that has the power to act as both an incentivizing or disincentivizing factor. After examining user reviews, it appears as though *CovTracer's* real and perceived efficacy and reliability is variable, with some users experiencing glitches, crashes, software bugs, and data loss (disincentive) and other users reporting positive five-star experiences (incentive). Ultimately, if *CovTracer's* developers and affiliates recognize,

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[141] Ibid.
[142] Google Play. (n.d.). CovTracer - Apps on Google Play. Retrieved from https://play.google.com/store/apps/details?id=edu.rise.ihnilatis&hl=en&gl=US
[143] Ibid.

assess, and control these potentially disincentivizing factors, as well as reinforce the app's incentivizing aspects, the app will likely become a clear asset in Cyprus's pandemic response tool kit, allowing the nation to further improve its already proactive and timely pandemic response.

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 4.
Case Study. **Ireland**

Dyllan Goldstein, Alisha Gauhar, Rebecca Babcock, Jennie Phillips

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Photo by Jesse Gardner on Unsplash

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DGHH

Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 4. Case Study: Ireland

4.1. Study Overview

4.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have some of the highest rates of the countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[144] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with

[144] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

4.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[145] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[146] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 4.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

4.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

[145] Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/
[146] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

4.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

4.2. Module Overview

This module aims to explore Digital Contact Tracing (D-CT) developed and implemented in Ireland for the COVID-19 response. Focus is on their D-CT app, *COVID Tracker Ireland*, and understanding user-uptake. The case study begins with a brief overview of the country's overall response to COVID-19 and the impact

of the virus on the country. Following, we explain Ireland's app by describing how it emerged, how it is designed and functions, how users engage with the app across the whole user-engagement process, and what user-uptake looks like in the country. The next section describes the main factors that emerged in our research for this country that suggest influencing user-uptake within the country's context. This section ends with a brief conclusion.

4.3. Case Study

4.3.1. COVID-19 in Ireland

Ireland reported its first case of COVID-19 on 29 February 2020. As of 9 February 2021, Ireland has seen upwards of 204,940 cases and 3,752 deaths.[147] The country was able to flatten the curve after its first and second waves (in April and October respectively) due to instituting more stringent health and safety measures.[148] There was a significant spike in cases however, at the end of December 2020 and early January 2021.[149] The country appears to be on a fall from this third wave as cases steadily drop. In the heavily populated Dublin area, the case count remains significantly higher than elsewhere throughout the sparsely populated nation. Ireland has a fairly low population density elsewhere, which may contribute to the slower spread of the virus in more rural areas.[150]

Ireland is currently operating off of their Resilience and Recovery Plan, which has varying stages of restrictions and lockdowns based on incidences of the virus. They are currently at a Level 5 of 5 due to the recent surge in cases throughout the country.[151]

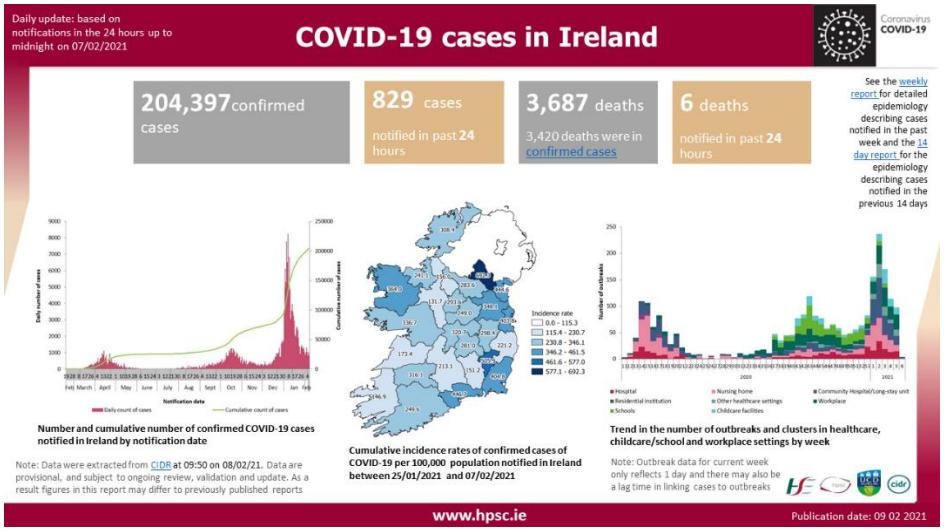

Figure 4.1.0: COVID-19 Spread in Ireland [152]*

[147] Geohive. (2020). Ireland's COVID19 Data Hub. Retrieved from https://covid19ireland-geohive.hub.arcgis.com/
[148] Ibid.
[149] Ibid.
[150] Ibid.
[151] Government of Ireland. (2020, September 15). Resilience and Recovery 2020-2021: Plan for Living with COVID-19. Retrieved from https://www.gov.ie/en/campaigns/resilience-recovery-2020-2021-plan-for-living-with-covid-19/
[152] Health Protection Surveillance Centre. (2021). COVID-19 Cases in Ireland. Retrieved from https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/casesinireland/

4.3.2. Evolution of the Digital Contact Tracing App

In an effort to leverage available technologies to support contact tracing efforts, *COVID Tracker Ireland* was implemented mid-March 2020. It was developed by the Irish Health Service Executive (HSE) alongside open source development company Nearform.[153]

Earlier efforts favored a GPS-based app to help establish COVID-19 hotspots. Around the time Singapore saw relative success with its centralized Bluetooth exposure notification system. Given this and other influences, the decision was made to pursue a centralized system similar to that of Singapore.[154]

Initially, the digital contact tracing system was developed using a centralized approach but due to the various trade-offs involved, the team decided to pursue a decentralized pandemic response app with proximity tracking, exposure notification, and symptom tracking capabilities. The team built and released a functioning app within a few weeks. Shortly after, the software was donated to the Linux Foundation Public Health,[155] titled COVID GREEN, giving other nations the opportunity to utilize the app for use in their own pandemic response. The app is now interoperable with several other countries that utilize the same base software, as well as several EU nations committed to interoperable apps.

At the time of writing, only one other digital contact tracing technology has been released in Ireland. Health Passport Ireland is meant to function as a health tracker and COVID-19 status indicator for use by businesses within the country.[156]

4.3.3. COVID-19 in Ireland

COVID Tracker Ireland is a decentralized, Bluetooth-based app developed by Nearform using the Google Apple Exposure Notification API (GAEN API). As such, the app is designed with privacy in mind. The choice to download the app is voluntary. Furthermore, any data collected via the app occurs only with consent. Potential voluntary data collection includes: phone number, demographic information (county/town, age group, gender), symptoms experienced, and COVID-19 status. Of this data, any exposure-related information is deleted after 14 days. Symptom check-in data is deleted after 28 days. The app is only functional on mobile phones that have iOS 13.5 and up or Android 6.0 and up. Finally, it is categorized as a pandemic response tool[157] as it goes beyond proximity tracking and exposure notification to provide users with pandemic statistics and a daily symptom check-in function.[158]

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* as of 7 February 2021

[153] Nearform. (2020, September 07). Covid App Development. Retrieved from https://www.nearform.com/work/covid-app-development

[154] Personal communication, October 27, 2020.

[155] Linux Foundation Public Health. (2020, October 09). Retrieved from https://www.lfph.io/

[156] Health Passport Ireland. (2020). Retrieved from https://www.healthpassportireland.ie/

[157] Personal communication, October 27, 2020

[158] COVID Tracker. (2020) App. Retrieved from https://covidtracker.gov.ie/privacy-and-data/

Table 4.1.0: *COVID Tracker Ireland* Details

	Ireland
Name of the App	COVID Tracker Ireland
Developer(s)	Nearform
Decentralized or Centralized Data Collection	Decentralized
Bluetooth, GPS, Both, Other	Bluetooth
Type of App: GAEN or Other	Google Apple Exposure Notification API
Mobile Requirements: e.g. iOS, Android, version	iOS 13.5 and up Android 6.0 and up
Alternate functionality?	❖ Provides users with Irish COVID statistics; ❖ optional daily health check in for users
Data Collected (Voluntarily) By App	❖ Phone number ❖ Demographic info (county/town, age group, gender) ❖ Symptoms experienced ❖ COVID-19 status
Data Collected (Voluntarily) By Third Parties	❖ Phone number ❖ Demographic info (county/town, age group, gender) ❖ Symptoms experienced ❖ COVID-19 status
Data Collection permission	Voluntary
Data Deletion period	14 days for: ❖ Diagnosis keys ❖ Exposure notification service identifiers 28 days for: ❖ daily symptom check-in

4.3.3.1. The App Engagement Process

Phase One: Downloading and Setup

COVID Tracker Ireland can be downloaded through Google Play or the Apple store. Bluetooth must be enabled for the app to function properly. Beyond this, the user is given the option to enter personal data such as: age range, location, telephone number, and gender.

Figure 4.2.0. Getting Started with COVID Tracker Ireland[159]

Phase Two: Usage

The app runs in the background and does not need to be opened for its proximity tracing function to work. The app additionally contains a voluntary personal symptom tracking service and information hub. The symptom tracking information can be voluntarily shared with the HSE for use in future research or app improvement.[160] The symptom checker and information hub was included to encourage uptake and use.[161]

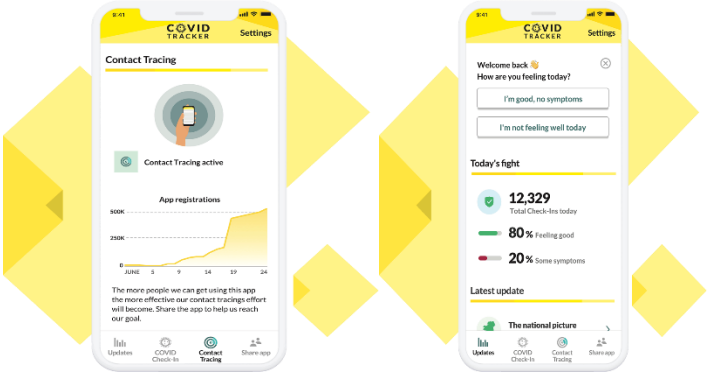

Figure 4.3.0. COVID Tracker Ireland's Contact Tracing Screen (left)[162] and Symptom Check-In Screen (right)[163]

Phase Three: Reporting

If a user were to test positive for COVID-19, the HSE's contact tracing team will phone the user and ask the user if they are willing to upload the anonymous IDs the phone has shared over the past 14 days. If the user consents to sharing this anonymous data, the contact tracing team will send an 'upload code' via text message which the user will enter into the app to enable the IDs to be uploaded to the HSE.

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[159] Health Service Executive. (2020.). COVID Tracker Ireland. Google Play. Retrieved from https://play.google.com/store/apps/details?id=com.covidtracker.hse

[160] COVID Tracker. (2020). Privacy & How We Use Your Data From The COVID Tracker App. Retrieved from https://covidtracker.gov.ie/privacy-and-data/

[161] Personal communication, October 27, 2020

[162] Health Service Executive. (2020). COVID Tracker Ireland. Google Play. Retrieved from https://play.google.com/store/apps/details?id=com.covidtracker.hse

[163] Ibid.

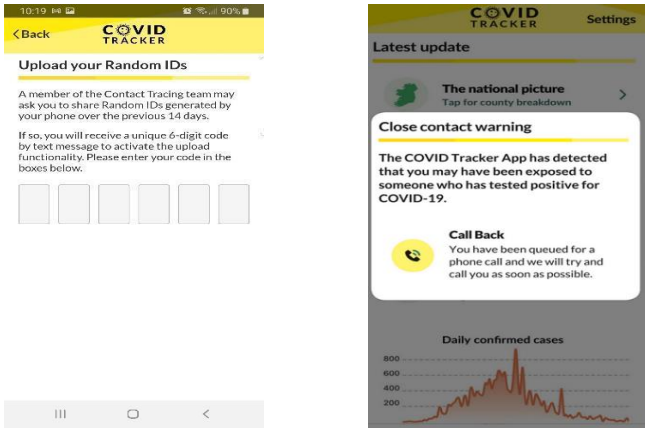

Figure 4.4.0. Unique Code Screen to Upload Random IDs (left)[164] and Exposure Notification Warning (right)[165]

Part Four: Reacting

Every two hours, the app checks to see if COVID-19 positive IDs match the IDs that the user has been exposed to. Exposure is determined as being within 2 meters for more than 15 minutes of another person.

If the IDs match with the user's exposure history, they will receive an exposure notification on the app. Those who have shared their phone number will be contacted by a member of the HSE's contact tracing team. If there is no connected phone number, the app will provide the information needed to continue the contact tracing process. In this way, the app has been integrated into the manual contact tracing process.[166]

[164] Ibid.

[165] Our Health Service. (2020, December 21). Why use the COVID Tracker app. Our Health Service. Retrieved from https://covidtracker.gov.ie/why-use-covid-tracker/

[166] COVID Tracker. (2020). How The COVID Tracker Free Mobile App From The HSE Works. Retrieved from https://covidtracker.gov.ie/how-the-app-works/

4.3.4. App-Uptake

4.3.4.1. Uptake Summary

Table 4.2.0: *COVID Tracker Ireland* Uptake Summary

	Ireland
Uptake (#downloads)	~2.10 million[167]
Uptake (active users)	~1.38 million users[168]
General Uptake (# of downloads general population)	~43%
Age Appropriate Uptake (# of downloads / people over age allowed to download)	~62% - 68%[169] [170]
Digital Uptake (# of downloads / connected population)	~49%[171]
Digital Capability Uptake (# of downloads / app-compatible population)	~43%

4.3.4.2. Uptake Description

The general uptake of 43% is based on a population of roughly 4,950,000 million. In terms of age appropriate uptake, *COVID Tracker Ireland* has been developed for persons ages 16+. Therefore, calculations were made using the 2016 census numbers[172] to roughly determine that Ireland has a population of about 3.83 million individuals over the age of 16 which suggests that 62-68% of the eligible population has uploaded the app.[173] Digital uptake was determined based on 2019 data that suggests 88% of the Irish population used mobile phones to access the internet, thereby providing a rough estimate that 49% of the connected population has downloaded the app. In terms of digital capability uptake, no data could be found on how many residents had smartphones that had the necessary operating system to download the app. Yet, 99.81% of smartphone users have either Android or iOS,[174] so a *very* rough estimate could suggest that approximately 43% of the eligible population in terms of digital capability has downloaded the app. Of course, there are major limitations to these percentage estimates,

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[167] Health Service Executive. (2020). COVID Tracker Ireland. Google Play. Retrieved from https://play.google.com/store/apps/details?id=com.covidtracker.hse
[168] Personal communication, October 27, 2020
[169] Central Statistics Office. (2018, October 04). Census 2016 Summary Results - Part 1 - CSO - Central Statistics Office.Retrieved from from https://www.cso.ie/en/csolatestnews/presspages/2017/census2016summaryresults-part1/
[170] Central Statistics Office. (2017, July 26). Census 2016 Profile 3 - An Age Profile of Ireland - CSO - Central Statistics Office. Retrieved from from https://www.cso.ie/en/csolatestnews/presspages/2017/census2016profile3-anageprofileofireland/
[171] Central Statistics Office. (2019, October 18). Information Society Statistics Households 2019. Central Statistics Office. Retrieved from https://www.cso.ie/en/releasesandpublications/ep/p-isshh/informationsocietystatistics-households2019/
[172] Central Statistics Office. (2018, October 04). Census 2016 Summary Results - Part 1 - CSO - Central Statistics Office. Retrieved from from https://www.cso.ie/en/csolatestnews/presspages/2017/census2016summaryresults-part1/
[173] This does account for population growth and is intended as only a rough estimate.
[174] StatCounter. (2020). Mobile Operating System Market Share Ireland. StatCounter GlobalStats. Retrieved from https://gs.statcounter.com/os-market-share/mobile/ireland/2016

including but not limited to: not accounting for changes in population size between 2016 and 2020, not accounting for smartphones that cannot run the app, lack of accuracy when using downloads as a measure of uptake, users and those with smartphones, and generally the issues with examining app success via uptake measures (see Module 1, Section 1.5, for a more complete description of the issues surrounding measurements of uptake).

4.4. Uptake Factors

4.4.1. Summary of Uptake Factors

Table 4.3.0: Summary of Uptake Factors for Ireland

Factor	Micro, Meso, and/or Macro	Brief Description
Perceptions of Data Management & Collection	Micro	There is a disconnect between Irish beliefs about perceived risk and actual risk of the app – particularly surrounding privacy and how personal data should be, and is being, managed – which is likely acting as an uptake barrier.
Sense of Community	Meso	General Irish attitudes towards community and social responsibility, such as the strong desire to protect friends and family, may be seen as an incentive to download the app.
Communications & Misinformation	Meso-Macro	The HSE has maintained a clear and consistent messaging campaign which may assist in app-uptake, yet disparaging memes and inaccurate social media content may similarly dissuade people from downloading the app.
Accessibility & Inclusion	Macro	Despite many efforts to make the app more inclusive, digital literacy and other barriers to accessibility – including smartphone compatibility with the app – must still be researched and addressed.
Trust in Public/Private Institutions	Macro	The choice to use an open source, seemingly trustworthy developer for the app alongside high trust towards Ireland's Healthcare System likely creates a context in which people may be more trusting to download a contact tracing app

4.4.2. Factor Descriptions

4.4.2.1. Perceptions of Data Management & Collection

In the Irish context, public privacy concerns appear to focus on the *kinds* of data that is being collected and *whether* the government is going to abide by its claims regarding the use of said data. This public perception, misguided or not, on the invasiveness of data collection seems to be an uptake barrier that appears early on in the app's development. For instance, in late July, professors Douglas Leith & Stephen Farrell from Trinity College raised concerns as to perceived weaknesses within the app.[175] Despite most of

[175] Irish Council for Civil Liberties. (2020, July 21). Serious privacy and data harvesting concerns about technology underlying HSE app. Retrieved from https://www.iccl.ie/news/serious-privacy-and-data-harvesting-concerns-about-technology-underlying-hse-app/

these concerns being deemed misplaced by the HSE,[176] this reflects some of the fears that have been publicized through news[177] and within some of the social media scrapes undertaken for this study. Some of this fear and misperception may be derived from misunderstandings of the app and relevant technology. For example, due to the specific Bluetooth function (Bluetooth Low Energy) that is used for *COVID Tracker Ireland*, location services must be turned on for the app as of Android 6.0 and up.[178] Some already concerned users may mistake this for an indication that the app is providing the government with personal location information.[179]

Indeed, many of the privacy concerns seem to be entirely separated from the reality of the risks actually posed by the app.[180] In line with the path established by the GAEN API, *COVID Tracker Ireland* was designed with privacy in mind. All data entry is voluntary, anonymized, and regularly deleted. This apparent disconnect between perceived risks and actual risks is a concern, as despite the good work done by the Linux Foundation Public Health (LFPH) and other organizations on security audits and the like,[181] misconceptions remain. There is not a clear pathway for technical explanations to reach end users. This communication difficulty may in itself be a barrier towards further uptake as it may limit the degree to which concerns can be allayed.

4.4.2.2. Sense of Community

For many, using the app appears to be considered a duty, similar to "washing your hands, or wearing a mask."[182] Pro-social actions appear to be highly valued within Irish society. This has been indicated in various places, including in app-focused behavioral studies undertaken by the HSE. In these studies, it was found that communitarian messaging tested better among respondents than did messaging reflecting a more individualistic mindset.[183] There is further support for this notion through the findings of O'Callaghan *et al*. (2020),[184] where protection of family and friends ranked higher than protection of self as a reason to install the app. From the same work,[185] one can see a general willingness to download the app (82% acceptance) prior to the release of the app itself. Exactly why is unclear, though following along the previously mentioned survey findings, and taken in tandem with social values descriptors such as those done by GLOBE,[186] this willingness may be partially due to a national leaning towards

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[176] Foxe, K., & Brennan, C. (2020, October 13). Dept of Health officials dismissed criticism of Covid tracker app as "incorrect." Irish Examiner. Retrieved from https://www.irishexaminer.com/news/arid-40063898.html

[177] Weckler, A. (2020, May 10). Ireland's contact-tracing app may struggle - and not just on privacy. Independent.ie Retrieved from https://www.independent.ie/business/technology/irelands-contact-tracing-app-may-struggle-and-not-just-on-privacy-39192270.html

[178] Android. (2020). Android 6.0 Changes: Android Developers. Retrieved from https://developer.android.com/about/versions/marshmallow/android-6.0-changes

[179] Personal communication, October 22, 2020

[180] Personal communication, October 15, 2020

[181] Personal communication, October 21, 2020

[182] Personal communication, October 27, 2020; Personal communication, October 22, 2020

[183] Personal communication, October 27, 2020

[184] O'Callaghan, M. E., Buckley, J., Fitzgerald, B., Johnson, K., Laffey, J., McNicholas, B., … Glynn, L. (2020). A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland. *Irish Journal of Medical Science.* https://doi.org/10.1007/s11845-020-02389-y

[185] Ibid.

[186] Global Leadership and Organizational Behaviour Effectiveness. (2020). Results - Ireland GLOBE Project. Retrieved from https://www.globeproject.com/results/countries/IRL?menu=list; For critiques detailing contradictory measurement systems see: Allik, J., & Realo, A. (2004). Individualism-Collectivism and Social Capital. *Journal of Cross-Cultural Psychology, 35*(1), 29–49. https://doi.org/10.1177/0022022103260381

communitarian values. As these values were targeted in the apps official public messaging,[187] Ireland may be an apt demonstration of the effective leveraging of social values to improve app-uptake.

4.4.2.3. Communications & Misinformation

The narratives surrounding D-CT technologies may directly influence user perceptions of the app. Sentiments of pride and responsibility have developed around *COVID Tracker Ireland*, as is evident through both news coverage and social media posts. This is especially visible on social media such as Twitter, where in mid-October, retweets and original posts celebrating the app's success (especially in comparison to the UK app), dominated much of the discussion.[188] These positive narratives can provide an incentive for user-uptake. These narratives can be partially attributed to the early[189] and consistent messaging on the part of the HSE. Some brief examples of this take the form of:

- Messages of responsibility via government and expert releases.
- An image of transparency built by making the source code public and donating the app to the Linux Foundation.
- Stressing the volume of exposure chains being broken to increase perceptions of efficacy.

Figure 4.5.0. Drake meme relating to download contact tracing apps

Less positive is the disparaging content found in the form of memes and messages. Much of it recycles content about privacy or data security risks, regardless of accuracy of the claims. These anti-app sentiments are not always specifically aimed at the Irish app, but their rapid proliferation through the internet ensures they reach Irish users. Overall, what narratives exist (be they positive or negative) and what meanings are being created is not entirely clear. This can be in part attributed to the complexity of narrative formation, and in part to limited capacity to monitor all that is being said on the subject.[190]

Overall there has been some degree of success with the HSE's approach. A positive narrative appears to be an incentive for use, while its opposite acts as a barrier. Importantly, because the process of narrative

[187] For examples of the language used in the pro-social messaging, see: Government of Ireland. (2020). Minister for Health welcomes launch of contact tracing apps in New York and New Jersey based on the Irish contact tracing app. Retrieved from https://www.gov.ie/en/press-release/02080-minister-for-health-welcomes-launch-of-contact-tracing-apps-in-new-york-and-new-jersey-based-on-the-irish-contact-tracing-app/

[188] Based on samples taken from Twitter during October, 2020.

[189] ITV News. (2020, June 24). 'Vast majority' of Irish adults willing to download Covid-19 contact tracing app. Retrieved from https://www.itv.com/news/2020-06-24/vast-majority-of-irish-adults-willing-to-download-covid-19-contact-tracing-app

[190] Personal communication, October 27, 2020

formation started early in Ireland's app development, concerns from both lay and expert communities were able to be raised and discussed early.[191]

4.4.2.4. Accessibility & Inclusion

The digital divide, or the unequal distribution of digital communication technologies, has been identified several times as a source of concern regarding D-CT technologies.[192] Due to the limitations created by the ENS API, there is currently no way for those in Ireland with older phones to access the app. This is by no means a uniquely Irish problem. Including those without smartphones, upwards of 2 billion people globally cannot access ENS API apps due to technological barriers.[193] The accuracy of this number, as well as the proportion of these individuals that reside in Ireland remains to be seen. That fact that this number is unknown is a problem in itself, as it provides a major potential blind spot for the HSE. To combat issues arising from phone access, there has been some discussion of supplying compatible tech to those who could not otherwise access the app.[194] Since the first few discussions of this issue occurring early in the pandemic, there has been little visible movement on the subject.

Beyond the barriers arising from the digital divide, some barriers may also stem from the app's user interface. Sensory disabilities, digital literacy, or other factors often out of the users control are an additional barrier to uptake for many communities. In many ways, the team developing *COVID Tracker Ireland* has done an excellent job mitigating some of these possible barriers. Early on in the process, the team is reported to have consulted with the Irish Counsel for the Blind to ensure that it was accessible to a broad range of visually impaired users.[195] The HSE also has provided an instructional video in sign language (ISL).[196] Both of the previously mentioned measures are important and valuable, but efforts to broaden accessibility must be continued. Beyond what has been done it is currently unclear what other accessibility efforts must still be made. Researching and understanding this will be important to improving uptake in many vulnerable communities.

Without understanding and mitigating the barriers that arise from accessibility, large portions of the population are excluded from the benefits of this app. To compound this issue, many of those excluded because of these barriers will be members of traditionally vulnerable groups such as the elderly, low income minorities, or those living with disability.

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[191] This is nowhere more apparent than in the interchange described here: Foxe, K., & Brennan, C. (2020, October 13). Dept of Health officials dismissed criticism of Covid tracker app as "incorrect. Irish Examiner. Retrieved from https://www.irishexaminer.com/news/arid-40063898.html

[192] Watts, G. (2020). COVID-19 and the digital divide in the UK. *The Lancet Digital Health*, *2*(8), 395–396. https://doi.org/10.1016/s2589-7500(20)30169-2

[193] Bradshaw, T. (2020, April 20). 2bn phones cannot use Google and Apple contact-tracing tech. Financial Times. Retrieved from https://www.ft.com/content/271c7739-af14-4e77-a2a1-0842cf61a90f; Doffman, Z. (2020, April 20). Apple and Google Contact-Tracing Surprise: 2.5 Billion Users Will Miss Out. Forbes. Retrieved from https://www.forbes.com/sites/zakdoffman/2020/04/20/apple-and-google-major-contact-tracing-surprise-25-billion-users-lose-out/?sh=4e912629190a

[194] Clarke, V. (2020, September 25). Covid-19: Half of Ireland moving in the wrong direction, expert warns. Irish Examiner. Retrieved from https://www.irishexaminer.com/news/arid-40054628.html

[195] Personal communication, November 3, 2020

[196] Our Health Service. (2020). COVID-19 Deaf and Hard of Hearing Communications Resources. Our Health Service. Retrieved from https://www.hse.ie/eng/services/news/newsfeatures/covid19-updates/partner-resources/covid-19-irish-sign-language-isl-resources/covid-19-irish-sign-language-isl-resources.html

4.4.2.5. Trust in Public/Private Institutions

The institutions that are involved in the development process likely impacts user-uptake. Specifically, it is the trust that users have in these institutions (both public and private) that will influence the app's use. Some of those involved in the app's development[197] see the decision to work with a privacy centric developer (Nearform), with a history of creating open source solutions, as a trust building feature of the app. This appears to be accurate, as given the level of concern surrounding data privacy and protection, concerned individuals would need to feel secure that those creating the app would not act against their interests. A lack of controversy surrounding those building *COVID Tracker Ireland*, means that user-developer or user-government trust started in relatively neutral territory. Though purely speculative, had the solution been solely developed by a larger multinational corporation (Google, Amazon, Apple), much greater effort might have been needed to build the requisite levels of trust to bring in new users. The O'Callaghan *et al.* (2020)[198] study found that the most reported reason for concern in downloading the app was that it would lead to increased surveillance from private industry. Given this, it is no stretch of the imagination to see that having an apparently trustworthy developer would be mitigative of the public fears surrounding this subject.

On the public side of the equation, trust in public institutions also influences user-uptake.[199] Though of lesser concern to respondents of the O'Callaghan study, worries of increased government surveillance still proved fairly common. Fortunately, Ireland's residents have a high level of trust in their health care system, specifically when compared against the rest of Europe.[200] It is likely that this has helped develop the foundations of trust necessary to reduce many such concerns.

4.5. Conclusion

COVID Tracker Ireland is a pandemic response app with exposure notification and proximity tracking capabilities. It runs off a decentralized model of data management, utilizing the Google-Apple ENS API. It uses Bluetooth to connect and share anonymous IDs with other users, and upon discovering contact with a COVID positive individual, will alert the phone's user to their potential exposure. Personal health information is routinely deleted. The app also contains a symptom tracker and statistics hub to encourage continued user engagement and uptake.
As of November, it has been downloaded more than 2 million times and has more than 1.38 million active users. The app itself has been widely lauded as a success, and has seen uptake not just within Ireland, but throughout the world as its base code is used throughout the UK and the United States. It has also been one of the first apps to boast select inter-app compatibility.

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[197] Personal communication, October 15, 2020
[198] O'Callaghan, M. E., Buckley, J., Fitzgerald, B., Johnson, K., Laffey, J., McNicholas, B., ... Glynn, L. (2020). A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland. *Irish Journal of Medical Science.* https://doi.org/10.1007/s11845-020-02389-y
[199] Discussion of this can be seen dating back to June: Digital Repository of Ireland. (2020, June 18). COVID-19 and Contact Tracing Apps - What Should Ireland Do. Digital Repository of Ireland. Retrieved from https://www.dri.ie/covid-19-and-contact-tracing-apps-what-should-ireland-do-0
[200] Eurofound. (2016). European Quality of Life Survey 2016 - Data visualisation. Eurofound. Retrieved from https://www.eurofound.europa.eu/data/european-quality-of-life-survey

Ireland may be fortunate that its residents seem to support the concept of contact tracing apps, and appear to believe that social responsibility is an important value. The government has been apt to use this, as they developed communication and marketing to fit this narrative. Those who do not align with this set of beliefs may be missed, and along with those who cannot access the app (due to technological or physical limitations) do not have a clear means to do so. Beneficial to all current and potential users of the Irish app, has been the transparent and privacy-centric approach used by both the development company (Nearform) and the Irish government. By making the app open source, and donating it to the Linux Foundation, they have given the app a level of integrity and transparency that may have been an important incentive for those who are considering its use.

Overall, the HSE and Nearform have been proactive in their approach to removing barriers and creating incentives for app use. This does not mean there is not work to be done, especially in addressing questions of technological limitations or public discourse. Given the collaborative and engaged development process up until now, it can be expected that where solutions can be found, they will be pursued.

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 5.
Case Study. **Scotland**

Alisha Gauhar, Dyllan Goldstein, Rebecca Babcock, Jennie Phillips

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DGHH

Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 5. Case Study: Scotland

5.1. Study Overview

5.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have some of the highest rates of the countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[201] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with

[201] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

5.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[202] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[203] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 5.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

5.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

[202]Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/
[203] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

5.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

5.2. Module Overview

This module aims to explore Digital Contact Tracing (D-CT) developed and implemented in Scotland for the COVID-19 response. Focus is on their D-CT app, *Protect Scotland*, and understanding user-uptake. The case study begins with a brief overview of the country's overall response to COVID-19 and the impact of

the virus on the country. Following, we explain Scotland's app by describing how it emerged, how it is designed and functions, how users engage with the app across the whole user-engagement process, and what user-uptake looks like in the country. The next section describes the main factors that emerged in our research for this country that suggest influencing user-uptake within the country's context. This section ends with a brief conclusion.

5.3. Case Study

5.3.1. COVID-19 in Scotland

The first case of COVID-19 was confirmed on 1 March 2020[204] and as of 9 February 2021, the total number of positive COVID-19 cases is 187,542 people with 6,501 deaths.[205] On 13 October 2020, during the daily national COVID-19 updates, First Minister Nicola Sturgeon urged caution as a second wave of COVID-19 cases swept across Europe and cases began to rise again.[206] During this time, Scotland was seeing a rise in positive cases among younger individuals aged 15 to 24.[207] While case numbers decreased in mid-November, there was a spike of cases at the end of December 2020 and early January 2021.[208] Currently cases are on a downward trajectory.[209] Levels of restrictions vary across council areas and currently vary from Level 1 to Level 3; no areas are currently in Level 4 or 5 – the most restrictive levels.[210]

In response to the pandemic the Scottish government and the country's Ministry of Health, NHS Scotland, launched an initiative called Test and Protect. Test and Protect aims to prevent community spread through vigorous manual contact tracing, public education about risk and prevention as well as supporting those who are asked to self-isolate.[211] Part of this campaign was the release of the exposure notification app *Protect Scotland*.

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[204] Mcsherry, M. (2020). Coronavirus: First Case is Confirmed in Scotland. Scottish Financial Review. Retrieved from https://scottishfinancialreview.com/2020/03/01/coronavirus-first-case-is-confirmed-in-scotland/

[205] Google News. (2021). Coronavirus (Covid-19): Scotland. Retrieved from https://news.google.com/covid19/map?hl=en-CA&mid=%2Fm%2F06q1r&gl=CA&ceid=CA%3Aen

[206] Scottish Government. (2020, October 13). Coronavirus (Covid-19) update: First Minister's speech 13 October 2020. Scottish Government. Retrieved from https://www.gov.scot/publications/coronavirus-covid-19-update-first-ministers-speech-13-october-2020/

[207] Sleight, C. (2020). Covid-19 in Scotland: Five numbers to watch. *BBC News*. Retrieved from https://www.bbc.com/news/uk-scotland-54535938

[208] Google News. (2021). Coronavirus (Covid-19): Scotland. Retrieved from https://news.google.com/covid19/map?hl=en-CA&mid=%2Fm%2F06q1r&gl=CA&ceid=CA%3Aen

[209] Ibid.

[210] Scottish Government. (2020, November 10). Changes to COVID-19 protection levels. Scottish Government. Retrieved from https://www.gov.scot/news/changes-to-covid-19-protection-levels/

[211] Test and Protect. (2020a). NHS Inform. Retrieved from https://www.nhsinform.scot/campaigns/test-and-protect

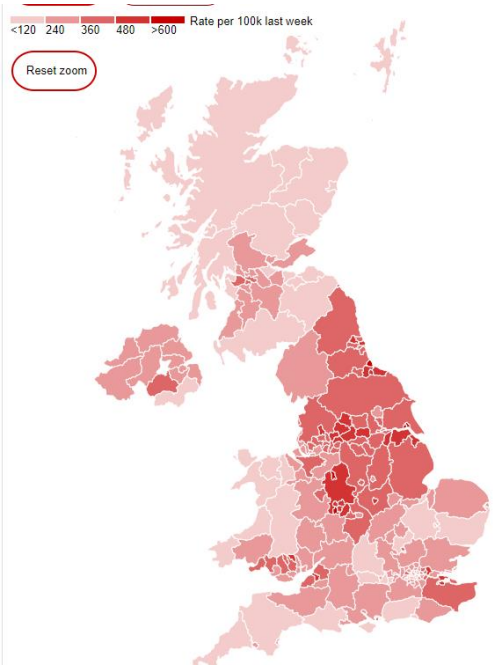

Figure 5.1.0. A heat map of COVID-19 Cases in the UK, by region[212] as of November 23rd 2020

5.3.2. Evolution of the Digital Contact Tracing App

The *Protect Scotland* app was launched on 10 September 2020[213] as an additional safeguard to curve the spread of COVID-19.[214] Key organizations involved in developing and implementing the GAEN-based app include: the Scottish Government (collects and controls app data), Public Health Scotland (determines app's effectiveness), NES Digital Service, an organization set up by the Scottish government to aid in Scotland's digital health and care strategy[215] (data processor and provides Amazon Web Services cloud account), NearForm (Developer), Amazon Web Services, NHS National Services Scotland (operate case management), and Gov.UK which is the UK Government.[216]

Although Scotland was initially working with the NHS England's digital contact tracing team, they announced on 31 July 2020 that they would be developing their own app based on Ireland's Bluetooth-based exposure notification system app.[217] This change in strategy was in part due to England's centralised model which raised privacy concerns.[218]

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[212] Covid cases and deaths today: coronavirus UK map. (2020). *The Guardian*. Retrieved from https://www.theguardian.com/world/2021/jan/20/coronavirus-uk-covid-cases-deaths-vaccinations-today
[213] Scottish Government. (2020a). *Protect Scotland App Launches*. Retrieved from https://www.gov.scot/news/protect-scotland-app-launches/#:~:text=Test%20and%20Protect%20was%20rolled%20out%20across%20Scotland%20on%2028%20May%202020
[214] Protect Scotland. (2020a). Protect Scotland. Retrieved from https://protect.scot/
[215] Digital Scotland. (2020). The NES Digital Service- A Platform approach for building a unified digital health and care service for Scotland. *Digital Scotland*. Retrieved from https://digitalscot.net/national-digital-platform/
[216] Protect Scotland. (2020b). How we use your data. Retrieved from https://protect.scot/how-we-use-your-data#scotgov
[217] Wise, J. (2020). Covid-19: Scotland launches contact tracing app with England and Wales to follow. *BMJ*, (8260), m3566. https://doi.org/10.1136/bmj.m3566
[218] Lomas, N. (2020). England's long-delayed COVID-19 contacts-tracing app to launch on September 24. *Tech Crunch*. Retrieved from https://techcrunch.com/2020/09/11/englands-long-delayed-covid-19-contacts-tracing-app-to-launch-on-september-24/

QR codes are another digital tool being leveraged in some locations across Scotland as a means to aid in contact tracing, although this is not via the *Protect Scotland* app.[219] These QR codes are a part of the Test and Protect initiative however, as a tool businesses can use to ensure customer information is collected for public health purposes securely.[220] For example, the University of Stirling[221] and the University of St. Andrews[222] are using QR codes to track who has entered certain buildings and teaching facilities on campus. There also are plans to begin trials of a health passport with passengers traveling from the UK to the US.[223]

5.3.3. How the app works/design

Table 5.1.0: *Protect Scotland* Details

	Scotland
Name of the App	Protect Scotland
Developer(s)	❖ Nearform ❖ NHS Scotland
Decentralized or Centralized Data Collection	Decentralized
Bluetooth, GPS, Both, Other	Bluetooth
Type of App: GAEN or Other	Google Apple Exposure Notification API
Mobile Requirements: e.g. iOS, Android, version	iOS 13 and up Android 6.0 and up Mobile phones must be 2015 or newer
Alternate functionality?	N/A
Data Collected (Voluntarily) By App	❖ Mobile number ❖ Estimated date of infection ❖ Authorization code that they receive if they receive a positive diagnosis ❖ IP address ❖ Diagnosis keys that are randomized ID codes from the devices of other people a user has come into contact with ❖ Confirmation of app use[224]
Data Collected (Voluntarily) By Government	❖ Confirmation of app use ❖ Metric data on the number of people

[219] Test and Protect. (2020b). Dundee and Angus Chamber of Commerce. Retrieved from https://www.dundeeandanguschamber.co.uk/203_TestProtect.html
[220] Scottish Government. (2020b). Protect Scotland App Launches. Retrieved from https://www.gov.scot/news/protect-scotland-app-launches/#:~:text=Test%20and%20Protect%20was%20rolled%20out%20across%20Scotland%20on%2028%20May%202020
[221] University of Stirling. (2020). Check in to buildings, locations and teaching rooms. Retrieved from https://www.stir.ac.uk/coronavirus/changes-at-stirling-for-2020/making-campus-safer/scan-in-to-buildings-on-arrival/
[222] University of St. Andrews. (2020). Current students. Retrieved from https://www.st-andrews.ac.uk/coronavirus/students/
[223] Staines, R. (2020). UK trials digital "health passport" to help borders reopen. Pharmaphorum. Retrieved from https://pharmaphorum.com/news/uk-trials-digital-health-passport-to-help-borders-reopen/
[224] Protect Scotland. (2020c). How we use your data. Retrieved from https://protect.scot/how-we-use-your-data#nhs-nss

	infected ❖ Metric data on the number of people who downloaded the app
Data Collection permission	Voluntary
Data Deletion period	72 hours for submitted data to Gov.UK 14 days for diagnostic keys (on mobile phone)

Protect Scotland is a decentralized, Bluetooth-based exposure notification app built by Nearform and NHS Scotland off of the Google Apple Exposure Notification API (GAEN API).[225] It is a privacy-preserving app that securely collects user mobile information, date of infection, positive diagnosis code, IP addresses, and diagnostic keys from other devices the user has come into contact with.[226] The user agrees to share this information with the app and the government when the app's terms and conditions are accepted prior to active tracing. The user also can consent to sharing the approximate date of infection and the user's positive COVID-19 diagnosis by uploading the code the user receives from the NHS. NHS Scotland collects metric data to create reports on the efficiency and trends in regards to app usage and COVID-19 in conjunction with the data collected from Test and Protect.[227] The data uploaded to the government is kept for 72 hours whereas data on the phone is deleted after 14 days.[228] It can be voluntarily downloaded but users must have iOS 13 and up or Android 6.0 and up.[229] The app has no alternate functionality.

5.3.3.1. The App Engagement Process

Phase One: Downloading and Setup

The *Protect Scotland* app can be downloaded from Google Play and the Apple Store. After the download process is complete, the app verifies if the user is over the age of 16 and living in Scotland. *Protect Scotland* then displays information about the benefits of using the app, how the app works, how user privacy is protected, and the app's privacy notice. Finally, the app is ready to use after the user accepts the app's terms and conditions.

[225] Wise, J. (2020). Covid-19: Scotland launches contact tracing app with England and Wales to follow. *BMJ*, (8260), m3566. https://doi.org/10.1136/bmj.m3566

[226] Protect Scotland. (2020d). Privacy Notice for the Protect Scotland app. Retrieved from https://protect.scot/privacy-policy-app

[227] Protect Scotland. (2020e). Terms & Conditions for the Protect-Scotland app. Retrieved from https://protect.scot/terms-and-conditions

[228] Protect Scotland. (2020f). How we use your data. Retrieved from https://protect.scot/how-we-use-your-data#scotgov

[229] Frequently asked questions. (2020). Protect Sctoland. Retrieved from https://protect.scot/faq

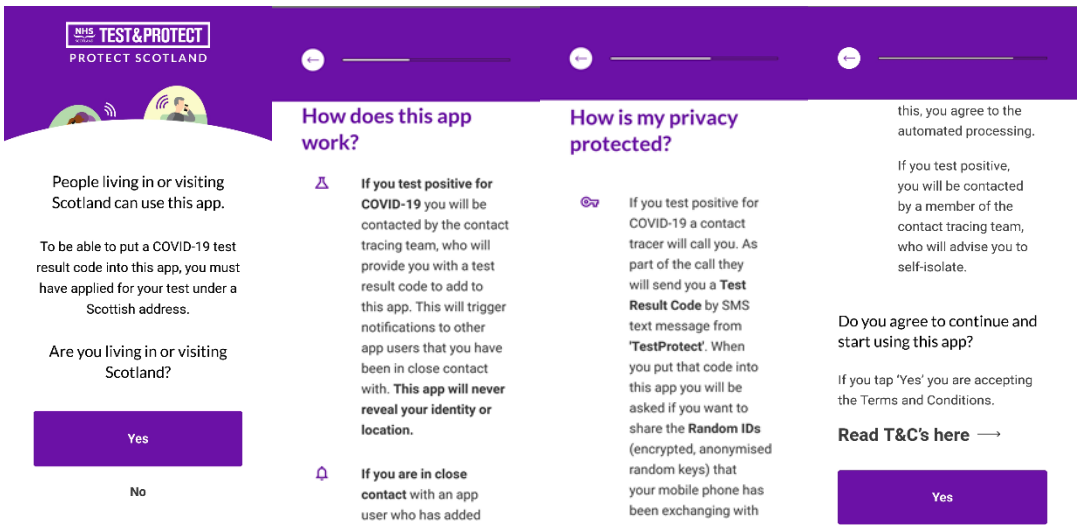

Figure 5.2.0. Screenshots of *Protect Scotland* when User is First Activating the App.[230]

Phase Two: Usage

In order to begin active tracing, the app requires Bluetooth to be enabled. Permission to trace is included in the terms and conditions and can be stopped according to the user's discretion by turning off the user's phone, disabling the exposure notification option in your phone's settings, or disabling Bluetooth.[231] The image on the left in Figure 5.4.0 depicts what a user's screen will display once tracing is active.

Phase Three: Reporting

If the user has tested positive, they will receive a code from NHS's Test and Protect via "text, email or phone" outside of the *Protect Scotland* app,[232] which they can enter into the app under 'Add Test Result.' This process allows the user to voluntarily agree to share their positive COVID-19 result as well as the approximate date of infection. The app will then anonymously inform the user's close contacts (who also have the app) that they have been exposed to COVID-19.[233]

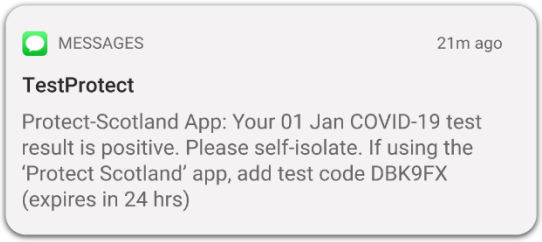

Figure 5.3.0. Example Text Message from Test and Protect Informing a User they have Tested Positive for COVID-19 and Next Steps To Take. [234]

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[230]Google Play. (2020). Protect Scotland (1.04). NHS Education for Scotland. https://play.google.com/store/apps/details?id=gov.scot.covidtracker&hl=en_GB

[231] Protect Scotland. (2020g). Frequently asked questions. Retrieved from https://protect.scot/faq

[232] Protect Scotland. (2020h). How it works. Retrieved from https://protect.scot/how-it-works

[233] Ibid.

[234] Ibid.

Part Four: Reacting

When a user has come into close contact with someone who has tested positive, they receive a notification on their mobile phone's locked screen as shown below. The user can then open up the app and will be met with recommendations on what to do next which can include getting tested if showing symptoms or begin self-isolating. The center and right images shown in Figure 4 depicts the user's lock screen requires action as they have come into contact with a positive user as well as how the app looks if a user has been in close contact with a positive individual.

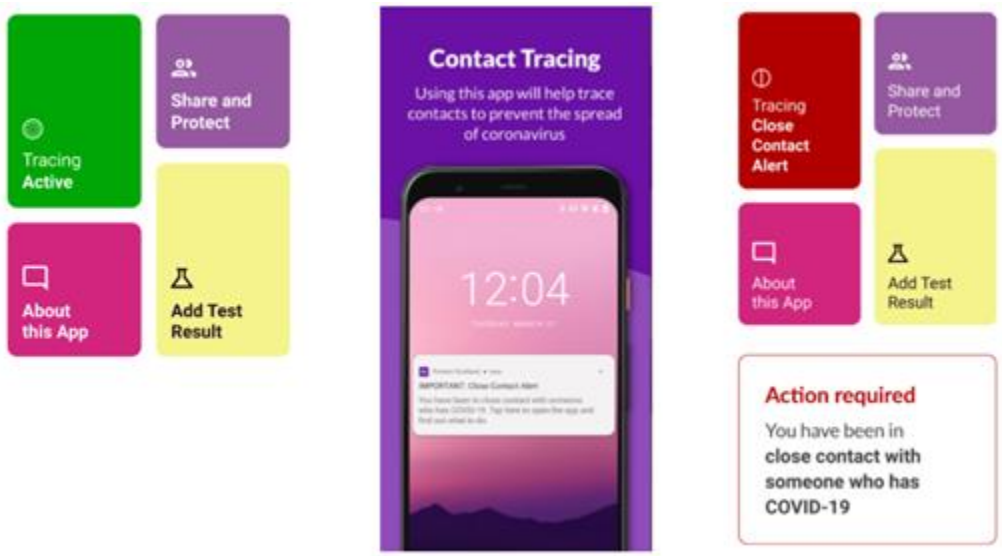

Figure 5.4.0. (Left) *Protect Scotland* when the app is active and tracing (Phase 3). (Center) A *Protect Scotland* Notification on a User's Lock Screen Indicating Action is Required Because the User has been Exposed to COVID-19 (Phase Four). (Right) *Protect Scotland* Indicating Action is Required Because the User has been Exposed to COVID-19 (Phase 4).[235]

[235] Protect Scotland. (2020i). Google Play. Retrieved from https://play.google.com/store/apps/details?id=gov.scot.covidtracker&hl=en_GB; Protect Scotland. (2020j). Frequently asked questions. Retrieved from https://protect.scot/faq

5.3.4. App-Uptake

5.3.4.1. Uptake Summary

Table 5.2.0: *Protect Scotland* Uptake Summary

	Scotland
Uptake (#downloads)	~1,500,000[236]
Uptake (active users)	Data could not be found
General Uptake (# of downloads general population)	~27.5%
Age Appropriate Uptake (# of downloads / people over age allowed to download)	~ 33%[237]
Digital Uptake (# of downloads / connected population)	~48.25%
Digital Capability Uptake (# of downloads / app-compatible population)	~27.5%

5.3.4.2. Uptake Description

With over 1.5 million downloads, about 27.5% of the entire Scottish population (5,454,000 million) has downloaded the app. Yet, it is important to consider that only users above the age of consent, 16, can use the app which means 33% of the eligible Scottish population (4, 526,820 people)[238] have downloaded the app. In terms of uptake within the connected population, in 2017, 57% of individuals used the internet through a mobile phone which could suggest that there is an uptake percentage of 48.25% amongst the connected population.[239] It is challenging to determine the number of app-compatible smartphones due to lack of data on residents who have iOS 13.0 and up or Android 6.0 and up. Furthermore, with available data only representing the mobile operating system market share in the United Kingdom, rather than in Scotland specifically, it further complicates estimating app-compatible smartphones. Although if one was to assume that, like the UK, 99.79% of the Scottish population was using Android or iOS operating systems, that could mean that 27.5% of users with app compatible smartphones have downloaded the app. It is important to note that, as mentioned in Module 1, Section 1.5, there are significant issues with determining app success via uptake percentages.

[236] Scottish Government. (2020c). Coronavirus (COVID-19): Scotland's Strategic Framework. Retrieved from https://www.gov.scot/publications/covid-19-scotlands-strategic-framework/pages/4/

[237] Swindon, P. (2020). 5,000 told to self-isolate by Scots app since launch as creators quash fears over privacy. *The Sunday Post*. Retrieved from https://www.sundaypost.com/fp/5000-told-to-self-isolate-by-scots-app-since-launch-as-creators-quash-fears-over-privacy/

[238] Ibid.

[239] Office of Communications. (2016). The Communications Market: Internet and online content. Retrieved from https://www.ofcom.org.uk/__data/assets/pdf_file/0013/105142/scotland-internet-online.pdf

5.4. Uptake Factors

5.4.1. Summary of Uptake Factors

Table 5.3.0: Summary of Uptake Factors in Scotland

Factor	Micro, Meso, and/or Macro	Brief Description
Perceptions of Data Collection & Management	Micro	From misuse of physical data at Scottish bars and restaurants to preconceived notions about data privacy, surrounding Amazon Web Services involvement in the app for instance, people's perceptions surrounding data collected and managed via the app may positively or negatively impact uptake.
Communications & Misinformation	Meso-Macro	Malicious actors are scamming residents and potentially decreasing uptake of the app yet adequate action by the government and other organizations may be an incentive to download the app. Alternatively, varied messaging may cause confusion or lack of trust relating to the app, thereby becoming a barrier to uptake.
Accessibility & Inclusion	Macro	While forcing university students to download the app may initially increase uptake amongst this population, it can lead to discrimination of this population. The associated legal and ethical concerns may also further lead to decreased uptake more broadly.
Trust in Public/ Private Institutions	Macro	While trust in the government is high in Scotland and the government is taking action to continually increase that trust, particularly in relation to the *Protect Scotland* app, the sharing of Test and Protect data with police has caused fear of discrimination and decreased trust amongst police authorities, potentially creating a barrier to uptake.
Digital Capability	Macro	The *Protect Scotland* app is now interoperable throughout the UK and can be used on trains and planes for commuters. This interoperability and increased digital capability has potentially minimized some barriers to accessing and using the app.

5.4.2. Factor Descriptions

5.4.2.1. Perceptions of Data Collection & Management

In Scotland, ensuring data is protected and privacy is upheld is of utmost importance to Scottish people, especially in a digital context. Yet, due to some measures put in place for the COVID-19 pandemic, some situations arise that may increase the risk of privacy breaches. For instance, people in Scotland are still required to sign in with hospitality services like restaurants and pubs even if they have *Protect Scotland*.[240] Yet, some individuals are misusing physically collected personal information at bars and other hospitality venues meant to be used to aid physical contact tracing efforts and to be given to the NHS as part of Test and Protect. Many women are claiming they have received "creepy" texts from men where they had left

[240] Protect Scotland. (2020k). Frequently asked questions. Retrieved from https://protect.scot/faq

their personal information.[241] Incidents such as this may be affecting the confidence these women have in the privacy and security of the physical information collected for Test and Protect. Whether this incentivizes or disincentivizes these women to download and use the app remains to be seen. On the one hand, anonymous data collected electronically may be perceived as more secure than physical data. Alternatively, the digital collection of data has its own set of risks (perceived or real).

For instance, some individuals perceive that there are privacy risks due to Amazon collecting personal information from users.[242] According to an article by FutureScot, some encrypted data is received by an Amazon Web Services cloud account which is owned by NHS Education for Scotland.[243] Yet, this data cannot be linked to someone's personal information. Furthermore, the Scottish Government assures that the data collection "complies to all NHS Scotland and GDPR (General Data Protection Regulation) data standards....Users' mobile number, test code (and the relevant date) and IP address are not stored by the app and they are not made visible by the app to anyone, including AWS."[244] Despite the government reiterating *Protect Scotland's* privacy-centric approach, people's perceptions surrounding privacy risks may not reflect reality, negatively influencing a user's willingness to download the app.

5.4.2.2. Communications & Misinformation

Misinformation surrounding the app may dissuade residents from using the app and as reported by the Government of Scotland, there have been reports of cash scams and malicious actors relating to the app.[245] These actors have been requesting personal information like passwords, bank details, and medical history from users, claiming this information was needed to access the app.[246] Other malicious actors claimed that COVID-19 tests were not free of change and therefore banking information was needed.[247] In reaction to these scams, NHS Scotland has stressed that they will only use one national number (0800 030 8012) should they contact users who have tested positive. NHS Scotland also has reiterated that they will never ask for personal information during these calls.[248] This information is especially relevant to targeted populations who are more at risk to be targeted for cash scams like the elderly. These scams, and the subsequent response from the government and other organizations such as Age Scotland,[249] may positively or negatively influence residents' willingness to download the app. On the one hand, the country's residents may be more willing to download and use the app if they feel as if the proper

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[241] Culliford, G. (2020). Scots bombarded with creepy texts after giving numbers out for Test and Protect. *The Scottish Sun*. Retrieved from https://www.thescottishsun.co.uk/news/6141337/nhs-scotland-test-protect-track-trace-coronavirus-data/

[242] Williams, M. (2020). "Only NHS has access': Ministers insist Amazon is not getting data from a million users of Scotland's Test and Protect app. *The Herald*. Retrieved from https://www.heraldscotland.com/news/18734001.only-nhs-access-snp-insists-amazon-not-getting-data-million-users-scotlands-test-protect-app/

[243] O'Sullivan, K. (2020). 'We can't even see your data', government insists, after contact tracing app privacy fears. *FutureScot*. Retrieved from https://futurescot.com/we-cant-even-see-your-data-government-insists-after-contact-tracing-app-privacy-fears/

[244] Ibid.

[245] NHS Inform. (2020a). Coronavirus (COVID-19): Contact Tracing. Retrieved from https://www.nhsinform.scot/illnesses-and-conditions/infections-and-poisoning/coronavirus-covid-19/test-and-protect/coronavirus-covid-19-contact-tracing

[246] Scam warning issued after launch of Scottish coronavirus app. (2020). *The Orcadian*. Received from https://www.orcadian.co.uk/scam-warning-issued-after-launch-of-scottish-coronavirus-app/

[247] Trading Standard Scotland. (2020). Contact Tracing Scams. Retrieved from https://www.tsscot.co.uk/contact-tracing-scams/

[248] NHS Inform. (2020b). Coronavirus (COVID-19): Contact Tracing. Retrieved from https://www.nhsinform.scot/illnesses-and-conditions/infections-and-poisoning/coronavirus-covid-19/test-and-protect/coronavirus-covid-19-contact-tracing

[249] Scam warning issued after launch of Scottish coronavirus app. (2020). *The Orcadian*. Received from https://www.orcadian.co.uk/scam-warning-issued-after-launch-of-scottish-coronavirus-app/

measures are being taken to prevent scams. Alternatively, residents may feel less inclined to use the app if they feel like they are at increased risk of scams, such as the elderly.

Alongside malicious actors, there also has been some misinformation and inconsistent messaging relating to the app, specifically from police authorities. While the Scottish Police Federation has encouraged the use of the *Protect Scotland* app, senior personnel in Police Scotland's health and safety group have allegedly labeled the app as "haphazard, unreliable and inaccurate."[250] Such conflicting messaging may cause confusion amongst residents who are looking for guidance as to what steps to take to mitigate the spread of the disease. Furthermore, when messages come from a seemingly trustworthy body, the trust people have in the app may start to decrease. In both cases, users may be deterred from committing to downloading and using the app as a result of poor, inconsistent communications.

5.4.2.3. Accessibility & Inclusion

Protect Scotland's accessibility refers to the ease and accommodations the app has in place to ensure as many Scottish people as possible are downloading and using the app. Due to the recent spike in cases among university aged students and outbreaks in at least 11 universities in Scotland, Universities Scotland, an organization that acts as "the representative body of Scotland's 19 higher education institutions"[251] says that they will require students to download the *Protect Scotland* app. The First Minister insisted it is not mandatory for students to download the app but universities say they will "take a strict 'Yellow Card/Red Card approach to breaches of student discipline."[252] Richard Leonard, the leader of the Scottish Labour Party claims the downloading requirement should be questioned, saying "students [are] being required to download test and protect app-unlike any other group in society."[253] He also lists the severity of the enforcement of these new measures as one of his seven areas of concern and has asked the Scottish Human Rights Commission to look into possible violations of student's human rights.[254] Although the uptake among the student population will increase as a result of this mandate, having one part of the population download the app could lead to discrimination as no other age group is required to download the app or face repercussions. Furthermore, forcing downloads also could potentially violate ethical or legal principles which may ultimately, in the long run and for the wider non-student community, result in lower uptake.

5.4.2.4. Trust in Public/Private Institutions

For high uptake and proper usage of digital contact tracing apps, it is paramount for users to have a high level of trust in governing bodies, those involved with developing and promoting the app, as well as those who collect and store data. It was reported that Police Scotland may have access to Test and Protect data and mentions that the First Minister is being warned by scientists that the involvement of Police Scotland

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[250] Morrison, H. (2020). Officers urged to use NHS app-despite senior Police Scotland personnel calling it 'unreliable'. *Glasgow Times*. Retrieved from https://www.glasgowtimes.co.uk/news/18784386.cops-urged-use-nhs-app---despite-top-cops-calling-unreliable/
[251] Universities Scotland. (2020a). The voice of Scotland's universities. Retrieved from https://www.universities-scotland.ac.uk
[252] Universities Scotland. (2020b). Preventing spread of coronavirus in universities. Retrieved from https://www.universities-scotland.ac.uk/preventing-spread-of-coronavirus-in-universities/
[253] Kersley, A. (2020). Scottish Labour: Covid inquiry in Scotland must investigate university chaos. Labour List. Retrieved from https://labourlist.org/2020/10/scottish-labour-says-covid-inquiry-must-investigate-university-chaos/
[254] Ibid.

in having this personal information may lead to less people getting tested for COVID-19 for fear of being fined by police if they violated safety measures.[255] According to the article, data can be shared "with police and other organizations that demonstrate an undefined 'legitimate reason' to access the data such as levying fines."[256] The First Minister commented that "The NHS is not routinely sharing Test and Protect data with Police Scotland'' but that the collected information by Test and Protect can be viewed by police on a "case by case basis."[257] It is reasonable to suggest that the fear and potential decreased trust surrounding the police in relation to their involvement with Test and Protect data may expand to concerns about *Protect Scotland*. In other words, since *Protect Scotland* is a component of the larger Test and Protect initiative, if residents are concerned about the larger initiative due to lack of trust and fear, they may similarly have those concerns surrounding *Protect Scotland*, thereby creating a disincentive to downloading the app.

While the paragraph above describes the context in which users' trust may be hindered, the government is trying to increase trust by being transparent and releasing an interim report relating to *Protect Scotland*. The report highlights the improvements and gaps the government would like to address as well as a phased plan on how to improve the app's uptake.[258] Trust in the Scottish government and health authorities is generally very high as satisfaction with how NHS Scotland is operated is about 65% of the Scottish population.[259] Yet by increasing transparency of areas for improvement, and what steps are being taken to increase uptake, the general public may have increased trust towards the government. This may positively impact uptake, or at the very least neutralize the negative impacts arising from the fear and distrust surrounding police authorities in relation to the app.

5.4.2.5. Digital Capability

The digital capability of the *Protect Scotland* app aims to ensure the app is technologically accessible to as many people as possible both in Scotland and those that visit the country. There has been mention in the literature of the desire to create an exposure notification app that would work across borders in the UK.[260] Progress seems to be in the works as *Protect Scotland* is now compatible with other tracing apps in the Island of Jersey, Northern Ireland, England, and Wales. This means that as long as the *Protect Scotland* app is kept active, users will not have to download any other app or change any settings if they travel to one of these states; their device will connect to the apps associated with *Jersey COVID Alert*, *StopCOVID NI*, and *NHS COVID-19* app which are the respective apps of Jersey, Northern Ireland, and England and

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[255] McLaughlin, M. (2020). Coronavirus: Police must be kept out of trace system, Sturgeon is warned. *The Sunday Times.* Retrieved from https://www.thetimes.co.uk/edition/scotland/coronavirus-police-must-be-kept-out-of-trace-system-sturgeon-is-warned-09wzw5wdh

[256] Ibid.

[257] McCall, C. (2020). Police Scotland 'can access Test and Protect details' but can't use it to enforce self-isolation. *Daily Record*. Retrieved from https://www.dailyrecord.co.uk/news/politics/police-scotland-can-access-test-22871031

[258] Digital Health & Care Scotland. (2020). Interim National Equality Impact Assessment Protect Scotland App. Retrieved from https://www.protect.scot/resources/docs/EQIA-17-september-2020.pdf

[259] Scottish Government. (2020d). Survey shows high levels of trust in Scottish Government. Retrieved from https://www.gov.scot/news/survey-shows-high-levels-of-trust-in-scottish-government/

[260] Hamilton, M. (2020). Covid-19: Test and trace app incapacity angers cross-border residents. *BBC News*. Retrieved from https://www.bbc.com/news/uk-england-54384743

Wales.[261] This compatibility is beneficial to travelers as well as essential workers who cross borders for work purposes. Another feature is that the app can work underground and on planes. This would mean the app is still active in subway stations and on moving subway trains, benefiting commuters and expanding the amount of locations where users can continue contact tracing.[262] By increasing the compatibility of the *Protect Scotland* app, the number of users are now extended to travelers and workers in Jersey, Northern Ireland, England and Wales, which may increase both uptake and may improve the people's willingness to download the app as they would only have to download one app instead of multiple when crossing borders.

5.5. Conclusion

The *Protect Scotland* app is a privacy-centric, decentralized exposure notification app that has been released in an effort to slow the spread of community transmission of COVID-19 in Scotland. The app has currently been downloaded by 1.5 million users since its release on 10 September 2020. The factors that have been identified above highlight both positive and negative influences that will affect the app's uptake. Perceptions of data collection & management, impacted by experiences (such as women receiving unwanted texts) and beliefs (regarding Amazon Web Services' involvement in data collection, for instance) create both barriers and incentives for app-uptake. Elements of communication & misinformation include cash scams and mixed messaging which could hinder or help uptake. Considerations of accessibility & inclusion are especially relevant in the context of university aged students who are allegedly required to download the app. Although uptake may increase with mandatory downloads, trust in authorities may decrease due to associated ethical and legal violations, thereby negatively impacting uptake. Other factors that affect trust include the release of the Interim report which strived to transparently highlight the government's findings about the *Protect Scotland* app, incentivizes users to download the app as it increases government transparency. Finally, from people from other countries being able to use their own country's app due to expanding interoperability to Scotland's commuters being able to use the app on planes and trains, the app's digital capabilities have potentially influenced app-uptake amongst various populations.

[261] Scottish Government. (2020e). Protect Scotland app compatible with tracing apps in Northern Ireland and Jersey. Retrieved from https://www.gov.scot/news/protect-scotland-app-compatible-with-tracing-apps-in-northern-ireland-and-jersey/

[262] Fraser, G. (2020). In context: Protect Scotland app. *Holyrood*. Retrieved from https://www.holyrood.com/inside-politics/view,in-context-protect-scotland

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 6.

Case Study. **South Africa**

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DGHH

Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 6. Case Study: South Africa

6.1. Study Overview

6.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have the highest rates of countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[263] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with

[263] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

6.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[264] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[265] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 6.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

6.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

[264]Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/
[265] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

6.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

6.2. Module Overview

This module aims to explore Digital Contact Tracing (D-CT) developed and implemented in South Africa for the COVID-19 response. Focus is on their D-CT app, *COVID Alert SA*, and understanding user-uptake. The case study begins with a brief overview of the country's overall response to COVID-19 and the impact

of the virus on the country. Following, we explain South Africa's app by describing, how it emerged, how it is designed and functions, how users engage with the app across the whole user-engagement process, and what user-uptake looks like in the country. The next section describes the main factors that emerged in our research for this country that suggest influencing user-uptake within the country's context. This section ends with a brief conclusion.

6.3. Case Study

6.3.1. COVID-19 in South Africa

On 5 March 2020, South Africa's Minister of Health Zweli Mkhize confirmed the country's first case of COVID-19.[266] As of 11 February 2021, South Africa has recorded 1,482,412 COVID-19 cases and 47,145 deaths.[267] South Africa has the most cases and deaths within the continent and is currently ranked 16th in the world as most impacted by COVID-19 (earlier during the pandemic it was ranked fourth).[268] After cases peaked in July 2020, South Africa managed to flatten its curve, yet from 7 September 2020 to 16 November 2020, the country was seeing anywhere from 1300-2000 cases a day.[269] This is an achievement given that at its peak the country was seeing 10,000-12,000 cases a day.[270] The country saw its second wave in late December 2020 and early January 2021 where, at its peak, there were 15,000-20,000 cases/day.[271] As such, the country is in Adjusted Alert Level 3 of 5 of its COVID-19 Risk Adjusted Strategy.[272]

With what has been described as "one of the world's strictest" lockdowns,[273] redirecting its TB and HIV-focused health networks to include caring for COVID-19 cases,[274] increasing its testing capacity,[275] and

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[266] National Institute for Communicable Diseases. (2020, March 5). FIRST CASE OF COVID-19 CORONAVIRUS REPORTED IN SA. NICD. Retrieved from https://www.nicd.ac.za/first-case-of-covid-19-coronavirus-reported-in-sa/

[267] Google News. (2020, November 20). Coronavirus South Africa. Google News. Retrieved from https://news.google.com/covid19/map?hl=en-CA&mid=%2Fm%2F0hzlz&gl=CA&ceid=CA%3Aen

[268] Caromba, L. (2020, August 5). Covid-19 exposure notification apps: We have most of the technology – we just need the trust. Daily Maverick. Retrieved from. https://www.dailymaverick.co.za/article/2020-08-05-covid-19-exposure-notification-apps-we-have-most-of-the-technology-we-just-need-the-trust/; Mwai, P. (2021, February 8). Coronavirus: Africa's new variants are causing growing concern. BBC. Retrieved from https://www.bbc.com/news/world-africa-53181555

[269] Roser, M., Ritchie, H., Ortiz-Ospina, E., & Hasell, J. (2020). Coronavirus Pandemic (COVID-19). *Our World in Data*. Retrieved from https://ourworldindata.org/coronavirus/country/south-africa?country=~ZAF

[270] Ibid.

[271] Google News. (2020, November 20). Coronavirus South Africa. Google News. Retrieved from https://news.google.com/covid19/map?hl=en-CA&mid=%2Fm%2F0hzlz&gl=CA&ceid=CA%3Aen

[272] COVID-19 South African Online Portal. (2020, April 25). COVID-19 Risk Adjusted Strategy. SA Corona Virus Online Portal. Retrieved from https://sacoronavirus.co.za/covid-19-risk-adjusted-strategy/; South African Government. (2021). COVID-19 / Novel Coronavirus. Retrieved from https://www.gov.za/Coronavirus

[273] Gevisser, M. (2020, May 5). The coronavirus crisis threatens what trust South Africans have left in their government. The Guardian. Retrieved from https://www.theguardian.com/commentisfree/2020/may/05/coronavirus-crisis-south-africans-lives-livelihoods

[274] Devermont, J., & Mukulu, T. (2020, May 12). South Africa's Bold Response to the Covid-19 Pandemic. CSIS. Retrieved from https://www.csis.org/analysis/south-africas-bold-response-covid-19-pandemic; Nordling, L. (2020, April 7). South Africa hopes its battle with HIV and TB helped prepare it for COVID-19. Science Magazine. Retrieved from https://www.sciencemag.org/news/2020/04/south-africa-hopes-its-battle-hiv-and-tb-helped-prepare-it-covid-19

[275] Caromba, L. (2020, August 5). Covid-19 exposure notification apps: We have most of the technology – we just need the trust. Daily Maverick. Retrieved from. https://www.dailymaverick.co.za/article/2020-08-05-covid-19-exposure-notification-apps-we-have-most-of-the-technology-we-just-need-the-trust/;

facilitating door-to-door "case finding,"[276] South Africa is leveraging its experience with these viruses to inform its response to the pandemic. Alongside these steps, the president, Cyril Ramaphosa, has been an effective communicator and has partnered with political opponents and religious and non-traditional leaders in an effort to enable resident compliance with public health measures.[277] Yet some critics are not as kind towards South Africa's response, highlighting issues and challenges that are hindering the effectiveness or complicating the response, such as: 1) the backlog in receiving test results;[278] 2) that the measures being enacted "will disproportionately affect vulnerable populations, likely perpetuate inequality, and lead to a rise in intergenerational poverty;"[279] 3) that the measures enacted are creating a discontinuity of care for TB and HIV communities;[280] and 4) the "appalling" mismanagement of COVID-19 funds and corruptions.[281]

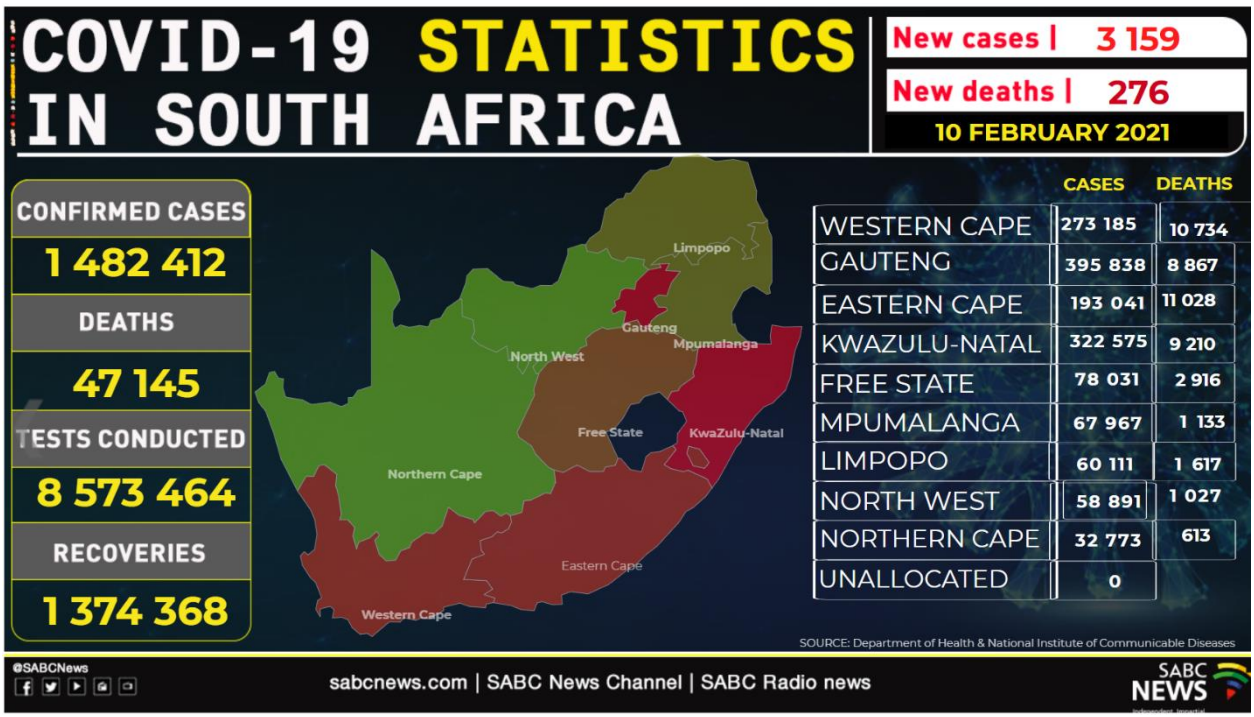

Figure 6.1.0. Map of COVID-19 cases in South Africa as of 10 February 2021[282]

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[276] Abdool Karim, S. S. (2020). The South African Response to the Pandemic. *New England Journal of Medicine, 382*(24), e95. https://doi.org/10.1056/nejmc2014960

[277] Devermont, J., & Mukulu, T. (2020, May 12). South Africa's Bold Response to the Covid-19 Pandemic. CSIS. Retrieved from https://www.csis.org/analysis/south-africas-bold-response-covid-19-pandemic

[278] Friedman, S. (2020, July 16). South Africa is failing on COVID-19 because its leaders want to emulate the First World. The Conversation. Retrieved from https://theconversation.com/south-africa-is-failing-on-covid-19-because-its-leaders-want-to-emulate-the-first-world-142732

[279] Staunton, C., Swanepoel, C., & Labuschagine, M. (2020). Between a rock and a hard place: COVID-19 and South Africa's response. *Journal of Law and the Biosciences, 7*(1). https://doi.org/10.1093/jlb/lsaa052

[280] Abdool Karim, S. S. (2020). The South African Response to the Pandemic. *New England Journal of Medicine, 382*(24), e95. https://doi.org/10.1056/nejmc2014960

[281] BBC News. (2020, September 2). Coronavirus in South Africa: Misuse of Covid-19 funds "frightening." BBC News. Retrieved from https://www.bbc.com/news/world-africa-54000930

[282] SABC News. (2021, February 11). Coronavirus: Your Daily Update. Retrieved from https://www.sabcnews.com/sabcnews/tracking-the-coronavirus/

6.3.2. Evolution of the Digital Contact Tracing App

One of the more recent attempts to mitigate the spread of COVID-19 is the development and implementation of an exposure notification system called *COVID Alert SA*. Built off the Google Apple Exposure Notification (GAEN) API, the app was developed by Discovery Health at minimalcost for the Department of Health and was released at the beginning of September 2020.[283] The reason for developing and implementing the app seems to be to support the country's manual contact tracing efforts and contribute "to avoiding a second wave of COVID-19 infections in South Africa, protecting South Africa's healthcare services and vulnerable people, and ending the pandemic."[284]

Prior to the release of *COVID Alert SA*, there were two other attempts at using technology to facilitate contact tracing. At the beginning of the pandemic (March 2020), the government developed regulations to curb the spread of COVID-19. One such directive "forced telecommunications providers to give government access to their customers data in a plan to track the movement of South Africans through their mobile phones."[285] This tracking of location-based data caused significant privacy concerns amongst residents and experts alike, with many critics stating this level of surveillance with such minimal privacy and security protections was in violation of the constitution.[286] While the government completed a significant rewrite of the directives to outline how it was going to protect privacy and collect, store, and delete data,[287] the government seemingly has stopped requesting this data from mobile companies because the data was not accurate enough to conduct contact tracing.[288]

By the end of April 2020, the focus turned to the development of a digital contact tracing app. There appeared to be a fleeting partnership between University of Cape Town and the government towards the development of COVI-ID.[289] Using a combination of QR Codes and geolocation data, the app is an open source, privacy-preserving tool designed for contact tracing.[290] This initiative did not evolve into a country-wide, government-driven implementation of the app. Why COVI-ID was abandoned in favour of a new initiative to develop what is now *COVID Alert SA* is uncertain, but COVI-ID is now a part of MIT's PathCheck Foundation.[291]

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[283] COVID-19 South African Online Portal. (2020, September 2). How the new Covid Alert SA smartphone app works. Retrieved from https://sacoronavirus.co.za/2020/09/02/how-the-new-covid-alert-sa-smartphone-app-works/
[284] Discovery. (n.d.). Turn your smartphone into a life-saving device. Discovery. Retrieved from https://www.discovery.co.za/corporate/download-covid-alert-sa-app-today
[285] Young, N. (2020, April 7). South Africans are worried the government will use coronavirus phone tracking to spy on them. Quartz Africa. Retrieved from https://qz.com/africa/1834409/coronavirus-south-africans-are-worried-about-cellphone-privacy/
[286] Singh, A., & Power, M. (2020, March 31). New digital regulations mean the state can track you — no questions asked. The Mail & Guardian. Retrieved from https://mg.co.za/article/2020-03-31-new-digital-regulations-mean-the-state-can-track-you-no-questions-asked/
[287] Hunter, M., & Thakur, C. (2020, April 3). Advocacy: New privacy rules for Covid-19 tracking a step in the right direction, but …. amaBhungane. Retrieved from https://amabhungane.org/advocacy/advocacy-new-privacy-rules-for-covid-19-tracking-a-step-in-the-right-direction-but/
[288] COVID-19 South African Online Portal. (2020, September 17). EXPLAINER: Should I download the new contact tracing app? Retrieved from https://sacoronavirus.co.za/2020/09/17/explainer-should-i-download-the-new-contact-tracing-app/
[289] Monzon, L. (2020, April 30). SA Government, UCT Partner on COVID-19 Tracing App. IT News Africa. Retrieved from https://www.itnewsafrica.com/2020/04/sa-government-uct-partner-on-covid-19-tracing-app/
[290] Yahoo Finance. (2020, September 10). PathCheck Foundation Adds Covi-ID Technology and Team to Increase Access to Exposure Notification to Vulnerable Communities Worldwide. Yahoo Finance. Retrieved from https://ca.finance.yahoo.com/news/pathcheck-foundation-adds-covi-id-142100438.html
[291] Ibid.

COVID Alert SA is a component of the National Department of Health's larger digital response to COVID-19, which is the COVIDConnect platform.[292] This platform provides news and information about COVID-19, a risk assessment tool, and COVID-19 test results via either WhatsApp or SMS.[293] If someone using COVIDConnect tests positive for COVID-19, they are prompted for further information regarding close contacts and those people are alerted of their potential exposure to COVID via SMS.[294] The COVIDConnect Platform is designed to increase the reach of technology as it is available for those who have smartphones that may not be new enough to download the contact tracing app or do not have a smartphone.[295]

6.3.3. How the app works/design

Table 6.1.0: *COVID Alert SA* Details

	South Africa
Name of the App	Covid Alert SA
Developer(s)	❖ Developer: Discovery Health SA ❖ Publisher: South African National Department of Health
Decentralized or Centralized Data Collection	Decentralized
Bluetooth, GPS, Both, Other	Bluetooth
Type of App: GAEN or Other	Google Apple Exposure Notification API
Mobile Requirements: e.g. iOS, Android, version	iOS 13.5 or later Android 6.0 or later
Alternate functionality?	N/A
Data Collected (Voluntarily) By App	❖ Exposure Notification Keys ❖ Time, Date, and Length of these Events
Data Collected (Voluntarily) By Government	❖ Exposure Notification Keys[296] ❖ Time, Date and Length of these Events
Data Collection permission	Voluntary
Data Deletion period	14 days[297]

[292] Covid Alert SA App. (2020, September 1). Download the app – Every COVID Alert SA app download means more lives saved in SA. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/2020/09/01/download-the-app-every-covid-alert-sa-app-download-means-more-lives-saved-in-sa/
[293] Ibid.
[294] Ibid.
[295] Ibid.
[296] Apple, & Google. (2020). Exposure Notification Frequently Asked Questions Preliminary -Subject to Modification and Extension. Retrieved from https://covid19-static.cdn-apple.com/applications/covid19/current/static/contact-tracing/pdf/ExposureNotification-FAQv1.1.pdf
[297] COVID-19 South African Online Portal. (n.d.). Privacy Policy. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/covidalert/privacy-policy

COVID Alert SA is a decentralized, Bluetooth-based exposure notification system built off the GAEN API. It was developed by Discovery Health for the South African National Department of Health who is the official publisher of the app. It is only available in English and users must have smartphones with either iOS 13.5 or later or Android 6.0 or later. The only data collected by the app is the exposure notification keys alongside the time, data, and length of these exposure events.[298] Users can choose to voluntarily upload the same data to the government if the user tests positive for COVID-19. Downloading, using, and uploading the data is completely voluntary. Data is deleted off the app after 14 days.[299]

6.3.3.1. The App Engagement Process

Phase One: Downloading and Setup

COVID Alert SA is available for download on Google Play or the Apple store. Once the user downloads and opens the app, the first screen highlights what the app does and how privacy is protected. Once the user clicks 'get started,' a pop-up screen will ask for permission to turn on exposure notifications at which point the user can click 'cancel' or 'turn on.' A final screen then reiterates that it is important to share a positive diagnosis to break the chain of transmission in the community at which point the user clicks 'done.'

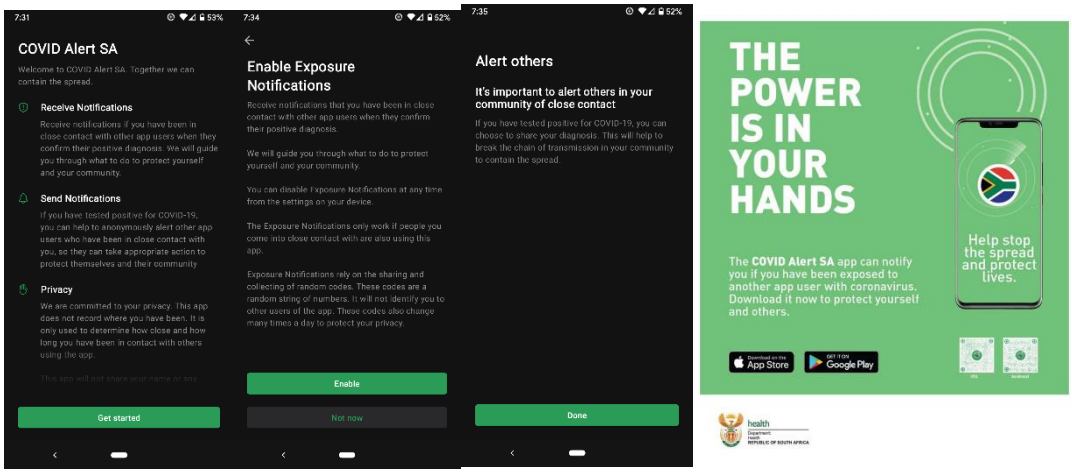

Figure 6.2.0. Initial Set-Up Screen Images of *COVID Alert SA*

Phase Two: Usage

The app simply runs in the background but Bluetooth must always be on[300] and the user must allow the app to run/refresh in the background.[301] The government also recommends that the user has their mobile network on or is connected to a WI-FI network while using the app. In saying that, the app will work without a mobile network or WI-FI, but exposure notifications will only be received once the user

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[298] Apple, & Google. (2020). Exposure Notification Frequently Asked Questions Preliminary - Subject to Modification and Extension. Retrieved from https://covid19-static.cdn-apple.com/applications/covid19/current/static/contact-tracing/pdf/ExposureNotification-FAQv1.1.pdf

[299] COVID-19 South African Online Portal. (n.d.). Privacy Policy. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/covidalert/privacy-policy

[300] For Android users, the app may request for location data but will not use it. Google is currently working on a fix to decouple Bluetooth with location data.

[301] COVID-19 South African Online Portal. (n.d.). COVID Alert SA app Frequently Asked Questions. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/covidalert/covidalert-faq/

reconnects to a mobile or WI-FI network. If the user was to open the app, and no exposures were detected, the screen would say 'no notifications found' and have a green radar screen, as in Figure 3.[302]

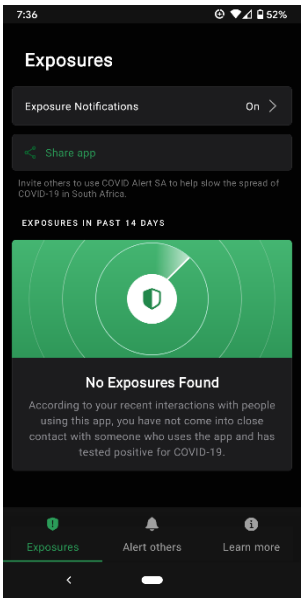

Figure 6.3.0. 'No Exposure Found' Screen on *COVID Alert SA*

Phase Three: Reporting

If the user receives a positive COVID-19 diagnosis, the user can choose to alert others by going to the 'Alert Others' tab on the app. The user can then select 'Alert others of close contact' at which point the user will be asked to enter the unique code the National Department of Health sent along with the COVID-19 test result as well as the user's date of birth. The user will then be asked to share the random codes the app has collected from the past 14 days to "initiate the process of notifying other app users' of a potential exposure."[303] The user will then be directed to a 'diagnosis shared' screen and then be asked to "assist the National Department of Health by going to the *COVID Alert SA* WhatsApp tool to help to identify people [the user has] been in contact with other the past few days. At this point, the user will receive instructions and guidance as to next steps.

[302] COVID-19 South African Online Portal. (n.d.). COVID Alert SA app Frequently Asked Questions. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/covidalert/covidalert-faq/
[303] Ibid.

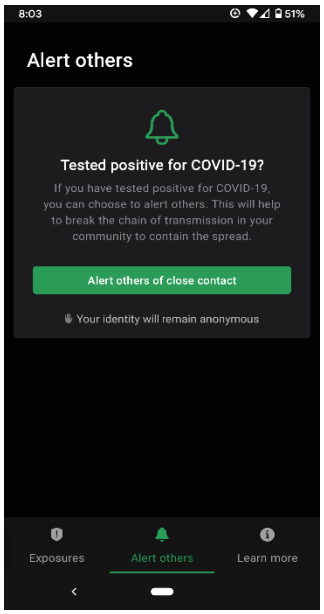

Figure 6.4.0. Reporting a Positive COVID-19 Diagnosis on COVID Alert SA

Part Four: Reacting

If a user has been potentially exposed to COVID-19, the user will receive a notification. When the user opens the app, the previous green radar screen will be orange and the message will say "possible exposure." Clicking on the radar screen will show the user the date of contact. The app will then provide next steps to take, such as self-quarantining for 10 days, monitoring symptoms, and accessing the National COVID-19 hotline.

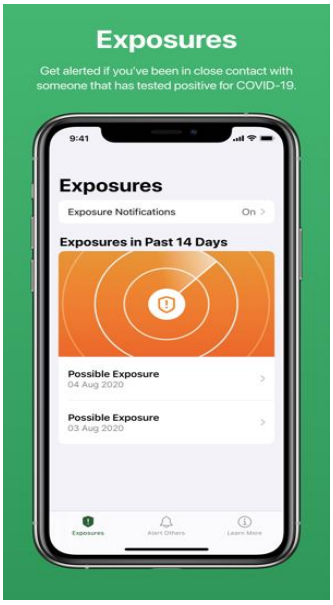

Figure 6.5.0 Exposure Alerts on *COVID Alert SA*

6.3.4. App-Uptake

6.3.4.1. Uptake Summary

Table 6.2.0: *COVID Alert SA* Uptake Summary

	South Africa
Uptake (#downloads)	~600,000[304]
Uptake (active users)	Data could not be found
General Uptake (# of downloads general population)	~1%
Age Appropriate Uptake (# of downloads / people over age allowed to download)	~1.5%
Digital Uptake (# of downloads / connected population)	~1.96%
Digital Capability Uptake (# of downloads / app-compatible population)	~1%

6.3.4.2. Uptake Description

With a population of 57,780,000 and 600,000 downloads, approximately 1% of the population has downloaded *COVID Alert SA*.[305] The government states that children must be 13 or older to use the app.[306] Using 2019 data that indicates 29% of the population was 0-14, roughly 41,030,000 people are eligible to download the app which would increase the uptake to 1.5%.[307] To calculate digital uptake, it was most appropriate to see how many individuals access the internet via mobile phones which is 52.8% or 30,507,840.[308] This means that digital uptake is about 1.96%. In terms of digital capability uptake, it was not possible to find data that highlighted how many Android users or iOS users were using 6.0 and later 13.5 and later respectively. It was only possible to determine that 99.4% of all smartphone users use either Android or iOS which would create a population of 52,379,187.84 and a *very* rough digital capability uptake percentage of just over 1%.[309] It is important to note that, as mentioned in Module 1, Section 1.5, there are significant issues with determining app success via uptake percentages.

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[304] As of 13 October 2020

[305] Nortier, C. (2020, October 13). COVID Alert SA app: The fine balance between public health, privacy and the power of the people. Maverick Citizen. Retrieved from https://www.dailymaverick.co.za/article/2020-10-13-covid-alert-sa-app-the-fine-balance-between-public-health-privacy-and-the-power-of-the-people/

[306] COVID-19 South African Online Portal. (n.d.). COVID Alert SA app Frequently Asked Questions. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/covidalert/covidalert-faq/

[307] The World Bank. (n.d.). Population ages 0-14 (% of total population) - South Africa. World Bank Group. Retrieved from https://data.worldbank.org/indicator/SP.POP.0014.TO.ZS?locations=ZA

[308] Statista. (2021). South Africa mobile internet user penetration 2015-2025. Statista Research Department. Retrieved from https://www.statista.com/statistics/972866/south-africa-mobile-internet-penetration/#:~:text=In%202020%2C%2052.8%20percent%20of,amounted%20to%20over%2031.29%20million

[309] StatCounter GlobalStats. (n.d.). Mobile Operating System Market Share South Africa. StatCounter. Retrieved from https://gs.statcounter.com/os-market-share/mobile/south-africa

6.4. Uptake Factors

6.4.1. Summary of Uptake Factors

Table 6.3.0: Summary of Uptake Factors in South Africa

Factor	Micro, Meso, and/or Macro	Brief Description
Communications & Misinformation	Meso-Macro	A comprehensive communications campaign has been a core component of South Africa's response to COVID-19, yet lack of trust in the government, misinformation swarming the app, and leveraging values that may not resonate with South Africans are factors that may discourage residents from downloading the app.
Accessibility & Inclusion	Macro	The government has taken steps, such as zero-rating the app (i.e. not charging individuals for the data used to download the app), to make the app more inclusive which may improve app-uptake. Yet only providing the app in English and not taking further steps to include other marginalized or vulnerable communities may also create barriers to downloading and using the app.
Trust in Public/ Private Institutions	Macro	There already exists a significant lack of trust towards the government which is further exacerbated by the fraud, corruption, and abuse surrounding initiatives relating to South Africa's COVID-19 response, thereby creating a disincentive to downloading a government-implemented app.
Response Infrastructure	Macro	While South Africa's experience with health epidemics has facilitated a more effective response to COVID-19 - in terms of increased testing, 'case finding' strategies, early implementation of lockdown, and other aspects highlighted in 4.2.4 - the country's healthcare infrastructure lacks capacity and is fraught with systemic inequality relating to access and quality of care which ultimately impacts healthcare processes that are intertwined with the app's processes.

6.4.2. Factor Descriptions

6.4.2.1. Communications & Misinformation

A significant part of South Africa's response to the pandemic was a "comprehensive communication campaign" through traditional media alongside social media and messaging apps to inform people about measures taken to mitigate the spread of the virus.[310] This tactic was similarly used for the launch of *COVID Alert SA*, with safety and privacy at the forefront of the communications content.[311] Alongside messages encouraging the understanding of the app's safety and privacy features, the campaigning around downloading and using the app uses phrasing that focuses on saving the day and protecting the community. The government has called people who download the app to be the "new superheroes."[312] Furthermore, they call upon residents to "become a part of a powerful digital network of app users who

[310] South African Government News Agency. (2020, September 3). The importance of leading communication during epidemics. Retrieved from https://www.sanews.gov.za/south-africa/importance-leading-communication-during-epidemics

[311] Nortier, C. (2020, October 13). MAVERICK CITIZEN: COVID Alert SA app: The fine balance between public health, privacy and the power of the people. Daily Maverick. Retrieved from https://www.dailymaverick.co.za/article/2020-10-13-covid-alert-sa-app-the-fine-balance-between-public-health-privacy-and-the-power-of-the-people

[312] COVID-19 South African Online Portal. (2020, September 1). Why are COVID Alert SA app users South Africa's new superheroes? Retrieved from https://sacoronavirus.co.za/2020/09/01/why-are-covid-alert-sa-app-users-south-africas-new-superheroes/

choose to work together for the benefit of everyone in the app community."[313] Yet interestingly, as will be further discussed in Section 6.4.2.3., trust in government is low – which could suggest that regardless of clear, consistent messaging, people may still not trust what the government is saying about the app. Furthermore, it is particularly interesting that the government is trying to leverage community relationships to encourage people to download the app. Data from the South African Reconciliation Barometer (SARB) revealed that South Africans: "only have a high degree of trust in their immediate circles of contact – relatives and neighbours – and low levels of trust in people of differing cultural backgrounds – language, religion, sexuality. Worryingly, a small majority of respondents do not trust foreigners, especially from African countries."[314] This data highlights that South Africans may not be motivated to download the app to be a superhero for the larger app-using community.

To further promote accurate communications, the government has implemented regulations to limit the spread and proliferation of fake news. Specific types of businesses are now mandated to remove fake news.[315] Furthermore, those who purposefully create or spread fake information can be prosecuted.[316] Despite these actions, the *COVID Alert SA* app has been surrounded by misinformation. The Daily Maverick used the Real411 platform to analyze disinformation trends surrounding COVID-19. As of 20 September 2020, there were 711 complaints regarding misinformation.[317] A social media post from a popular South African musician – David Scott of The Kiffness – was the source of 20 of these complaints because the musician 'satirically' suggested that the app collects credit card information.[318] While this claim is wildly inaccurate and the musician retrospectively claimed it was satire, within the pandemic context, anything that shares confusing, inaccurate information can "very well contribute to further distrust, confusion, skepticism, and encourage the public to do the complete opposite to the call from the president by not downloading the app."[319] Ultimately, while the government is trying its best to promote uptake of the app through effective communication, various factors from systemic mistrust of the government to misinformation surrounding the app may negate these actions, creating disincentives to download the app.

6.4.2.2. Accessibility and Inclusion

Generally speaking, South Africa's digital response to COVID-19 has attempted to be inclusive in some ways. For instance, COVIDConnect, described in Section 6.3.2 ,was implemented for the purpose of creating opportunities for people to access information and healthcare resources despite not having a

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[313] COVID-19 South African Online Portal. (n.d.). COVID Alert SA App. Retrieved from https://sacoronavirus.co.za/covidalert/
[314] Mosa, M. (n.d.). South Africa's Trust Deficit and Covid-19. The Institute for Justice and Reconciliation. Retrieved from https://www.ijr.org.za/2020/06/30/south-africas-trust-deficit-and-covid-19/
[315] COVID-19 South African Online Portal. (2020, March 30). COVID-19 Fake News Reporting. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/2020/03/30/covid-19-fake-news-reporting/
[316] South African Government. (n.d.). Fake news - Coronavirus COVID-19 | South African Government. Republic of South Africa. Retrieved from https://www.gov.za/covid-19/resources/fake-news-coronavirus-covid-19
[317] Smith, T., & Bird, W. (2020, September 20). OP-ED: Disinformation in a time of Covid-19: Weekly trends in South Africa. Daily Maverick. Retrieved from https://www.dailymaverick.co.za/article/2020-09-20-disinformation-in-a-time-of-covid-19-weekly-trends-in-south-africa-10/
[318] Ibid.
[319] Ibid.

smartphone that was compatible with *COVID Alert SA*.[320] While *COVID Alert SA* still remains inaccessible for some, the government has taken steps to increase its accessibility, including: 1) having mobile network providers zero-rate the app (which means that individuals are not charged for the data used to download the app); and 2) making the app only 3MB so that more people could download it.[321]

These actions certainly reduce the barriers to downloading the app, yet it is important to note that there will be certain communities who struggle to access the app, including the elderly, the homeless, and potentially visually impaired individuals. Furthermore, the app is only offered in English and only roughly 8.4% of households speak English,[322] thereby potentially creating a significant barrier to app-uptake. Finally, what will become very clear in Section 6.4.2.4. is that the racial inequalities that are a deeply rooted issue in South Africa may not necessarily create an issue of accessibility in terms of downloading the app, but certainly create issues in accessing healthcare. Healthcare services are needed for individuals to get tested (and upload on the app a positive COVID-19 diagnosis if required) as well as to receive healthcare for particularly serious cases of COVID-19.

6.4.2.3. Trust in Public/Private Institutions

The trust residents have in their government can certainly determine the extent to which COVID-19 public health policies are followed.[323] Yet, only 33% of South Africans claim they trust their legislature 'a lot' or 'somewhat.'[324] This lack of trust is reflective of South Africa's history as an abusive state during the apartheid era; the continued "disaffection" with the political parties in power, such as the ANC (largely due to the corruption of these parties);[325] and the "deep-seated inequality" that continues to exist.[326] This lack of trust continues to exist during the pandemic. In fact, even during the COVID-19 pandemic, "there was fraud and corruption in how the government dealt with the allocation of funds."[327] For instance, there are reports that personal protective equipment was bought for "five times more than the price the national treasury had advised."[328] While the president, Cyril Ramaphosa, has already started to take action surrounding the politicians accused of corruption (including being told to resign), residents are wanting to see these politicians face trial and be convicted for corruption.[329] Additionally, security forces – deployed to enforce regulations when the lockdown was imposed early during the pandemic – have allegedly been

[320]Covid Alert SA App. (2020, September 1). Download the app – Every COVID Alert SA app download means more lives saved in SA. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/2020/09/01/download-the-app-every-covid-alert-sa-app-download-means-more-lives-saved-in-sa/

[321] COVID Alert SA App. (2020, September 1). Why are COVID Alert SA app users South Africa's new superheroes?. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/2020/09/01/why-are-covid-alert-sa-app-users-south-africas-new-superheroes/

[322] Editor. (2018, June 28). WORLDVIEW: Few South Africans speak English, so why is it the language of business and politics. BizNews. Retrieved from https://www.biznews.com/premium/2018/06/28/english-language-business-politics#:~:text=According%20to%20Statistics%20South%20Africa,%2C%20and%20Setswana%20(8.9%25)

[323] Devermont, J., & Mukulu, T. (2020, May 12). South Africa's Bold Response to the Covid-19 Pandemic. CSIS. Retrieved from https://www.csis.org/analysis/south-africas-bold-response-covid-19-pandemic

[324] Ibid.

[325] Ibid.

[326] Devermont, J., & Mukulu, T. (2020, May 12). South Africa's Bold Response to the Covid-19 Pandemic. CSIS. Retrieved from https://www.csis.org/analysis/south-africas-bold-response-covid-19-pandemic

[327] BBC News. (2020, September 2). Coronavirus in South Africa: Misuse of Covid-19 funds "frightening." BBC News. Retrieved from https://www.bbc.com/news/world-africa-54000930

[328] Ibid.

[329] Ibid.

excessively and/or unnecessarily abusive towards residents.[330] Instances of fraud, corruption, and abuse hardly promote trust in the public eye and can certainly impact how residents look at public health measures.

In fact, some South Africans suggest that the *COVID Alert SA* app "is just another case of the government trying to track and control us, farm our data, and other similar concerns."[331] While many experts have dismissed many of privacy and security claims – citing that the app does not track location, cannot identify individuals, and is far less invasive than day-to-day social media apps – the mistrust residents have towards the government will establish, or reinforce existing, perceptions regarding the government's actions.[332] Furthermore, these perceptions may not be focused on whether information is being stolen, but as to who is in charge of tracing, as a recent UK study found.[333] Since the *COVID Alert SA* app is owned and managed by the government, rather than a health organization – the preferred option[334] – it may truly be the trust in the government, rather than perceptions surrounding privacy, that are acting as a barrier to uptake.

6.4.2.4. Response Infrastructure

Having extensive experience combating TB and HIV epidemics as well as having a health infrastructure to support these crises has proven to be of benefit for South Africa's response to COVID-19. South Africa is not only leading the continent in testing per capita (and is ranked 19th globally),[335] but went into a strict lockdown early, implemented door-to-door case findings,[336] "proactively set up a National COVID-19 Modelling Consortium" for COVID-19-related projections,[337] and redirected its TB and HIV health care infrastructure to manage COVID-19 cases. Amongst other initiatives taken to mitigate the spread of COVID-19, it appears South Africa had the experience and infrastructure to make decisions and implement specific measures.

Despite their long history with battling epidemics and having built a 'strong' healthcare and emergency management infrastructure that is tailored to these epidemics, South Africa's infrastructure simply cannot effectively manage COVID-19. This is in part due to the continued care needed by HIV, TB, diabetes, and

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[330] Human Rights Watch. (2020, April 7). South Africa: Set Rights-Centered COVID-19 Measures. Human Rights Watch. Retrieved from https://www.hrw.org/news/2020/04/07/south-africa-set-rights-centered-covid-19-measures
[331] Stone, J. (2020, September 21). What Security Experts Say About Downloading The 'COVID Alert SA' App. 2OceansVibe News. Retrieved from https://www.2oceansvibe.com/2020/09/21/what-security-experts-say-about-downloading-the-covid-alert-sa-app/#ixzz6eCF0uVtu
[332] Ibid.
[333] Botes, M. (2020, November 10). Unpacking the legal and ethical aspects of South Africa's COVID-19 track and trace app. The Conversation. Retrieved from https://theconversation.com/unpacking-the-legal-and-ethical-aspects-of-south-africas-covid-19-track-and-trace-app-147137
[334] Ibid.
[335] Travaly, Y., & Mare, A. (2020, July 8). Learning from the best: Evaluating Africa's COVID-19 responses. Brookings. Retrieved from https://www.brookings.edu/blog/africa-in-focus/2020/07/08/learning-from-the-best-evaluating-africas-covid-19-responses/
[336]Investec. (2020, June 8). Is SA's healthcare system prepared for Covid-19? Investec. Retrieved from https://www.investec.com/en_za/focus/beyond-wealth/is-south-africas-healthcare-system-prepared-for-covid-19.html
[337] Travaly, Y., & Mare, A. (2020, July 8). Learning from the best: Evaluating Africa's COVID-19 responses. Brookings. Retrieved from https://www.brookings.edu/blog/africa-in-focus/2020/07/08/learning-from-the-best-evaluating-africas-covid-19-responses/

high blood pressure patients that continues to tax the healthcare system.[338] Furthermore, the country has a severe shortage of 'skilled' healthcare workers.[339] Finally, while South Africa is the highest testing country in the continent, it is also facing a backlog of unprocessed COVID-19 tests (due to factors such as relying on imports).[340] Ultimately, lack of capacity (from both medical supplies and personnel standpoints), the healthcare system is extremely overburdened and lacks efficacy. This context creates the question as to whether residents who download and use the app would be able to upload a positive case or receive care (if told by the app to do so) if test results are delayed or healthcare facilities do not have the capacity to care for COVID-19 cases, thereby questioning the usefulness of downloading the app.

On top of these issues, lies the systemic inequality impacting whether a person can receive healthcare, what type of healthcare the person receives, and even if people have the luxury of following public health measures. With half of the nation living in poverty, and many lacking access to electricity and water, public health measures – like washing hands, let alone downloading a contact tracing app – may not be accessible to many.[341] Furthermore, while 90% of South Africans live within two hours of a health facility, Black Africans tend to live farther away and do not necessarily have the resources to travel to healthcare centres.[342] Finally, 66% of South Africa's ventilators are in private hospitals, creating not only an accessibility divide to those who cannot afford private healthcare, but unequal care that is based on what a person can afford.[343] This means that if someone were to be notified of a possible exposure, they may not be able to take the next step to get tested and upload a positive diagnosis on the app (if necessary). Another consideration is that the app may recommend that the user "seek[s] medical care if symptoms start or get worse.''[344] This raises questions not only about whether the user is able to access healthcare, but whether they receive equal and standardized care.

Ultimately, this context highlights that vulnerable communities, such as those of low socioeconomic status, in rural areas, and Black communities, are very likely disproportionately impacted by COVID-19 and also are not necessarily equally benefited by the actions taken by the government nor the infrastructures that are in place. Given that getting tested and being provided with care are necessary during the pandemic and are intertwined with the *COVID Alert SA* app's process, the lack of equal accessibility to, and benefits of, public health measures and healthcare, may prove to be a disincentive to downloading the using the app.

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[338] Investec. (2020, June 8). Is SA's healthcare system prepared for Covid-19? Investec. Retrieved from https://www.investec.com/en_za/focus/beyond-wealth/is-south-africas-healthcare-system-prepared-for-covid-19.html; Due to the high prevalence of these disease, the healthcare system in South Africa is already particularly burdened
[339] Ibid.
[340] Anna, C. (2020, May 29). South Africa has virus testing backlog of nearly 100,000. CTV News. Retrieved from https://www.ctvnews.ca/health/coronavirus/south-africa-has-virus-testing-backlog-of-nearly-100-000-1.4960080
[341] Devermont, J., & Mukulu, T. (2020, May 12). South Africa's Bold Response to the Covid-19 Pandemic. CSIS. Retrieved from https://www.csis.org/analysis/south-africas-bold-response-covid-19-pandemic
[342] Ibid.
[343] Ibid.
[344] COVID-19 South African Online Portal. (n.d.). COVID Alert SA app Frequently Asked Questions. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/covidalert/covidalert-faq/

6.5. Conclusion

COVID Alert SA is a decentralized, Bluetooth-based exposure notification system built off of the GAEN API. With 600,000 downloads, approximately 1% of the country has downloaded the app. South Africa's response to COVID-19 generally has been quite strong, with many positive aspects. The development and implementation of *COVID Alert SA* also has positive features. Communications have been consistent and informative, steps have been taken to make the app more inclusive, and South Africa's history of managing complex crises has assisted with its response to COVID-19, allowing it to be more effective than it would have been without this experience with epidemics. These factors may have helped promote residents to download and use the app. Yet the significant lack of trust in the government, misinformation surrounding the app, deep-seated inequality, and a general lack of capacity within the healthcare system creates barriers or disincentives to downloading *COVID Alert App* which may explain the country's low uptake.

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 7.

Analysis of User-Uptake Factors: **Individual- & Community-Level Influences**

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Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 7. Analysis of User-Uptake Factors: Individual & Community Level Influences

7.1. Study Overview

7.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have the highest rates of countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[345] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps

[345] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

around the world, how context plays a role, as well as the association of perceived benefits and risks with user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

7.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[346] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[347] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 7.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

7.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

[346]Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/
[347] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

7.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

7.2. Module Overview

This module aims to explore the individual- and community-level factors identified in our research in more depth through comparative analysis across case studies. We explore three factors – 1) Perceptions

of Data Collection & Management; 2) Sense of Community; and 3) Communications & Misinformation – identified as potential influencers of app-uptake at the individual (micro) and community (meso) levels as well as at the intersection of the community-system (meso-macro) levels. Discussion will begin with a brief summary of user-uptake across case studies to provide context. We then briefly describe how each factor fits within each level of analysis before exploring the research findings across the five case studies. We then situate these findings within the global scope (i.e. what these factors look like beyond the case studies) alongside broader discussion and emerging research on D-CT uptake in relation to risk and benefit perception.

7.3. Summary of Uptake Across Case Studies

User-uptake varied considerably across our five case studies (Iceland, Ireland, Scotland, Cyprus, and South Africa). The following is an overview of each of these case studies in terms of uptake rates,[348] the name, description, design, and implementation approach of their apps (see Table 1.0 for a summary).

Uptake rates for each country were determined by using a combination of media outlet statements on D-CT app download numbers and/or uptake rates alongside manual calculations based on a country's estimated population. Ireland's *COVID Tracker Ireland* had the highest uptake rate at 43%[349] (although if considering just active users that percentage drops to 28% of the population or 34% of the adult population),[350] followed by Iceland's *Rakning C-19* at 40%.[351] Scotland's *Protect Scotland* had 27.5%[352] user-uptake, meanwhile South Africa's *COVID Alert SA*[353] and Cyprus' *CovTracer* hovered around 1%.[354] All apps were implemented by the national government and developed through collaborative partnerships between the government and public, private, and/or academic organizations. Ireland, Scotland, and South Africa use a Bluetooth-based approach to D-CT as required when using the Google Apple Exposure Notification (GAEN) Application Programming Interface (API). Meanwhile, Iceland uses an open-source GPS-based app and Cyprus uses a combination of Bluetooth and GPS for their app which is based on MIT's free, open-source SafePaths Platform. The mobile operating system requirements for these apps

[348] Uptake rates are framed as a percentage representing the number of app downloads for the national population size in this section of the study. In case studies, uptake rates also are described as active users over downloads (as this measure is deemed to more accurately represent uptake) where data exists. Uptake rates also are situated in different populations including: the population that meet the age requirements to download the app (age appropriate uptake); the population that uses the internet on mobile phones (digital uptake); and the population that have Android or iOS smartphones (digital capability uptake).

[349] Hawkins, L. (2020, September 25). NearForm's privacy-first contact tracing app has high uptake. Healthcare Global. Retrieved January 27, 2021 from https://www.healthcareglobal.com/telehealth-and-covid-19/nearforms-privacy-first-covid-tracking-app-has-high-uptake

[350] Department of Health. (2020, October 21). Ireland is one of the first countries to link contact tracing apps with other EU Member States. Government of Ireland. Retrieved from https://www.gov.ie/en/press-release/2dc55-ireland-is-one-of-the-first-countries-to-link-contact-tracing-apps-with-other-eu-member-states/

[351] Johnson, B. (2020, May 11). Nearly 40% of Icelanders are using a covid app—and it hasn't helped much. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing

[352] Scottish Government. (2020, November 5). Protect Scotland app compatible with English and Welsh app. Scottish Government. Retrieved from https://www.gov.scot/news/protect-scotland-app-compatible-with-english-and-welsh-app/

[353] Nortier, C. (2020, October 13). COVID Alert SA app: The fine balance between public health, privacy, and the power of the people. Maverick Citizen. Retrieved from https://www.dailymaverick.co.za/article/2020-10-13-covid-alert-sa-app-the-fine-balance-between-public-health-privacy-and-the-power-of-the-people/

[354] Financial Mirror. (2020, April 7). COVID19: Thousands download Cyrpus COVTRACER app. Financial Mirror: Cyprus: Life & Style. https://www.financialmirror.com/2020/04/07/covid19-thousands-download-cyprus-covtracer-app/

span iOS 9.0 and up for Cyprus and Iceland to iOS 13.0 and up for Scotland to iOS 13.5 and up for Ireland and South Africa. For Android users in Cyprus and Iceland, the OS must be 5.0 and up whereas in Ireland, Scotland, and South Africa the OS must be 6.0 and up.

Table 7.1.0: D-CT App Overview Across Case Studies[355]

	Cyprus	Iceland	Ireland	Scotland	South Africa
Name of the App	CovTracer	Rakning C-19	COVID Tracker Ireland	Protect Scotland	COVID Alert SA
Developer(s)	Cyprus' Deputy Ministry of Research, Innovation and Digital Policy; the Research Centre of Excellence on Information and Communication Technologies in Cyprus; the Massachusetts Institute of Technology, XM.com, Prountzos & Prountzos LLC	Department of Civil Protection and Emergency Management; the Directorate of Health	Nearform	Nearform; NHS Scotland	Developer: Discovery Health SA Publisher: South African National Department of Health
Bluetooth, GPS, Both, Other	Both: GPS and Bluetooth	GPS-based	Bluetooth	Bluetooth	Bluetooth
Type of App: GAEN or Other	Other: MIT's free, open-source SafePaths platform	Other: GPS-based, open-source app	Google Apple Exposure Notification API	Google Apple Exposure Notification API	Google Apple Exposure Notification API
Mobile Requirements: e.g. iOS, Android, version	iOS 9.0 and up Android 5.0 and up	iOS 9.0 and up Android 5.0 and up	iOS 13.5 and up Android 6.0 and up	iOS 13 and up Android 6.0 and up Mobile phones must be 2015 or newer	iOS 13.5 or later Android 6.0 or later
Alternate functionality?	Symptoms checker. news function	Chat features for users to speak to public health officials additional information for tourists	Provides users with Irish COVID statistics; optional daily health check-in for users	N/A	N/A
Data Deletion period	1 year	14 days for data on user's phone 14 days for data uploaded (with consent) to a centralized database	14 days for diagnosis keys, and exposure notification service identifiers; 28 days for daily symptom check-in	72 hours for submitted data to Gov.UK; 14 days for diagnostic keys (on mobile phone)	14 days

[355] Please note that data collected by the app and by third parties is not shown in this summarizing table. Please see individual case studies (Modules 2-6) for more specifics.

While the apps across the case studies use a decentralized method of data storage, once a user is positively diagnosed with COVID-19, all apps provide the opportunity for the user to upload the data collected by the app to a centralized source for epidemiological follow-up, manual contract tracing, and/or sending out exposure notifications. Across four of the countries (Iceland, Ireland, Scotland, and South Africa), data is stored on the app for 14 days. The exception in Ireland is the symptom check-in data which is stored for 28 days. Meanwhile, Cyprus' app stores its data for 1 year. In terms of the data collected by the centralized database (should a user upload their data), the period before data is deleted is typically the 14 days except for Scotland where the data is deleted after a 72-hour period. Only some apps offer alternate functionality beyond contact tracing. For example, Iceland's app provides a chat feature that enables users to speak with public health officials; there is also additional information for tourists. Ireland provides users with COVID-19 statistics as well as the option for daily health diagnostic check-ins. Similarly, Cyprus offers symptom checker functionality with their app.

7.4. Micro Analysis

7.74.1. Factor 1: Perceptions of Data Collection & Management

One factor that appears to strongly influence uptake is individual perceptions and comprehension of the management and use of user data in relation to privacy – such as what data is collected, how it is managed, and how it is used. This factor is considered to exist at the individual (micro) level since it is the intrinsic beliefs around the data management process and understanding of privacy that influence behaviour.

Across case studies, five main themes were identified that may explain the link between perceptions of data collection & management and uptake of D-CT apps. The first theme identified is the **level of trust** in government and private institutions during, or at least prior to, the pandemic, which varies in line with uptake rates.[356] Iceland, Scotland, and Ireland – countries with higher uptake – have generally demonstrated a high level of trust. The Icelandic population, for example, is reported to have high trust in government officials including the Directorate of Health and the Department of Civil Protection and Emergency Management, both of which have been crucial in coordinating the government response to the COVID-19 pandemic.[357] Before the pandemic, Scotland conducted a social attitudes survey prior to lockdown. In contrast with UK perceptions, 61% of the population trusted the government to work in their best interests (versus 15% in the UK) and 73% were in favour of the government having the most influence over how the country was run (versus 15% in the UK).[358] Similarly, Ireland reportedly has one of the highest levels of pre-pandemic trust in its health care system compared to the pre-pandemic trust in the EU in general.[359] Meanwhile, countries with lower uptake, such as South Africa and Cyprus, have shown

[356] Note, reporting on public trust for all case studies during the pandemic due to limited information available
[357] NPR Weekend Edition Sunday. (2020, May 17). How Iceland handles contact tracing [Audio recording]. https://perma.cc/EBW8-2QQZ
[358] Government of Scotland. (2020, September 29). Survey shows high levels of trust in Scottish government. Government of Scotland. Retrieved from https://www.gov.scot/news/survey-shows-high-levels-of-trust-in-scottish-government/
[359] Eurofound. (2016). European Quality of Life Survey 2016 - Data visualisation. Retrieved from https://www.eurofound.europa.eu/data/european-quality-of-life-survey

a lower sense of public trust. In South Africa, trust in the government is particularly low, with only 33% of South Africans having claimed they trust their legislature 'a lot' or 'somewhat.'[360] In Cyprus, prior to the pandemic, people were largely pessimistic about their country's government, parliament, and political parties, with 66% revealing that they "distrust the government", 63% reporting lack of trust in parliament, and 87% of Cypriots stating that they do not "trust political parties."[361]

Extent of user input in the development, implementation, and regulation of D-CT apps – as well as throughout the entire user engagement process – is the second theme identified in the research. Research indicates that people's willingness to adopt and engage with apps is influenced by whether the app "seeks user input before delivering personalized services."[362] Apps that consult users before harvesting and mining their personal data are viewed more favourably than apps that do so "covert[ly]."[363] Furthermore, users are more likely to trust apps that prioritize total transparency and high user control and "the more they trust it, the greater their involvement in the app and the more positive attitudes."[364] In other words, high transparency creates incentives for app-uptake and engagement. Iceland, for example, has very clear privacy policies that are accessible to the general public in terms of what data is being collected and the limited purposes the data is being used for. Similarly, Ireland's app process gives the user a significant amount of control in what specific data is shared with both the app and the government. Cyprus' *CovTracer* also seems to focus on user input by explaining the purpose of each tracking feature and consulting users at every stage of the data collection process.

The **extent and nature of data collected** – the third identified theme – is also anticipated to have an impact on uptake. Across case studies, the scale and scope of data collected varied quite substantially. In Iceland, for example, data collected includes a user's location data and telephone number. Furthermore, the app explicitly states that data will not be shared with Iceland's contact tracing team unless actively shared by the user which they can do by entering their national ID number into the app. Meanwhile, the Cyprus app collects the most data among cases studied. As it uses both GPS and Bluetooth-based proximity tracing, the data collected by *CovTracer* about user behaviour extends well beyond others. Furthermore, the manual input data required during user registration – personal information about the account holder, health history and current health status, travel history, movement purposes (i.e. why an individual is leaving their home), and various phone-related data (location, memory, contacts, browser settings, etc.) – is extensive. The Cypriot government claims however, that all data is decentralized and that this data is stored on the user's phone unless actively supplied to health providers (like Iceland's app). Yet, when the broad data collection is combined with more sensitive user data, this report speculates that

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[360] Devermont, J., & Mukulu, T. (2020, May 12). South Africa's Bold Response to the Covid-19 Pandemic. Center for Strategic and International Studies. Retrieved from https://www.csis.org/analysis/south-africas-bold-response-covid-19-pandemic

[361] Hadjioannou, B. (2020, February 20). Eurobarometer: Cypriots distrust political parties, tend to trust the army more than other institutions. In-Cyprus.Com. https://in-cyprus.philenews.com/eurobarometer-cypriots-distrust-political-parties-tend-to-trust-the-army-more-than-other-institutions/; Financial Mirror. (2020, February 20). Cypriots trust the army more than politicians. Retrieved from https://www.financialmirror.com/2020/02/20/cypriots-trust-the-army-more-than-politicians/; Cymar. (2018, March 22). Trust and satisfaction with Institutions in Cyprus. Cymar. https://www.cymar.com.cy/en-gb/results/cyprus-institutions/

[362] Swayne, M. (2018, April 24). User control and transparency are key to trusting personalized mobile apps. Scienmag. Retrieved from https://scienmag.com/user-control-and-transparency-are-key-to-trusting-personalized-mobile-apps/

[363] Ibid.

[364] Ibid.

the sheer amount of data shared is a deterrent to app-uptake and participation. One of the reasons Ireland may have more uptake than other countries may be linked to the point made above regarding how the Ireland app provides significant user control in what data is shared: users provide consent to share data and the data shared is not only determined by the user, but is minimal.

The fourth identified theme – **risk of poor data management**, i.e. the risk of data breach – is also a major factor of consideration for user-uptake. In Scotland, for example, there were incidents of women providing their contact details offline in bars and private establishments later being contacted and harassed by the staff of those establishments.[365] This breach of privacy could work both in favour of, or against, app-uptake. For instance, in comparison to the physical data collected at restaurants, anonymized data collected via the D-CT app may be perceived as more secure. Alternatively, the breach of privacy seen with physical data may cause individuals to be skeptical of any personal data collection, digital or otherwise. Furthermore, there is the issue that the digital collection of data has its own set of perceived and actual risks.[366] Also in Scotland, the use of Amazon Web Services in relation to the country's app has raised flags among citizens and residents about the potential collection of personal information associated with using this service.[367] While NHS Scotland, assures that all data is encrypted and anonymized and states that this process adheres to NHS Scotland and GDPR data and privacy standards, the history of Amazon sharing data[368] may give reason for concern.

The final theme identified in relation to perceptions of data collection & management is **misunderstandings or misinterpretations that exist in relation to privacy**. Across the case studies and broader research, miscalculations of risk – both around general privacy protections and specifically how privacy varies between apps – may also play a role in influencing user-uptake. In Ireland, the subject matter expert interviews conducted by the DGHH Lab's team highlighted that many of the privacy concerns seemed to be disconnected from the reality of risks posed by the app. For example, as of Android 6.0 and up, location services must be turned on for the app's Bluetooth functionality to work.[369] Yet, concerned users may perceive the app requesting access to location data to be an indication of the app providing the government with personal location information and media outlets and privacy experts have had to stress that this is not the case. Therefore, the users of apps that use strictly Bluetooth – Ireland, Scotland, and South Africa – may be impacted by this misconception. Indeed, some South Africans are claiming that the *COVID Alert SA* app "is just another case of the government trying to track

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[365] Culliford, G. (2020). Scots bombarded with creepy texts after giving numbers out for Test and Protect. *The Scottish Sun.* Retrieved from https://www.thescottishsun.co.uk/news/6141337/nhs-scotland-test-protect-track-trace-coronavirus-data/

[366] Plutora. (2020, November 12). Digital Risk: What It Is And How to Manage It in Your Org. Retrieved from https://www.oecd-ilibrary.org/docserver/5jlwt49ccklt-en.pdf?expires=1613502651&id=id&accname=guest&checksum=C2CC72B43E05A3AEB3C9C4E1AE1FA932

[367] Williams, M. (2020). "Only NHS has access': Ministers insist Amazon is not getting data from a million users of Scotland's Test and Protect app. *The Herald*. Retrieved from https://www.heraldscotland.com/news/18734001.only-nhs-access-snp-insists-amazon-not-getting-data-million-users-scotlands-test-protect-app/

[368] Daws, R. (2020, January 28). Amazon's Ring causes further concerns over third-party data-sharing. Internet of Things News. Retrieved from https://iottechnews.com/news/2020/jan/28/amazon-ring-concerns-third-party-data-sharing/; Peters, J. (2020, April 23). Amazon reportedly accessed third-party seller data to develop private-label products. *The Verge*. Retrieved from https://www.theverge.com/2020/4/23/21233121/amazon-employees-seller-data-private-label-products

[369] Android. (n.d.). Bluetooth Overview. Retrieved from https://developer.android.com/guide/topics/connectivity/bluetooth

and control us, farm our data, and other similar concerns."[370] Further interviews revealed that this disconnect poses a major challenge in terms of encouraging uptake. Ultimately, despite *Covid Tracker Ireland's* affiliation with the Linux Foundation Public Health (LFPH) (an open-source initiative) and extensive security audits, the app's developers have not had a clear pathway for accurate information relating to privacy to reach end users.

Beyond case studies, broader research reinforces the perception that trust in government has a substantial impact of D-CT app-uptake. In the US, for example, trust has been so low in government that even manual contact tracing methods have been ineffective.[371] By contrast, roughly 75% of Singaporeans trust the government and other authorities[372] in how they manage personal data which may explain why the country's app, *TraceTogether*, has a claimed 4.2 million downloads (as of February 2021).[373] Other apps, like Canada's *COVID Alert* app, have been widely lauded for its privacy-by-design approach. Even with privacy watchdogs in support of the app,[374] uptake rates (in terms of downloads) in Canada lie around 16% (as of February 15 2021).[375] Beyond the actual privacy-preserving measures embedded in D-CT apps, our research suggests that, in many cases, privacy perceptions may have a stronger influence on app-uptake than the extent privacy is actually accounted for in these apps. That being said, people's fears regarding sharing data and potentially having their identity exposed have been substantiated, with cases like the breach of Dr. Ngolo's health status in New Brunswick, Canada leading to public shaming and removal from his place of work.[376] Similarly, in the Philippines, *COVID-KAYA*, a platform used by frontline healthcare workers to collect and share COVID-19 cases with their department of health, was found to have vulnerabilities that enabled unauthorized users to access and exploit this private health data.[377] In many contexts, the risk of exposing one's health status may be higher than the risk of contracting the virus itself, including potential ramifications for future health insurance apps, or when dealing with sensitive data of marginalized communities that require stricter data sharing protocols (including women escaping domestic violence, refugees and migrants, minors, the LGBTQ2+ community, and others). Furthermore, as will be discussed in Section 7.6.1, malicious actors spreading misinformation can help perpetuate an individual's misperceptions, or alternatively actualize their fears, relating to data collection, management, and privacy – thereby influencing user-uptake.

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[370] Stone, J. (2020, September 21). What Security Experts Say About Downloading The "COVID Alert SA" App. 2oceansvibe News. Retrieved from https://www.2oceansvibe.com/2020/09/21/what-security-experts-say-about-downloading-the-covid-alert-sa-app/#ixzz6eCF0uVtu

[371] Khazan, O. (2020, August 31). The Most American COVID-19 Failure Yet. *The Atlantic*. Retrieved from https://www.theatlantic.com/politics/archive/2020/08/contact-tracing-hr-6666-working-us/615637/

[372] Pierson, D. (2020, March 25). Singapore says its coronavirus app helps the public. Critics say it's government surveillance. *The Los Angeles Times.* Retrieved from https://www.latimes.com/world-nation/story/2020-03-24/coronavirus-singapore-trace-together

[373] Trace Together. (n.d.a.). TraceTogether, safer together. Retrieved from https://www.tracetogether.gov.sg/

[374] Laurenco, D. (2020, August 3). Canadian privacy watchdogs support COVID-19 exposure app. *CTVNews*. Retrieved from https://www.ctvnews.ca/health/coronavirus/canadian-privacy-watchdogs-support-covid-19-exposure-app-1.5049847

[375] Based on population of 37,742,154 (from Worldometer.info) and 6,286,807 downloads (from Canada.ca) as of Feb 15, 2021.

[376] Trinh, J. (2020, September 2). Tracing N.B. doctor's steps and contacts casts doubt on whether he was source of spring COVID-19 outbreak. *CBC.* Retrieved from https://www.cbc.ca/news/canada/new-brunswick/doubt-ngola-family-doctor-source-outbreak-campbellton-new-brunswick-1.5706918

[377] Lin, P., Knockel, J., Senft, A., Poetranto, I., Tran, S., & Delbert, R. (2020, November 10). Unmasked: COVID-KAYA and the Exposure of Healthcare Worker Data in the Philippines. The Citizen Lab. Retrieved from https://citizenlab.ca/2020/11/unmasked-covid-kaya-and-the-exposure-of-healthcare-worker-data-in-the-philippines/

7.5. Meso Analysis

7.5.1. Factor 2: Sense of Community (e.g. Trust in Community, Shared Trust, Shared sense of community, Communitarian)

Beliefs surrounding app engagement as a shared responsibility appear to have a noticeable effect on user-uptake of D-CT apps. Sense of community is considered community (meso) level because it is constructed through the mutual influence of the individual on community and the community on the individual.

Across case studies, countries with higher uptake rates (mainly Iceland and Ireland) showed strong **communitarian values**, the only prominent theme identified in relation to a sense of community. In Ireland, for example, the subject matter experts the DGHH Lab interviewed framed using the app as a duty similar to washing your hands or wearing a mask. The Irish commitment to community is supported by early behavioral studies undertaken by the Irish Health Service Executive (HSE), where communitarian messaging tested better among respondents than did messaging reflecting a more individualistic mindset.[378] As such, communications relating to the app refer to "the success of the app [being] founded on the solidarity of the Irish people in [their] aim to suppress the spread of COVID-19. This is a testament to the efforts of the Irish public…".[379] Similarly, in a survey looking at attitudes associated with COVID-19 digital contact tracing, O'Callaghan *et al*., (2020) found that protection of family and friends ranked higher than protection of self as a reason to install the app, as well as a general willingness to download the app (82% acceptance) prior to the release of the app itself.[380] Value rankings by the GLOBE[381] further reinforce the idea that commitment to community may stem from a national predisposition to communitarian values. Similarly, as a small island nation, Iceland is considered to be a country with strong social networks, with high levels of shared trust and social interaction.[382] The national approach to limiting the spread of COVID-19 has been described as a "collaborative model" that prioritizes faith in citizens and residents to follow public health measures over fines and regulations.[383] In other words, Iceland's model emphasizes cooperation and coordination.[384] Iceland's government also uses communitarian messaging,

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[378] Personal Communication, October 27, 2020

[379] Government of Ireland. (2020). Minister for Health welcomes launch of contact tracing apps in New York and New Jersey based on the Irish contact tracing app. Retrieved from https://www.gov.ie/en/press-release/02080-minister-for-health-welcomes-launch-of-contact-tracing-apps-in-new-york-and-new-jersey-based-on-the-irish-contact-tracing-app/

[380] O'Callaghan, M. E., Buckley, J., Fitzgerald, B., Johnson, K., Laffey, J., McNicholas, B., … Glynn, L. (2020). A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland. *Irish Journal of Medical Science*. https://doi.org/10.1007/s11845-020-02389-y

[381] GLOBE Project. (2020). Results - Ireland GLOBE Project. GLOBE project. Retrieved from https://www.globeproject.com/results/countries/IRL?menu=list; For critiques detailing contradictory measurement systems see: Allik, J., & Realo, A. (2004). Individualism-Collectivism and Social Capital. *Journal of Cross-Cultural Psychology*, 35(1), 29–49. https://doi.org/10.1177/0022022103260381

[382] Hjelmgaard, K. (2020, April 10). Iceland has tested more of its population for coronavirus than anywhere else. Here's what it learned. *USA Today*. Retrieved from https://www.usatoday.com/story/news/world/2020/04/10/coronavirus-covid-19-small-nations-iceland-big-data/2959797001/

[383] Johnson, B. (2020, May 11). Nearly 40% of Icelanders are using a covid app—and it hasn't helped much. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing/

[384] Anttiroiko, A. V. Successful Government Responses to the Pandemic: Contextualizing National and Urban Responses to the COVID-19 Outbreak in East and West. *International Journal of E-Planning Research (IJEPR)*, *10*(2), 1-17.

such as asking people to "be a strong link in the chain,"[385] once again highlighting the focus on strong social connections and civic responsibility. Interestingly, the South African government also invokes communitarian values in its *COVID Alert SA* app marketing. Yet, sources suggest that South Africans have very low trust beyond their most immediate family and neighbours, particularly if those people/communities are of different cultural or religious backgrounds, speak a different language, or are a part of the LGBTQ2S+ community.[386] The disconnect between the people's lack of communitarian values and the government trying to invoke those values likely results in an ineffective communications campaign. Both ineffective messaging and the lack of connection to helping others may be some reasons why uptake has been low in the country.

Beyond cases studied, other aspects of shared community that influence uptake were identified in our research. Complementary potential factors are population size and an island nation's "powerful sense of community."[387] As mentioned above, Singapore's *TraceTogether* contact tracing app has roughly 4.2 million downloads of a population of 5.639 million (74% uptake as of February 15 2021).[388] New Zealand's contact tracing app called *NZ COVID Tracer* has over 2,591,784 downloads as of February 16 2021.[389] With a population of 4.886 million, New Zealand's app has a 53% uptake.[390] Like Iceland, both countries have smaller populations, are island nations, and their COVID-19 responses have been well received and effective. These attributes may explain high app-uptake.

Another factor that may impact the sense of community is **inequality**. In South Africa, systemic inequality – such as between black and white, rich and poor, amongst others – likely contributes to the lack of trust (see Module 8, Section 8.4.2: Factor 5) and sense of community. Many of these contact tracing apps have highlighted existing health and socio-economic inequalities in various nations, such as Australia,[391] the UK,[392] the United States,[393] amongst others. For instance, in Canada, Katie Crocker, Chief Executive Officer of the Affiliation of Multicultural Societies and Service Agencies of British Columbia, stated that "a pandemic exaggerates the inequities that already exist" alongside "folks who don't speak English, who are

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[385] Government of Iceland. (2020). Tracing app Rakning C-19. Retrieved from https://www.covid.is/app/en

[386] Moosa, M. (n.d.). South Africa's Trust Deficit and Covid-19. IJR. Retrieved from https://www.ijr.org.za/2020/06/30/south-africas-trust-deficit-and-covid-19/

[387] Burholt, V., Scharf, T., & Walsh, K. (2013). Imagery and imaginary of islander identity: Older people and migration in Irish small-island communities. *Journal of Rural Studies*, *31*, 1–12. https://doi.org/10.1016/j.jrurstud.2013.01.007

[388] Trace Together. (n.d.b.). TraceTogether, safer together. Retrieved from https://www.tracetogether.gov.sg/

[389] New Zealand Government Ministry of Health. (2021). COVID-19: NZ COVID Tracer app data. Retrieved from https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-data-and-statistics/covid-19-nz-covid-tracer-app-data

[390] Blake-Persen, N. (2020, September 2). 2.1 million download Covid Tracer app, but who is signing in? RNZ. Retrieved from https://www.rnz.co.nz/national/programmes/checkpoint/audio/2018762292/2-point-1-million-download-covid-tracer-app-but-who-is-signing-in

[391] Lodders, A., & Paterson, J. M. (2020). Scrutinising COVIDSafe: Frameworks for evaluating digital contact tracing technologies. *Alternative Law Journal, 45*(3), 1037969X2094826. https://doi.org/10.1177/1037969x20948262

[392] Gann, B. (2020). Combating Digital Health Inequality in the Time of Coronavirus. *Journal of Consumer Health on the Internet, 24*(3), 278–284. https://doi.org/10.1080/15398285.2020.1791670

[393] Toh, A., & Brown, D. (2020, June 4). How Digital Contact Tracing for COVID-19 Could Worsen Inequality. Human Rights Watch. Retrieved from https://www.hrw.org/news/2020/06/04/how-digital-contact-tracing-covid-19-could-worsen-inequality

racialized, who are working on the front lines, who may not have digital access are being impacted."[394] When some communities are included in the development and implementation of the app and some communities are not, it seems as though there is an inevitable degradation of sense of community which can impact uptake.

Other considerations related to a strong or weak sense of community and app-uptake are as follows. First, high communitarian values may imply higher shared trust which can mitigate the perceived risk of stigmatization in the event an app user is infected and potentially identified. Second, communities that prioritize the "stronger together" mentality (as emphasized by Kropotkin)[395] over survival of the fittest (as emphasized by Darwin)[396] may be more likely to engage in initiatives like COVID-19 D-CT apps that require community collaboration. As argued by Slim (2020), surviving a pandemic is not just about human rights but also human duty, i.e. "we have to give up some of our rights – to freedom of movement, to family life, and to economic entitlements – in order to protect others."[397] For instance, in countries that have been described as having an "individualistic culture" – like the United States – people may be less inclined to help others which may explain the low uptake seen across the country's many D-CT apps.[398] In comparison, India – a country that has been described as collectivistic[399] – has a singular app that has over 160 million downloads.[400] Despite being only roughly a 12% uptake rate in a country of an estimated 1.353 billion, the sheer amount of downloads is potentially representative of the country's communitarian values and desire to protect others. Third, communities with high communitarian values may perceive that the risk is lower and benefit is higher with engagement in a contact tracing app and vice versa (there is higher risk and lower benefit to not participating).

7.6. Meso-Macro Analysis

7.6.1. Factor 3: Communications & Misinformation

Communications between media, responders (government, response agencies), and communities/individuals, as well as the management of misinformation around D-CT apps, appear to influence uptake. This factor is considered to exist at the intersection of the community (meso) and system (macro) levels because the nature and spread of information constructed and shared is believed to

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[394] Lum, Z.-A. (2020, August 3). HuffPost Canada: COVID Alert App Is A Glaring Reminder Of Health Inequality In Canada – AMSSA. AMSSA. Retrieved from https://www.amssa.org/about/media/huffpost-canada-covid-alert-app-is-a-glaring-reminder-of-health-inequality-in-canada/

[395] Kropotkin, P. A. (1908). *Mutual aid: A factor of evolution*. London: Heinemann.

[396] University of Cambridge. (n.d.) Survival of the fittest. Retrieved from https://www.darwinproject.ac.uk/commentary/survival-fittest

[397] Slim, H. (2020, March 18). This age of COVID-19 demands new emergency ethics. The New Humanitarian. Retrieved from https://www.thenewhumanitarian.org/opinion/2020/03/18/coronavirus-pandemic-emergency-ethics

[398] Cherry, K. (2020, December 11). How Do Individualistic Cultures Influence Behavior? Verywell Mind. Retrieved from https://www.verywellmind.com/what-are-individualistic-cultures-2795273#:~:text=A%20few%20countries%20that%20are

[399] Ibid.

[400] 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

be a product of individual interactions with immediate communities, but also as an external influence coming from broader socio-political systems beyond an individual's immediate network.

Across case studies, three main themes were identified that may explain the link between communications and misinformation and uptake of D-CT apps. The first theme identified within the Communications & Misinformation factor is the **influence of positive and negative narratives.** In Ireland, the DGHH Lab's social media scraping of Twitter[401] (sampled in October 2020) show that narratives relating to the app were often positive from the individual-driven perspective. People expressed that the *COVID Tracker Ireland* app is a symbol of national pride in comparison to the D-CT app in the United Kingdom. These positive narratives may relate to increased uptake. Scraping also revealed however, that global concerns regarding D-CT apps expressed online are easily spread and eventually reach the local Irish population. Discussion with app developers explained that the mix of narratives built up around the app are not completely understood and that the developers lack the capacity to thoroughly monitor dialogue around the app. These conflicting narratives and the lack of management around the narratives could potentially lead to decreased uptake of the app. Similarly in Scotland, there were both positive and negative narratives being shared by groups with an authoritative presence, who citizens and residents would likely listen to and look towards for accurate information. For instance, the Scottish government alongside the Scottish Police Federation has been promoting use of the app and has been sharing accurate information. Yet, Police Scotland's health and safety group have labeled the app "haphazard, unreliable and inaccurate."[402] Conflicting messaging and narratives, particularly from bodies of authority (the importance of who is sharing app-related information will be discussed in more detail in the third theme identified below), may result in confusion as to whether people should or should not download and use the app. Referring back to Section 7.5.1, Iceland and Ireland were able to establish positive narratives through their app communications campaigns by invoking pre-existing communitarian values that define their respective societies. Meanwhile, South Africa's government tried to leverage the same communitarian values – which are not strong in the nation – thereby potentially creating a negative narrative (or at the very least a non-persuasive/neutral narrative).

Malicious actors and the spread of misinformation is the second theme that seems to influence user-uptake. In Scotland, app-uptake may have been hindered due to the spread of scams and government warnings about scams and malicious actors associated with their *Protect Scotland* app. The government reported that malicious actors were engaging in cash scams[403] by impersonating officials representing the country's D-CT app and requesting personal information like passwords, bank details, and medical history.[404] Banking information was frequently requested in these scams under the pretense that tests were not free of charge.[405] This is an egregious privacy violation and may negatively influence user-

[401] Twitter scraping consisted of looking at Twitter posts in October containing six sets of COVID app related keywords
[402] Morrison, H. (2020). Officers urged to use NHS app-despite senior Police Scotland personnel calling it 'unreliable'. *Glasgow Times*. Retrieved from https://www.glasgowtimes.co.uk/news/18784386.cops-urged-use-nhs-app---despite-top-cops-calling-unreliable/
[403] Coronavirus (COVID-19): Contact Tracing. (2020). NHS Inform. Retrieved from https://www.nhsinform.scot/illnesses-and-conditions/infections-and-poisoning/coronavirus-covid-19/test-and-protect/coronavirus-covid-19-contact-tracing
[404] Scam warning issued after launch of Scottish coronavirus app. (2020). The Orcadian. Received from https://www.orcadian.co.uk/scam-warning-issued-after-launch-of-scottish-coronavirus-app/
[405] Contact Tracing Scams. (2020). Trading Standard Scotland. Retrieved from https://www.tsscot.co.uk/contact-tracing-scams/

uptake. Furthermore, reports also highlighted that the elderly population were most vulnerable to these scams, thereby disproportionately impacting an already vulnerable community. This increased vulnerability may lower uptake from this specific elderly demographic. Similarly in South Africa, misinformation plagued the launch of *COVID Alert SA*. One of the more notable cases was when a famous musician – David Scott from The Kiffness – satirically suggested that the app collects credit card information.[406] The dissemination of this false information likely contributed to the ongoing lack of trust towards *COVID Alert SA*.

Meanwhile, the third theme identified – ***who* is communicating contact tracing app information -** is an important theme that can both positively and negatively impact uptake. For instance, in South Africa, the lack of trust in government likely means that, despite consistent, communitarian messaging that highlights the privacy-preserving components of *COVID Alert SA*, the general public may not trust what is being claimed because it is coming from an untrusted source. Contrastingly, as mentioned in above, the fact that Police Scotland's health and safety group negatively reviewed the app also has a negative impact on app-uptake as citizens and residents may look towards this trusted authority for guidance in complex crises. Meanwhile in Ireland and Iceland, individuals generally trust their government and the messaging has been consistent across these countries and amongst relevant organizations, likely assisting with increased uptake. Similarly, in Scotland, where there seems to be a high level of trust towards the government, malicious scammers leveraged that trust and pretended to be government officials in order to collect people's personal information. Finally, there must be consideration when celebrities voice their opinions because they can influence their followers' opinions towards public health measures like a contact tracing app. As mentioned above, a South African celebrity musician satirically stated inaccurate information about the country's contact tracing app to his thousands of followers. While some citizens and/or residents reported this act of spreading misinformation on a national platform designed to receive such reports, these events also can easily reinforce and instill negative connotations and inaccurate perceptions towards the app for others.

Beyond the cases studied, in the United States, the combination of inaccurate messaging and generally negative narratives relating to COVID-19[407] by the country's president may play a role in why a survey from Avira found that more than 71% of Americans would not download a contact tracing app.[408] Furthermore, researchers found that the battle to control misinformation is a global phenomenon, with inaccurate information relating to COVID-19 being found in 25 languages in 87 countries.[409] Our research also found that other communication factors may impact uptake. First, the language used to describe D-CT apps appears to be high priority among public institutions. Over the course of the research, D-CT apps were increasingly re-labelled as exposure notification tools. Canada, for example, is very clear their app is

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[406] Smith, T. (2020, September 20). OP-ED: Disinformation in a time of Covid-19: Weekly trends in South Africa (W. Bird, Ed.). *Daily Maverick*. Retrieved from https://www.dailymaverick.co.za/article/2020-09-20-disinformation-in-a-time-of-covid-19-weekly-trends-in-south-africa-10/

[407] United States Congressman Lloyd Doggett. (2021, January 21).Timeline of Trump's Coronavirus Responses. Retrieved from https://doggett.house.gov/media-center/blog-posts/timeline-trump-s-coronavirus-responses

[408] Cousins, B. (2020, June 18). 4 takeaways from contact tracing apps in other countries. *CTV News*. Retrieved from https://www.ctvnews.ca/health/coronavirus/4-takeaways-from-contact-tracing-apps-in-other-countries-1.4990497

[409] Howard, J. (2020, August 10). Covid-19 misinformation is spreading in 25 different languages, study finds. *CNN*. Retrieved from https://www.cnn.com/2020/08/10/health/covid-misinformation-spread-study-wellness/index.html

an exposure notification not a contact tracing tool. This reframing of the tools appears to stem from the perception that using the word "tracing" in the branding of D-CT apps created a higher apprehension of being surveilled than the notion of exposure. Second, the laws and policies surrounding communications and misinformation is a particularly interesting factor that can indirectly impact uptake. For instance, South Africa implemented a regulation mandating that businesses remove misinformation and that those spreading misinformation can be prosecuted.[410] On the one hand, if more accurate information about contact tracing apps is reaching the public and less inaccurate information is being shared, then uptake may increase. Yet, the restrictions being placed on free speech, and other human rights considerations relating to prosecution, may discourage uptake. South Africa is not the only country to take these steps. Hungary and Bolivia for instance, also made it illegal to spread misinformation.[411] Interestingly, in India, the Prime Minister has demanded that journalists only publish "official" information (i.e. information relayed by the government) regarding COVID-19 and the country's response.[412] Once again, these actions may promote accurate information – including information relating to India's contact tracing app – being shared with the country's people, yet there are significant concerns that these steps are being taken to ultimately control the press and manipulate the narrative.[413] Third, as mentioned throughout this section, consistency of messaging also seems to be an important consideration that may impact uptake. Again, using South Africa as an example, the country has had three 'contact tracing initiatives' which may result in confusion, frustration, and distrust (particularly because the first initiative was very invasive in terms of data collected. In contrast, Iceland implemented one app early into the pandemic with consistent messaging and app-uptake was relatively high.

7.7. Conclusion

Module 7 provided an overview of the individual (micro) and community (meso) level factors as well as the community-system (meso-macro) level factors identified in our research. The first factor identified was Perceptions of Data Collection & Management, an individual (micro) level factor. Level of trust, extent of user input, extent and nature of data collected, risk of poor data management, and misunderstandings or misinterpretations that exist in relation to privacy were the five main themes identified in relation to the first factor. The second factor identified was Sense of Community, a community (meso) level factor. The main theme associated with this factor was communitarian values. Finally, the third factor identified was Communications & Misinformation, a community-system (meso-macro) level factor. The influence of positive and negative narratives, malicious actors and the spread of misinformation, and who is communicating information were the main factors associated with the third factor. For an overview of the system-level (macro) factors influencing user-uptake, see Module 8

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[410] COVID-19 South African Online Portal. (2020, March 30). COVID-19 Fake News Reporting. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/2020/03/30/covid-19-fake-news-reporting/; South African Government. (n.d.). Fake news - Coronavirus COVID-19 | South African Government. Republic of South Africa. Retrieved from https://www.gov.za/covid-19/resources/fake-news-coronavirus-covid-19

[411] Walker, S. (2020, April 3). Hungarian journalists fear coronavirus law may be used to jail them. *The Guardian*. Retrieved from https://www.theguardian.com/world/2020/apr/03/hungarian-journalists-fear-coronavirus-law-may-be-used-to-jail-them

[412] Goel, V., Gettleman, J., & Khandelwal, S. (2020, April 2). Under Modi, India's Press Is Not So Free Anymore. *The New York Times.* Retrieved from https://www.nytimes.com/2020/04/02/world/asia/modi-india-press-media.html

[413] Ibid.

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 8.

Analysis of User-Uptake Factors: **System-Level Influences**

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DGHH

Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 8. Analysis of User-Uptake Factors: System Level Influences

8.1. Study Overview

8.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have the highest rates of countries studied at approximately 43% and 40% respectively, while places like Cyprus or South Africa fall below 1%. And, while many argue that any degree of uptake can make a difference,[414] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these

[414] O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

8.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[415] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[416] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 8.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

[415] Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/
[416] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

8.1.3 Overview of Cases & Factors Identified

As will be shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

8.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences

Module 9 - Recommendations & Future Research

8.2. Module Overview

This module aims to explore the system-level factors identified in our research in more depth through comparative analysis across case studies. We explore five factors – 1) Accessibility & Inclusion; 2) Trust in Public/Private Institutions; 3) Policy & Governance; 4) Response Infrastructure; and 5) Digital Capability – identified as potential influencers of app-uptake at the system (macro) level. Discussion will begin with a brief summary of user-uptake across case studies to provide context. We then briefly describe how each factor fits within the system-level before exploring the research findings across the five case studies. We then situate these findings within the global scope (i.e. what these factors look like beyond the case studies) alongside broader discussion and emerging research on D-CT uptake in relation to risk and benefit perception.

8.3. Summary of Uptake Across Case Studies

User-uptake varied considerably across our five case studies (Iceland, Ireland, Scotland, Cyprus, and South Africa). The following is an overview of each of these case studies in terms of uptake rates,[417] the name, description, design, and implementation approach of their apps (see Table 8.1.0 for a summary).

Uptake rates for each country were determined by using a combination of media outlet statements on D-CT app download numbers and/or uptake rates alongside manual calculations based on a country's estimated population. Ireland's *COVID Tracker Ireland* had the highest uptake rate at 43%[418] (although if considering just active users that percentage drops to 28% of the population or 34% of the adult population),[419] followed by Iceland's *Rakning C-19* at 40%.[420] Scotland's *Protect Scotland* had 27.5%[421] user-uptake, meanwhile South Africa's *COVID Alert SA*[422] and Cyprus' *CovTracer* hovered around 1%.[423] All

[417] Uptake rates are framed as a percentage representing the number of app downloads for the national population size in this section of the study. In case studies, uptake rates also are described as active users over downloads (as this measure is deemed to more accurately represent uptake) where data exists. Uptake rates also are situated in different populations including: the population that meet the age requirements to download the app (age appropriate uptake); the population that uses the internet on mobile phones (digital uptake); and the population that have Android or iOS smartphones (digital capability uptake).
[418] Hawkins, L. (2020, September 25). NearForm's privacy-first contact tracing app has high uptake. Healthcare Global. Retrieved January 27, 2021 from https://www.healthcareglobal.com/telehealth-and-covid-19/nearforms-privacy-first-covid-tracking-app-has-high-uptake
[419] Department of Health. (2020, October 21). Ireland is one of the first countries to link contact tracing apps with other EU Member States. Government of Ireland. Retrieved from https://www.gov.ie/en/press-release/2dc55-ireland-is-one-of-the-first-countries-to-link-contact-tracing-apps-with-other-eu-member-states/
[420] Johnson, B. (2020, May 11). Nearly 40% of Icelanders are using a covid app—and it hasn't helped much. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing
[421] Scottish Government. (2020, November 5). Protect Scotland app compatible with English and Welsh app. Scottish Government. Retrieved from https://www.gov.scot/news/protect-scotland-app-compatible-with-english-and-welsh-app/
[422] Nortier, C. (2020, October 13). COVID Alert SA app: The fine balance between public health, privacy, and the power of the people. Maverick Citizen. Retrieved from https://www.dailymaverick.co.za/article/2020-10-13-covid-alert-sa-app-the-fine-balance-between-public-health-privacy-and-the-power-of-the-people/
[423] Financial Mirror. (2020, April 7). COVID19: Thousands download Cyprus COVTRACER app. Financial Mirror: Cyprus: Life & Style. https://www.financialmirror.com/2020/04/07/covid19-thousands-download-cyprus-covtracer-app/

apps were implemented by the national government and developed through collaborative partnerships between the government and public, private, and/or academic organizations. Ireland, Scotland, and South Africa use a Bluetooth-based approach to D-CT as required when using the Google Apple Exposure Notification (GAEN) Application Programming Interface (API). Meanwhile, Iceland uses an open-source GPS-based app and Cyprus uses a combination of Bluetooth and GPS for their app which is based on MIT's free, open-source SafePaths Platform. The mobile operating system requirements for these apps span iOS 9.0 and up for Cyprus and Iceland to iOS 13.0 and up for Scotland to iOS 13.5 and up for Ireland and South Africa. For Android users in Cyprus and Iceland, the OS must be 5.0 and up whereas in Ireland, Scotland, and South Africa the OS must be 6.0 and up.

Table 8.1.0: D-CT App Overview Across Case Studies[424]

	Cyprus	Iceland	Ireland	Scotland	South Africa
Name of the App	CovTracer	Rakning C-19	COVID Tracker Ireland	Protect Scotland	COVID Alert SA
Developer(s)	Cyprus' Deputy Ministry of Research, Innovation and Digital Policy; the Research Centre of Excellence on Information and Communication Technologies in Cyprus; the Massachusetts Institute of Technology, XM.com, Prountzos & Prountzos LLC	Department of Civil Protection and Emergency Management; the Directorate of Health	Nearform	Nearform; NHS Scotland	Developer: Discovery Health SA Publisher: South African National Department of Health
Bluetooth, GPS, Both, Other	Both: GPS and Bluetooth	GPS-based	Bluetooth	Bluetooth	Bluetooth
Type of App: GAEN or Other	Other: MIT's free, open-source SafePaths platform	Other: GPS-based, open-source app	Google Apple Exposure Notification API	Google Apple Exposure Notification API	Google Apple Exposure Notification API
Mobile Requirements: e.g. iOS, Android, version	iOS 9.0 and up Android 5.0 and up	iOS 9.0 and up Android 5.0 and up	iOS 13.5 and up Android 6.0 and up	iOS 13 and up Android 6.0 and up Mobile phones must be 2015 or newer	iOS 13.5 or later Android 6.0 or later
Alternate functionality?	Symptoms checker. news function	Chat features for users to speak to public health officials additional information for tourists	Provides users with Irish COVID statistics; optional daily health check in for users	N/A	N/A

[424] Please note that data collected by the app and by third parties is not shown in this summarizing table. Please see individual case studies (Modules 2-6) for more specifics.

Data Deletion period	1 year	14 days for data on user's phone 14 days for data uploaded (with consent) to a centralized database	14 days for diagnosis keys, and exposure notification service identifiers; 28 days for daily symptom check-in	72 hours for submitted data to Gov.UK; 14 days for diagnostic keys (on mobile phone)	14 days

While the apps across the case studies use a decentralized method of data storage, once a user is positively diagnosed with COVID-19, all apps provide the opportunity for the user to upload the data collected by the app to a centralized source for epidemiological follow-up, manual contract tracing, and/or sending out exposure notifications. Across four of the countries (Iceland, Ireland, Scotland, and South Africa), data is stored on the app for 14 days. The exception in Ireland is the symptom check-in data which is stored for 28 days. Meanwhile, Cyprus' app stores its data for 1 year. In terms of the data collected by the centralized database (should a user upload their data), the period before data is deleted is typically the 14 days except for Scotland where the data is deleted after a 72-hour period. Only some apps offer alternate functionality beyond contact tracing. For example, Iceland's app provides a chat feature that enables users to speak with public health officials; there is also additional information for tourists. Ireland provides users with COVID-19 statistics as well as the option for daily health diagnostic check-ins. Similarly, Cyprus offers symptom checker functionality with their app.

8.4. Macro Analysis

8.4.1. Factor 4: Accessibility & Inclusion

Accessibility and inclusivity appear to have widespread influence on the ability and decision to download and use D-CT apps. Here, the notion of the digital divide (a factor frequently highlighted in the literature) has a substantial impact on uptake. This factor is considered a system (macro) level factor as it directly influences individual and community capability as a product of socio-economic (e.g. access to education, gender divides, marginalization, household income), political (e.g. political priorities) and digital information and communication technology infrastructure (e.g. internet access) contexts.

Across case studies, three main themes were identified that may explain the link between accessibility and inclusivity and uptake of D-CT apps. The first theme is **digital constraints**. Specifically, uptake is frequently impacted by mobile phone constraints, i.e. populations with older phones, out-of-date operating systems, insufficient storage space, and/or no access to phones at all are unable to download the app. Collectively, these issues are expected to impact upwards of an estimated 2 billion people globally.[425] Across case studies, iOS requirements span iOS 9.0 up to 13.5 and Android 5.0 to 6.0;

[425] Bradshaw, T. (2020, April 20). 2bn phones cannot use Google and Apple contact-tracing tech. Retrieved from https://www.ft.com/content/271c7739-af14-4e77-a2a1-0842cf61a90f; Doffman, Z. (2020, April 20). Apple and Google Contact-

individuals with prior versions are unable to download the app. In response to these challenges, there has been some discussion in Ireland, for instance, of supplying individuals with phones or other alternative tech to reduce health disparities and enhance uptake.[426] Yet, little to no movement has occurred since the topic was broached early on in the pandemic.[427] Uptake also is impacted by internet connectivity constraints. In South Africa, a region where internet penetration is 62%,[428] *COVID Alert SA* has been designed to require very little phone space (only 3MB) and mobile services companies have zero-rated the app so that people are not charged for the data required to download the app.[429]

The second theme identified is **app usability**, i.e. the extent D-CT apps are designed and implemented in a way that populations have equal opportunity and capability to use the apps. App usability can impact vulnerable groups most, including people living with disabilities; individuals with vision, literacy, language, and digital literacy challenges; and elderly populations. Usability is heavily impacted by compliance with accessibility standards. For instance, while Scotland's app is compatible with Apple and Google screen readers, Scotland's Equality Impact Assessment Report found that further consideration was required for those in the deaf and blind community, those who use British Sign Language, and people with learning disabilities.[430] Relatedly, it is unclear how *COVID Tracker Ireland* and Cyprus' *CovTracer* leverage smartphone assistive technology. In addition, an app's language options impact usability. Iceland launched their website in eight languages[431] while *COVID Tracker Ireland* released an instructional video in sign language on how to use the app,[432] both of which are important steps in broadening access to the app. In Scotland however, support for additional languages is pending. Furthermore, in South Africa, the app is only provided in English[433] despite the country having 11 official languages and only 1 in 10 people using the English language at home.[434] Specific measures to include elderly populations also have had an impact on usability. Many elderly persons, like those reported in Cyprus,[435] have been struggling to adapt

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Tracing Surprise: 2.5 Billion Users Will Miss Out. Retrieved from https://www.forbes.com/sites/zakdoffman/2020/04/20/apple-and-google-major-contact-tracing-surprise-25-billion-users-lose-out/?sh=4e912629190a

[426] Clarke, V. (2020, September 25). Covid-19: Half of Ireland moving in the wrong direction, expert warns. *Irish Examiner*. Retrieved from https://www.irishexaminer.com/news/arid-40054628.html

[427] Ibid.

[428] Kemp, S. (2020). Digital 2020: South Africa. *DataReportal – Global Digital Insights*. Retrieved from https://datareportal.com/reports/digital-2020-south-africa#:~:text=There%20were%2036.54%20million%20internet

[429] COVID Alert SA App. (2020, September 1). Why are COVID Alert SA app users South Africa's new superheroes?. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/2020/09/01/why-are-covid-alert-sa-app-users-south-africas-new-superheroes/

[430] Digital Health & Care Scotland. (2020a). Interim national equality impact assessment - Protect Scotland app. Protect Scotland. Retrieved from https://www.protect.scot/resources/docs/EQIA-17-september-2020.pdf

[431] Bishop, T. (2020, May 17). COVID-19 lessons from Iceland: How one Nordic country has all but stopped the virus in its track. *GeekWire*. https://perma.cc/RKS6-LG4G

[432] Our Health Service. (2020). COVID-19 Deaf and Hard of Hearing Communications Resources. Retrieved from https://www.hse.ie/eng/services/news/newsfeatures/covid19-updates/partner-resources/covid-19-irish-sign-language-isl-resources/covid-19-irish-sign-language-isl-resources.html

[433] Editor. (2018, June 28). WORLDVIEW: Few South Africans speak English, so why is it the language of business and politics. BizNews. Retrieved from https://www.biznews.com/premium/2018/06/28/english-language-business-politics#:~:text=According%20to%20Statistics%20South%20Africa,%2C%20and%20Setswana%20(8.9%25)

[434] Alexander, M. (2018, July 18). The 11 languages of South Africa. *South Africa Gateway*. Retrieved from https://southafrica-info.com/arts-culture/11-languages-south-africa/

[435] Browne, B. (2020, November 8). Tech push leaving the elderly behind. *CyprusMail*. Retrieved from https://cyprus-mail.com/2020/11/08/tech-push-leaving-the-elderly-behind/

to the new digital landscape that COVID-19 has ushered in. Beyond simply not having access to these technologies, most elderly Cypriots are not tech savvy and also do not have children nearby to help them.[436] One interview in Iceland unveiled similar findings – that older parents relied on their children to help them download the app.[437] In Scotland's Equality Impact Assessment Report,[438] findings in relation to age revealed that those aged over 85 as well as people aged under 16 (due to app age restrictions) may be excluded from using the app. Given that South Africa, Ireland, and Cyprus require those who download the app to be aged 13+, 16+, and 18+ respectively, evidence suggests that younger populations are being excluded from using the app. Finally, in Scotland's Equality Impact Assessment Report, when looking at race "it was also unclear what the differences may be between a BME (Black and minority ethnic) older person and a white Scottish older person."[439] In South Africa, it does not appear that the government has taken steps to make the app more inclusive to the elderly, the visually impaired, or other marginalized communities.

In some instances, inclusivity also has impacted uptake in the form of **discrimination** – the third theme. For example, following a recent spike in COVID-19 cases across 11 universities in Scotland, students are being forced to download and use the *Protect Scotland* app. Although universities claim students are not required to download the app, the institutions say they will "take a strict 'Yellow Card/Red Card approach to breaches of student discipline."[440] According to the leader of the Scottish Labour Party, Richard Leonard, "students [are] being required to download test and protect app-unlike any other group in society"[441] and he has asked the Scottish Human Rights Commission to look into possible violations of students' human rights.[442] In this case, although user-uptake is forced, the inherent lack of inclusivity in encouraging app-engagement alongside the forced participation of a specific group of individuals is perceived to hinder motivations for uptake within broader communities. Meanwhile, as mentioned in Module 7, Section 7.5.1: Factor 2, systemic inequality in South Africa between black and white and rich and poor may result in inherent discrimination that continues to exclude groups of people from accessing and using the app on the basis of socio-economic status or race.

Accessibility and inclusivity is frequently highlighted as a major factor hindering uptake across the literature and complementary research. Interestingly, despite New Zealand's reasonably high app-uptake percentage of 53% as of February 16 2021, it is not accessible to those who are visually impaired.[443] This

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[436] Ibid.
[437] Personal communication, October 9, 2020
[438] Digital Health & Care Scotland. (2020b). Interim National Equality Impact Assessment Protect Scotland App. Digital Health & Care Scotland. Retrieved from https://www.protect.scot/resources/docs/EQIA-17-september-2020.pdf
[439] Digital Health & Care Scotland. (2020c). Interim National Equality Impact Assessment Protect Scotland App. Digital Health & Care Scotland. Retrieved from https://www.protect.scot/resources/docs/EQIA-17-september-2020.pdf
[440] Universities Scotland. (2020). Preventing spread of coronavirus in universities. Retrieved from https://www.universities-scotland.ac.uk/preventing-spread-of-coronavirus-in-universities/
[441] Kersley, A. (2020). Scottish Labour: Covid inquiry in Scotland must investigate university chaos. Labour List. Retrieved from https://labourlist.org/2020/10/scottish-labour-says-covid-inquiry-must-investigate-university-chaos/
[442] Ibid.
[443] RNZ. (2020, May 25). Covid 19 coronavirus: Tracing app "unusable" for the blind and those with low vision. *NZ Herald.* Retrieved from https://www.nzherald.co.nz/nz/covid-19-coronavirus-tracing-app-unusable-for-the-blind-and-those-with-low-vision/RM4LQCBBX5O54PATZXZRLENAHE/

example highlights that an app may have higher uptake should it be inclusive to all. Digital literacy and the ability to adequately comprehend the app, including linguistic issues that arise when apps are only available in one or two languages in a multilingual society, impacts user-uptake. For instance, India has increased accessibility by making their app available in 12 languages (the Indian Constitution recognizes 22 official languages).[444] Moreover, social stratification and the differential experiences of groups as they interact with D-CT technologies is a recurrent theme that also must be taken into consideration when analyzing user-uptake and engagement with these apps. For example, groups like the Citizen Lab have raised concerns about the difficulty of certain Canadian populations gaining access to the app, specifically "marginalized groups who are often the most affected by the pandemic, including Black people, Indigenous people, people of colour and those from lower socio-economic brackets."[445] The Canadian Civil Liberties Association also noted how socio-economic factors exacerbate whether a person is able to gain access to a device capable of running the app, let alone be able to use it effectively.[446] In places like India, with growing socio-economic inequality, large swaths of the population are simply unreachable for D-CT apps.[447] Yet, the government has taken a hardline approach to contact tracing and made the app mandatory for workers in specific sectors as well as for all people living within certain districts.[448] Experts and government officials in the United Kingdom also have stressed that millions of residents will be excluded from the contact tracing app due to the digital divide.[449]

Finally, in certain contexts, the digital gender divide also plays a role in up-to-date and accurate population tracking.[450] Access to smartphones also is coded along gender lines,[451] meaning women and people who identify as women may not be able to download and use D-CT apps if only one phone is available for the male head of the household. Also, populations that are at an increased, disproportionate risk of surveillance – such as racialized communities, sex workers and victims of domestic violence, migrants and refugees, and stateless persons – also may be less willing and able to use and download government-based D-CT apps for fears of data sharing with authorities.[452]

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[444] Wikipedia Contributors. (2020, January 16). Languages of India. Retrieved from https://en.wikipedia.org/wiki/Languages_of_India
[445] Wells, N. (2020, August 3). COVID 19 Alert app faces accessibility criticism for older Canadians, marginalized groups. *Global News*. Retrieved from https://globalnews.ca/news/7247362/covid-19-alert-app-accessibility-criticism/
[446] Wells, N. (2020, August 3). Rollout of COVID Alert app faces criticism over accessibility. *CBC*. Retrieved from https://www.cbc.ca/news/politics/covid-alert-app-accessibility-1.5672881
[447] Raina, P. (2020). Problems Follow India's Virus Tracing App. US News & World Report. Retrieved from https://www.usnews.com/news/best-countries/articles/2020-06-08/indias-poor-left-out-by-governments-coronavirus-contact-tracing-app
[448] Clarance, A. (2020, May 14). Aarogya setu: Why India's Covid-19 contact tracing application is 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
[449] Hern, A. (2020, May 15). Millions risk being locked out of Covid-19 contact tracing app. *The Guardian*. Retrieved from https://www.theguardian.com/technology/2020/may/15/millions-risk-locked-out-covid-19-contact-tracing-app
[450] Rowntree, O. (2020). The Mobile Gender Gap Report 2020. *GSMA: Connected Women*. Retrieved from http://www.oecd.org/digital/bridging-the-digital-gender-divide.pdf
[451] Ibid.
[452] See generally https://www.nytimes.com/2020/04/15/opinion/coronavirus-surveillance-privacy-rights.html

8.4.2. Factor 5: Trust in Public & Private Institutions

Trust has been observed to be a prolific influencer of behavior from the individual level (discussed as perceptions of data collection) to the community level (shared trust, resilience) and also the system level, i.e. trust in private institutions (like big tech firms and app development agencies) and public institutions (any entity established by local, provincial, or federal governments). Trust in public institutions also broadly includes trust in government, i.e. the degree to which residents view their government as responsive, reliable, fair, open, and possessing integrity.[453] At the system level, trust is perceived to be a product of the behaviours and regulations set forth by both public and private institutions in combination with socio-economic influence.

Themes identified in the case studies that may contribute to the level of trust in public and private institutions include, first, the **role of government in developing D-CT apps**. Comparing Ireland to Cyprus, for example, Ireland leveraged partnerships with Nearform (a privacy-centric developer with a history of developing open-source solutions) to develop and implement their app. The Ireland app also was donated to Linux Foundation Public Health (an open-source software initiative between developers, technology companies, and academics to help combat COVID-19) which, according to the subject matter and context-specific experts the DGHH Lab interviewed, is perceived to be a trust building solution.[454] Meanwhile, although Cyprus leveraged MIT Safepaths (an academic initiative for D-CT app development), the app was developed and implemented with heavy government involvement. The app has been associated with the Cyprus Deputy Ministry of Research, Innovation, and Digital Policy and was developed by the government-funded RISE research centre. Furthermore, publicly available information about data protection and oversight mechanisms is unclear (see Module 7, Section 7.4.1: Factor 1 for more information). As discussed in the aforementioned section, a majority Cypriots lack trust in their government,[455] so the course of action taken in developing and implementing the app, alongside the lack of transparency, may negatively influence user-uptake.

The second theme is linked to the **role of politics in the country's COVID-19 response**, i.e. a political approach versus an apolitical, scientific approach. Iceland experienced a 96% citizen approval rating of the COVID-19 response by Icelandic authorities.[456] Research shows this high approval may be in part because the government placed scientific expertise at the forefront during the pandemic,[457] with the government taking a back seat to medical experts in leading the response. This finding aligns with Bhatia *et al.* (2020)

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[453] OECD. (n.d.). Trust in Government - OECD. Retrieved from https://www.oecd.org/gov/trust-in-government.htm
[454] Personal communication. (2020, November 3)
[455] Hadjioannou, B. (2020, February 20). Eurobarometer: Cypriots distrust political parties, tend to trust the army more than other institutions. In-Cyprus.Com. https://in-cyprus.philenews.com/eurobarometer-cypriots-distrust-political-parties-tend-to-trust-the-army-more-than-other-institutions/; Financial Mirror. (2020, February 20). Cypriots trust the army more than politicians. Retrieved from https://www.financialmirror.com/2020/02/20/cypriots-trust-the-army-more-than-politicians/; Cymar. (2018, March 22). Trust and satisfaction with Institutions in Cyprus. Cymar. https://www.cymar.com.cy/en-gb/results/cyprus-institutions/
[456] Askham, P. (2020, April 21). COVID-19 in Iceland: Tenth death, new government package announced. *Grapevine*. Retrieved from https://grapevine.is/news/2020/04/21/covid-19-in-iceland-tenth-death-new-government-package-announced/
[457] Hjelmgaard, K. (2020, April 10). Iceland has tested more of its population for coronavirus than anywhere else. Here's what it learned. *USA Today*. Retrieved from https://www.usatoday.com/story/news/world/2020/04/10/coronavirus-covid-19-small-nations-iceland-big-data/2959797001/

who suggest that science-focused strategic communications that are transparent and expert-driven are a contributing factor to public cooperation with contact tracing and containment measures.[458] Along the same lines, Scotland stressed that the government's COVID-19 advisory group were all experts and the group's names and academic affiliations were released to the public.[459] Ireland had a similar advisory board of doctors, epidemiologists, and researchers that have been heavily engaged in the process, i.e. were placed on the advisory group for the D-CT app.[460] Similarly, in Cyprus, the government refused to politicize science and established a two-way relationship between government authorities and scientific experts: "the politicians truly listened to the scientists and the scientists gave them a correct strategy."[461] Conversely, In South Africa, while the country's COVID-19 response has been driven by science, politics still seems to be ever-present and influential. For instance, the government's history as an abusive state during the apartheid era and its historical corruption and fraud within and between political parties continue to exist and have plagued the country's COVID-19 response, thereby continuing to perpetuate individuals' distrust in the government and ultimately, decrease user-uptake of *COVID Alert SA*.[462]

The third theme identified is the **D-CT app development approach** governments and implementers use, e.g. a privacy-by-design approach. All countries studied either adopted the Google Apple Exposure Notification (GAEN) API (Ireland, Scotland, and South Africa) or open-source (Iceland and Cyprus) approaches to their backend as a privacy-preserving measure. Regarding the former approach, according to the Google website, the GAEN API is built "to enable the use of Bluetooth technology to help governments and health agencies reduce the spread of the virus, with user privacy and security central to the design."[463] Alternatively, an open-source backend is believed to be more secure as it limits the risk of vulnerabilities or hidden backdoors in the code, while also providing transparency and openness in the data collection process. Although these measures are not immune to privacy risk, such apps help to ensure better privacy than many of the less-privacy centric apps like those used in Bahrain, Kuwait, or Norway.[464]

Beyond countries studied, the factors above are seen to be influential in other countries. For instance, Denmark is regarded as leading a science-based response rather than a political one. The country has

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[458] Bhatia, D., Morales-Vazquez, M., Song, K., Roerig, M., Allin, S., & Marchildon, G. (2020). COVID-19 Case and Contact Tracing: Policy Learning from International Comparisons. Toronto: North American Observatory on Health Systems and Policies. *Rapid Review* (No.25).

[459] Government of Scotland. (2020). Scottish Government COVID-19 Advisory Group. Government of Scotland. Retrieved from https://www.gov.scot/groups/scottish-government-covid-19-advisory-group/

[460] Personal communication. (2020, November 3)

[461] Hadjicostis, M. (2020, April 22). Cyprus. In Fighting Virus, Politicians Listened to Experts. ABC News. Retrieved from https://abcnews.go.com/International/wireStory/cyprus%E2%80%90fighting%E2%80%90virus%E2%80%90politicians%E2%80%90listened%E2%80%90experts%E2%80%9070293442

[462] Stone, J. (2020, September 21). What Security Experts Say About Downloading The "COVID Alert SA" App. 2oceansvibe News. Retrieved from https://www.2oceansvibe.com/2020/09/21/what-security-experts-say-about-downloading-the-covid-alert-sa-app/#ixzz6eCF0uVtu

[463] Google. (2020, April 10). Apple and Google partner on COVID-19 contact tracing technology. Google.com. Retrieved from https://blog.google/inside-google/company-announcements/apple-and-google-partner-covid-19-contact-tracing-technology/

[464] 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/

taken a two-step approach in launching its contact tracing app to provide evidence to its residents that the app is effective in order to ultimately gain their trust to download the app.[465] This approach may have influenced user-uptake, which is currently around 24% as of December 18 2020.[466] On the contrary, the politicized response to COVID-19 in the United States may partially explain the lack of user-uptake across the country's many D-CT apps.[467] There are other factors influencing uptake in relation to trust in public and private institutions. In South Korea where contact tracing initiatives are highly invasive – with tracking occurring via apps, credit card history, CCTV footage, and other methods[468] – the country's residents remain trusting of the government. This trust may exist due to the government's transparency about the surveillance[469] as well as the implementation of publicly-supported legislation to provide health authorities with "CCTV and smartphone location data on infected citizens" in order to prevent a failure like the one the country experienced with the MERS outbreak.[470] Public understanding around government app effectiveness and the prioritization of public trust also plays a role in uptake, particularly in countries with relatively robust privacy protecting legislation. Finally, trust in public and private institutions involved in developing and deploying D-CT apps is largely tied to meaningful safeguards, accountability, and oversight mechanisms that are grounded in protecting fundamental human rights, including the right to privacy and non-discrimination. For instance, Australia and Switzerland implemented legislation regulating how their respective contact tracing app data will be collected, protected, stored, used, and deleted. This regulation may in part explain these countries' moderate app-uptake percentages which are at roughly 24%[471] and 29%[472] respectively. Policy and governance will be discussed in detail in the following section.[473]

8.4.3. Factor 6: Policy & Governance

User-uptake is also likely to be influenced by the existence of robust policies and governance mechanisms that foreground human rights concerns, including the right to privacy and non-discrimination and access

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[465] Trendall, S. (2020, May 7). How Denmark aims to 'create trust' in contact-tracing tech. PublicTechnology.net. Retrieved from https://www.publictechnology.net/articles/features/how-denmark-aims-%E2%80%98create-trust%E2%80%99-contact-tracing-tech

[466] The Local. (2020, September 24). What you need to know about technical error with Denmark's Smittestop Covid-19 app. The Local dk. Retrieved from https://www.thelocal.dk/20200924/what-you-need-to-know-about-technical-error-with-denmarks-smittestop-covid-19-app

[467] Hart, P. S., Chinn, S., & Soroka, S. (2020). Politicization and Polarization in COVID-19 News Coverage. S*cience Communication*. https://doi.org/10.1177/1075547020950735

[468] 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

[469] Ryan, M. (2020). In defence of digital contact-tracing: human rights, South Korea and Covid-19. *International Journal of Pervasive Computing and Communications, 16*(4), 383–407. https://doi.org/10.1108/ijpcc-07-2020-0081

[470] Chakravorti, B. (2020, July 6). Digital contact tracing's mixed record abroad spells trouble for US efforts to rein in COVID-19. *The Conversation*. Retrieved from https://theconversation.com/digital-contact-tracings-mixed-record-abroad-spells-trouble-for-us-efforts-to-rein-in-covid-19-140414

[471] Meizner, S. (2020, June 1). How many people have downloaded the COVIDSafe app and how central has it been to Australia's coronavirus response? ABC News. Retrieved from https://www.abc.net.au/news/2020-06-02/coronavirus-covid19-covidsafe-app-how-many-downloads-greg-hunt/12295130

[472] Künzi, M. (2020, October 29). How 80% of the Swiss population will download the COVID-App. Enigma. Retrieved from https://enigma.swiss/en/blog/how-80-of-the-swiss-population-will-download-the-covid-app/

[473] See for example https://www.healthcareitnews.com/blog/emea/test-and-trace-three-point-plan-regain-public-trust, https://www.policingthepandemic.ca/

to meaningful oversight and accountability mechanisms. This is considered a system (macro) level influence on individuals that is the product of both political and socio-economic spheres of influence.

The first theme connecting policy and governance with user-uptake is **level of compliance with existing privacy regulations**. Beyond national borders, four of the five countries (Ireland, Scotland, Iceland and Cyprus) are governed by, and adhere to, the European-wide General Data Protection Regulation (GDPR) on data protection and privacy in the European Union and the European Economic Area. This regulation also addresses the transfer of personal data outside the EU and EEA areas.[474] These countries also are governed by the Directive on Privacy and Electronic Communications (ePrivacy Directive).[475] Research suggests however, that Cyprus' *CovTracer* app may be at risk of breaching regional and international data protection laws, including the General Data Protection Regulation (GDPR). Extrapolating from the European Commission's "Common EU Toolbox for Member States," Cyprus may be a problematic jurisdiction as it is unclear what safeguards exist regarding the sharing of users' personal and location data. According to the Commission, collecting "location data is not necessary nor recommended for the purpose of contact tracing apps'' and tracking users' "movements in the context of contact tracing apps would violate the principle of data minimization and create major security and privacy issues."[476] The European Data Protection Board acknowledges however, that collecting and storing location data "on the user's device" is permissible if "the user has given consent."[477] Since *CovTracer* stores all data on users' devices and requires consent before harvesting said data, the app may meet legal standards but not best practice principles. In addition, there is speculation that (1) *CovTracer* may be relying on algorithmic decision making (governed by Article 12 of the GDPR),[478] and (2) the app's security measures may be insufficient to comply with the European Data Protection Supervisor (EDPS) and other compliance bodies.[479] Finally, the Cyprus app has a data deletion period of one year which greatly exceeds the deletion period of many other D-CT apps (both within these case studies and more broadly). Even – and especially – in times of emergency like a global pandemic, international human rights law dictates[480] that any and all measures that limit people's rights and freedoms must be lawful, necessary, and proportionate. In contrast, in South Africa, Emma Sadleir, a social media law expert, has claimed that the app is compliant with South Africa's Disaster Management Act as well as its Protection of Personal

[474] Note, it remains to be seen how Scotland will be affected by the upcoming BREXIT regulations and their impacts on the applicability of the GDPR.
[475] 4 Consolidated Version of the Directive on Privacy and Electronic Communications (ePrivacy Directive), 2002 O.J. (L 201) 37, https://perma.cc/YHA5-EFXV
[476] eHealth Network. (2020, April 15). *Mobile applications to support contact tracing in the EU's fight against COVID-19*. Retrieved from https://ec.europa.eu/health/sites/health/files/ehealth/docs/covid-19_apps_en.pdf
[477] European Data Protection Board. (2020, April 21). *Guidelines 04/2020 on the use of location data and contact tracing tools in the context of the COVID-19 outbreak*. Retrieved from https://edpb.europa.eu/sites/edpb/files/files/file1/edpb_guidelines_20200420_contact_tracing_covid_with_annex_en.pdf
[478] Ibid.
[479] Ibid.
[480] See for example analysis by Human Rights Watch of binding international instruments such as the International Covenant on Economic, Social, and Cultural Rights (ICESCR), the Syracusa Principles, and Others: https://www.hrw.org/news/2020/03/19/human-rights-dimensions-covid-19-response#_Toc35446577

Information Act.[481] The app has even gained the approval of Justice Catherine O'Regan, the COVID-19 designated judge.[482] Ultimately, D-CT apps are not immune to international legal standards and their compliance with these overarching frameworks of governance and accountability will likely only increase uptake by users who have the right to have their freedoms protected while also limiting the spread of COVID-19.

The second theme is at the intersection of **transparency of policies** and **lack of additional safeguards** surrounding the collection and management of D-CT app data. In Scotland for example, data can be shared "with police and other organizations that demonstrate an undefined 'legitimate reason' to access the data such as levying fines."[483] Such vague framing and potentially overbroad data sharing with law enforcement without adequate safeguards in place is unlikely to withstand legal scrutiny. This type of data sharing is likely to impact public trust in government-initiated D-CT apps, as real concerns exist around the sharing of sensitive health data, location, and personal indicators with law enforcement. Marginalized communities are particularly vulnerable in this case, especially those that already face the brunt of over-policing and increased surveillance such as racialized communities, sex workers, LGBTQ2S+ persons, persons facing precarious housing situations, Indigenous groups, and persons with precarious immigration status, among others.[484] Indeed, any limits on human rights must take into consideration disproportionate impacts on marginalized groups and specific vulnerable populations.[485] Similarly, in Ireland, although individuals possess a high sense of trust in the government, O'Callaghan *et al*'s (2020) study on national attitudes of D-CT reflected deep rooted fear of D-CT apps acting as a conduit to more invasive, longer term surveillance measures.[486] Once again, this highlights the need for safeguards to protect people and their data. Meanwhile, the *Rakning C-19* (Iceland) privacy policy is easy-to-digest,[487] the country "transposed the GDPR into Icelandic law" to "promote that personal data be treated in accordance with fundamental principles and rules on the protection of personal data and respect for private life,"[488] and has an independent body – the Icelandic Data Protection Authority – enforcing data protection rules.[489] It seems as though the policy surrounding *Rakning C-19* is perceived as sufficient and appropriate to regulate D-CT. This context may not only explain higher uptake rates in Iceland, but also provide understanding as to why the country does not have legislation directly regarding D-CT, as will be

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[481] Nortier, C. (2020, October 13). COVID Alert SA app: The fine balance between public health, privacy and the power of the people. *Maverick Citizen*. Retrieved from https://www.dailymaverick.co.za/article/2020-10-13-covid-alert-sa-app-the-fine-balance-between-public-health-privacy-and-the-power-of-the-people/

[482] South African Government News Agency. (2020, September 2). Health launches COVID-19 contact tracing app. South African Government News Agency. Retrieved from https://www.sanews.gov.za/south-africa/health-launches-covid-19-contact-tracing-app

[483] McLaughlin, M. (2020). Coronavirus: Police must be kept out of trace system, Sturgeon is warned. *The Sunday Times*. Retrieved from https://www.thetimes.co.uk/edition/scotland/coronavirus-police-must-be-kept-out-of-trace-system-sturgeon-is-warned-09wzw5wdh

[484] See for example https://www.policingthepandemic.ca/

[485] See also https://www.hrw.org/news/2020/05/13/mobile-location-data-and-covid-19-qa

[486] O'Callaghan, M. E., Buckley, J., Fitzgerald, B., Johnson, K., Laffey, J., McNicholas, B., … Glynn, L. (2020). A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland. *Irish Journal of Medical Science.* https://doi.org/10.1007/s11845-020-02389-y

[487] Zhang, M., Chow, A., & Smith, H. (2020). COVID-19 Contact-Tracing Apps: Analysis of the Readability of Privacy Policies (Preprint). *Journal of Medical Internet Research*. https://doi.org/10.2196/21572

[488] Act on Data Protection and the Processing of Personal Data art. 1

[489] Library of Congress Law Library. (2020, June). *Regulating Electronic Means to Fight the Spread of COVID-19.* Retrieved from https://www.loc.gov/law/help/coronavirus-apps/coronavirus-apps.pdf

briefly explored in the paragraphs following. This rights-respecting approach and clear messaging around the protection of people's rights and liberties strengthens user trust in the interventions and reassures the public that their data will not be misused. This approach also ensures that users' health status will not be used to discriminate now and in the future, and that false positives will be dealt with quickly and transparently with a recognition of their potential far reaching impacts, including on job loss in precarious employment situations, health insurance claims, and other potential far-reaching ramifications.[490]

Beyond case studies, policy and governance has been a globally contentious issue linked to uptake. As more and more countries turn towards various innovative solutions to trace the spread of COVID-19, risks are beginning to emerge. Ultimately, if insufficient safeguards exist, these interventions may be co-opted and turned into mechanisms of surveillance. This is not only problematic for the general public, but it also disproportionately impacts marginalized groups.[491] Although these concerns are exacerbated in jurisdictions with weaker rights protecting mechanisms, they are by no means isolated. Groups like Amnesty International and Human Rights Watch have been tracing the far-reaching ramifications of D-CT apps across the globe – from Norway to Kuwait, from Israel to Australia, from Iran to England.[492] For instance, the voluntary D-CT app in Iran, *AC19*, was accused by residents as being a governmental surveillance tactic upon discovering the app was developed by Smart Land Strategy (a company that recently was accused of building spyware for the government).[493] While Iran has not "enacted comprehensive data protection legislation," there are some provisions in existing laws and regulations.[494] Furthermore, the country is in the process of drafting the Personal Data Protection and Safeguarding Act. Unfortunately, the Draft Act "is inconsistent with the international legal obligations of Iran to adequately protect the privacy rights of its citizens."[495] In this case, there does not seem to be the policies or governance in place to adequately protect residents if they were to engage with a D-CT app and share personal data nor stop the government from surveilling its residents. This factor may explain why the country had roughly 5% app-uptake prior to the app being taken down from Google Play.[496]

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[490] Canadian Civil Liberties Association. (2020, August 6). CANADA'S CONTACT TRACING APP: TO DOWNLOAD OR NOT. Retrieved from https://ccla.org/contact-tracing-app/

[491] Molnar, P., & Naranjo, D. (2020, April 15). Opinion | Surveillance Won't Stop the Coronavirus. *The New York Times.* Retrieved from https://www.nytimes.com/2020/04/15/opinion/coronavirus-surveillance-privacy-rights.html

[492] 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/ ; Human Rights Watch. (2020, May 13). Covid-19 Apps Pose Serious Human Rights Risks. Human Rights Watch. Retrieved from https://www.hrw.org/news/2020/05/13/covid-19-apps-pose-serious-human-rights-risks

[493] Gilbert, B. (2020, March 10). The Iranian government released an official coronavirus app for Iranians, but Google pulled it from its app store. *Business Insider.* Retrieved from https://www.businessinsider.com/iran-coronavirus-app-pulled-by-google-2020-3?r=US&IR=T

[494] DLA Piper. (2019, May 23). Data Protection Laws of the World: Iran. Retrieved from https://www.dlapiperdataprotection.com/index.html?t=law&c=IR#:~:text=Iran%20has%20not%20enacted%20comprehensive,regulations%20incorporate%20data%20protection%20provisions.&text=The%20Law%20Concerning%20Protection%20of,and%20Access%20to%20Data%202010

[495] Article 19. (2019, June 27). Iran: Personal Data Protection and Safeguarding Draft Act. Retrieved from https://www.article19.org/resources/iran-data-protection-draft-act/

[496] Udin, E. (2020, March 11). Coronavirus: Google Deletes Detection App after 4 million Downloads. GizChina. Retrieved from: https://www.gizchina.com/2020/03/11/coronavirus-google-deletes-detection-app-after-4-million-downloads/

Even in Canada, where the *COVID Alert* app has been approved by the Office of the Privacy Commissioner of Canada (OPC) and the Office of the Information and Privacy Commissioner of Ontario (IPC), their report stated that "it bears noting that an app, described worldwide as extremely privacy sensitive and the subject of reasoned concern for the future of democratic values, is defended by the Government of Canada as not subject to its privacy laws"[497] Therefore, in Canada, it appears as though people are not protected by privacy laws when using the app. In fact, groups like the Canadian Civil Liberties Association (CCLA) have recognized the privacy-preserving, voluntary nature of the app in Canada's approach,[498] but also have called for greater transparency around data sharing, surveillance, and the recognition of differential impacts on various groups across the socio-political spectrum.[499]

At the regional level, there has been some recognition of these risks. For example, the European Commission and the European Data Protection Board published guidance on the need to protect privacy and other fundamental rights as early as April 2020.[500] Similarly, Switzerland's parliament passed a legal amendment (prior to the implementation of the country's D-CT app) to govern the app and protect data collected by the app.[501] Meanwhile, Australia passed legislation (after the implementation of the country's D-CT app) to regulate how long data is retained, when data is deleted, how data could be used and by whom, as well as to prevent data from being moved offshore.[502] Beyond existing privacy regulations, these countries have implemented further legislation to safeguard personal data as it relates directly to D-CT apps which may explain the countries' respective 29%[503] and 24%[504] app-uptake rates.

8.4.4. Factor 7: Response Infrastructure

Another uptake factor is the state of a nation's response infrastructure, specifically as it relates to health and emergency management. This factor is especially important during COVID-19 as it impacts individual access to testing and treatment as well as broader management of the pandemic. This is a system (macro)

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[497] Office of the Privacy Commissioner of Canada. (2020, July 31). Federal and Ontario privacy commissioners support use of COVID Alert application subject to ongoing monitoring of its privacy protections and effectiveness [News Release]. Retrieved from https://www.priv.gc.ca/en/opc-news/news-and-announcements/2020/nr-c_200731/

[498] Office of the Premier. (2020, June 18). Ontario Enhancing COVID-19 Case and Contact Management [News Release]. Retrieved from https://news.ontario.ca/en/release/57279/ontario-enhancing-covid-19-case-and-contact-management

[499] Canadian Civil Liberties Association. (2020, August 6). CANADA'S CONTACT TRACING APP: TO DOWNLOAD OR NOT. Retrieved from https://ccla.org/contact-tracing-app/

[500] European Data Protection Board. (2020, April 21). Guidelines 04/2020 on the use of location data and contact tracing tools in the context of the COVID-19 outbreak. Retrieved from https://edpb.europa.eu/sites/edpb/files/files/file1/edpb_guidelines_20200420_contact_tracing_covid_with_annex_en.pdf

[501] 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

[502] Taylor, J. (2020, May 15). Covidsafe app: how Australia's coronavirus contact tracing app works, 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/

[503] Künzi, M. (2020, October 29). How 80% of the Swiss population will download the COVID-App. Enigma. Retrieved from https://enigma.swiss/en/blog/how-80-of-the-swiss-population-will-download-the-covid-app/

[504] Meizner, S. (2020, June 1). How many people have downloaded the COVIDSafe app and how central has it been to Australia's coronavirus response? ABC News. Retrieved from https://www.abc.net.au/news/2020-06-02/coronavirus-covid19-covidsafe-app-how-many-downloads-greg-hunt/12295130

level factor influencing individuals, considered to be the product of political and socio-economic spheres of influence.

Two main themes emerged in the research that suggest a link between the response infrastructure and uptake. The first theme relates to **response infrastructure experience and capability**. Comparing case studies, both Iceland (high uptake) and South Africa (low uptake) have extensive experience in managing crises yet the state of their health and emergency management infrastructure dramatically differs. From avalanches to volcanoes, Iceland labels itself as "...used to catastrophes."[505] They have legislation and public infrastructure in place for rapid response, which was apparent in their initial response to COVID-19. Preparation started early with free widespread testing available and contact tracing plans in place prior to the first positive case. Similarly, South Africa has widespread experience managing health epidemics like HIV and Tuberculosis (TB). Through efforts like redirecting HIV and TB clinics to assist with COVID-19 cases and ongoing door-to-door case finding, South Africa is leading the continent in testing per capita.[506] Yet, their health system has been unable to meet resource demands to effectively contain and control the virus. This is due to a lack of trained medical professionals, the inability to meet demands beyond managing the existing high prevalence of disease (HIV, TB, etc.), and reliance on imports for medical supplies.[507] Also, the health system is not equally accessible to the entire population. Black Africans typically live farther away from health facilities and do not necessarily have the resources to travel.[508] Furthermore, not everyone has health insurance and the poor have to go to public hospitals even though most ventilators are in private hospitals.[509]

The **dynamics between manual and digital contract tracing** is the second theme that may influence uptake. Iceland established their manual contact tracing infrastructure well before COVID-19 cases started to increase and before *Rakning C-19* was implemented. Once the app was implemented, there were clear lines of interoperability between digital and manual methods. Manual contact tracers for example, have the ability to reach out to people through the app to request sharing their information to help track the virus. Similarly, in Ireland and Scotland (also quite high uptake), contact tracing team members will phone, text, or send an email to individuals that test positive (if they have it on record). Individuals also will be provided with a code which they then enter into the app so that other app users that may have contact with that person will receive an exposure notification. This approach is also seen in South Africa. Yet, while app-related communications highlight why the app is needed to supplement manual contact tracing (M-

[505] Kolbert, E. (2020, June 1). How Iceland beat the Coronavirus. The New Yorker. Retrieved from https://www.newyorker.com/magazine/2020/06/08/how-iceland-beat-the-coronavirus
[506] Travaly, Y., Mare, A. (2020, July 8). Learning from the best: Evaluating Africa's COVID-1i responses. Brookings. Retrieved from https://www.brookings.edu/blog/africa-in-focus/2020/07/08/learning-from-the-best-evaluating-africas-covid-19-responses/
[507] Investec. (2020, June 8). Is SA's healthcare system prepared for Covid-19? Investec. Retrieved from https://www.investec.com/en_za/focus/beyond-wealth/is-south-africas-healthcare-system-prepared-for-covid-19.html; Anna, C. (2020, May 29). South Africa has virus testing backlog of nearly 100,000. CTV News. Retrieved from https://www.ctvnews.ca/health/coronavirus/south-africa-has-virus-testing-backlog-of-nearly-100-000-1.4960080;
[508] Devermont, J., & Mukulu, T. (2020, May 12). South Africa's Bold Response to the Covid-19 Pandemic. CSIS. Retrieved from https://www.csis.org/analysis/south-africas-bold-response-covid-19-pandemic
[509] Ibid

CT), it appears as though the D-CT and manual contract tracing methods are less integrated in South Africa in comparison to other countries.[510]

Beyond the case studies, study suggests that there must be a perceived benefit to app users regarding system capability to encourage uptake of D-CT apps. Specifically, the higher the perception of the response system capability, the more likely to have app-uptake. This implies access to testing and treatment is widely available and digital interventions are released in a timely and integrated manner (i.e. at the start of the pandemic and in complement to established systems and approaches like manual contact tracing initiatives). Without testing or treatment capability, there may be little incentive to download D-CT apps. As an example, Denmark has "carried out more tests per capita than any other country in Europe"[511] and research suggests that the country's healthcare infrastructure is sufficient to manage the pandemic.[512] For instance, modelling two situations – one based on COVID-19 data from China and one based on data from Italy – Denmark will have "sufficient capacity of both ICU beds and ventilators."[513] The perceived strong capability of Denmark's healthcare infrastructure to manage the pandemic may have influenced user-uptake, which is currently around 24%.[514] Meanwhile, in Canada, healthcare infrastructure capacity is certainly a concern, particularly for Indigenous communities where they had insufficient "physical infrastructure and supplies needed to manage an outbreak" prior to the pandemic.[515] As a final example, France's complex healthcare context further created challenges surrounding the capacity of the healthcare infrastructure. Many nurses and specialists were on strike in Nov-Dec 2019 demanding additional resources for hospitals.[516] Combined with insufficient PPE and diagnostic tests (a result of the "overreaction" of H1N1),[517] residents may perceive the healthcare system to be unable to test or treat positive cases, thereby creating a disincentive to download the TousAntiCovid app, of which 16% of the population has downloaded.[518]

Revisiting an earlier discussion in Section 8.4.2 that apolitical/scientific-based management of pandemics may enhance uptake, in situations where a country's emergency response strategies are intertwined with political priorities, individual perceptions of the health system's capacity to respond will likely be impacted, thereby impacting uptake. The United States is a particularly poignant example as the action

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[510] Discovery. (2020, November 20). "Turn your smartphone into a life-saving device." Discovery Insurance. Retrieved from https://www.discovery.co.za/corporate/download-covid-alert-sa-app-today

[511] Kavacevic, T., Butcher, B. (2020, October 9). Covid in Europe: How much testing do other countries do? *BBC*. Retrieved from https://www.bbc.com/news/54181291

[512] COVID-19 Health System Response Monitor. (n.d.). Denmark. Retrieved from https://www.covid19healthsystem.org/countries/denmark/livinghit.aspx?Section=2.1%20Physical%20infrastructure&Type=Section

[513] Ibid.

[514] The Local. (2020, September 24). What you need to know about technical error with Denmark's Smittestop Covid-19 app. The Local dk. Retrieved from https://www.thelocal.dk/20200924/what-you-need-to-know-about-technical-error-with-denmarks-smittestop-covid-19-app

[515] COVID-19 Health System Response Monitor. (n.d.). Canada. Retrieved from https://www.covid19healthsystem.org/countries/canada/livinghit.aspx?Section=2.1%20Physical%20infrastructure&Type=Section

[516] COVID-19 Health System Response Monitor. (n.d.). France. Retrieved from https://www.covid19healthsystem.org/countries/france/livinghit.aspx?Section=2.1%20Physical%20infrastructure&Type=Section

[517] Ibid.

[518] 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/

taken in response to COVID-19 at the federal level has been quite politicized and not driven by science. As a result, not only may residents perceive that the national health system's capacity is unable to respond,[519] but the actuality is that the "explosive growth" in COVID-19 cases – arguably a direct result of the unscientific nature of the response – is causing a significant strain on an already ill-prepared healthcare system.[520] Indeed, this context may negatively influence app-uptake. Finally, for systems that are not as prepared to respond to crises, e.g. much of the developed world, they may fare poorer than those that frequently face similar crises. As stated by Umar Ruhi, an associate professor of business analytics and information systems at the University of Ottawa: "these countries tend to have limited resources for enforcing containment measures and fragile health systems."[521] In the case of Africa, as seen in South Africa amongst other countries, these countries are possibly very capable in terms of epidemic response capacity, but in many cases they have other challenges in responding to a pandemic that are more so linked to resources, politics, and broader socio-economic status.

8.4.5. Factor 8: Digital Capability (e.g. how effective the app can be, e.g. Bluetooth issues, modelling issues, etc.)

Perceptions of D-CT apps to act as a viable intervention to help contain and control the spread of COVID-19 emerged as another uptake factor in this study. We refer to this factor as digital capability, i.e. the level of effectiveness and efficiency of D-CT apps in achieving their intended purpose. This is considered a system (macro) level factor that is the product of the political, digital infrastructure, and socio-economic spheres of influence.

Across cases, five themes were identified regarding digital capability as an influencer of uptake. First, from Canada to the UK,[522] countries around the world have highlighted the need for **interoperability** to enhance D-CT capability. Specifically, apps need to be designed so that they can work across state and national borders, enabling a consistent exposure pathway for people moving between areas to not have to download a new app for each region. This functionality is, for example, fundamental for essential workers that must cross borders. Ireland, Scotland, and Northern Ireland have made great strides in building interoperability into their apps which may improve app-uptake. Many of the apps developed by Nearform (their shared app developer), and using the code developed for the Irish contact tracing app, are now interoperable.[523] Therefore, for these countries where the developer and code are shared, the process to make an app interoperable is much easier. Yet, some countries have gone farther to interlink apps beyond a shared code or developer. In Ireland's case, *CovidTracker Ireland* is now interoperable with

[519] Santhanam, L. (2020, September 1). COVID-19 has eroded confidence in the U.S. health care system. PBS News Hour. Retrieved from https://www.pbs.org/newshour/health/covid-19-has-eroded-confidence-in-the-u-s-health-care-system
[520] Unruh, L., Alexander, M., Koval, A., & Webb, E. (2020). North American COVID-19 Policy Response Monitor: United States. *Toronto, Canada: North American Observatory on Health Systems and Policies.* Retrieved from https://ihpme.utoronto.ca/wp-content/uploads/2021/01/US-COVID19-Response-Monitor_20201223.pdf
[521] Rocha, R. (2020, June 22). What countries did right and wrong in responding to the pandemic. *CBC News.* Retrieved from https://www.cbc.ca/news/canada/covid-19-coronavirus-pandemic-countries-response-1.5617898
[522] Government of Scotland. (2020). Protect Scotland app compatible with tracing apps in Northern Ireland and Jersey. Retrieved from https://www.gov.scot/news/protect-scotland-app-compatible-with-tracing-apps-in-northern-ireland-and-jersey/
[523] Ibid.

the apps from Germany and Italy which are not developed by Nearform.[524] These apps are a part "of the first wave of national apps linked through the European interoperability gateway."[525] While Scotland, Cyprus, and Iceland may be included in the European interoperability gateway in the future, only Scotland currently is interoperable with other countries. Similarly, South Africa also seems to not be interoperable. Lack of interoperability may prove to be a disincentive for app-uptake. Any implementation of interoperability however, also must include a discussion of its risks both from an international as well as at the domestic app level. Interoperable data sharing between different jurisdictions may not be legally compliant, particularly if one jurisdiction does not have robust governance mechanisms in place. There also must be robust regulations and disincentivization against interoperability across various government entities, including law and border enforcement, as not only will such data sharing breach national and regional privacy-protecting legislation but user-uptake will likely be impacted if their data collected for the purpose of D-CT applications are widely shared, leading to profound potential human rights infringements.

Second, uptake challenges also have been associated with poor app functionality in **less connected environments**. In response, Scotland has designed their app to function in areas underground or on trains benefiting commuters.[526] As described in Section 8.4.1, South Africa has developed their app so that it requires minimal space to download and mobile service providers have zero-rated the app so that people are not charged for the data used to download the app.[527] In the above examples, improving app functionality in less connected environments may influence user-uptake. Whereas lack of action to address this issue, as seen in Ireland, Iceland, and Cyprus, may prove to be a disincentive.

Third, app implementers also appear to operate on the assumption that uptake challenges are associated with the **single-purpose functionality** of D-CT apps. As such, many of the apps studied also integrate additional functionality to help build their perceived usefulness. Some apps have additional chat features to connect with health officials (Iceland) to symptom checkers (Cyprus) to general statistics and optional health check-ins (Ireland). The extent these apps were useful and/or impacted uptake of these apps however, is inconclusive at this time as insufficient data currently exists on the benefits of added functionality. Therefore, whether Iceland, Cyprus, and Ireland's additional app features improve uptake in comparison to the single-purpose functionality as seen in Scotland and South Africa remains to be seen.

Fourth, perceptions of **app reliability** also appear to influence uptake. Glitches have been claimed across the case studies. In Cyprus, many app users claim the app does not work at all – claiming that glitches in the app force them to uninstall and reinstall and update the app regularly, which leads to a loss of all

[524] Gorey, C. (2020, October 19). Irish Covid Tracker app now linked with apps from Germany and Italy. Silicon Republic. Retrieved from https://www.siliconrepublic.com/enterprise/irish-covid-tracker-app-interlinked-germany-italy
[525] Ibid.
[526] Fraser, G. (2020). In context: Protect Scotland app. Holyrood. Retrieved from https://www.holyrood.com/inside-politics/view,in-context-protect-scotland
[527] COVID Alert SA App. (2020, September 1). Why are COVID Alert SA app users South Africa's new superheroes?. COVID-19 South African Online Portal. Retrieved from https://sacoronavirus.co.za/2020/09/01/why-are-covid-alert-sa-app-users-south-africas-new-superheroes/

tracing data lost and created new every time.[528] In Scotland, as highlighted in Module 7, Section 7.6.1: Factor 3, senior personnel in Police Scotland's health and safety group have allegedly labeled the app as unreliable.[529] In Ireland, the app was rapidly draining the battery of users' phones.[530] These glitches and negative narratives may negatively influence app-uptake. Whether app updates fix these issues positively influence app-uptake will likely be determined over time as developers work out the issues and users start to experience a more consistent, reliable app.

The use of **centralized versus decentralized data collection** was identified as a fifth theme perceived to have strong uptake implications in terms of perceived digital capability. Ireland, for example, used a centralized approach in the initial stages of their digital contact tracing system.[531] According to participant interviews, this form of data management was deemed to be more inline with traditional epidemiological approaches where one uses an index patient and their known contacts to develop a potential exposure chain. Bluetooth issues associated with their current app however, forced developers to reconsider their approach and weigh the many trade-offs between centralized and decentralized exposure notification systems associated with the scale of data collected and user metrics, data security risk, privacy concerns, and other technological barriers. These trade-offs are outlined in Table 8.2.0 below, which was developed by the DGHH Lab team and is based on the team's research and analysis. Ultimately, the Ireland team made the decision to switch to a decentralized approach that prioritized proximity tracking/exposure notification over centralized data collection for more streamlined tracking of the virus.

Table 8.2.0: Overview of Centralized vs. Decentralized Trade-Offs

Centralized	Decentralized
+ More data for epidemiology and tracing	- Less epidemiological data
+ Metrics on app may be easier to collect or access	- Metrics may be harder to access
- Central data storage may present security risk	+ more secure
- Harder to scale	+ Easier to scale
- Potential user reluctance due to privacy concerns	+ More privacy centric may encourage greater use
- Technological barriers to function, no current fix	+ Google/Apple API was developing support this model

Meanwhile, Scotland, Iceland, and Cyprus used a decentralized approach from the beginning due to its perceived benefits, privacy-preserving components, and the negative connotations associated with a centralized approach. South Africa, on the other hand, started with a centralized approach of mobile

[528] Google Play. (n.d.). CovTracer - Apps on Google Play. Google Play. https://play.google.com/store/apps/details?id=edu.rise.ihnilatis&hl=en&gl=US
[529] Morrison, H. (2020). Officers urged to use NHS app-despite senior Police Scotland personnel calling it 'unreliable'. *Glasgow Times*. Retrieved from https://www.glasgowtimes.co.uk/news/18784386.cops-urged-use-nhs-app---despite-top-cops-calling-unreliable/
[530] Irish Examiner. (2020, August 10). HSE says Covid app update will deal with glitch. Irish Examiner. Retrieved from https://www.irishexaminer.com/news/arid-40030187.html
[531] Where data is stored and managed via a central location.

phone data collection to track people before moving to *COVID Alert SA* which takes a decentralized approach.[532] Ultimately, study suggests that due to the negative and positive perceptions of centralized and decentralized methods of data collection respectively, a decentralized approach will increase user-uptake whereas a centralized approach will hinder user-uptake.

Beyond the case studies, similar themes surrounding digital capability can be seen in the literature and in D-CT apps globally. Germany's app has had a multitude of glitches, from not working as reliably on buses, trains, and subways to error messages that require users to uninstall the app.[533] Up until a recent update, the UK's app was sending false alarms and phantom reports alongside not notifying people of exposure (amongst other issues).[534] In terms of the decentralized versus centralized discussion, France has chosen, and defended, a centralized approach despite many countries within the EU abandoning that model due to privacy concerns. Yet, it may be a contributing factor as to why France has moderate app-uptake. In fact, Norway was forced to backtrack on its *SmitteStopp* app because the data collection posed "a disproportionate threat to user privacy – including by continuously tracking and uploading people's GPS location to a national database for half a year."[535] The centralized component seems to be a key component in the ruling against Norway being able to continue using its D-CT app. Finally, returning to the interoperability discussion at the beginning of this section, Canada's *COVID Alert* app – which started in only a few provinces including Ontario – has started to expand and is now available for download and use in 9 of its 13 provinces and territories which may positively influence app-uptake.[536]

8.5. Conclusion

Module 8 provided an overview of the system (macro) level factors identified in our research. The first factor was Accessibility & Inclusion. Digital constraints, app usability, and discrimination were the three themes explored in relation to the first factor. Trust in Public & Private Institutions was the second macro level factor identified. The main themes identified were the role of government in developing D-CT apps, role of politics in the country's COVID-19 response, and D-CT app development approach. The third factor was Policy & Governance where the level of compliance with existing privacy regulations alongside the intersection of transparency of policies and lack of additional safeguards surrounding the collection and management of D-CT app data were the two main themes identified. Response Infrastructure was the fourth factor identified. Response infrastructure experience and capability as well as the dynamics between manual and digital contact tracing were the two themes explored. The final factor was Digital Capability where interoperability, less connected environments, single-purpose functionality, app

[532] Young, N. (2020, April 7). South Africans are worried the government will use coronavirus phone tracking to spy on them. Quartz Africa. Retrieved from https://qz.com/africa/1834409/coronavirus-south-africans-are-worried-about-cellphone-privacy/
[533] Oltermann, P. (2020, September 23). Glitches dent German enthusiasm for Covid contact-tracing app. *The Guardian*. Retrieved from https://www.theguardian.com/world/2020/sep/23/glitches-dent-german-enthusiasm-for-covid-contact-tracing-app
[534] 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
[535] Hoeksma, J. (2020, June 18). Norway forced to backtrack on mass surveillance track and trace app. Digital Health. Retrieved from https://www.digitalhealth.net/2020/06/norway-track-and-trace-app/
[536] Government of Canada. (2020, October 30). Download COVID Alert today. Government of Canada. Retrieved from https://www.canada.ca/en/public-health/services/diseases/coronavirus-disease-covid-19/covid-alert.html

reliability, and centralized versus decentralized data collection were the five themes discussed. For an overview of the individual (micro), community (meso), and community-system (meso-macro) level factors influencing user-uptake, see Module 7. For recommendations and future research, see Module 9.

EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 9.
Recommendations & Future Research

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DGHH

Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps

Module 9. Recommendations & Future Research

9.1. Study Overview

9.1.1 Background

At the onset of the COVID-19 pandemic, Digital Contact Tracing (D-CT) emerged as a complement to Manual Contact Tracing (M-CT) to help enhance the capacity of global health systems to track and control the rapid spread and impact of the virus. This innovative approach to contact tracing attracted global attention due to its immense potential to enable faster and more widespread tracing of the virus among symptomatic and asymptomatic infected populations, while also compensating for lower resource availability and physical distancing rules hindering face-to-face care. D-CT apps and interventions from eBracelets to QR codes surged around the world, in the hope that they would make a substantial impact on curbing the global spread of the virus.

To date however, little research exists demonstrating the true impact of these tools. Specifically, despite the widespread implementation of these tools, there is little evidence that shows that D-CT tools (most often apps) do more good than harm. Coupled with issues pertaining to human rights, privacy, efficacy, and digital inclusion, one of the major problems faced with D-CT interventions (mainly those that are voluntary) is the low level of user engagement in these apps – engagement meaning uptake of the app (download and registration), but also using and updating the app, reporting a positive diagnosis through the app, and reacting to an exposure alert received through the app (see our four-stage continuum of D-CT app engagement outlined in Module 1). Looking at uptake of D-CT apps alone, rates vary drastically across different contexts. Ireland and Iceland, for example, have the highest rates at approximately 43% and 40% respectively,[537] while places like Cyprus or South Africa fall below 1%.[538] And, while many argue that any degree of uptake can make a difference,[539] the dominant perception is that all of these rates are insufficient to make a substantial impact on tracing and controlling the virus. In an effort to better characterize the relationship between user engagement and app effectiveness, taking into account there is currently no magic uptake number, research is needed to understand why user-uptake varies between countries.

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[537]Johnson, B. (2020, May 11). Nearly 40% of Icelanders are using a covid app—and it hasn't helped much. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing/; Hawkins, L. (2020, September 25). NearForm's privacy-first contact tracing app has high uptake. Healthcare Global. Retrieved January 27, 2021 from https://www.healthcareglobal.com/telehealth-and-covid-19/nearforms-privacy-first-covid-tracking-app-has-high-uptake

[538]Nortier, C. (2020, October 13). MAVERICK CITIZEN: COVID Alert SA app: The fine balance between public health, privacy and the power of the people. Daily Maverick. Retrieved from https://www.dailymaverick.co.za/article/2020-10-13-covid-alert-sa-app-the-fine-balance-between-public-health-privacy-and-the-power-of-the-people

[539]O'Neill, P. (2020, June 5). No, coronavirus apps don't need 60% adoption to be effective. MIT Technology Review. Retrieved from https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

Through a preliminary literature review and an interdisciplinary workshop, our research team found this problem can be partly attributed to the lack of recognition and understanding of the target users of these apps. Yet, little is known regarding what incentivizes versus inhibits people from downloading these apps around the world, how context plays a role, as well as the association of perceived benefits and risks with user engagement. As part of The Digital Global Health and Humanitarianism (DGHH) Lab's larger study on the factors impact user-engagement across the four-stage continuum, this study focuses specifically on trying to address this gap by exploring stage 1 – user-uptake of D-CT apps – across various countries.

9.1.2 Methodology

This research asks the following research question:

Why is there higher user-uptake of D-CT apps in some countries over others?

This question is addressed with the following sub-questions:

i. How does uptake vary across contexts?
ii. What factors influence uptake across contexts?
iii. How does risk-benefit perception influence uptake?

To answer these questions, we first established the scope of our research. Our focus is on user-uptake of D-CT apps (the most prevalent form of D-CT interventions worldwide) implemented by governments around the world at the national level, that are voluntary to download, and primarily decentralized in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).[540] Second, a multiple case study approach was used to generate country-specific understanding of user-uptake of D-CT apps and address our research questions. Cases selected include: Ireland, Cyprus, Ireland, Scotland, and South Africa. Data was collected through interdisciplinary workshops, interviews, and meta-analysis of existing peer-reviewed and grey literature. Research findings were analyzed through a systems-approach based on Bronfennbrenner's ecological systems theory to identify varied contextual factors that influence uptake (through a risk-benefit lens).[541] Bronfennbrenner's theory aims to define user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels in their surrounding system: individual (micro-level), community (meso-level), and system (macro-level). Research findings are presented through a series of modules (identified in Section 9.1.4 below) through an introduction to D-CT and user-uptake; case study; systems analysis of factors identified that influence uptake; and recommendations and future research. For a more detailed overview of our research approach, the full methodology is available here.

[540] Lomas, N. (2020, April 6). EU privacy experts push a decentralized approach to COVID-19 contacts tracing. TechCrunch. Retrieved from https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/

[541] Wikipedia Contributors. (2019, February 10). Ecological systems theory. Wikipedia; Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Ecological_systems_theory

9.1.3 Overview of Cases & Factors Identified

As shown through the five case studies, **eight factors** that can explain uptake across the individual (micro), community (meso), and system (macro) level dimensions have been identified. Each factor is explained below.

1. **Perceptions of Data Collection & Management** - how people perceive actual data collection and management as it relates to privacy and trust; and individual understanding of privacy and security (independent of actual privacy and security measures built into D-CT apps).
2. **Sense of Community** - the level of shared trust, shared identity, sense of duty, and/or communitarian values individuals have in relation to their community; and the strength of ties/connectedness individuals have with each other.
3. **Communications & Misinformation** - the timeliness, transparency, method, and nature of information provided to the nation alongside the prevalence, spread, and control of misinformation.
4. **Accessibility & Inclusion** - the degree to which D-CT apps are equally accessible to, usable for, and inclusive of, the entire population, as well as the level of discrimination and marginalization that results from interventions that fail to account for the digital divide or socially vulnerable populations.
5. **Trust in Public/Private Institutions** - the widespread level of trust and faith in public institutions (e.g. government, response agencies) and private institutions (e.g. internet corporations like Google, Apple, as well as the developers of D-CT apps).
6. **Policy & Governance** - the use of, and adherence to, policies and governance mechanisms that regulate the development, implementation, and use of the app.
7. **Response Infrastructure** - the ability of the health infrastructure alongside the first-line response and emergency management infrastructure to manage the COVID-19 pandemic (such as access to testing, and the capacity to respond to and treat the virus).
8. **Digital Capability** - the ability of D-CT apps to effectively and efficiently serve their purpose and facilitate the management of the pandemic.

9.1.4 Practitioner Guide Outline

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

9.2. Module Overview

This module first aims to provide high-level recommendations for implementers ranging from decision-makers in government to app developers to humanitarian responders, on reasons why app-uptake may vary across contexts and how risks versus benefits should be considered in efforts to enhance uptake. Second, this module aims to identify areas of future research that are worth pursuing to gain more understanding of the risks and benefits towards users. Recommendations are provided through five main challenges identified in the research which are linked to user-uptake. Each challenge is described and recommendations specific to that challenge are provided. Each challenge is coupled with a visual depiction of how each recommendation addresses the eight factors influencing user-uptake. Future research is described specific to user-uptake, the four stages of user engagement, and the context of D-CT study in general.

9.3. Recommendations

Through a synthesis of research findings, five main challenges consistently emerged across case studies and in the broader literature that may increase the perception of risk of D-CT apps over benefit, thereby ultimately leading to lowered uptake. Described in depth below, these challenges are associated with fears regarding personal data collection in connection with short-term and long-term surveillance, overriding misconceptions of privacy, disproportionately impacted communities, poor perceptions of D-CT app effectiveness, and digital capability hurdles. A series of recommendations are provided below to address each of these challenges identified in our research which, if pursued, may mitigate the risks and optimize the benefits of D-CT apps to improve app-uptake. Table 9.0 provides a high-level overview of these recommendations and how they can address the eight factors identified in this study that influence user-uptake of D-CT apps.

Table 9.0: High Level Overview of Recommendations and Corresponding Factors Addressed

	MICRO	MESO		MACRO				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
RECOMMENDATIONS	Perceptions of Data	Sense of Community	Communications & Misinformation	Accessibility & Inclusion	Trust in Government	Policy & Governance	Response Infrastructure	Digital Capability
CHALLENGE 1: Fears of immediate and future surveillance, and alternative uses of personal data								
Build Open & Transparent Communication between Government Officials and Citizens and Residents	☑	☑	☑	☑	☑	☑	☑	☑
Ensure a clear data deletion period and D-CT surveillance end date	☑	☐	☑	☐	☑	☑	☐	☐
Build and/or Leverage "Trust Building" Relationships	☑	☐	☐	☐	☑	☑	☐	☐
Make D-CT Apps Open-Source	☑	☐	☐	☐	☑	☑	☐	☑
Employ Ethical Hacking as a Proactive Cybersecurity Strategy	☑	☐	☑	☐	☑	☑	☐	☐
CHALLENGE 2. Privacy perceptions may override privacy-by-design principles								
Increase education & awareness on data privacy	☑	☐	☑	☑	☑	☑	☐	☑
Encourage an Apolitical, Science-Led Response	☑	☐	☑	☐	☑	☐	☑	☐
Create a National Hotline to Report on Misuse/Scams associated with D-CT Apps	☑	☐	☑	☑	☑	☑	☑	☐
Ensure Open & Transparent Data Collection & Data Management Process	☑	☐	☑	☑	☑	☑	☐	☐
CHALLENGE 3: Some communities are disproportionately affected by and/or excluded from D-CT applications/measures								
Build Perceptions of Working Together & Highlight Shared Values	☐	☑	☑	☑	☐	☐	☐	☐
Understand and Prevent/Mitigate Differential Impacts	☑	☑	☑	☑	☑	☑	☐	☐
Expand Media Coverage With More Inclusive Social Media Campaign	☐	☑	☑	☑	☐	☐	☐	☐
Build Multilingual Functionality	☐	☑	☑	☑	☐	☐	☐	☐
Ensure Compliance with Accessibility Standards	☐	☑	☑	☑	☐	☐	☐	☐
Ensure Equal Incentives	☑	☑	☐	☑	☐	☑	☑	☐
CHALLENGE 4: Perceptions of D-CT app effectiveness are poor								
Build, Strengthen & Communicate the Relationship Between Manual and Digital Contact Tracing	☐	☐	☑	☑	☑	☑	☑	☑
Strive to limit false positives; strive to better embed incubation and infection risk into D-CT software	☐	☐	☐	☐	☐	☐	☑	☑
Minimize Digital Glitches	☐	☐	☑	☑	☐	☐	☑	☑
Build Communication Channels Between App-Users and App Developers	☑	☐	☑	☑	☑	☐	☐	☑
Build App Functionality	☑	☐	☑	☑	☐	☐	☑	☑
CHALLENGE 5: Digital limitations inhibit people from downloading D-CT apps								
Minimize Technical & Connectivity Requirements	☐	☑	☐	☑	☐	☐	☐	☑
Make App-Installation and App-Use Tutorials That are Brief	☑	☐	☑	☑	☐	☐	☐	☑
Supply Individuals with Mobile Phones or Alternative Technologies to enable Participation	☐	☑	☐	☑	☐	☐	☑	☐

9.3.1. CHALLENGE 1: Fears of immediate and future surveillance, and alternative uses of personal data

Since D-CT apps rely on the use of personal data, fears around the potential of immediate and future surveillance and questionable data practices impact user-uptake. Without adequate safeguards, transparent communication around data storage and use, and robust risk mitigation strategies, sensitive personal data may be compromised leading to potential present and future surveillance risks as well as risks to human rights in terms of privacy, autonomy, among others. The recommendations below may reduce the risk users perceive and/or optimize the benefits users perceive in downloading and using D-CT apps by addressing the factors highlighted in Table 9.1.

Table 9.1.0.: Challenge 1 Recommendations and Corresponding Factors Addressed

	MICRO	MESO		MACRO				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
RECOMMENDATIONS	Perceptions of Data	Sense of Community	Communications & Misinformation	Accessibility & Inclusion	Trust in Government	Policy & Governance	Response Infrastructure	Digital Capability
CHALLENGE 1: Fears of immediate and future surveillance, and alternative uses of personal data								
Build Open & Transparent Communication between Government Officials and Citizens and Residents	☑	☑	☑	☑	☑	☑	☑	☑
Ensure a clear data deletion period and D-CT surveillance end date	☑	☐	☑	☐	☑	☑	☐	☐
Build and/or Leverage "Trust Building" Relationships	☑	☐	☐	☐	☑	☑	☐	☐
Make D-CT Apps Open-Source	☑	☐	☐	☐	☑	☑	☐	☑
Employ Ethical Hacking as a Proactive Cybersecurity Strategy	☑	☐	☑	☐	☑	☑	☐	☐

9.3.1.1. Build Open & Transparent Communication between Government Officials and Citizens and Residents

Open and transparent communication between government officials and citizens and residents can address all eight factors across the individual (micro), community (meso), and system (macro) levels including: 1) Perceptions around Data Collection & Management; 2) Sense of Community; 3) Communications & Misinformation; 4) Accessibility & Inclusion; 5) Trust in Government; 6) Policy & Governance; 7) Response Infrastructure; and 8) Digital Capability. For instance, early, clear, and effective communication practices about D-CT app data protection, sharing, and privacy protections that also are reinforced through open communications policies may further build trust between government officials and citizens and residents and address the latter groups' perceptions of data collection and management. Alternatively, if communication measures account for the country's context so as to leverage people's values, address their concerns, and communicate in a way that is accessible to as many people as possible, it can build a sense of community, be inclusive, as well as address any misinformation. As a final example, transparent communication about uncertainties may increase public understanding and perception of evolving government strategies relating to the COVID-19 response infrastructure's capacity. High levels of approval of the government's response may increase willingness to comply with directives such as downloading contact tracing apps, thereby also actually improving the COVID-19 response. Similarly, having strong policies that regulate communicating a D-CT app's current glitches and expected updates to fix the problem also may help navigate users' perceptions about the app's digital capability and encourage continued user engagement.

9.3.1.2. Ensure a Clear Data-Deletion and D-CT Surveillance Period End-Date

Introducing limits on use of data and storage times while also providing privacy policies in plain language can address four of the eight factors: 1) Perceptions of Data Collection & Management; 2) Communications & Misinformation; 3) Trust in Government; and 4) Policy & Governance. Clearly defined policy surrounding data deletion and surveillance that is shared openly with the public can build trust in government and perceptions around data collection & management. Clearly and transparently communicating these policies similarly will address these factors. For example, the privacy policy of Iceland's *Rakning C-19* is written in simple language, making it accessible to many regardless of their level of education. Additionally, it is explicitly communicated that the user's data is stored on their phone for only 14 days and that further consent is required to share their data with a contact tracing team if they test positive for COVID-19. If shared, their data is deleted from the contact tracing team's database in 14 days. This clear delineation of who has access to the data, for how long, and that their data will not be repurposed is essential to increase the confidence of users by reducing fears of mission creep (the risk of data being used for more than its original intended purpose), and reassuring users that privacy infringements will be avoided.[542] These have been suggested as important prerequisites for wide-spread adoption of voluntary D-CT apps.

9.3.1.3. Build and/or Leverage Trust Building Relationships

Establishing trust-building relationships (relationships with external entities that are perceived favourably and trustworthy by the general public) – particularly with developers – can address three factors: 1) Perceptions of Data Collection & Management; 2) Trust in Government; 3) and Policy & Governance. With the Google Apple Exposure Notification (GAEN) Application Programming Interface (API) dominating D-CT apps around the world, the partnership between governments and Google and Apple has raised mixed emotions in terms of privacy perception. On one hand, while Google and Apple are widely recognized for their products and services worldwide (already having gained the trust of millions), the space in which they operate is highly unregulated making it difficult to pinpoint specific instances of privacy violations. There is substantial evidence however, of cases where these businesses have breached privacy rights.[543] Furthermore, the use of Amazon Web Services to store data collected through some D-CT apps has resulted in users expressing concerns regarding the storage of their personal data on servers that are connected to Amazon and also may be outside of their country of origin. Risks may range from alternate liability risks[544] to loss of control over the use and repurposing of their data beyond state borders. Meanwhile, Ireland's approach to working with Nearform and the Linux Foundation Public Health (both open-source software initiatives, explained further in Section 9.3.1.4) appears to have reflected positively on the perception of the app. The success of this initiative has led to Nearform implementing their app in

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[542] Klar, R., & Lanzerath, D. (2020). The ethics of COVID-19 tracking apps – challenges and voluntariness. *Research Ethics, 16*(3-4), 174701612094362. https://doi.org/10.1177/1747016120943622

[543] Bogost, I. (2020, Jan 31). Apple's Empty Grandstanding About Privacy. The Atlantic. Retrieved from https://www.theatlantic.com/technology/archive/2019/01/apples-hypocritical-defense-data-privacy/581680/ ; Shead, S. (2020, Dec 10). Google and Amazon fined for cookies breach by French privacy regulator. CNBC. Retrieved from https://www.cnbc.com/2020/12/10/google-and-amazon-fined-for-cookies-breach-by-french-privacy-regulator.html

[544] Robson, E. S. (2012). Responding to liability: evaluating and reducing tort liability for digital volunteers. Woodrow Wilson International Center for Scholars, Washington, DC. Retrieved from https://www.wilsoncenter.org/publication/responding-to-liability-evaluating-and-reducing-tort-liability-for-digital-volunteers

other countries such as Germany and Italy.[545] There remains however, an accountability gap when it comes to the development of third-party apps by the private sector, nor is there sufficient governance around the development and deployment of D-CT apps across contexts, particularly where privacy and other fundamental rights protections vary greatly from state to state.[546] In order for D-CT apps to be legally compliant in many jurisdictions, and contribute to building trust perception in governments that leverage these relationships, developers will at minimum have to prove that they are able to implement robust and comprehensive data protection measures at the highest standard that fully adhere to international standards and comply with regional and national data protection and privacy laws (where available and applicable).

9.3.1.4. Make D-CT Apps Open-Source

From the case studies, countries that adopted an open-source backend to their D-CT apps exhibited higher uptake, likely linked to the four factors it addresses: 1) Perceptions of Data Collection & Management; 2) Trust in Government; 3) Policy & Governance; and 4) Digital Capability. Ireland, for example, partnered with Nearform (a privacy centric developer of open-source solutions) and donated their app to the Linux Foundation Public Health (an open-source software initiative). Open-sourced code can be publicly checked for potential security flaws and reveal issues within the code itself. These features can improve trust in government, perceptions around privacy, as well as digital capability, all of which may influence app-uptake.[547] Though many of the benefits derived from making code public are not understood or known by most users, open source technology has widespread support within the development community, and these opinions and beliefs of experts find their way into the public narrative via social media, blogs, and articles. Building the requirement of having D-CT apps open-source into policy so that open-source protocols are adhered to may further address these factors, mitigating the perceived risks and optimizing the perceived benefits of app-uptake.

9.3.1.5. Employ Ethical Hacking as a Proactive Cybersecurity Strategy

Employing ethical hacking can address a multitude of the individual (micro), community (meso), and system (macro) level factors including: 1) Perceptions of Data Collection & Management; 2) Communications & Misinformation; 3) Trust in Government; and 4) Policy & Governance. Although governments may take measures to minimize varied cybersecurity risks, like making their software open-source discussed above, there is inherent risk to privacy and security with any digital products. As such, developers and implementers should take a proactive and innovative approach to cybersecurity, rather than a reactive approach. Ethical hacking is one such proactive cybersecurity strategy that allows private, public, and non-governmental organizations to perform penetration testing in the form of web application and infrastructure penetration testing, mobile device and mobile app penetration testing, and red teaming.[548] As per cybersecurity consultants, penetration testing minimizes risk by showing

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[545] Gorey, C. (2020, October 19). Irish Covid Tracker app now linked with apps from Germany and Italy. Silicon Republic. Retrieved from https://www.siliconrepublic.com/enterprise/irish-covid-tracker-app-interlinked-germany-italy

[546] See also https://www.article19.org/resources/coronavirus-tracking-apps-and-human-rights-what-you-need-to-know/

[547] Hoepman, J. H., & Jacobs, B. (2007). Increased security through open source. *Communications of the ACM*, *50*(1), 79-83.

[548] Nicholson, S. (2019). How ethical hacking can protect organisations from a greater threat. *Computer Fraud & Security*, *2019*(5), 15–19. https://doi.org/10.1016/s1361-3723(19)30054-5

organizations how malicious actors would gain "access rights to a system" or app including those "that are created specifically for mobile devices such as apps on the iOS and Android platforms."[549] While some apps studied are not utilizing this ethical hacking approach (e.g. Cyprus' *CovTracer*), governments, technology corporations, and banks across the globe have adopted this solution to protect their digital architecture and network infrastructure. Leveraging this solution, communicating that this step has been taken to protect data and people's privacy, and building such proactive cybersecurity strategies into policies may improve perceptions relating to data privacy as well as trust in the government.

9.3.2. CHALLENGE 2. Privacy perceptions may override privacy-by-design principles

Beyond the actual risks associated with D-CT apps designed with lower privacy and security protocols (from countries that bypass data protection safeguards to countries with questionable surveillance approaches), our research shows that lack of comprehension surrounding app functionality and misunderstanding the privacy safeguards that are in place are also quite common. This finding implies that, in some cases, following privacy-by-design principles may not be enough to change perceptions around privacy. These interpretations – combined with the lack of user education around the app and its privacy-preserving components alongside barriers to providing that education – have been identified as important factors hindering uptake. Also, as demonstrated in Figure 9.1.0, there is a disconnect between app-use and claimed privacy needs.

Figure 9.1.0. Comparison of permissions required between Facebook, Instagram, Tinder and Canada's *COVID Alert* App

[549] Ibid.

Comparing apps like the *COVID Alert* app in Canada to some of the most popular social apps in use today (e.g. TikTok, Tinder, Twitter, etc.), the *COVID Alert* app collects far less data and has more privacy-preserving components built into the app. Yet, the above social media platforms have millions of users.[550] Generally, user research suggests people are willing to forfeit privacy in exchange for services. Yet, this discrepancy in uptake of contact tracing tools highlights that perhaps privacy is not the prominent factor in determining uptake and should not be the sole focus of developers, implementers, and regulators. The following recommendations below take this discrepancy into consideration and address the Perceptions of Data Collection & Management factor as well as a variety of other factors as outlined in Table 9.2.0.

Table 9.2.0: Challenge 2 Recommendations and Corresponding Factors Addressed

	MICRO	MESO		MACRO				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
RECOMMENDATIONS	Perceptions of Data	Sense of Community	Communications & Misinformation	Accessibility & Inclusion	Trust in Government	Policy & Governance	Response Infrastructure	Digital Capability
CHALLENGE 2. Privacy perceptions may override privacy-by-design principles								
Increase education & awareness on data privacy	☑	☐	☑	☑	☑	☑	☐	☑
Encourage an Apolitical, Science-Led Response	☑	☐	☑	☐	☑	☐	☑	☐
Create a National Hotline to Report on Misuse/Scams associated with D-CT Apps	☑	☐	☑	☑	☑	☑	☑	☐
Ensure Open & Transparent Data Collection & Data Management Process	☑	☐	☑	☑	☑	☑	☐	☐

9.3.2.1. Increase Education & Awareness on Data Privacy

Increasing education and awareness on D-CT data privacy may address six of the eight factors including: 1) Perceptions of Data Collection & Management; 2) Communications & Misinformation; 3) Accessibility & Inclusion; 4) Trust in Government; 5) Policy & Governance; and 6) Digital Capability. As described above and throughout the case studies, even when countries adopt rigorous privacy-preserving mechanisms and exhibit high compliance with privacy regulations, many users still lack full comprehension of privacy and security in the general sense of how it relates to D-CT apps. Consequently, the need exists to help users better understand the concept of privacy and how it relates to D-CT apps. Once again using Iceland's *Rakning C-19* app as an example, the easy-to-understand privacy policies were made accessible to users in the early stages of the pandemic. In combination with clear and transparent communications regarding how data was stored, shared, and used with contact tracers, these education and awareness campaigns were inclusive and likely strengthened trust in government as it helped to make the purpose and intentions of the app more clear. Meanwhile, the shift seen in many countries from using the phrase 'digital contact tracing apps' to using 'exposure notification apps' can be interpreted as a linguistic reframing measure to shift people's perceptions of D-CT apps as a means for surveillance to a means of participation in monitoring and controlling the spread of the virus. This reframining can ultimately be considered a trust building measure.

[550] Mello, J. (2020, October 27). Social Media Companies Top Data Grabber List. Tech News World. Retrieved from https://www.technewsworld.com/story/86897.html

9.3.2.2. Encourage an Apolitical, Science-Led Response

Encouraging an apolitical, science-led response is a recommendation that addresses four of the eight factors: 1) Perceptions of Data Collection & Management; 2) Communications & Misinformation; 3) Trust in Government; and 4) Response Infrastructure. Across case studies, many governments not only built task-forces or advisory groups encompassing epidemiologists, researchers, and experts in the field of pandemic management, but also prioritized apolitical messaging with the public. As reported in Module 8, Icelandic authorities had a 96% approval rating from citizens and residents regarding the country's COVID-19 response.[551] Research attributes the approval rating to the government's reliance on scientific expertise during the pandemic,[552] holding daily press briefings framed as just the facts "no politics and no politicians getting in the way."[553] Conversely, South Africa's science-based response inherently was mixed with political ongoings which likely further exacerbated distrust in the government. Study shows that apolitical, science-led approach that is heavily exhibited through public communications and subsequent action may encourage app-uptake by promoting trust in government, improving perception of the country's COVID-19 response infrastructure, and even influencing perceptions of data and privacy as it relates to D-CT apps and the necessity of them within a scientifically-backed COVID-19 response.

9.3.2.3. Create a National Hotline to Report on Misuse/Scams associated with D-CT Apps

Creating a national hotline to report misinformation on, scams relating to, or misuse of, D-CT apps can address five factors across the individual (micro), community (meso), and system (macro) levels. These factors include: 1) Perception of Data Collection & Management; 2) Communications & Misinformation; 3) Accessibility & Inclusion; 4) Trust in Government; and 5) Response Infrastructure. In South Africa, while not specifically a national hotline designated for COVID-19 misinformation/scams, some citizens and residents used the Real411 platform to report cases of misinformation in relation to the country's D-CT app and COVID-19.[554] A national hotline would be beneficial in situations like those seen in Scotland where scammers acted as government officials affiliated with the *Protect Scotland* app to gain personal information. Addressing misinformation surrounding, and the misuse of, D-CT apps through such safeguard mechanisms may not only help facilitate accurate information being shared, but may improve trust in the government because the institution, for instance, is not being impersonated by scammers. Furthermore, a hotline may help assure citizens and residents that the government is taking action to protect privacy, thereby improving perceptions surrounding data collection and management. Similarly, it can minimize the risk of malicious actors targeting vulnerable populations which can improve a D-CT apps inclusivity. Finally, perceptions surrounding the response infrastructure may be positively influenced by improving the efficacy of the COVID-19 response through a national hotline.

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[551] Askham, P. (2020, April 21). COVID-19 in Iceland: Tenth death, new government package announced. Grapevine. https://grapevine.is/news/2020/04/21/covid-19-in-iceland-tenth-death-new-government-package-announced/.

[552] Hjelmgaard, K. (2020, April 10). Iceland has tested more of its population for coronavirus than anywhere else. Here's what it learned. *USA Today*. Retrieved from https://www.usatoday.com/story/news/world/2020/04/10/coronavirus-covid-19-small-nations-iceland-big-data/2959797001/.

[553] Kolbert, E. (2020, June 1). How Iceland beat the Coronavirus. *The New Yorker*. https://www.newyorker.com/magazine/2020/06/08/how-iceland-beat-the-coronavirus

[554] Smith, T., & Bird, W. (2020, September 20). OP-ED: Disinformation in a time of Covid-19: Weekly trends in South Africa. Daily Maverick. Retrieved from https://www.dailymaverick.co.za/article/2020-09-20-disinformation-in-a-time-of-covid-19-weekly-trends-in-south-africa-10/

9.3.2.4. Ensure Open & Transparent Data Collection & Data Management Process

An open and transparent data collection and management process can address five factors including: 1) Perceptions of Data Collection & Management; 2) Communications & Misinformation; 3) Accessibility & Inclusion; 4) Trust in Government; and 5) Policy & Governance. Perceptions of data collection and management may be positively influenced through centering transparency in data collection and management processes alongside subsequent communications in the development and deployment of D-CT. Focus should be placed on communicating the purpose of the app and the intention behind data collection. Furthermore, to avoid mission creep (defined in Section 9.3.1.2), apps should only collect data that is absolutely necessary. To combat mission creep, regulations against data sharing across public entities must contain a commitment to no data sharing with law enforcement, including any and all health data or location tracking data. Strict regulation of third-party access also must be managed. If third party access is essential, a potential risk minimizing intervention could be allowing users to see which organizations are accessing their data in real time. Users can then be provided an opt-out option for certain third-party organizations without which the app's functionality would not be compromised. This would give users a sense of security and control over where and when their data is accessed and would have full knowledge of organizations privy to their information. There should also be a robust chain of custody agreements for data passed between government, industry, and researchers, which includes a process to delete data, in compliance with various regional mechanisms like the General Data Protection Regultaion (GDPR), if applicable. The protection of data sovereignty must ensure that all data are subject to domestic and international laws and governance structures and that there are mechanisms of judicial oversight of government, industry and researchers developing and deploying D-CT apps. Any meaningful oversight also must include a commitment to corporate accountability if data is misused, stolen, or sold. Not only do these measures strengthen policy and governance surrounding data collection and management processes and perceptions surrounding data collection and management, but will likely increase trust in government in relation to these processes. Furthermore, by strengthening the protections around data collection and management processes, certain vulnerable or marginalized communities may feel more confident in using the government's D-CT app, thereby improving accessibility and inclusion. It is important to note that these open and transparent processes also must be communicated in an inclusive and clear manner, as iterated in Section 9.3.1.1, 9.3.1.2, 9.3.2.1, 9.3.3.2, and 9.3.3.3.

9.3.3. CHALLENGE 3: Some communities are disproportionately affected by and/or excluded from D-CT apps/measures

As highlighted in Modules 7 & 8, there are some communities that are disproportionately affected by COVID-19 and/or excluded from D-CT apps, such as the elderly or the visually impaired. Additionally, there also are certain communities that have historically been at the forefront of state surveillance. It is particularly within these communities that privacy, data protection risks, and other rights infringements must be considered contextually, considering these communities' experiences at the intersection of various factors such as race, ability to access and adequately use mobile smartphones, age, social location, socioeconomic status, and other characteristics that may impact a user's willingness to engage with D-CT apps. This contextual analysis should inform any development and deployment of D-CT apps to be human

rights compliant and inclusive, particularly for communities disproportionately impacted by COVID-19 yet reticent to engage in tracking technologies due to histories of surveillance and discrimination. The recommendations in this section focus on improving accessibility and inclusion alongside building a sense of community while also addressing other factors as outlined in Table 9.3.0.

Table 9.3.0: Challenge 3 Recommendations and Corresponding Factors Addressed

	MICRO	MESO		MACRO				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
RECOMMENDATIONS	Perceptions of Data	Sense of Community	Communications & Misinformation	Accessibility & Inclusion	Trust in Government	Policy & Governance	Response Infrastructure	Digital Capability
CHALLENGE 3: Some communities are disproportionately affected by and/or excluded from D-CT applications/measures								
Build Perceptions of Working Together & Highlight Shared Values	☐	☑	☑	☑	☐	☐	☐	☐
Understand and Prevent/Mitigate Differential Impacts	☑	☑	☑	☑	☑	☑	☐	☐
Expand Media Coverage With More Inclusive Social Media Campaign	☐	☑	☑	☑	☐	☐	☐	☐
Build Multilingual Functionality	☐	☑	☑	☑	☐	☐	☐	☐
Ensure Compliance with Accessibility Standards	☐	☑	☑	☑	☐	☐	☐	☐
Ensure Equal Incentives	☑	☑	☐	☑	☐	☑	☑	☐

9.3.3.1. Build Perceptions of Working Together & Highlight Shared Values

Building perceptions of working together & highlighting shared values may address three factors: 1) Sense of Community; 2) Communications & Misinformation; and 3) Accessibility & Inclusion. As seen in the Iceland and Ireland case studies, both countries' governments leveraged pre-existing communitarian values – such as asking people to "be a strong link in the chain" – to encourage app-uptake. It is thought that promoting perceptions of working together may influence individuals to download the app. It should be noted though, that in the case of South Africa, promoting communitarian values seemed not to be as effective because the sense of community is quite low. Therefore, it seems that communitarian values need to be pre-existing in order for building perceptions of working together to be effective. In saying that, should South Africa's government highlight other shared values, that tactic may be effective in influencing user-uptake. Building perceptions of working together and highlighting shared values through communications strategies very clearly addresses the sense of community and communications & misinformation factors. Furthermore, in building a sense of community there seems to be a component of strengthening inclusivity.

9.3.3.2. Understand and Prevent/Mitigate Differential Impacts

Understanding and preventing or mitigating differential impacts can address six factors: 1) Perceptions of Data Collection & Management; 2) Sense of Community; 3) Communications & Misinformation; 4) Accessibility & Inclusion; 5) Trust in Government; and 6) Policy & Governance. It is important to recognize and mitigate the differential impacts of D-CT apps on marginalized groups such as racialized communities, sex workers, LGBTQ2S+ persons, persons facing precarious housing situations, Indigenous groups, persons with precarious immigration status, and elderly populations, among others. As an example, Cyprus is facing an issue where its elderly population is unable to engage with the D-CT app due

to digital literacy amongst other factors.[555] Groups that have historically faced surveillance and subsequent discrimination also require specific attention to understand and prevent or mitigate the differential impacts of D-CT apps. This is because these communities will be more reticent to engage in state-sanctioned tracking apps even though these groups may be at greater risks associated with COVID-19. As such, context-specific messaging and interventions, as well as robust privacy-protecting and anti-discrimination mechanisms, must be part of every D-CT app that is developed and deployed to ensure human rights compliance as well as to encourage user-uptake from marginalized communities. For instance, in the Interim Report released on *Protect Scotland*, the component looking at gender reassignment pointed out that security and confidentiality were top priorities in the community not just for the *Protect Scotland* app but also for the wider Test and Protect health initiative.[556]

Inclusive, accessible, and contextualized messaging is important to regulate the perceptions of data collection and management that can be particularly negative as a consequence of these populations' previous experiences. Considering these communities within D-CT app development and implementation strategies can improve the accessibility of D-CT apps to a wider audience, be increasingly inclusive, and strengthen the sense of community within these communities as well as across the nation. Revisiting the elderly for example, taking steps to mitigate the disproportionate impacts that may result from not being able to download and/or use the app – such as by providing wearable tokens that require significantly less digital literacy – D-CT becomes more inclusive. Facilitating the above actions, particularly implementing robust privacy-protecting and anti-discrimination policies, may start to strengthen these populations' trust towards the government.

9.93.3.3. Expand Media Coverage with More Inclusive Social Media Campaign

Expanding media coverage with more inclusive social media campaigning can address: 1) Sense of Community; 2) Communications & Misinformation; and 3) Accessibility & Inclusion. The Interim Report released on *Protect Scotland* outlined a communications campaign plan to reach 90% of the Scottish population across a four-week period though a variety of mediums including television and press.[557] The 90% reach is impressive, but could also be reintroduced to target specific communities to be even more inclusive. Other countries can also learn from Scotland's strategy to facilitate inclusive communications that is both more accessible to various populations but also inclusive of populations that are often marginalized. This recommendation directly focuses on improving accessibility to accurate information and is thereby expanding who is included in D-CT app development, implementation, and communications as well as continuing to build a sense of community.

9.3.3.4. Build Multilingual Functionality

Building multilingual functionality in D-CT apps can address three factors: 1) Sense of Community; 2) Communications & Misinformation; and 3) Accessibility & Inclusion. In the case studies, countries that

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[555] Browne, B. (2020, November 8). Tech push leaving the elderly behind. *CyprusMail*. Retrieved from https://cyprus-mail.com/2020/11/08/tech-push-leaving-the-elderly-behind/

[556] Interim National Equality Impact Assessment Protect Scotland App. (2020). Digital Health & Care Scotland. Retrieved from https://www.protect.scot/resources/docs/EQIA-17-september-2020.pdf

[557] Ibid.

offered their D-CT apps in more languages were also those with higher uptake. For example, Iceland (high uptake) offered their app in eight languages[558] while with 11 official languages South Africa (low uptake) has, to date, only implemented their app in English.[559] Research from Scotland investigating disability suggests further consideration is required for those in the deaf and blind community, those who use British Sign Language, and people with learning disabilities.[560] In building multilingual functionality, D-CT becomes accessible to more people and subsequently can contribute to help bridge and build a deeper sense of community if all groups are included. Furthermore, since some D-CT apps also share important pandemic-related information, distributing accurate information in multiple languages increases accessibility as well as combats misinformation.

9.3.3.5. Ensure Compliance with Accessibility Standards

Ensuring compliance with accessibility standards can address three of the eight factors: 1) Sense of Community; 2) Communications & Misinformation; and 3) Accessibility & Inclusion. Although some countries made efforts to include accessibility features into their app designs, e.g. Ireland offering app instruction in sign language and Scotland ensuring the app is compatible with Apple and Google screen readers, it was difficult to identify how apps leverage smartphone assistive technologies. This finding highlights the importance of identifying areas where D-CT apps do not meet accessibility standards and to take steps to ensure that they comply with these standards. This recommendation will improve accessibility of the D-CT app – and subsequently improve the sense of community – but also improve accessibility to any information the app provides, thereby strengthening the sharing of accurate information.

9.3.3.6. Ensure Equal Incentives

Ensuring equal incentives will address four factors: 1) Perceptions of Data Collection & Management; 2) Sense of Community; 3) Accessibility & Inclusion; 4) Policy & Governance; and 5) Response Infrastructure. Discussions surrounding the benefits of D-CT apps ultimately refer to what factors incentivizes users to download and use an app. For instance, across all apps, the benefit accrued to the user is that they can be notified if exposed to COVID-19. Subsequently, they are provided with information on next steps to take, such as getting tested and/or being treated. Yet, this is only truly a benefit in countries with equitable access to healthcare. For example, in South Africa, where healthcare is not equally accessible and the healthcare system is overburdened and under-resourced, the incentive to use a D-CT app diminishes because users often cannot fulfill the next steps after receiving an exposure notification. Beyond providing testing and treatment, mechanisms must exist to protect personal data and identities while also being robust and secure enough to prevent the risk of a positive test not being leaked to their surrounding community. In some communities, leaking a positive COVID-19 test result poses severe stigmatization risk. In New Brunswick, Canada, for example, the leak of a local doctor's positive COVID-19 result led to

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[558] Bishop, T. (2020, May 17). COVID-19 lessons from Iceland: How one Nordic country has all but stopped the virus in its track. *GeekWire*. https://perma.cc/RKS6-LG4G

[559] Alexander, M. (2018). The 11 languages of South Africa. *South Africa Gateway.* Retrieved from https://southafrica-info.com/arts-culture/11-languages-south-africa/

[560] Digital Health & Care Scotland. (2020). Interim National Equality Impact Assessment Protect Scotland App. *Digital Health & Care Scotland*. Retrieved from https://www.protect.scot/resources/docs/EQIA-17-september-2020.pdf

him being labelled as "patient zero" of the local outbreak, the target of racist threats, rejected by his community, and a scapegoat for local officials.[561] To encourage a more inclusive, human-rights preserving approach to D-CT implementation, these incentives must be equally available to all subsets of the population. This recommendation once again can increase accessibility and inclusivity by promoting equity and equality while also building a sense of community. Furthermore, in considering how integrally tied the D-CT process is with the response infrastructure, if action is taken to ensure equitable access to the response infrastructure, not only does the efficacy of D-CT improve but the efficacy of the response infrastructure also improves. Finally, returning to the discussion of robust and secure mechanisms to protect personal data and identities, taking these steps may influence perceptions of data collection and management, particularly if supported through policies.

9.3.4. CHALLENGE 4: Perceptions of D-CT app effectiveness are poor

Despite efforts to push D-CT apps, a large portion of the population may not download D-CT apps simply because they feel these apps are ineffective. This belief may stem from the lack of research able to formally demonstrate the effectiveness of D-CT initiatives, the flood of negative media highlighting the digital capability issues (i.e. inaccuracies in Bluetooth proximity measurement, risk of false positives, challenges with incubation periods), and/or misinformation linked to the purpose of these apps. This lack of buy-in into the effectiveness of these apps may be sufficient to let perceived risks associated with these apps described above outweigh the benefits. These recommendations address the Digital Capability factor alongside a variety of other factors, as outlined in Table 9.4.0.

Table 9.4.0: Challenge 4 Recommendations and Corresponding Factors Addressed

	MICRO	MESO		MACRO				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
RECOMMENDATIONS	Perceptions of Data	Sense of Community	Communications & Misinformation	Accessibility & Inclusion	Trust in Government	Policy & Governance	Response Infrastructure	Digital Capability
CHALLENGE 4: Perceptions of D-CT app effectiveness are poor								
Build, Strengthen & Communicate the Relationship Between Manual and Digital Contact Tracing	☐	☐	☑	☑	☑	☑	☑	☑
Strive to limit false positives; strive to better embed incubation and infection risk into D-CT software	☐	☐	☐	☐	☐	☐	☑	☑
Minimize Digital Glitches	☐	☐	☑	☑	☐	☐	☑	☑
Build Communication Channels Between App-Users and App Developers	☑	☐	☑	☑	☑	☐	☐	☑
Build App Functionality	☑	☐	☑	☑	☐	☐	☑	☑

9.3.4.1. Build, Strengthen, & Communicate the Relationship Between Manual and Digital Contact Tracing

Building, strengthening, and communicating the relationship between manual and digital contact tracing can address six of the eight factors: 1) Communications & Misinformation; 2) Accessibility & Inclusion; 3) Trust in Government; 4) Policy & Governance; 5) Response Infrastructure; and 6) Digital Capability. Research identified that digital exposure notifications from D-CT apps may not provide the same sense of

[561] Levinson-King, R. (2020, Nov 25). New Brunswick outbreak: How a smalltown doctor became a Covid pariah. *BBC News.* Retrieved from https://www.bbc.com/news/world-us-canada-54686672

urgency as a phone call would be from a contact tracer. As a result, D-CT app users may not take the necessary next steps to isolate. This risk may be minimized by fully integrating the app into the M-CT system. For instance, at-risk individuals (if they enter their phone number voluntarily) can be contacted by a member of the contact tracing team in the case of an exposure. The success of the app in Iceland, for example, has been partially attributed to their approach to the app as a supplement to M-CT.[562] Linking contact tracing apps to public health infrastructure so individuals who receive exposure notifications are given further useful instructions through discussions with a contact tracer not only promotes the sharing of accurate information (and subsequent appropriate action), but also may improve perceptions of the usefulness of the app (digital capability of the app). Where the integration of M-CT and D-CT increases the efficacy of user response to COVID-19 exposure notifications, it may improve the perceptions of the response infrastructure's capacity as well as trust in the government's response to the pandemic. Relatedly, upon being involved in the M-CT process and experiencing the activities and outcomes of M-CT and D-CT integration, users may have a better understanding of how the contact tracing system works and how the government is using a user's data. These outcomes may ultimately improve trust towards the government and its response. Meanwhile, for communities that may not have digital access to D-CT apps, they are still included in manual methods of contact tracing, thereby increasing the inclusivity of the contact tracing process as an integrated process. Certainly, the integration of D-CT and M-CT should be fortified via policy to ensure privacy regulations are followed, to govern how data will be exchanged, and protect privacy rights alongside other human rights, such as the right to equality and freedom from discrimination.

9.3.4.2. Strive to limit false positives; strive to better embed incubation and infection risk into D-CT software

Improving the digital capability of D-CT apps by improving the software, addresses two of the eight factors: 1) Response Infrastructure; and 2) Digital Capability. Currently, most D-CT apps rely upon the standard measurement of 6 ft for 15 minutes as its base for registering a potential exposure. While it is currently inconclusive whether this measurement in itself is accurate, there also is the consideration that the COVID-19 virus may last on surfaces and therefore be transmitted should someone touch their eyes, nose, or mouth. Furthermore, it is important to note that Bluetooth-based D-CT apps cannot recognize walls, therefore if one person contracts COVID-19 and is isolating in one apartment, their neighbours may receive an exposure notification despite the neighbours having no true exposure to the COVID-19 positive individual. These factors suggest that the risk calculation is fairly ineffective at determining exposure risk and can ultimately result in false positives.[563] Therefore, it is important to continue developing D-CT software to limit false positives. In doing so, users may gain confidence in the efficacy of the D-CT app system as well as the emergency response infrastructure overall. This improved perception may mean that the individual is more likely to isolate which also assists in improving the efficacy of the COVID-19 response. Limiting the amount of false positives also can reduce the negative impacts that occur due to work and social disruption. Not only can work be done to limit false positives, but an individual's infection

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[562] NPR Weekend Edition Sunday. (2020, May 17). How Iceland handles contact tracing [Audio recording]. https://perma.cc/EBW8-2QQZ.

[563] Masel, J,. (2020, October 28). *Risk Scoring in GAEN Applications* [Video file]. Retrieved from https://www.youtube.com/watch?v=EG_Bd5Y2MvY

risk and incubation period can be embedded into the D-CT software to determine an individual's necessary isolation time. This also can improve perceptions of the D-CT app's digital capability as well as the response infrastructure as a whole.[564]

9.3.4.3. Minimize Digital Glitches

To optimize D-CT app benefits to users, implementers and developers must identify, assess, and correct technological glitches, especially those that force users to uninstall and reinstall the app (a process that causes the user's personal and geolocation data to be lost). This recommendation addresses four factors: 1) Communications & Misinformation; 2) Accessibility & Inclusion; 3) Response Infrastructure; and 4) Digital Capability. Across the case studies, there was public disappointment in the quality of their D-CT apps at various times. Many users in Cyprus for instance, claimed that the app did not work at all (see Module 3, Section 3.2.2.4).[565] Correcting such glitches can help build the effectiveness of these apps and ultimately, improve the response infrastructure. Furthermore, it may also positively influence the user's perceived effectiveness of these apps and response infrastructure. Relatedly, when glitches occur and users have a negative experience and express it through reviews or social media, it creates a negative narrative about the app. By reducing glitches or fixing them as quickly as possible, it is possible to mitigate the potential deleterious impact of such narratives. Furthermore, if government and developer communications with the public about glitches are transparent and timely, there also arises the opportunity for users' negative perceptions about the app to be altered because there is a solution on the horizon. Finally, there is a component of improving accessibility by removing digital barriers for users.

9.3.4.4. Build Communication Channels Between App Users and App Developers

Building communication channels between app users and app developers can potentially address five factors: 1) Perceptions of Data Collection & Management 2) Communications & Misinformation; 3) Accessibility & Inclusion; 4) Trust in Government; 5) Digital Capability. D-CT developers should consider increasing their presence across all social media platforms as this will allow users to communicate quickly and directly with the D-CT app team (as opposed to emails which are less efficient and timely). Currently, in Cyprus, three of the four social media links (Facebook, Twitter, and Instagram) of *CovTracer*'s developer (RISE) redirect visitors to error pages. For a technology non-profit like RISE, this is problematic as it decreases real and perceived efficacy and authenticity if channels of communication are defective. In today's social media age, it is essential for D-CT apps to have an online presence to help build transparency around the app. Alternatively, much like Iceland's built-in chat feature to their *Rakning C-19* app with responders, similar functionality could be built to chat with app developers to address questions and concerns related to efficacy to privacy. Building communication channels will not only promote transparent and timely communication, but it could lead to conversations and the sharing of information that change perceptions of data collection and management, the efficacy of the app, and trust towards public and private institutions. Furthermore, building these platforms can improve accessibility for users to share their concerns or app issues. Relatedly, if persons from marginalized, vulnerable, or excluded groups

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[564] Ibid.

[565] Google Play. (n.d.). CovTracer - Apps on Google Play. Retrieved from https://play.google.com/store/apps/details?id=edu.rise.ihnilatis&hl=en&gl=US

are able to voice their desire to be included and/or considered in D-CT app development, there also arises the potential for developers to ultimately develop an app that is more inclusive.

9.3.4.5. Build App Functionality

Building app functionality may mitigate the risk and optimize the benefit for users of D-CT apps by addressing five of the eight factors: 1) Perceptions of Data Collection & Management; 2) Communications & Misinformation; 3) Accessibility & Inclusion; 4) Response Infrastructure; and 5) Digital Capability. Some cases studied integrated features beyond contact tracing into their apps (e.g. Iceland, Ireland, and Cyprus). For example, Iceland integrated a chat feature to enable users to connect with health officials. Although the impacts on uptake are inconclusive at this time, it is hypothesized that added functionality may encourage uptake, but may also facilitate the second stage of engagement (app use). Scotland's experience with women being harassed after providing their contact details in bars and other public establishments for manual contact tracing further suggests the benefit of increasing app functionality. For instance, users could sign into hospitality services and other locations through the *Protect Scotland* app, eliminating the need to physically leave personal information. This situation in particular highlights how additional functionality could improve inclusivity by incentivizing certain populations – such as women – to download the app, or alternatively reduce risks associated with M-CT for other populations. Relatedly, the transition from physical to digital sharing of information may positively influence perceptions related to data collection and management by minimizing the risks associated with malicious actors who are exploiting physical data. Finally, by adding additional features to a D-CT app – whether it be chat features for health officials, additional information for tourists, or a symptom check-in feature – not only may users perceive the digital capability of the app to be improved, but broadly may influence users' perception of the capacity of the response infrastructure as many additional services or resources are available to users via their phone.

9.3.5. CHALLENGE 5: Digital limitations inhibit people from downloading D-CT apps

As with any digital intervention, there is always the risk that a proportion of the population will not be able to engage in full capacity or at all due to digital limitations. These limitations may include a lack of phone ownership, an out-of-date phone, or residing and/or working in an area with limited to no internet connectivity. The risk associated with the digital divide is particularly prevalent with this challenge, given that D-CT apps are specifically designed for smart phones with very specific technical requirements, connectivity needs, and digital literacy capacity. Given the effectiveness of these apps depends so heavily on widespread representation of the population, this population is at risk of not being alerted of exposure without access to these apps and the effectiveness of these apps are at risk when key sources of the virus may not be traceable (i.e. digitally connected). Furthermore, it is often the populations that are excluded from D-CT apps due to the digital divide that also are disproportionately impacted by COVID-19 and could have the most to gain from such an app. The following recommendations address the Accessibility & Inclusion factor while touching upon other factors, such as Digital Capability, as outlined in Table 9.5.0.

Table 9.5.0: Challenge 5 Recommendations and Corresponding Factors Addressed

	MICRO	MESO		MACRO				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
RECOMMENDATIONS	Perceptions of Data	Sense of Community	Communications & Misinformation	Accessibility & Inclusion	Trust in Government	Policy & Governance	Response Infrastructure	Digital Capability
CHALLENGE 5: Digital limitations inhibit people from downloading D-CT apps								
Minimize Technical & Connectivity Requirements	☐	☑	☐	☑	☐	☐	☐	☑
Make App-Installation and App-Use Tutorials That are Brief	☑	☐	☑	☑	☐	☐	☐	☑
Supply Individuals with Mobile Phones or Alternative Technologies to enable Participation	☐	☑	☐	☑	☐	☐	☑	☐

9.3.5.1. Minimize Technical & Connectivity Requirements

Minimizing D-CT apps' technical and connectivity requirements can address three of the eight factors: 1) Sense of Community; and 2) Accessibility & Inclusion; 3) Digital Capability. To include individuals with older phones, poor-connectivity, and/or low-income, apps should be designed to be as inclusive as possible by reducing digital limitations. In South Africa, for example, the *COVID Alert SA* app has been designed to require little phone space (3MB) and the government has worked together with mobile phone companies to make the app zero-rated, i.e. people are not charged for the data required to download the app. Whereas this action improves inclusivity and accessibility, the operating system requirements of the D-CT apps studied span iOS 9.0 up to 13.5 and Android 5.0 to 6.0 which reduces accessibility because individuals with prior versions are unable to download the app. Lowering digital requirements also can contribute to building a sense of community because the app is designed to be inclusive of as many communities as possible and equally accessible. Beyond accessibility and inclusivity, expanding the types of phones and operating systems that the app can run on for instance, also improves the app's digital capabilities which can change people's perceptions of the app's efficacy, thereby influencing app-uptake.

9.3.5.2. Make App-Installation and App-Use Tutorials That are Brief

Brief app-installation and app-use tutorials can address three factors: 1) Communications & Misinformation; 2) Accessibility & Inclusion; and 3) Digital Capability. D-CT app implementers can take the lead from countries such as Canada, Ireland, and Israel and create a tutorial video that briefly describes the app and walks users through app installation, setting customization, app use, and data sharing. However, as most tutorial videos exceed two minutes and research indicates that the average human attention has dropped from twelve seconds to eight seconds,[566] this study's research team proposes TikTok-style videos that guide users through app installation, use, and sharing in 60 seconds or less. Tutorial videos can address individuals' unfamiliarity or misconceptions surrounding data collection and management and strengthen transparency and share accurate information. Furthermore, by including videos in different languages – such as sign language – the app can be made inclusive of more populations. Finally, these tutorials can address digital literacy issues which will help mitigate negative perceptions of the app's digital capability.

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[566] Desk, W. (2018, September 10). The Human Attention Span [INFOGRAPHIC]. *Digital Information World.* Retrieved from https://www.digitalinformationworld.com/2018/09/the-human-attention-span-infographic.html

9.3.5.3. Supply Individuals with Mobile Phones or Alternative Technologies to enable Participation

Supplying phones or alternative technologies to individuals can assist in addressing four factors: 1) Sense of Community; 2) Accessibility & Inclusion; 3) Response Infrastructure; and 4) Digital Capability. As highlighted in Module 1, other countries have started to use other forms of digital technologies such as QR codes (that do not require download of an app) and eBracelets or wearable tokens (which work on Bluetooth but do not require a mobile phone). Some are offered for free, as seen in Singapore.[567] The above efforts are aiming to engage populations that may otherwise be disconnected. The potential effect of increasing accessibility and inclusivity can be improving a sense of community. Furthermore, increasing the individuals with the digital capacity to engage with D-CT can increase the capacity of the response infrastructure to connect with those that may have been previously disconnected. Finally, when individuals are supplied with a mobile phone that can download the app or provided with alternative technologies designed to interface with the D-CT app, it therefore expands the digital capability of D-CT apps to have an impact.

9.4. Future Research

Our research alongside the broader literature has highlighted gaps or areas that need further exploration to understand user engagement with D-CT apps in relation to efficacy. Some of these areas align with research we have reported but also gaps we have been unable to report on given insufficient data or longevity of D-CT apps in use. These fall under three main categories. The first area of study is regarding the user-uptake phase of user engagement specifically. Our research was a preliminary exploration of the factors potentially impacting user-uptake within the broader user engagement framework but further understanding, such as how to most appropriately measure user-uptake, is required. The second area of study is the other three phases of research: use, report, react. While this project briefly described the user engagement process within the case studies, in-depth research is required to fully explore the factors that impact each stage of user engagement as well as what success looks like within each stage and across the stages. The final area of study is in relation to this research topic in general. For instance, exploring different regions, increasing the granularity of the study's focus, and the effectiveness of D-CT apps in general are all future avenues of research.

9.4.1. Uptake Phase of User Engagement

This section outlines four potential avenues of research that relate specifically to the uptake phase of user engagement. This includes, first, **examining the factors identified in this project in further depth**. For example, following our findings regarding misinformation and community-focused messaging, more understanding is needed on how narratives develop around the app and the impact of these narratives on the uptake and usage of these D-CT apps. By investigating these narratives, governments and creators will be able to better reach their intended audience and will provide an understanding as to why and how users react to these perceptions of these apps. Second, relatedly, there is the need for **quantitative study**

[567] BBC News. (2020, September 14). Singapore distributes Covid contact-tracing tokens. *BBC News*. Retrieved from https://www.bbc.com/news/business-54143015

of the factors identified in this research, specifically to evaluate if they have a quantifiable impact on uptake, the nature of their impact, and how they may correlate with other factors. Although our study was able to identify recurrent themes that appear to influence uptake, without quantitative study it is difficult to truly understand the nature of their influence. Third, **the study of uptake curves i.e. graphs of how uptake rates vary over time** is needed, specifically looking at moments of change in these curves as potential inflection points for research. This may include, for example, looking at where and why uptake may decrease after initial release (which was often observed in our study). Investigating drops in the uptake curve after a certain amount of time or due to an additional factor, such as technological issues, will help identify where and what counter measures need to be taken to continue the amount of user-uptake of the apps, enabling higher uptake and usage.

Finally, future research **must find better ways to measure uptake**. In many cases, D-CT app download numbers are unknown, outdated, estimated, or inaccurate. This is, in part, due to data limitations. In the case studies it was extremely challenging to determine uptake amongst the population that own phones that can download the app (referred to as digital capability uptake) versus those that lack this capability, or those that are within eligible age limits. Relatedly, our research found that uptake measurement in terms of registrations are more accurate, yet only one country (Ireland) could find metrics beyond aggregate downloads. Looking into what these numbers are and why they are hard to find as well as studying which demographics are downloading the app and how they interact with the app may aid in researching ways to better characterize uptake and understand how uptake is affected over time across contexts.

9.4.2. Other Stages of User Engagement (use, report, react)

Beyond user-uptake (the first phase of user engagement), there is a need to **study the other stages of user engagement - use, report, and react** (see the four-stage continuum of D-CT engagement in Module 1, Section 1.5) through a risk-benefit lens. Specifically, while the media tends to focus on uptake rates as a measure of success for D-CT apps, app effectiveness also requires users to engage in the other three phases. Therefore, **understanding what success looks like individually within each of the phases as well as collectively** is an important area of study as it may help explain the disconnect between an app's number of downloads and the number of positive COVID-19 diagnoses reported via the app (a recurrent theme in the research). Relatedly, how success is defined may vary between contexts – suggesting a further research area. It is uncertain if success should be measured through the number of downloads of the app, whether this metric involves redownloads, the number of users who consent to share data, and/or the number of actual app users as well as other unidentified factors which may contribute to uptake numbers and measures of success. In Cyprus for example, a recent article reported that "21 out of 41 [COVID-19] cases were detected from the contact tracing process"; however, it is unclear if *contact tracing* meant manual contact tracing or D-CT through *CovTracer*. In simple terms what exact metrics are used by governments to determine uptake and thereby success and which metrics are not used (nor defined). Third, relatedly, **the types of incentives and their relationship with success** is a worthy area to study. This research would help further understanding of why some users engage and others do not, as well how to reach users that are either disinterested or inaccessible. For instance, incentives may be useful in bridging the gap between app users who have tested positive and forget to

input their code given by public health into contact tracing apps.[568] Beyond factors identified, it was difficult to identify specific incentives that encouraged users to download D-CT for example. Meanwhile, initial focus group research suggested that incentives from financial reward to access to treatment can be important conduits to bridge engagement. Finally, **recognizing which populations are excluded or have particularly low uptake and why** can help in finding ways to reach out to these populations further expanding uptake and usage. As seen in a 2018 report from Scotland, certain populations such as minority groups, people with disabilities, and seniors are more likely to be digitally excluded.[569]

9.4.3. General Areas of Study

There also are gaps within this general area of study that require further research. First, **the scale of study** can be varied. For instance, this study focused on various countries, but more insight could be gained by focusing on specific regions and facilitating cross-country comparisons. Alternatively, increasing the granularity and comparing cities like Madrid versus Lisbon could be extremely insightful. There may be some benefit in narrowing the focus of research and analysing regions and cities that may have higher infection rates than the general population or that may have slowed the spread more effectively then the surrounding regions. Second, relatedly, there is a **need to study more of the global south**. Given the experience many countries in Africa have with epidemics, for example, some countries in Africa have fared better than many in the global north during the COVID-19 pandemic. Understanding why they have done so would be useful for future disaster and emergency response measures. Third, **evaluating the dynamics between manual and digital contact tracing** could lead to identifying ways to generate optimal impact, and improve the broader the efficacy of the contribution of D-CT to disaster and emergency response. Fourth, due to the relative novelty of D-CT apps, it is important to continue to **measure the effectiveness of these D-CT interventions** through reflective study on the apps implemented thus far, taking into account other D-CT interventions[570] (e.g. QR codes, eBracelets and tokens described in Module 1) and their relationship to one another. Relatedly, the final area of study is **exploring, understanding, and evolving the technology behind these apps to further build digital capability**. For instance, examining Bluetooth functionality and efficacy is frequently questioned as research has found that "Bluetooth attenuation is not a reliable measure of distance." [571] Despite guidelines such as the WHO standard risk measurements, constantly advancing science dictates the need for more accurate and precise methods of measurement. There must be continued research into technological specifics such as Bluetooth functionality, the underlying risk calculations, secure data management, and accessible development. Ensuring that these apps function in a way that rewards the

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[568] O'Sullivan, K. (2020). Protect Scotland app has notified more than 10,000 contacts of positive cases, First Minister confirms. *FutureScot*. Retrieved from https://futurescot.com/protect-scotland-app-has-notified-more-than-10000-contacts-of-positive-cases-first-minister-confirms/

[569] Sawers, L. (2018). Is Scotland Fairer? The state of equality and human rights 2018. *Equality and Human Rights Commission*. Retrieved from https://www.equalityhumanrights.com/en/publication-download/scotland-fairer-2018

[570] Goldstein, D., Babcock, R., (2020, Nov 12). More Than Just An App: the Many Forms of D-CT During COVID-19. *Digital Global Health & Humanitarianism Lab*. Retreived from https://dghhlab.com/more-than-just-an-app-the-many-forms-of-d-ct-during-covid-19/

[571] Wilson, A. M., Aviles, N., Beamer, P. I., Szabo, Z., Ernst, K. C., & Masel, J. (2020). Quantifying SARS-CoV-2 infection risk within the Apple/Google exposure notification framework to inform quarantine recommendations. *MedRxiv*. https://doi.org/10.1101/2020.07.17.20156539

time and resources committed to them, as well as are usable by all audiences regardless of disability are all topics without which app development may stagnate.

9.5. Conclusion

Module 9 provided an overview of the recommendations and future research identified as a result of our research. The recommendations were organized based on the challenge they address. Five challenges – 1) fears of immediate and future surveillance, and alternative uses of personal data; 2) privacy perceptions may override privacy-by-design principles; 3) some communities are disproportionately affected by and/or excluded from D-CT apps/measures; 4) Perceptions of D-CT app effectiveness are poor; and 5) digital limitations inhibit people from downloading D-CT apps – were identified. Numerous recommendations were provided for each challenge and also provided insight into which of the eight individual (micro), community (meso), and system (macro) level factors were addressed by each recommendation. Future research areas were grouped into three main categories: 1) uptake phase of user engagement; 2) other stages of user engagement (use, report, react); and 3) general areas of study. A number of potential research avenues were posed for each category. For an overview of the individual (micro), community (meso), and community-system (meso-macro) level factors influencing user-uptake, see Module 7. For an overview of the system (macro) level factors influence user-uptake, see Module 8. Alternatively, for the case studies, see Modules 2-6.

DGHH
Digital Global Health & Humanitarianism Lab

EXPLORING USER-UPTAKE OF DIGITAL CONTACT TRACING (D-CT) APPS

A PRACTITIONER GUIDE

METHODOLOGY

© 2020 Digital Global Health and Humanitarianism Lab
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Exploring User-Uptake of Digital Contact Tracing (D-CT) Apps
Module 0. Methodology

0.1. Methodology Overview

This supplementary document provides a detailed overview of the methodology used to guide the Digital Health and Humanitarian Lab's (DGHH Lab) study on user-uptake of Digital Contact Tracing (D-CT) apps during COVID-19. First, the guiding research questions and scope of research are identified. Second, our research approach is described through four phases: 1) Workshop/Focus Group; 2) Meta-Analysis; 3) Multiple Case Study & Interviews; and 4) Systems Analysis. Third, the structure of our research findings is outlined, which encompasses a series of modules that compose this practitioner guide. Finally, study constraints and limitations are provided.

0.2. Research Questions

This study asks the following research question:

Why is there higher user-uptake of Digital Contact Tracing (D-CT) apps in some countries over others?

Research is guided by the following sub-questions:

1. How does uptake vary across contexts?
2. What factors influence uptake uptake across contexts?
3. How does risk-benefit perception influence uptake?

0.3. Scope of Research

To address our research questions, we established the scope of our research.

0.3.1. A focus on D-CT Apps Only

Our research focuses solely on ***D-CT apps***, (the most prevalent form of D-CT interventions worldwide) that are ***voluntary*** for download (users have the freedom to download these apps) and primarily ***decentralized*** in their data collection (a measure that mitigates privacy and human rights concerns that are widely recognized as a factor that deters app engagement).

0.3.2. A focus on User-Uptake on D-CT Apps

In order to study engagement with D-CT apps, we first characterized engagement as a four stage process (see Figure 1).

Figure 1. Continuum of User Engagement in Digital Contact Tracing Apps

Each stage is described below:

1. **Uptake** - App users download, install, and register on the app
2. **Use** - App users ensure the app is running and up-to-date on their phone
3. **Report** - App users, identified as positive for COVID-19, report their status in the app so that others they may have had contact with get an exposure alert
4. **React** - App users that have received an exposure notification get tested and/or follow local quarantine protocol

As the need has been identified to garner deeper understanding of all stages of engagement, both through the literature (see Module 1) and a preliminary workshop/focus group (explained below) this study focuses on **uptake** as part of a larger study researching the other stages of engagement.

0.4. Research Approach

Research is conducted using qualitative methods through four phases including: initial focus group/workshop, qualitative meta-analysis, multiple case study & interviews, and systems analysis. Each of these phases are described below.

0.4.1. Phase 1. Workshop/Focus Group

On July 23rd, 2020, The DGHH Lab held an International, Interdisciplinary, Academic-Practitioner Workshop that focused on current challenges faced with Digital Contact Tracing (D-CT). The purpose of the workshop was to:

- Gather interdisciplinary insights on high level challenges currently associated with D-CT, key contextual factors that dictate the nature and outcomes of these challenges, and inform the development of the final product of the research
- Facilitate partnership-building across disciplines, academia, and practitioners across the globe to initiate building a global interdisciplinary academic-practitioner network to act as a source of knowledge exchange

The workshop was held remotely with 25 participants with expertise in areas including: Humanitarian

Work, Manual Contact Tracing, Medical Service Delivery, Epidemiology, Emergency Management, Government Application Development and Policy, Big Tech / Innovation, Law, Privacy and Human Rights, Surveillance, NGOs and Marginalized Groups, Digital Contact Tracing, and Ethics & Governance. Participants came from all over the world from countries including Canada, the United States, the United Kingdom, Switzerland, Greece, South Korea, and Japan. Participants were sampled using both purposeful and snowball sampling methods. For purposeful sampling, we searched for individuals who were experts in the above areas by exploring news outlet content, reviewing scholarly literature, conducting internet searches, joining virtual groups that housed academics and practitioners conducting related work, and reaching out to pre-existing contacts. After identifying these individuals and gauging their interest, we also requested the provision of other contacts that may be interested in participating in the workshop.

At the workshop, participants were divided into interdisciplinary groups to discuss digital contact tracing from the perspective of 1) the individual (i.e. individual people using or not using D-CT apps); 2) communities (i.e. communities that do or do not use D-CT apps, such as the elderly, refugees, employees, etc.); 3) implementers (i.e. those implementing the app such as the government, public health agencies, and private companies); and developers (i.e. those developing D-CT apps such as big tech companies). Within each group, discussion was led by the participants with some prompting from the DGHH Lab team on the following topics: identifying the main challenges associated with D-CT, main benefits and risks associated with D-CT, and the contextual factors that can increase risk or increase benefit associated with D-CT. With permission from participants, all data was collected through note-taking and audio transcription.

Qualitative analysis of the notes and audio transcription was used to identify main themes in need of deeper research. One of the primary findings identified in this workshop was the need to focus on the user perspective of D-CT initiatives, specifically incentives to engagement from a risk-benefit perspective. This finding established the foundation of our study.

0.4.2. Phase 2. Meta-Analysis

Initial focus group findings were combined with a literature review that focused on 1) the risks and benefits of D-CT apps; and 2) D-CT apps within specific contexts (i.e. within countries, regions, and communities around the world) in order to define the user-uptake problem, and identify existing knowledge and gaps in need of research (Module 1). Using these findings, a multiple-case study approach was designed to gather further insight on user-uptake with D-CT apps.

0.4.3. Phase 3. Multiple Case Study & Interviews

Five case studies were selected to generate in-depth, qualitative insight into reasons why some individuals download D-CT apps over others. The study aimed to characterize the evolution of D-CT apps by country, detail the nature of the D-CT app (i.e. how it is developed and implemented), describe user uptake in that country, identify themes that help to explain user-uptake of D-CT apps (from a risk or benefit to the user perspective), and interventions used that have led to higher or lower uptake.

0.4.3.1. Case Selection

The criteria used to identify cases for study included:

- Use of a decentralized D-CT app
- Voluntary uptake
- Uptake rate similarity and variation
- Population size similarity and variation
- Regional similarity and regional variation (e.g. Scotland versus Ireland, developing versus developed world)

The final case studies selected include: Iceland, Cyprus, Ireland, Scotland, and South Africa.[572]

0.4.3.2. Data collection

Data was collected using a combination of qualitative meta-analysis and individual interviews.

Qualitative analysis consisted of a secondary literature review of peer-reviewed literature combined with grey literature specific to the countries being studied. Topics researched included a country's response to COVID-19, COVID-19's impact on the country, and about the country's D-CT app (how it works, how people use it, how many people downloaded it, and factors seemingly impacting uptake). Given this is a novel area of study, little published materials were available specific to the subject matter. Subsequently, research relied heavily on grey literature including media reports, non-peer reviewed academic work, op-eds, and social media, among other materials. Social media was studied in part through Twitter scraping. Three samples of Twitter conversations on the subject of a country's contact tracing app were taken (two in October and one in November). The sample was taken via a scraper using the Twitter API. The primary library used for the script was Tweepy[573]. As an example, keywords for Ireland's twitter scraping included "Contact Tracer Ireland", "Irish", "Ireland", "Contact Tracing", and "app". Samples covered October 10 - October 30 and November 24 - December 1.

Individual interviews also were conducted to gain deeper insight into some of the areas where literature was lacking. Participants were identified based on a) involvement with design and implementation of D-CT apps in the respective case study countries, or b) subject-matter expertise as it relates to user-uptake of D-CT apps, digital contact tracing, and the broader digital response. Participants were selected using purposeful and convenience sampling and contacted via e-mail. Due to the need to provide timely outputs, the timeframe in which interviews could be conducted was short, and as a result, only five of those contacted were able to participate in an interview (which were conducted in October 2020). Four interviewees spoke in relation to Ireland's D-CT app and one interviewee addressed Iceland's D-CT app.

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[572] Initial study also included Argentina to encourage regional variation, but this country was removed from the study given insufficient available data within project timelines. See discussion on *constraints and limitations* for further information.

[573] Tweepy. (n.d.). Tweepy: An easy-to-use Python library for accessing the Twitter API. Tweepy. Retrieved from https://www.tweepy.org/

Interview protocol questions spanned context-specific and subject matter expert questions, aimed to gather further insight on uptake in the target country, challenges associated with uptake, existing incentives, perceptions of the participants country performance in comparison to other countries, and measures that have been taken to account for risk/benefit of D-CT apps. Data was collected using note taking, audio recording, and transcription. Data was analyzed through qualitative coding strategies. In the Practitioner Guide Modules, interviewees are either identified by name or are anonymous and cited as 'personal communication' depending on what interviewees agreed to via the consent process.

0.4.4. Phase 4. Systems Analysis

Research findings were analyzed using a systems approach to identify key uptake factors that contribute to user-uptake. Bronfennbrenner's ecological systems theory is used as a foundation for systems analysis.[574] His theory defines user behaviour as a product of intrinsic and extrinsic interactions and influences with different levels of their surrounding system. Specifically the user is understood by identifying the internal factors that influence their motivations and behaviours (micro-level system); external factors that influences them and they have influence on (meso-level system), like their community and family; and/or factors that directly influence them only (macro-level system) like socio-cultural, political, technological, and economic systems. By looking at these different levels of the system, one can gather insight on the different spheres that influence behaviour. In the context of D-CT engagement, this approach lends insight on the intrinsic factors that may lead individuals to download D-CT apps, while also explore the influences of community and social networks, as well as the broader political structures, health system capabilities, digital and educational capacities, social norms, and so forth.

0.5. Research Findings

The findings of this study are presented through nine modules including:

Module 1 - Digital Contact Tracing (D-CT) and User-Uptake: A Primer
Module 2 - Case Study: Iceland
Module 3 - Case Study: Cyprus
Module 4 - Case Study: Ireland
Module 5 - Case Study: Scotland
Module 6 - Case Study: South Africa
Module 7 - Analysis of User-Uptake Factors: Individual- & Community-Level Influences
Module 8 - Analysis of User-Uptake Factors: System-Level Influences
Module 9 - Recommendations & Future Research

0.6. Constraints & Limitations

Over the course of study, a series of research constraints and limitations were experienced.

[574] Bronfenbrenner, U. (1992). Ecological systems theory. Jessica Kingsley Publishers.

First, given the novel nature of this area of research, there was a **lack of available data** to draw from. This lack of data spanned peer-reviewed literature and grey literature specific to user-uptake as well as user-uptake measurements and the effectiveness of D-CT apps, especially specific to the case studies. Some interviews were conducted to fill research gaps, but even interviews revealed a lack of data to date that could fully characterize the impact of digital contact tracing and behaviours around the associated D-CT interventions. While the lack of available data was a limitation, the team was as resourceful as possible to fill in the gaps and gain an understanding of user-uptake -- particularly surrounding app download data -- across the case studies.

Second, to accommodate the growing need for information in a fast-moving, high-risk pandemic, this study prioritized timely outputs over longer-term, in-depth study. As such, **time constraints** hindered the ability to explore themes that emerged in more depth.

Third, **some case studies were cancelled**. Additional countries were initially included in the research design to help diversify cross-comparison of countries. Given previous constraints (lack of data, time) some cases selected were deemed insufficient for study given insufficient data was available and/or their D-CT apps were unclearly defined.

Relatedly, fourth, **variable D-CT app release dates** made it difficult to effectively compare uptake along a shared time continuum. This study hoped to plot uptake over time, for example, and evaluate variability in uptake curves as a means to identify factors that influence uptake. Yet, insufficient data was available given these variable release dates.

Fifth, in the late stages of the study, researchers faced challenges with **standardizing user-uptake statistics**. While most countries report D-CT user-uptake in terms of downloads, interviews with D-CT app developers revealed that standards were changing for uptake measurement. Specifically, that reporting on downloads was an inaccurate measure and that user registrations provide a better indicator. Because of the differences in available data, the only case study for which more detailed uptake percentages were found (beyond aggregate downloads) was Ireland. The decision was made, given data and time constraints, to report on data available for each country. For those countries with only downloads available, downloads were reported. Consensus was that downloads still provide valuable insight into user-uptake.

Finally, this study is **unable to characterize the level of influence** of factors identified because this was a qualitative study with the aim to identify recurrent themes associated with uptake (with plans for future quantitative study given more time and resources available). Without quantitative study, this study is limited in its ability to evaluate the extent each of factors influenced user-uptake. For a detailed explanation of how some of these limitations could be addressed in future study, e.g. the need for quantitative research, see *Module 9 - Future Research*.