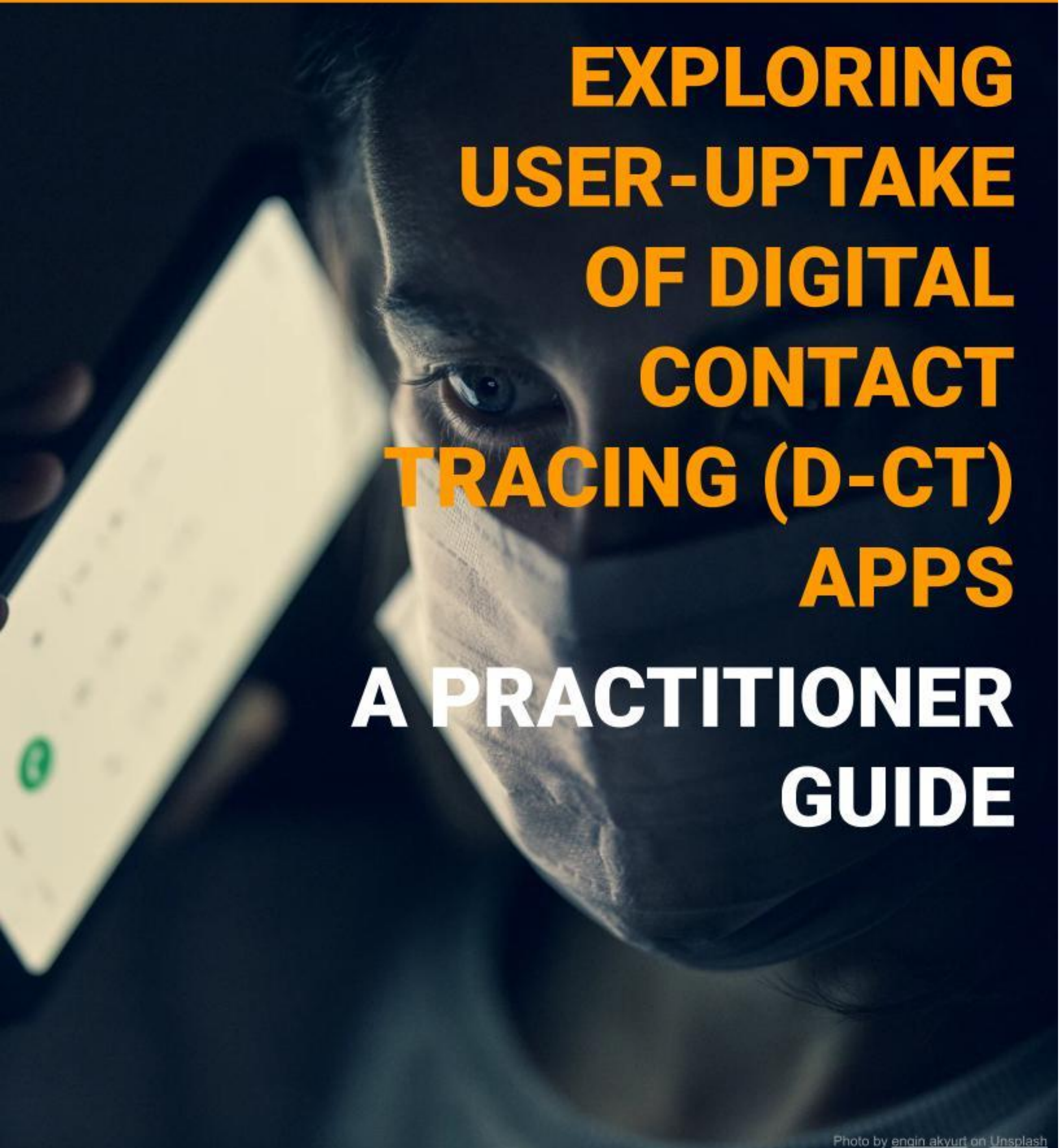


EXPLORING USER-UPTAKE OF DIGITAL CONTACT TRACING (D-CT) APPS

A PRACTITIONER GUIDE

Photo by engin akyurt on Unsplash

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

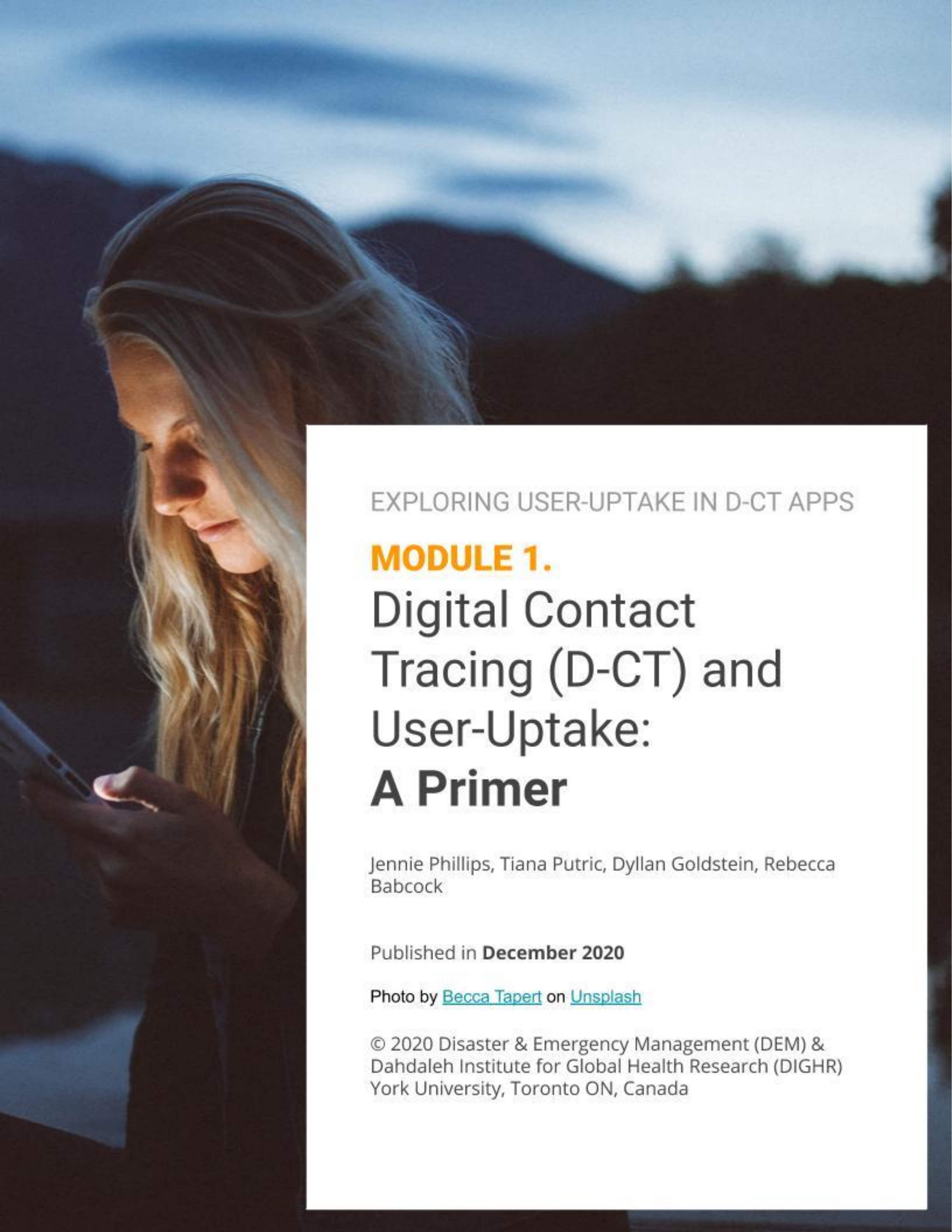
DGHH
Digital Global Health & Humanitarianism Lab

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.

Photo by engin akyurt on Unsplash

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



EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 1. Digital Contact Tracing (D-CT) and User-Uptake: **A Primer**

Jennie Phillips, Tiana Putric, Dyllan Goldstein, Rebecca Babcock

Published in **December 2020**

Photo by [Becca Tapert] on [Unsplash]

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 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:

[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/

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, please see the full methodology.

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.

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.

[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

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 eleven modules including:

Module 00 – Executive Summary
Module 0 - Methodology
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 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.

---

[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

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 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

---

[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/

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 surveillance states – extending control under the "guise of measures for the public's health."[13] Further, it is

---

[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

[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

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.

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

---

[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.

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

---

[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.

[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*

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 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.

PHONE APP UPTAKE AND ENGAGEMENT TO INFORM DIGITAL CONTACT TRACING TOOLS FOR COVID-19.
https://doi.org/10.31234/osf.io/qe9b6

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

---

[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.

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%.

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

---

[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

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 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

---

[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

[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

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?

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

---

[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

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 on 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