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

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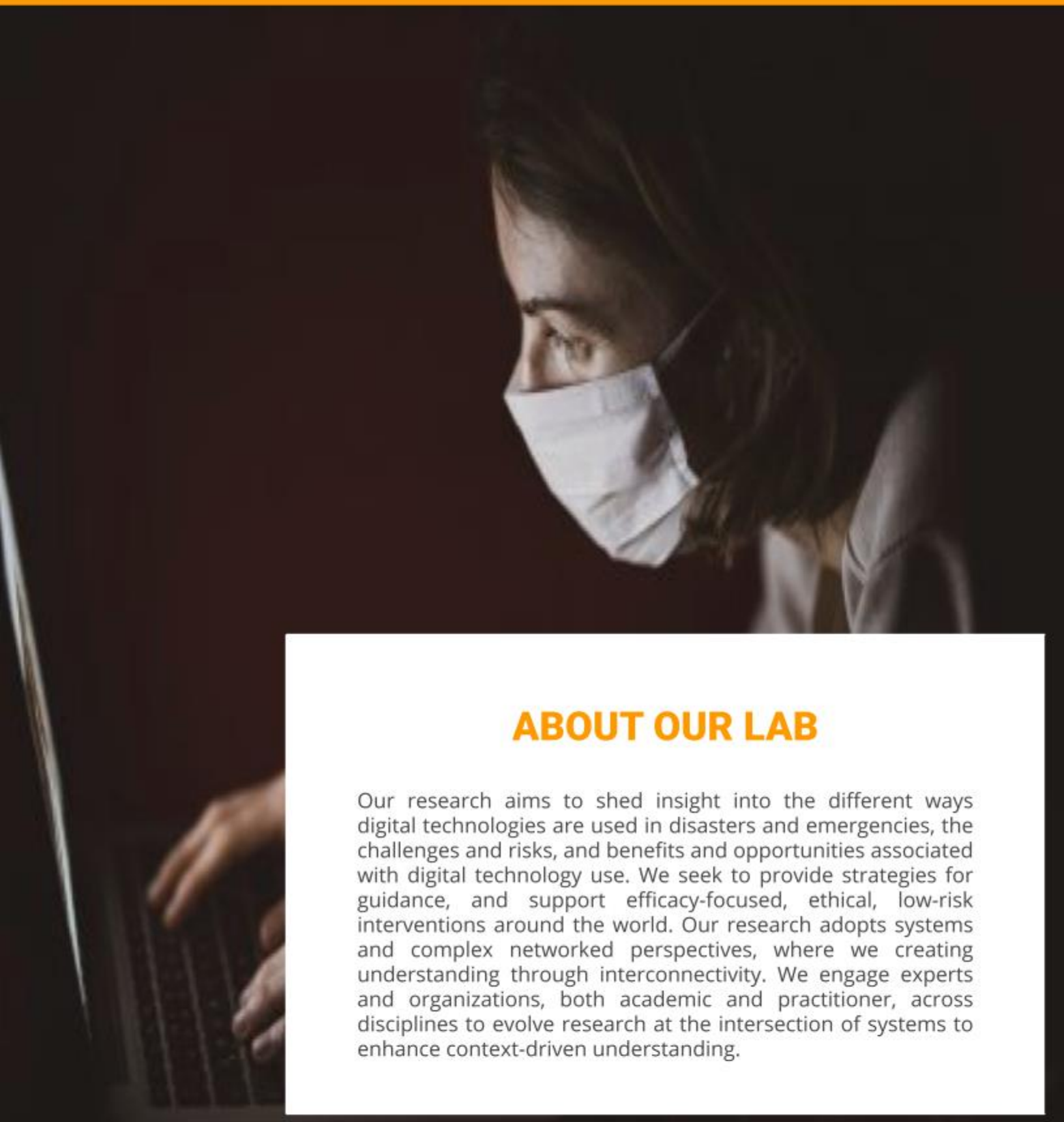

ABOUT OUR LAB

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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EXPLORING USER-UPTAKE IN D-CT APPS

MODULE 3.
Case Study. **Cyprus**

Petra Molnar, Tiana Putric, Rebecca Babcock, Jennie Phillips

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

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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,[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] 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/

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).[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 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, please see the full methodology.

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.

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]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

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 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

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.[4] 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").[5] 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.[6]

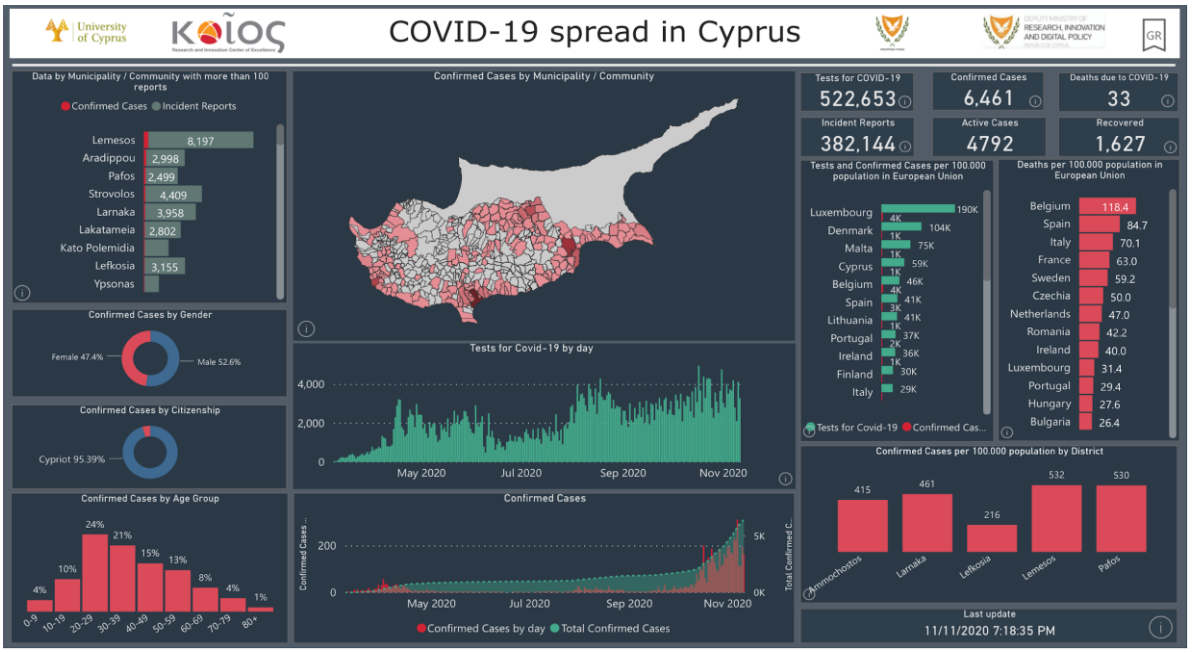

Figure 3.1.0. COVID-19 Spread in Cyprus[7]*

[4] 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/

[5] 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.

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

[7] 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*.[8] 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."[9] 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."[10] 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."[11] 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.[12] As of 28 October 2020, Cyprus is not employing alternative digital technologies in complement to *CovTracer*.

[8] 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/
[9] Hadjicostis, M. (2020, May 2). Cyprus backs voluntary tracking app use to halt virus spread. AP NEWS. Retrieved from https://apnews.com/article/c2063f20458aec53ea4bed6965c62be6
[10] 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/
[11] Massachusetts Institute of Technology [MIT]. (n.d.). Project Overview: Safe Paths. MIT Media Lab. Retrieved from https://www.media.mit.edu/projects/safepaths/overview/
[12] 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[13]
Data Collection permission	Voluntary
Data Deletion period	One year

[13] 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.[14] 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."[15] *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.[16]

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.[17] 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.[18] 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).[19] 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."[20]

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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[14] Massachusetts Institute of Technology [MIT]. (n.d.). Project Overview: Safe Paths. MIT Media Lab. Retrieved from https://www.media.mit.edu/projects/safepaths/overview/
[15] CovTracer. (n.d.). CovTracer. Retrieved from https://covid-19.rise.org.cy/en/
[16] 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
[17] CovTracer. (n.d.). Privacy – CovTracer. Retrieved from https://covid-19.rise.org.cy/en/privacy/
[18] Ibid.
[19] Ibid.
[20] Ibid.

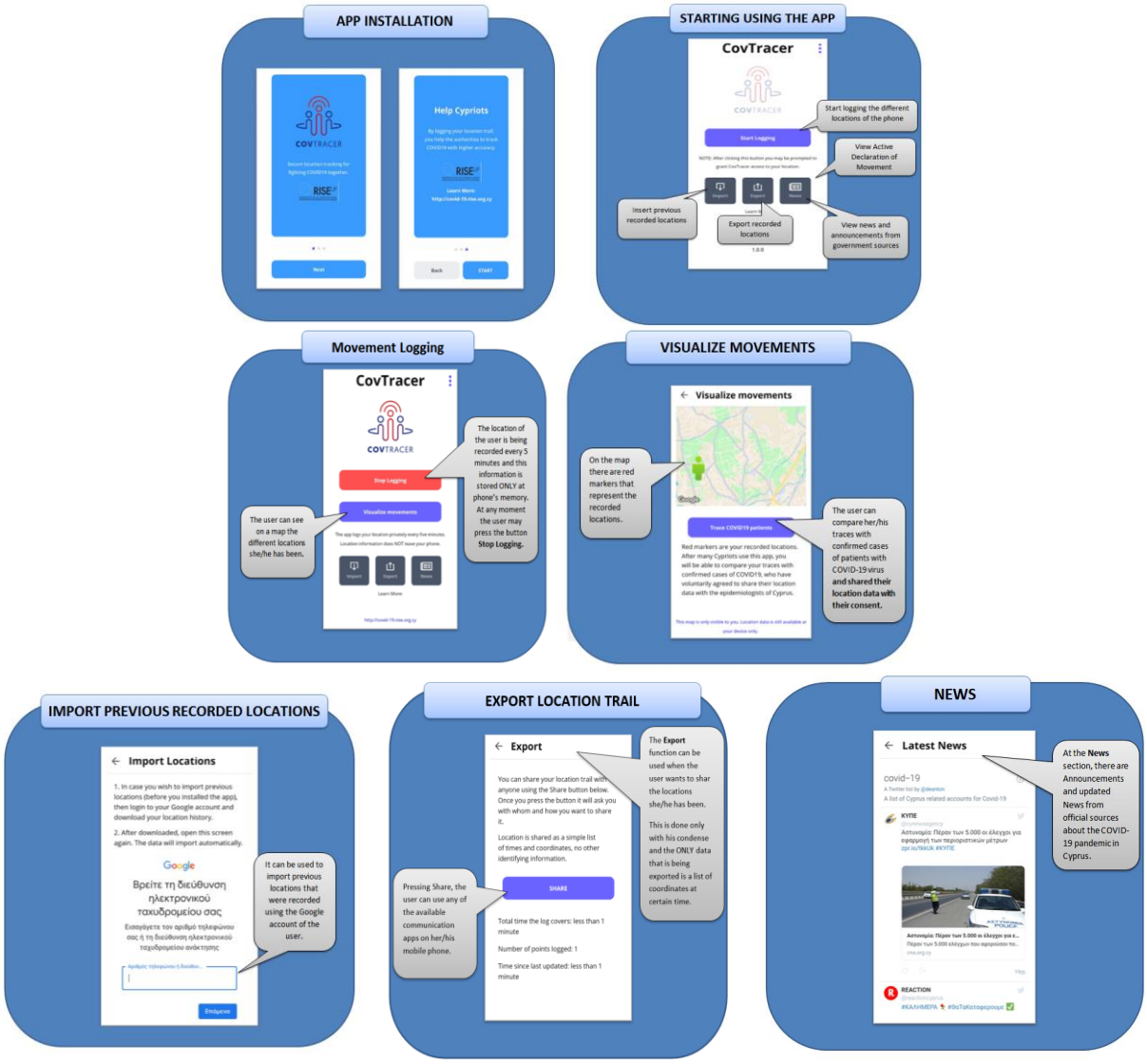

Figure 3.2.0. A Step-by-Step Visualization of *CovTracer* From Installation to Export[21]

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[22] 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."[23] 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,

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

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

[23] 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."[24] 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.

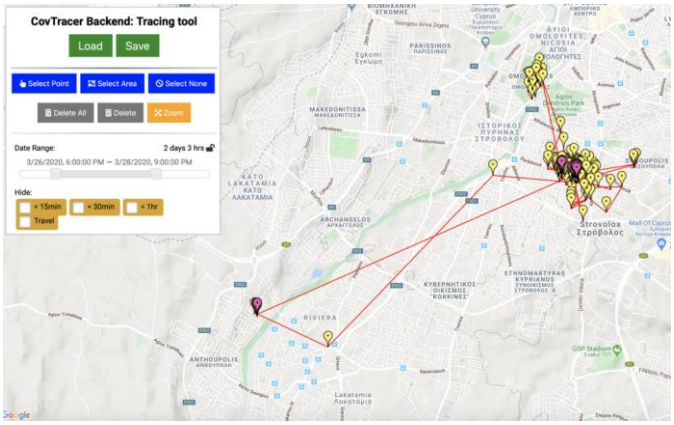

Figure 3.3.0. *CovTracer's* Backend Tracing Tool (used by Epidemiologists for Virus Tracking and Tracing)

3.3.4. App-Uptake

3.3.4.1. Uptake Summary

Table 3.2.0: *CovTracer* Uptake Summary

	Cyprus
Uptake (#downloads)	~8,000 downloads[25]
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.[26] Using this data, it is possible to estimate uptake

[24] Ibid.
[25] 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/
[26] 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.[27] 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%.[28] Given that 1,197,240 Android and iOS mobile devices are currently in use in Cyprus, digital capability uptake is estimated to be 1%.[29] 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."[30] 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

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

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

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

[30] 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.[31] *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.[32] The more users trust an app, "the greater their involvement in the app and the more positive [their] attitudes."[33] 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,[34] 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).[35] 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.[36] 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."[37] 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 Prountzos & Prountzos LLC, a Cyprus-based law firm that specializes in "Digital and GDPR/Data Protection

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[31] Ibid.

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

[33] 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/

[34] 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.

[35] 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

[36] 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

[37] 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/

Law;" and is affiliated with XM, a global investment and brokerage firm.[38] 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"[39] – from occurring once a person turns on the location sharing data.[40] 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.[41]

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.[42]

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.[43]

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

[39] 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

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

[41] 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

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

[43] 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.[44] 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."[45] 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."[46] 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,

[44] Ibid.
[45] 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
[46] 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.