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The Role of Technology in Tracking COVID-19 Patients and their Contacts

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Abstract - The number of COVID-19 cases is surging around the world. With a vaccine likely to be unavailable for several months, countries are working on strategies to contain the spread of the virus even as they lift restrictions on the movement of their citizens. Contact tracing is a method that has been employed by several countries to limit the spread of COVID-19. It includes tracing and quarantining people who have been infected with the disease or exposed to the virus. Manual contact tracing has to rely heavily on human memory in times of stress, is time-intensive, and needs to reach a large scale in order to be an effective tool to combat the disease. Artificial intelligence (AI) and other technologies can help overcome these challenges and achieve the goal. There are multiple ways of using technology in contact tracing, with several nations producing their own solutions. This article reviews the use of technology in available methods of contact tracing along with the limitations, concerns and challenges of those techniques. With appropriate safeguards, technology-based contact tracing methods will help us to manage the current infection spreads and the future spikes that are expected, while continuing to allow our economies to remain open.

Keywords - *COVID-19; Contact tracing; Technology in contact tracing; Artificial intelligence; Mobile applications in COVID-19; Coronavirus.*

1. Introduction

COVID-19 is an infection caused by the SARS-CoV-2 coronavirus [1]. It was first identified in Wuhan, China, on December 31, 2019 [2]. On March 11, 2020, the World Health Organization characterized the COVID-19 outbreak as a pandemic [3], and at the time of submitting this article for publication, nearly eight million people across the world have been affected by the virus, resulting in more than 433,490 deaths [4].

Along with the quick development of a vaccine and a definitive treatment plan, decision-making on testing and tracking the people that the patients have been in close proximity with (their "contacts") are ongoing challenges worldwide. If a person is infected with the virus, that person spreads the virus to 2.5 people on average, with those people also transmitting the virus to others. Within a span of 30 days, 406 people would be infected [5]. The present strategy in many countries has been to isolate and quarantine patients and their contacts. Rapid and complete contact tracing is imperative to contain COVID-19, especially as economies open up and cities ease lockdown restrictions.

Contact tracing helps to limit the spread of a virus by finding people who might have been exposed to the virus, and then notifying, testing and quarantining them depending on the situation. When a person is diagnosed with a disease (which, in this case, would be COVID-19), they are asked to identify the people who they might have been in recent contact with, which makes it easier to determine the people who could have possibly been infected, and also the location where the people were infected. This is a form of manual contact tracing, which is not the best way of gathering information since it is nearly impossible for the patient to recollect every single bit of information from the past few weeks. It would be especially hard to do so if they are currently under a lot of pressure and stress, or were part of a large group of travelers and were not paying much attention to their movements and interactions prior to their diagnosis [6]. Contact tracing is also time-intensive work, and it is here that artificial intelligence (AI) and other technologies can help achieve the scale required for the method to be effective.

2. Materials and Methods

The authors reviewed the literature pertaining to this subject using MEDLINE, PubMed, Google Scholar and Google Search. The search terms used include *coronavirus*, *SARS-CoV-2*, *contact tracing for COVID-19*, *artificial intelligence in contact tracing*, and *technology in contact tracing*. There are very few articles published in peer-reviewed journals regarding the tracking of COVID-19 patients and the ones that they came in contact with. However, COVID-19 is a serious pandemic with grave consequences that could potentially wipe out the human race, and hence, the authors have had to refer to the internet and print media, in addition to scientific journals, as reference sources.

3. Applications of Technology in Contact Tracing

3.1 Mobile applications

Mobile phone applications have been the most common mediums of tracing possible contacts. These apps come in a multitude of flavors, depending on the objectives of the government endorsing that app.

3.1.1 Apps that use Bluetooth

These apps focus on using distance tracking via Bluetooth technology. In this method, a person downloads the contact tracing application on their phone, and their mobile phone swaps encrypted data with other nearby phones, with the data being used to calculate its distance from the other phones [7,8].

Singapore has been a leader in creating contact tracing applications [9], with Trace Together being the first nationwide Bluetooth tracing application to be launched in any country [10]. The app on a mobile device detects another device with the app installed, leading to an exchange of proximity information between the two devices. The app uses readings obtained from Bluetooth to estimate the proximity and duration of the chance encounter. No location data is collected by the government, and all the information is stored in an encrypted form on the person's phone for 21 days. If a person does happen to contract COVID-19, the information stored on the TraceTogether app helps the government in mapping their past activity and tracing their contacts [11].

The National Health Service (NHS) in the United Kingdom has developed an application which they are trialing on the Isle of Wight, with a full rollout of the app in the UK expected towards the end of June 2020. When people with the app happen to encounter each other, their phones exchange critical information and store it for 28 days. If a user begins to develop coronavirus symptoms, they need to report them by answering a series of questions on the app. The NHS' AI program then analyzes the answers given and decides whether the person has met the threshold required to self-isolate. The program informs the user accordingly, and reviews the data of their contacts to gauge the possibility of infection for each person. Those at a high risk of infection will be sent an alert through the app with the necessary precautions that they would need to take [12].

Switzerland is the first country in the world to use Google's and Apple's APIs in its contact tracing application, the SwissCovid app. It uses Bluetooth beaconing technology - when two devices are close to each other, they exchange private keys through random beacons. If a user turns COVID-positive, they can anonymously inform other users about the diagnosis through the app. The other users can then check if they were in contact with an infected patient, with the app able to inform users if they have spent more than 15 minutes within a 2-meter radius from a COVID-19 patient [13].

Each of the above three apps is voluntary to download and collects only as much data as it requires for contact tracing. However, the NHS COVID-19 app does not have any limitations on how the user's data can be used, i.e., it could potentially use the data for purposes other than healthcare, like law enforcement [7]. These apps are also transparent in terms of their design; for e.g., the SwissCovid app is open-sourced, and therefore, can be accessed by the public [13]. Bluetooth-based applications have brought out challenges that need to be addressed. The experience with contact tracing in Singapore has shown that there is a possibility of the app producing false positives [11]. This would result in government officials wasting their time and precious resources on somebody who has not actually contracted the virus, and that person would also have to deal with the social implications of being termed as COVID-positive. Although there are obvious advantages to the apps, such as their non-invasive nature, their success depends on how many citizens download the app. The apps may also face issues with noting encounters between phones with different operating systems (for e.g., iOS and Android) [8].

3.1.2 Apps that use location tracking

Some applications use GPS or cell phone towers to track the movements of a user and identify other people who might have come in contact with that user.

Since then, Israel's Health Ministry has launched an application called Hamagen (The Shield), which detects if, in the past 14 days, a user was near anybody who had caught the virus. The installed app keeps track of the user's movements and compares the procured GPS history with the Health Ministry's stored data on the geographical locations of the patients [14,15]. The information regarding the app user's movements would be stored on the user's smartphone, with that information being constantly updated. If the app finds that the user happened to be in the same vicinity as a diagnosed patient and at the same time, it links the user to the Health Ministry website for information on self-isolation and the next steps for that user [14].

The local government in China launched the Alipay Health Code, first introduced in Hangzhou, with the aid of Alibaba's affiliate company Ant Financial. As part of this system, people in China have to sign up through Ant's wallet application, Alipay. They are assigned a green, yellow or red color code depending on the status of the person. A green color code generally implies that the person can travel freely. A yellow or red color code might possibly be assigned if the user was in contact with an infected person, visited a virus hot zone, or exhibited any of the symptoms linked with COVID-19. The creators of the Alipay Health Code claim that they use big data to conclude if somebody is infected by the virus. The system makes use of information about actual coronavirus cases, as well as data about travel bookings made by individuals. Workers at train stations and outside residential buildings all across China scan people's apps to record critical information about those people, such as their recent travel history. A New York Times article found that when a person's code from the app is scanned at one of these places, their location gets uploaded to that systems server, which could allow authorities to track people [16].

Israel's Hamagen app is voluntary for its citizens to download. It only collects information that is essential for the task at hand, and any data of the user's that is stored on the app is deleted after a certain time period [7]. In contrast to that, China's Alipay Health Code appears to be sharing confidential information with the police, which could be used to establish some amount of social control even after this pandemic is over. The New York Times' analysis found that once a user of the system gives their permission to access their personal data, a server receives the person's private details, which can then be accessed by the police [16]. These details include personal health and travel history that goes beyond the requirements for contact tracing [8,16]. It is mandatory for citizens to use the Alipay Code. Most importantly, people in China have not received any detailed explanations from either Ant Financial or the governments, on how the color code classification works [16]. Whereas in Israel, the methodology of the app including its use of GPS, and its policies have been explained clearly [7,15].

Overall, location tracking is characterized as an invasive approach due to the access afforded to one's location. Another disadvantage of these apps is that the data collected from GPS could be slightly inaccurate in certain scenarios (for e.g., in crowded high-rise buildings) [8].

3.1.3 Apps that use Bluetooth and location tracking

India has produced its own coronavirus tracker application called Aarogya Setu, which marries both technologies - Bluetooth and location data from the app user's phone - to determine the person's proximity from someone who has the coronavirus [17]. In order to use the app, the user is asked a series of questions. In the assessment, the app asks about the person's name, gender, age, travel history and history of cough and fever. It gives the user a designated status of low, moderate or high, based on the user's answers provided to the app during the assessment and their distance from COVID-19 patients nearby, which is calculated based on Bluetooth data, artificial intelligence and algorithms [17,18]. Depending on the user's assigned risk status, the user is directed on the appropriate measures and steps that are needed to be taken [17]. The users are tracked using a social graph created using location data, which can show a user's interactions with every single person that they have come in contact with [18]. The app also contains a chatbot feature and an option to put their names up for volunteering in times of need [18].

It is currently not mandatory for all citizens to download and use this system [17], although certain groups of people have had to download it. For instance, it has been made compulsory for all those living in containment zones to download and activate Aarogya Setu. The data is only preserved on phones for a finite amount of time. The government has also shown a reasonable level of transparency by making the codebase open-source [7,19] On the flip side, the application does collect more data than it needs for the task at hand, and does not have any restrictions on how the information procured by the application could be utilized [7].

3.2 CCTV video analytics

Video analytics software allows us to take in streams of data from CCTV and other types of cameras, and performs real-time analysis on that visual data without the constant supervision of humans. Important analytics capabilities include facial recognition and traffic monitoring [20].

Traces.ai, a startup based in Sunnyvale, California, analyzes videos using several different attributes of a person, except their face, using artificial intelligence. In doing so, Traces overcomes the difficulties linked with using facial recognition. The founders noted that CCTV cameras did not capture the face of a person with much detail, so other attributes are used to identify people. If there is ever a situation where a few employees working at a manufacturing plant contract the virus, the owner of a plant can use CCTV and Traces to identify and isolate those who came in close proximity with the patients, while the rest of the people can continue to perform their duties. When combined with thermal vision, Traces can also monitor people's temperature levels [21].

By eschewing the use of facial features in favor of characteristics such as hairstyles, backpacks and clothing, software like Traces prevent any racial and gender bias that could occur with facial recognition while giving predictions. However, that also creates limitations; Traces faces difficulties with tracking people over a long period of time, since people's clothing items would change daily [22]. Thus, Traces works best as a short-term solution [21,22].

3.3 Digital systems

Digital systems use QR codes and barcodes from ID cards to record people's arrival and departure times to facilitate automated contact tracing. The Singapore government has also recently rolled out SafeEntry, a digital system that has been deployed at places where people are likely to be near one another. These places include offices, businesses, supermarkets, schools, and retail outlets. The system records people's arrival and departure times to facilitate automated contact tracing, in a bid to reduce the amount of effort that would otherwise need to be taken by businesses. SafeEntry has now been launched as an app for business owners, with the option of using a handheld barcode scanner. Every time a visitor enters or exits a business location, their ID is scanned via a barcode or QR code on the Business' SafeEntry app. For foreign visitors, their passport details are manually entered. In case the crowd restrictions set by the business for a given day have been exceeded, an alert is sent stating that they are not allowed to enter that day. By checking in and out of offices and other places, people can aid contact tracers in preventing new COVID-19 clusters from forming [23-26].

This system does prove to be cumbersome for people as they need to scan their QR codes every time they enter and leave a facility. Nevertheless, it provides an easy way for the government to gather location information from people, and acts as a good complement to the Bluetooth-based TraceTogether app.

3.4 Online platforms

Online platforms can operate on the metadata stored on people's mobile phones, and monitor every part of the country in blocks of certain square meters. The government of South Africa has deployed Channel SQREEM, an online platform system for AI contact tracing to counter the COVID-19 pandemic. Once a person is found to be positive for COVID-19, the platform applies AI and machine learning (ML) models to determine how many other devices were in contact with the infected patient over the past 14 days. The authorities can then send appropriate alerts to each of those devices through SMS and ads, without identifying personal details, thereby maintaining privacy [27-29].

Online platforms are useful as they can be accessed online and usually do not require their users to download an app of any form. However, since the data on the platform could be overseen by the government, one would have to ensure that the mobile phone metadata does not contain any personal information [27-29].

Table 1: Review of the Applications

Applications	***Methodology***	***Examples***
Mobile Applications		
• Bluetooth	Swap data using Bluetooth on mobile phones	TraceTogether, NHS COVID-19, SwissCovid
• Location tracking	Track movements with GPS or cellphone towers	Hamagen, Alipay Health Code
• Bluetooth + location tracking	Combines both technologies	Aarogya Setu

CCTV Video Analytics	Analyze visual data from CCTV footage using AI	Traces.ai
Digital Systems	Scan people's QR codes and barcodes to record locations	SafeEntry
Online Platforms	Use metadata on mobile phones to trace movements	Channel SQREEM

4. Conclusion

Contact tracing has been adopted to various degrees by different nations. Some countries have deployed mobile applications on a large scale, incorporating Bluetooth, location tracking, and artificial intelligence technologies; others have opted for establishing software solutions based on video analytics and machine learning, that work with physical systems. These techniques have a lot of benefits. While it may be too early to see how contact tracing technological solutions have improved our current situation, we should continue to apply vigorous contact tracing.

Companies and authorities that are launching these solutions should also focus on setting and maintaining strict privacy norms. Any obtained data dealing with personal information should only be stored temporarily, and safeguards should be built in to prevent the misuse of any details like video footage and travel history. The best way for the authorities and companies behind the technology involved to establish trust with the people is to be transparent about the inner-workings of each solution, and insert protective measures to prevent an excessive amount of user data from reaching the servers [7,30]. At the same time, the efficiency of the system should not be compromised. An effective solution should be able to use its technology to immediately apprise people of the appropriate actions that they need to take if they are at risk.

Most of the contact tracing solutions that are currently out there do more to prevent others from contracting the virus once you have caught it, rather than help prevent you from getting infected by it. In order to reduce the number of coronavirus infections, the technology built to defeat COVID-19 should take a more proactive stance against the virus, and not just be reactionary in nature. We need to predict where an infected person is likely to go and whom that person might meet. The technology does not need to be completely accurate – it just needs to figure out if there is a possibility of such an event occurring, and accordingly decide if people should be warned about entering a particular area. Big technology companies like Facebook and Google have enough behavioral data on people that can be used to produce technology that can predict people's movements using artificial intelligence. The data from all the applications and platforms introduced for contact tracing can be used along with the streams of data provided by technology companies as training data, to improve the accuracy of the artificial intelligence prediction algorithm, thereby preventing further cases of COVID-19 [9].

Artificial intelligence can also be used in drones and robots to track people and ensure that they are taking adequate safety precautions and maintaining social distancing. The datasets fed to the AI systems should be expansive, as the inclusion of credit card transactions, GPS tracking and temperature monitors can improve the results produced by algorithms for contact tracing [31]. As the threat of coronavirus surges throughout the world, technology and contact tracing together have a huge potential to limit the spread of the disease, and they will remain the best remedies that we have to combat COVID-19 until the development of a vaccine for the virus.

References

[1] Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020;20:533–4

[2] Hui DS, Azhar EI, Madani TA, Ntoumi F, Kock R, Dar O, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health — The latest 2019 novel coronavirus outbreak in Wuhan, China. Int J Infect Dis. 2020;91:264–6

[3] WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. World Health Organization. 2020. Available from: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020/

[4] COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). Johns Hopkins Coronavirus Resource Center. Available from: https://coronavirus.jhu.edu/map.html

[5] McCullough M. Coronavirus math shows the importance of social distancing, and the horrible consequences of not doing it. The Philadelphia Inquirer. 2020 Mar 24. Available from: https://www.inquirer.com/health/coronavirus/coronavirus-wuhan-math-behind-social-distancing-20200324.html

[6] Coldewey D. What is contact tracing? TechCrunch. 2020. Available from:

https://techcrunch.com/2020/04/18/what-is-contract-tracing/

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

[8] Reuters. COVID-19 contact tracing apps: Here is how different countries are taking different approaches-Technology News, Firstpost. Tech2. 2020. Available from: https://www.firstpost.com/tech/news-analysis/covid-19-contact-tracing-apps-here-is-how-different-countries-are-taking-different-approaches-8369731.html

[9] Lopez GHJ. How We Can Use Social Media To Predict COVID Contact Tracing. Becoming Human. 2020 Mar27. Available from: https://becominghuman.ai/how-we-can-use-social-media-to-predict-covid-contact-tracing-88ea86bd5f53

[10] Hui M. Singapore wants all its citizens to download contact tracing apps to fight the coronavirus. Quartz. 2020. Available from: https://qz.com/1842200/singapore-wants-everyone-to-download-covid-19-contact-tracing-apps/

[11] Sookman BB. COVID-19 and privacy: artificial intelligence and contact tracing in combatting the pandemic. 2020. Available from: https://www.lexology.com/library/detail.aspx?g=0d657003-bccc-44c1-8bb9-351ab28b3d04

[12] Chowdhury H, Field M, Murphy M. NHS track and trace app: how will it work and when can you download it? . The Daily Telegraph. 2020. Available from: https://www.telegraph.co.uk/technology/2020/06/13/nhs-app-trace-track-coronavirus-download/

[13] Schmid F. Swiss tracing app goes on trial. ETH Zurich. 2020. Available from: https://ethz.ch/en/news-and-events/eth-news/news/2020/05/swiss-covid-app.html

[14] Winer S. Health Ministry launches phone app to help prevent spread of coronavirus. The Times of Israel. 2020Mar23. Available from: https://www.timesofisrael.com/health-ministry-launches-phone-app-to-help-prevent-spread-of-coronavirus/

[15] HaMagen - The Ministry of Health App for Fighting the Spread of Coronavirus. gov.il. Available from: https://govextra.gov.il/ministry-of-health/hamagen-app/download-en/

[16] Mozur P, Zhong R, Krolik A. In Coronavirus Fight, China Gives Citizens a Color Code, With Red Flags. The New York Times. 2020Mar1. Available from: https://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html

[17] Garg S, Bhatnagar N, Gangadharan N. A Case for Participatory Disease Surveillance of the COVID-19 Pandemic in India. JMIR Public Health and Surveillance. 2020;6:e18795.

[18] How to use Aarogya Setu app and find out if you have coronavirus symptoms. The Economic Times. 2020Apr15. Available from: https://economictimes.indiatimes.com/tech/software/how-to-use-aarogya-setu-app-and-find-out-if-you-have-covid-19-symptoms/articleshow/75023152.cms

[19] Patra I. Aarogya Setu app is now open source: what does it mean? The Hindu. 2020May27. Available from: https://www.thehindu.com/sci-tech/technology/aarogya-setu-app-is-now-open-source-what-does-it-mean/article31689459.ece#:~:text=Aarogya%20Setu%2C%20India's%20coronavirus%20

[20] Millman R. CCTV Software: a General Guide for Security Professionals. IFSEC Global | Security and Fire News and Resources. 2017. Available from: https://www.ifsecglobal.com/video-surveillance/cctv-software-a-general-guide-for-security-professionals/

[21] Guttman A. This Startup Is Using AI To Trace COVID-19 Patient Contacts At Risk. Forbes. 2020Mar31. Available from: https://www.forbes.com/sites/amyguttman/2020/03/31/this-startup-is-using-ai-to-trace-covid-19-patient-contacts-at-risk/#6b57caba44ab

[22] Weiss E. Traces AI Introduces an Alternative to Face-Based Surveillance. Mobile ID World. 2019. Available from: https://mobileidworld.com/traces-ai-introduces-alternative-face-based-surveillance-081603

[23] COVID-19: SafeEntry digital check-in system deployed to more than 16,000 venues. CNA. 2020. Available from: https://www.channelnewsasia.com/news/singapore/covid-19-safe-entry-digital-checkin-deployed-16000-venues-12717392

[24] SafeEntry for Business. SafeEntry. Available from: https://www.safeentry.gov.sg/downloads/SafeEntry-for-Business-User-Guide-v1.0.2.1.pdf

[25] National digital check-in system. SafeEntry. Available from: https://www.safeentry.gov.sg/

[26] National digital check-in system. SafeEntry. Available from: https://www.safeentry.gov.sg/individual_help

[27] Kumar V. Tackling COVID-19: The Technology behind Contact Tracing. GreatLearning. 2020. Available from: https://www.mygreatlearning.com/blog/covid-contact-tracing/

[28] AIT News Desk. Tracing a Million Steps: SQREEM Launches AI-Driven Contact Tracing and Communications Platform to Fight COVID-19. AiThority. 2020. Available from: https://www.aithority.com/technology/analytics/tracing-a-million-steps-sqreem-launches-ai-driven-contact-tracing-and-communications-platform-to-fight-covid-19/

[29] DiBiasio J. A.I. shop goes from tracing Covid-19 to virtual banking. DigFin. 2020. Available from: https://www.digfingroup.com/sqreem-covid/

[30] Cho H, Ippolito D, Yu YW. Contact tracing mobile apps for COVID-19: Privacy considerations and related trade-offs. arXiv preprint arXiv:2003.11511. 2020.

[31] Greenman S. How governments can build trust in AI while fighting COVID-19. World Economic Forum. 2020. Available from:

https://www.weforum.org/agenda/2020/04/governments-must-build-trust-in-ai-to-fight-covid-19-here-s-how-they-can-do-it/

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