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Review Article

COVID-19: digital contact tracing technologies and ethical challenges

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ABSTRACT

Digital contact tracing technologies (DCTT) are used in public health surveillance to support rapid reporting, data management and analysis with the intention to improve the efficacy of the health system. One form DCTT that has been receiving attention in many countries facing COVID-19 epidemics is proximity tracking. Globally 47 contact tracing apps are available and for maximally effective for contact identification it should be adopted by 60-75% of a country's population. But no country could achieve this in near future. Even with no proven efficacy for controlling the present pandemic and it has been deployed in several countries at unprecedented swiftness and in an unregulated environment. From a public health perspective, the essentiality of DCTT can be approved only if it is proved to be necessary, proportionate and sufficiently effective. Any public health measure is ethically correct, if it provides sufficient public health benefit to justify the burdens associated with it. In this context global health experts like WHO, Johns Hopikins university and Oxford university released recommendations on ethics and governance on the use of DCTT. Based on this principle a public health ethical review was done using available literature. Currently, there are no established methods for assessing the effectiveness of digital proximity tracking. More research to evaluate their effectiveness is needed. Governments, developers must ensure that COVID-19 contact- tracing apps satisfactorily address the ethical questions and must ensure the necessary but least intrusive measures for disease surveillance.

Keywords: COVID-19, Contact tracing, Digital contact tracing technologies, Ethical issues, Public health

INTRODUCTION

Early identification of cases and their close contacts are key in suppressing transmission of infectious diseases. Successful efforts in epidemic detection and control demand a strong leadership of the national public health institutions, an efficient policy and a determined political leadership and support.[1,2] In the present COVID-19 pandemic, with no effective pharmacological intervention or vaccines available, prevention depended on non-pharmacological measures like contact tracing, quarantine or isolations as the only methods to control the disease.[3,4]

As asymptomatic patients constitute up to 80% of people who acquire infection, and since they are speculated to be as contagious as those who have symptoms, it is critical to identify close contacts of COVID-19 patients and to implement effective self-isolation and quarantine.[1] Along with social distancing, massive efforts in contact tracing have paid off in containing the COVID-19 pandemic in the China.[1]

Contact tracing is the process of identifying, assessing and managing people who have been exposed to a disease to prevent onward transmission. When systematically

applied it will break the chains of transmission and thus act as an essential public health tool for controlling out breaks.[4] Manual contact tracing (MCT) has been used till date, which involves collecting information from people who have tested positive and their contacts which include collection of personal information and data about the places they have been to and the people they have had contact with. MCT efforts use these data to uncover ongoing transmission, provide useful information tailored to the individual, and enable isolation and quarantine, as necessary.[5]

Digital technologies, including the use of artificial intelligence is being used in surveillance in addition to human resources. Digital contact tracing technologies (DCTT) are used in public health surveillance to support rapid reporting, data management and analysis in many countries with the intention to improve the efficacy of the health system.[6-8] The Ebola and Zika virus epidemics have shown the utility of mobile health (mHealth) applications (apps).[8-10] One form of digital technology for surveillance that has been receiving attention in many countries facing COVID-19 epidemics is proximity tracking, a new tool for contact tracing. It measures signal strength to determine whether two devices e.g. smartphones were close enough together for their users to spread the virus from an infected person to an uninfected person. If one user is infected, others who have been identified as within proximity of the other person can be notified, and thereby take appropriate steps to reduce health risks to themselves and others.[11] Once they are installed on a cell phone, they can alert the person if they have spent time near someone who was tested positive with the virus. The individual can then take appropriate measures such as self-isolation depending on the local guidelines of the country. Corresponding to the incubation period of COVID-19 prompt alerts are given up to two weeks.[8] Furthermore, data generated by DCTT could be useful for researchers to prepare for future COVID-19 outbreaks and to assist general preparedness for future epidemics and pandemics.[5] Singapore and Israel have shared their app source code with researchers.[13] The DCTT, like SARS CoV-2 virus, is a new tool in public health with no proven efficacy. It has been deployed in several countries at unprecedented swiftness and in an unregulated environment.[4,5,12] In this context, a public health ethical review was done using available literature.

RELEVANT DIFFERENCES BETWEEN MCT AND DCTT

The pros and cons of both manual and digital contact tracing are summarized below. There is a significant amount of evidence regarding the effectiveness of manual contact tracing (MCT).[5] DCTT, being a novel technology lacks compelling supportive evidence. DCTT interact with all users regardless of circumstances, meanwhile MCT only involves individuals who are confirmed or suspected to have the virus and not the general public. MCT functions through human-to-human interactions with an opportunity to clarify doubts, misconceptions, address concerns and express sympathy. DCTT could potentially communicate to a certain extent, but lacks other human capabilities and characteristics. MCT's are with fewer intermediaries and fewer entities handling data so privacy can be maintained. Whereas there are several intermediaries in DCTT like the mobile network operators and technology developers. There is also connected with relevant data continuously so any problems can identify and improve it timely and functionally. In these contexts, DCTT has been proposed as a potential compliment rather than a replacement for MCT.[4,5] Because DCTTs are so new, very little is known about their actual utility to public health authorities for controlling the present pandemic. Although multiple countries that have had success in greatly reducing transmission of SARS-CoV-2 have included DCTT in their response, these countries have employed multiple simultaneous approaches to controlling the virus, including MCT and it is difficult to disentangle what made those responses successful.[5,12]

Both have got its own limitations.[13] Historically, limitations of MCT's are well known. It is very resource intensive and has feasibility, accessibility issues. A white paper on the limitations of DCTT was recently published and it includes the following information.[14] This technology cannot capture all the situations in which a user may acquire COVID-19, and it cannot replace traditional MCT in public health or outreach which is usually done over the phone or face to face. DCTT applications can only be effective in terms of providing data to help with the COVID-19 response when they are fully integrated into an existing public health system and national pandemic response. Such a system would need to include health services personnel, testing services and the MCT infrastructure.[4,13] Thus, in the present scenario, digital proximity tracking applications could play a useful role in supporting contact tracing for COVID-19. A report from Iceland, a country with the highest public download rate of any DCTT app thus far, suggests that DCTT, compared with methods of MCT , such as phone calls was more effective in control of COVID-19.[5] But currently, there are no established methods for assessing the effectiveness of digital proximity tracking.[4,13] However, with time and by the use of artificial intelligence (AI), it is possible that the technology could overcome the differences and may replace MCT.[5] More research to evaluate their effectiveness is needed and, ultimately, robust methodologies need to be developed for this purpose. If such technologies do not prove effective against COVID-19, then the technology should be phased out.[4]

COVID-19 DCTT: GLOBAL STANDARDS

COVID-19 DCTT apps have been inspired by the experiences of South Korea and Singapore. The former is regarded as a model as the authorities in Korea claimed

that it avoided severe lockdowns.[12,15] As of May, 47 contact tracing apps are available globally.[12] WHO was used to classify the app functions under the categories of the clients (general public), health workers, health system managers and data services.[16] Despite the pandemic's global nature, countries are developing apps independently, and there are no global standards. Like any health-care intervention, coronavirus apps need to conform to the highest standards of safety and efficacy.[8,15] Even if a digital proximity tracking application works in one country, these technologies may only be effective in other countries with sufficient technological infrastructure and safeguards to ensure ethical use. First, a country must already have widespread diffusion of smartphones or other appropriate devices and internet access. Recent studies have estimated that a digital proximity tracking technology should be adopted by 60-75% of a country's population to be maximally effective for contact identification.[13,16,17] For uniform use for all countries, enabling environment for the use of DCTT need to develop a uniform global standard and technologies acceptable to all.[4]

COVID-19 DCTT IN DIFFERENT COUNTRIES

South Korea: Corona 100m app shares location and time to authorities along with CCTV to monitor their movements. Route taken by the infected patients will be published online.[12,18]

Singapore: Trace together app requires users to check in to public places using their national identity card or by scanning a QR code with their phone. Only 20% of the population of Singapore have it which means that in any encounter between two randomly chosen people, there is only a 4% chance that both will have the app.[12,15,19]

India: Aarogya Setu app which uses a phone's Bluetooth and location data and lets users know if they have been near a person with COVID-19 by scanning a database of known cases of infection in 500 meters proximity. The calculated risk is then shared with the government.[20]

China: Alipay health code app assigns a digital QR code to each user, which is color-coded red, amber or green to indicate that person's quarantine status and thus their ability to move around.[12,19]

Hong Kong: People quarantined must wear an electronic bracelet that shares their location with local authorities through an app.[12,19]

Australia: COVID safe app have had close contact with tests positive for COVID the health officials will be contacted, it is working on centralized mode.[19]

Egypt: COVID app, uses a phone's location services to alert users if they have been near anyone with COVID-19.[19]

Germany: Germany's app will store coronavirus data on individuals' phones test results are sent as alerts to the phone. The app was initially centralized but later decentralized due to protests.[12,19]

Poland: Prote GO app through which citizens in quarantine are required to send geo tagged 'selfies' to the police to prove they are at home.[19]

United Kingdom: NHSX apps works only with iOS devices and incompatible with older android devices ask users to self-report their symptoms.[12,20]

Norway: Smittestopp app relies on the user having a formal diagnostic test. Records indicate only 1.43 million downloads in a population of 5.5 million.[12,19]

Argentina: Ministerio de Salud *app* ask users to self-report their symptoms and direct them to treatment centers.[12]

Italy: Immuni app can be downloaded voluntarily. It sends notification to users when coming in contact with positive persons, its launch was delayed due to protests regarding concerns of privacy breach.[19]

PUBLIC HEALTH AND ETHICAL PERSPECTIVES OF DCTT

As per the WHO guidance report, the effectiveness of DCTT to assist contact tracing remains unknown.[4] The current technological plurality in the absence of robust data exchange mechanisms and coordination, can be detrimental for technology-assisted contact tracing.[13]

From a public health perspective, the essentiality of DCTT can be approved only if it is proved to be necessary, proportionate, sufficiently effective , timely, accurate and popular(acceptable, affordable, accessible) and if it used for prevention but not as a passport permit to work.[12] Proximity indicator of two individuals in DCTT may not be always indicate the infection risk. They may be in the same space physically separated by a thin wall or may be on different floors of the same building. Thus, there are chances of false positivity leading low sensitivity. Similarly, people located in highly dense areas will get high positivity rates. This may create panic and may compel them to remain in quarantine which may adversely affect their job and thereby the economy along with stigmatization and rejection from people in their local neighborhoods.[12,21] A review in Lancet state that in long term consequences following such situations will affect the health-care system that administered the quarantine and the politicians and public health officials who mandated it.[21] Furthermore, people not using the app will not report their proximity or chances of infection increasing chances of higher reporting of false negatives (low specificity) leading to a false sense of safety which poses an increased risk.[12] Some high risk people may use or turn

off the app selectively (e.g. while meeting others) which also leads to false negative reporting. It was reported that the COVID app had elicited a false sense of security or drive demand for COVID testing from Belgium which lead to the suspension.[22]

Equity and fairness in distribution of DCTT will also affect its effectiveness especially in countries reported to have lower use of smartphones and/or erratic access to technology. Here older people, disadvantaged or lower socioeconomic groups are less likely to own smartphones or use old phones without the required capabilities. They are also disproportionally experiencing higher rates of morbidities.[5] Communities with disparities will be hit hardest by the pandemic and will likely not gain as much benefit from DCTT due to lesser access. DCTT is being used by different platforms in various regions which results in incompatibility. To negate this, European countries have adopted a uniform criterion.[23]

Generally, any public health measure is ethically correct, if it provides sufficient public health benefit to justify the burdens associated with it. Key ethical questions concern the features connected with DCTT are whether/what/ how data on individuals should be collected and shared with public health authorities, how to ethically encourage the use of DCTT, what kind of support and equity-promoting measures should accompany the use of DCTT, how to structure the governance and oversight of DCTT.[2-5] Use of this data may threaten fundamental human rights and liberties during and after COVID-19 pandemic. There is also a broader concern that the private companies, through their service platform may capture data with government and share it for commercial purposes or may permanently integrate this application in their products within public health infrastructure. Thus, there is a need for policy, law and oversight mechanism in DCTT.[4] In this context global health experts like Johns Hopikins university and Oxford university released recommendations on ethics and governance on the use of DCTT developed to fight COVID-19.[5,19] To provide guidance factors involved in DCTT to practice ethical, appropriate use following 17 principles have been identified by WHO which has been published in May which will be discussed in the paper.[4]

Time

All measures shall be temporary in nature and limited in scope. Current monitoring and surveillance powers only continue for as long as necessary to address the current pandemic. Measures should be fully withdrawn at the earliest moment after the epidemic has ended locally.[4,12] To the extent technically feasible, any technological system created should be dismantled at the end of the pandemic.[4]

According to this criterion before adopting DCTT the government should state the conditions under which the period of time the identifiable data will be stored, the program will be terminated as per the 'sunset clause' in advance.[5]

Testing and evaluation

Every effort should be made to test the technologies prior to widespread use to ensure they function as intended, are technically robust, and have no security flaws. The evaluations should be conducted by an independent agency or research body and should be published.[4] Evidence of effectiveness, appropriateness and acceptance should be produced before implementation. Contrary to this, the China has declined to explain the working of DCTT used there.[19]

Proportionality

The gravity of the situation justifies the potential negative impact.[12] Collection and processing of personal data and health data shall be proportionate and provided by law (a) justified by legitimate public health objectives; (b) suitable to achieve the intended goal; (c) necessary; and (d) reasonable and proportionate to the aims pursued.[4] The least intrusive (privacy-preserving) measures should always be preferred for an application's design, including avoiding the use of physical location (geographic position) tracking for digital proximity tracking.[4]

Data minimization

DCTT shall be limited to the minimum necessary amount of data that is needed to achieve the public health objective. Thus, data collection should not require the identity or location data of a user, or a time stamp of a proximity event (though the date of a proximity event may be useful). Data collected, retained and aggregated must be limited in scope.[4] There is uncertainty about the potential harms and benefits of collecting and sharing location data; so mandated use of location is not justifiable. When identifiable location data are made public, personal and private information will be revealed.[5] In South Korea and India DCTT include location mapping, the benefit of which will be that they will fill the memory gaps of people and help to identify other people with them at that location so the contact tracers can reach them to include in the list.[5,19,20] On the flip side, this may intrude on the privacy of a person's activities and possibly impose a taboo on the place where the person contracted COVID.

Use restriction

The sale and use of data for commercial purposes or advertising activities should be strictly prohibited. The sharing of data with government departments, agencies or third parties that are not involved in the public health response like law enforcement or immigration departments should be prohibited.[4,12] Considering the above principles it might be feared that the surveillance capacity in COVID-19 response sets an unwelcome

precedent for future use of personal data so protection must be put in place to prevent "surveillance creep".[3-5] The surveillance technologies/capacities should not be permitted to use beyond public health purposes, beyond the time of pandemic; which are applicable to state and corporate actors.[12,19] Efforts should be made to assure that the data of a particular group (immigrants)/community (religion) will not be misused or made available to those outside public health or future use in another contexts like law or immigration inforcement.[5]

Voluntariness

An individual's decision to download and install DCTT, should be voluntary and informed. Governments should not mandate use of such an application. No individual should be denied services or benefits from either a government or private parties for refusing to use an application, including the right to use health services. An individual should be free to turn off the application at any time and should be free to delete the application at any time, without any consequences.[4,12] DCTT was implemented without explicit voluntary agreement in China, Israel and India.[5,20] In India, it is mandatory to use it for certain areas, government and private employees and it is used by more than 100 million users. In Singapore it is voluntarily used by 20% of the population and in Norway by 30% of the population. In European union, following protests from human right activists, the DCTT has now been made voluntary.[12,19,20] WHO advises that additional incentives or inducements should not be offered to individuals who download and use such an application.[4] Others opined that there is an inherent incentive behind the technology i.e. the promise of more lives saved, faster pandemic recovery, reduction or elimination of blanket physical distancing to be realized.[5] They suggests that small incentives like small monitory token, free or discounted mobile phone service for a period of time, mobile phone credit are ethically acceptable.[5]

Transparency and explain ability

Data collection and processing shall be transparent, and individuals shall be provided with concise and reader-friendly information in clear and unambiguous language regarding the purpose of collection, the types of data collected, how data will be stored and shared, and how long data shall be retained.

There should be full transparency about how the applications and application programming interfaces (APIs) operate, and publication of open source and open access codes.[4,12] Individuals should also be provided with meaningful information about the existence of automated decision-making and how risk predictions are made.[4]

They should be sufficiently informed, which should be done by coordinated public engagement campaigns and there should be a meaning full mechanism for users' consent.[5] Following this principle, India and many countries in the EU have made DCTT an open source.[20,22]

Privacy-preserving data storage

There are differing views as to whether data storage should be decentralized or centralized. A centralized app will collect pseudonymized data from users' phone to a central data base like National health agency where the contacts are matched. Decentralized approach matched contacts on the user's device.[5,13] India, Australia, Singapore and China continue to follow a centralized approach.[8,20] As mandated by EU, Apple and Google are developing a common interface to support apps that do not require central data storage.[12,20] There is an emerging consensus, including opinions issued recently by several data protection authorities, that decentralized approaches enhance privacy, since they provide users with greater control. The collection and use of such data by health authorities can therefore be limited to what is strictly necessary for the operation of a DCTT.[4] Since identification of a COVID-19 positive person could potentially result in stigma and discrimination, data collected must not be made publicly available by including identifying information.[5] The South Korean app uploads the video of persons tested positive online against this principle.[19]

Security

Every effort should be made to ensure high security, including encryption, applications, servers, networks, services involved in collection, transmission, processing and storage. Applications should be subject to third-party audits and penetration testing, and developers should publish full details about their security protocols.[4] Many countries do not seem to be following these measures.[19,20]

Limited retention

Data retention shall be limited to the period of the pandemic response, except for the purposes of research or epidemic planning. Data used for research purposes or epidemic planning should be aggregated and anonymized where possible. Where aggregation of data is not possible for research purposes, such exceptions should be justified, and all such data should still be anonymized. Data collected for public health purposes related to COVID-19 shall be deleted following the pandemic.[4]

Infection reporting

The reporting into a digital proximity tracking application that a user has tested positive for COVID-19 could be done through several channels. In any scenario, notification of the application should require the consent of the individual. In one scenario, a user could self-report an infection to the application. Alternatively, upon a patient being confirmed as positive for COVID-19, a medical professional could notify the digital proximity

tracking application.[4] After notification the system should provide arrangements for testing and treatment facilities.[5,12] Failure to test lead to pausing of DCTT in Belgium.[22] Stigma of users may result from any individual identified COVID positive from neighborhood, area becoming hot spot by many positive people living in that area or having visited that area.[5,12] This false positive reporting may also lead to blaming of a particular group in that area.[5]

Notification

Notification of individuals who may have been in contact with a person infected with COVID-19 could, for example, be delivered directly by an application to close contacts. The notification of other users must preserve the privacy of the infected individual. Users who receive a notification should receive information on the steps they should take. This should be provided in clear, accessible language and explain the options that users have. This information should be provided in several languages and be accessible to people with disabilities.[4] Users should be able to consent as to whether they wish to have the health authorities contact them for follow-up (for e.g. testing), including disclosure of their contact information to the health authorities. A user who has been notified by an application should not be penalized, punished or denied medical services or economic benefits for failing to follow instructions provided by the application.[4,12]

Tracking of COVID-19 positive cases

After an individual who uses a DCTT application tests positive for COVID-19, the application should not be used to track that individual's movements during his or her period of infection and recovery, including who that individual may encounter thereafter.[4] This is in context of purpose of contact tracing, but many countries are not following this principle.[20,22]

Accuracy

Algorithmic models used to process data and assess risk of transmission must be reliable, verified and validated. Such applications should be open to testing by third parties and risk models should be developed with epidemiologists to establish parameters for duration and proximity before a contact is recorded and should be adjusted and improved over time. Data quality should be assessed for biases to avoid any adverse effects, including giving rise to unlawful and arbitrary discrimination.[4] DCTT does not include detailed data as in MCT and may be in accurate as people may enter incorrect information which may affect it's efficacy.[5] If the program is not calibrated well may overly inclusive may create false positive leading to distract public health efforts. Similarly, congregate settings could receive frequent notification s which may result in their in ability to leave quarantine for a long time to be remaining at home.[5] The sensitivity, specificity and positive predictive value of the tool should be evaluated.

Accountability

Individuals must be given the opportunity to know about and challenge any COVID-19 related measures to collect, aggregate, retain and use data. Individuals subjected to unwarranted surveillance must have access to effective remedies and mechanisms of contestation and safe guarded against abuse.[4,5] For this, a cyber data protection law should be formulated in connection with the pandemic.[23,24]

Independent oversight

The knowledge about SARS-CoV 2 and COVID-19 is still evolving and there are crucial gaps in our understanding.[5,25] There should be an independent oversight body established to examine the ethical and human rights aspects, of both the public agencies and the businesses that design, develop and operate DCTT. The existence of agreements between government and business, and information necessary to assess their impact on privacy and human rights, must be publicly disclosed, along with sunset clauses and oversight. Such oversight must ensure that any use of the applications by governments is firewalled from other government functions and, from other business and commercial interests.[4] An oversight body must also have access to all information necessary to ascertain that digital proximity tracking measures are necessary and proportionate to their impact and effectiveness. An oversight body should also monitor the collection and use of data to ensure they are consistent with laws and regulations existing in the country. Finally, the body should remain in place after the end of the pandemic to ensure that any DCTT that have been implemented are fully dismantled.[4,5,12]

Civil society and public engagement

Civil society can play a crucial role in holding governments and companies accountable for the deployment and operation of DCTT. COVID-19 related responses that include data collection efforts should include free, active and meaningful participation of relevant stakeholders, such as experts from the public health sector, civil society organizations, and the most marginalized groups. This participatory approach is not only mandated from an ethics perspective, it will also enhance buy-in, voluntary participation and compliance.[4] It was observed that people are willing to use DCTT when potential benefits are well communicated (e.g. lifting lock downs/community distancing measures), and data transferring , apps distribution by public health agencies rather than tech company or insurer.[5] DCTT should align with local culture and connect with vulnerable populations. Proper information campaigns and human follow-up after issuing app warnings are vital. It is also important to ensure that the media accurately

relays the relevance of the apps. Contact tracing apps should be available and accessible to any one irrespective of technology needed or their level of digital literacy.[8,12,25]

CONCLUSION

The efficacy of contact tracing apps has not yet been proved. Hence, DCTT cannot replace manual contact tracing and other public health measures. The efficacy of such an app is dependent on other factors such as public health measures taken by that country. At the best, it can be a complementary tool in the future. Even in a crisis, a 'try-everything' approach is dangerous when it ignores the real costs, and the opportunity costs of not devoting resources to something more important. With community transmission in all countries it is time to recognize that travel ban and mandatory quarantine alone cannot end the outbreak. Newer and efficient constructive tools are needed.

Ethical preparedness is an important component of the plan for dealing with public health emergencies or outbreaks, because it helps ensure best standards and quality of deliverables without any compromise on human safety and the ethical values. Like any health care intervention, COVID-19 apps need to conform to the highest standard of safety and efficacy along with ethical evaluation. Lack of consideration of ethics could erode trust in the government and public-health services. Governments, developers and deployers must ensure that COVID-19 contact tracing apps satisfactorily address the above ethical questions and governments must ensure the necessary but least intrusive measures for disease surveillance.

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