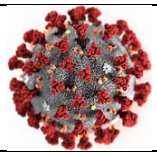
National COVID-19 Science Task Force (NCS-TF)



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Contact person: Marcel Salathé, Viktor von Wyl, Effy Vayena, Edouard Bugnon

Title: Digital Proximity Tracing

Summary of request/problem Proximity tracing (PT) is a novel method to support contact tracing. First mentioned in a previous policy brief on contact tracing, the method has met with considerable interest from the scientific community, policy makers, and the public. This document describes PT in more detail, specifically with respect to the PT app planned in Switzerland.

Executive summary: Contact Tracing is widely regarded as a crucially important method to bring the COVID-19 pandemic under control. Starting from a positive index case, contact tracing allows for the retrospective identification of contacts relevant for the transmission of SARS-CoV-2, which can then undergo precautionary isolation (quarantine). Rapid contact tracing is of particular importance in the COVID-19 pandemic due to the substantial contribution of pre-symptomatic transmission. Fundamentally, the strategy of contact-tracing and quarantining rests on the notion that quarantining can be applied very *precisely*, namely to the contacts of known cases, and thus in a limited fashion, instead of *indiscriminately*, which is the case during a lockdown where the vast majority of the population has to go into quarantine.

Contact tracing (CT) is classically done by trained personnel, thus requiring expertise and resources. At the beginning of the COVID-19 outbreak in Switzerland, person-based contact tracing capacities were quickly overwhelmed almost everywhere. The Swiss lockdown managed to rapidly decrease the daily reported case numbers, and cantons have since been asked by the Federal Office of Public Health to increase their person-based contact tracing capacities in order to deal with new cases during the post-lockdown period.

In the past few months, work has also started on so-called digital proximity tracing. Digital proximity tracing (PT) is the idea to use bluetooth-enabled smartphones (and potentially other bluetooth-enabled devices) to support person-based contact tracing. As mentioned in the policy brief on contact tracing and quarantine (Swiss National COVID-19 Science Taks Force, 2020), “digital proximity tracing uses very different methods from those of person-based classic contact tracing, with different implications for data privacy. Its ultimate goal is to rapidly notify users of possible exposure to an infected person whom they may not know personally. Person-based contact tracing and digital proximity tracing are complementary methods that work together to improve the effectiveness of a contact tracing strategy that contributes to SARS-CoV-2 prevention and control.”

In this document, we outline the basic functionality of the digital proximity tracing app to be deployed in Switzerland (in here referred to as the Swiss PT App, or PT app, as a final name has not yet been officially announced), and address common questions and concerns. As the PT app development is ongoing, the writing reflects the situation on the publication of this policy brief.

The Swiss Proximity Tracing Model

The Federal Office of Public Health has committed to the use of a decentralized PT system, based on the DP3T protocol (Decentralized Privacy-Preserving Proximity Tracing). The protocol has been described in detail elsewhere (Troncoso et al. 2020), but briefly, phones with the app installed send and receive signals via low-energy bluetooth (BLE). These signals, which contain ephemeral identifiers, are then recorded on the phones. When a user is diagnosed as being infected with SARS-CoV-2, the health authorities provide a code to the user that she can use to voluntarily upload non-personal data to a central server. The nature of the data does not allow the server to identify the user. Apps regularly request such data from the central server in order to locally - i.e. on their phone - compute whether they have in the past been exposed to an infected person. If exposure has occurred, the user is notified, and asked to voluntarily contact the health authorities through a hotline (Figure 1).

This model is called *decentralized* because the key information - whether or not a user A has been in contact with a positively diagnosed user B during a time window in which transmissions could have occurred - is not done on a central server, but only on the phone of user A. Because no personal information is shared, and because the central server has no information about individuals, it is wrong to speak of surveillance in the context of this app. The app simply notifies users of exposure.

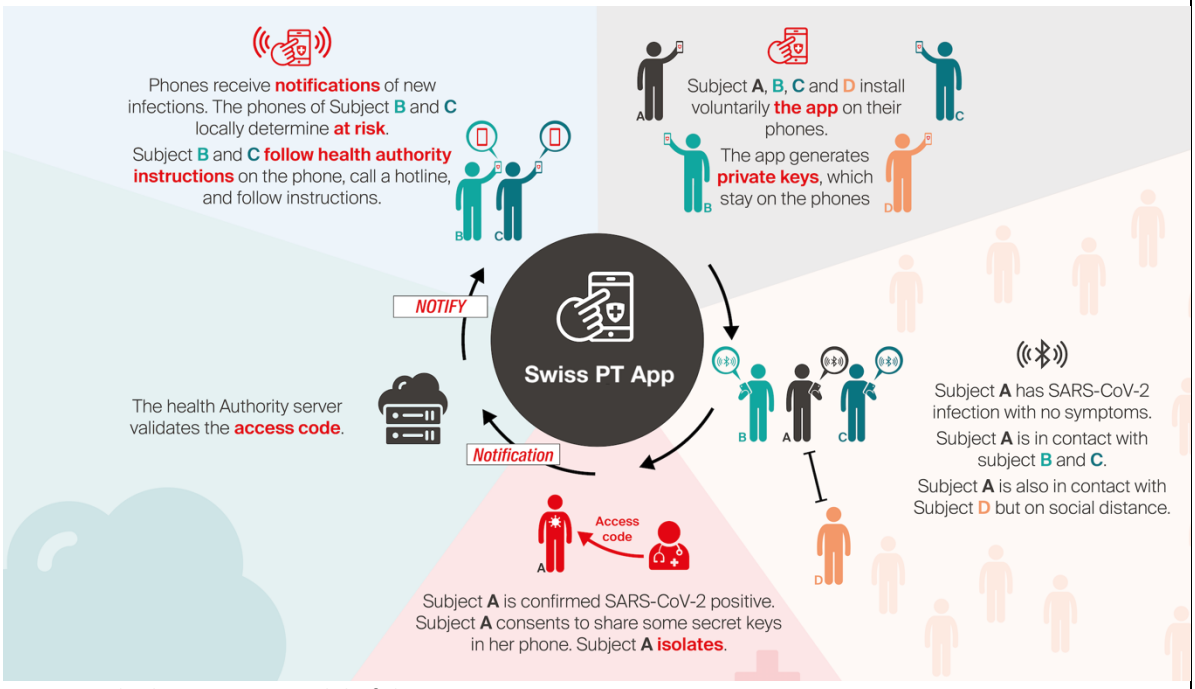

Figure 1. The basic usage model of the Swiss PT app.

Key premises of the Swiss PT app

1. **The use of the Swiss PT app should be entirely voluntary.**There is a very broad agreement in Switzerland that it should be entirely voluntary to install the app, to activate and use the app, to report any positive test results, or to respond to an exposure notification and call the recommended hotline. Nevertheless, the effect of the PT app on preventing transmission chains rests on following the recommended actions in case of a positive COVID-19 test result or receiving the exposure notification.

2. **The Swiss PT app communicates with nearby devices that also have the app installed, but it gathers no personal information about their owners.** The only information that is exchanged between users of the PT app is an ephemeral unique ID that changes frequently and is unrevealing with respect to a user's identity. The app does not access or exchange any data on a user's smartphone. In particular, the app does not use, store or transmit a user's location via GPS.

3. **The Swiss PT app does not upload any data without explicit permission by the user.** There is only one situation when data will be uploaded to a central server: if a person receives a positive COVID-19 diagnosis, and decides to voluntarily share this information anonymously with other users. In this case, the user receives a code that she can enter into the app, which triggers the upload of the user's regularly generated keys from the time period in which the user is assumed to have been contagious - calculated based on the onset of symptoms - to the server. No other data are ever uploaded, and the user's identity remains unknown in this process. Importantly, no data collected from phones in close proximity - i.e. from contacts - are ever uploaded.

4. **The Swiss PT app only downloads lists of keys from people who were tested positive for COVID-19 and who voluntarily triggered the data upload.** The PT app regularly accesses a central server to compare new keys associated with COVID-19 index cases (which are not revealing of a person's identity) to its own records.

5. **The information whether a user has been in contact with a contagious index case can only be made on the phone, not on the central server.** The central server has no knowledge of whether a person was in contact with an index case. All contact matching is done in a decentralized fashion on a users' device.

6. **The PT app is an early warning tool.** The only data that are exchanged between phones are encrypted, ephemeral IDs. The decentralized approach integrates privacy by design. If a person's smartphone is stolen, there is no way to retrace this person's contact network or the locations visited during the past days. Because no personal data is collected, and no personal data is stored on a central server, it is wrong to link the PT app to surveillance. Indeed, preventing surveillance was the original goal of the DP3T protocol design on which the Swiss PT app is based.

7. **Data will be regulary deleted.** All data will be regularly deleted. The phone deletes any collected data older than a few weeks (as it has gotten irrelevant for exposure notification due the latency period and the time period of being infectious). Data on the server will be deleted regularly.

Epidemiological goals of the Swiss PT app

Person-based contact tracing is at heart of the Swiss contact tracing strategy. The Swiss PT app will support this strategy in two ways. First, it will notify contacts of exposure that may otherwise be missed during person-based contact tracing (e.g. longer close proximity contacts with strangers in public transport). In other words, PT is able to notify exposed contacts who were simply in physical proximity of an index case, but without the social connection that traditional CT - based on recall - requires, thus contributing to a more thorough coverage of contact tracing. Second, the app can notify exposed contacts very rapidly, substantially reducing the delay between diagnosis of the index case and quarantine of the contacts compared with traditional CT.

As indicated in the policy brief on contact tracing, the success of a contact tracing strategy stands and falls with a system's ability to properly and rapidly identify index cases. This is also true for the PT system, as the Swiss PT app will only notify contacts of exposure following the entering of a code, provided by the healthcare system following a positive PCR test result. Thus, broad testing availability and testing uptake is essential for the PT system to maximize its potential impact.

It is important to note that there is no hard threshold with respect to the number of PT app users for the system to be useful. While early work in this area (Ferretti et al., 2020) has shown that about 60% of the population using a PT app can be sufficient on its own to bring R below 1, later work has clarified that *any percentage* of usage will contribute to mitigation efforts.

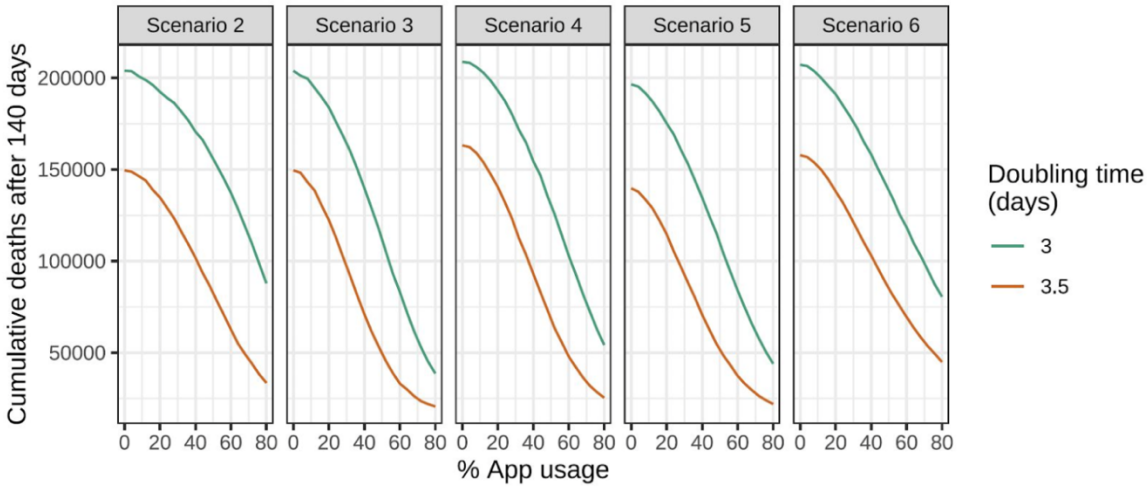

Figure 2: Effect of app usage on cumulative deaths in different scenarios, based on a UK model published by Hinch et al. 2020.

Speed is of essence in the response to the COVID-19 pandemic. SARS-CoV-2 has several biological characteristics that make its containment harder than the containment of other infectious agents. The latency period can be very short, i.e. contagion can occur already a few days after infection. Unfortunately, symptom onset often occurs a few days *after* a person has become contagious. Multiple studies indicate that presymptomatic transmissions 1-3 days before symptom onset are thought to be responsible for about half of all transmissions (see e.g. He et al. 2020).

Due to such substantial presymptomatic transmission, isolating only symptomatic individuals is likely insufficient for outbreak control, as it will not be able to prevent presymptomatic transmission (Figure 3).

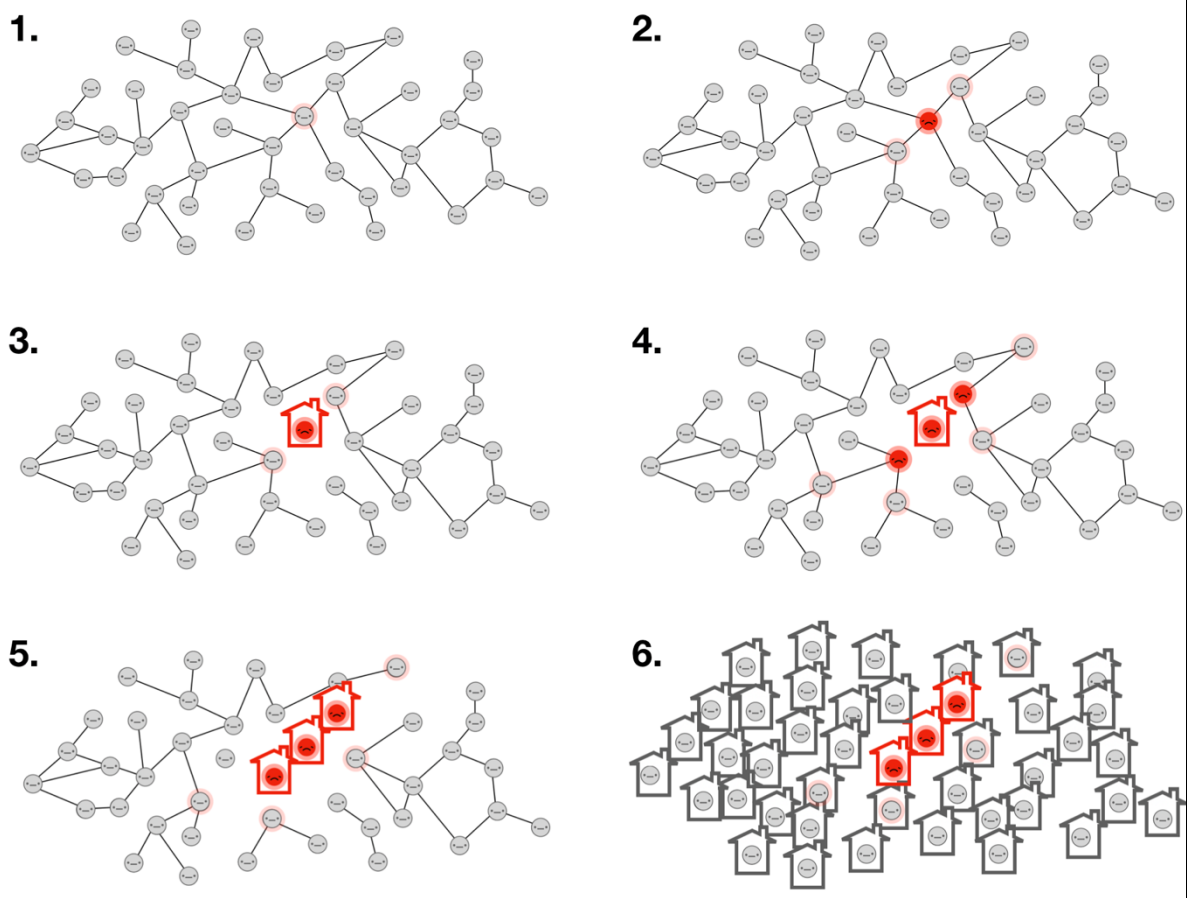

Figure 3. Testing and Isolation alone cannot prevent presymptomatic transmission. 1) An infected individual is contagious (illustrated by a red halo), but does not yet experience symptoms. 2) Once the individual develops symptoms, it may already have infected some of its contacts (they may not yet be contagious, but for illustrative purposes, they're shown as such). 3) Isolating the symptomatic individual is important in order to prevent ongoing transmission from that individual. However, the infected contacts may continue to spread the virus. 4) Once the contacts of the first infected individual become symptomatic, they will also be asked to isolate. 5) Ongoing pre-symptomatic transmission will again be missed. 6) Eventually, the case numbers may again spiral out of control, and in the worst case, a population-wide quarantine ("lockdown") is established in order to prevent transmission.

To achieve the goal of preventing presymptomatic transmission, testing and isolation should be combined with contact tracing, and the quarantining (i.e. precautionary isolation) of identified contacts (Salathé et al. 2020), a strategy known as Test-Trace-Isolate-Quarantine (TTIQ). Importantly, a contact person notified of a potentially relevant exposure to a known case should be encouraged to go into quarantine, even if the person is not (yet) symptomatic (Figure 4).

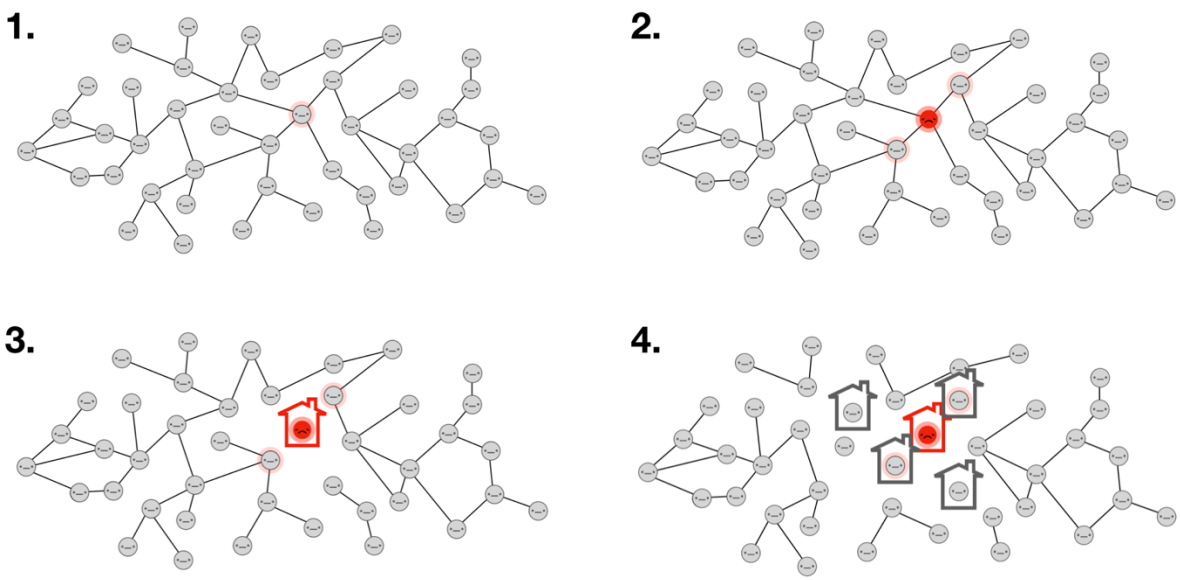

Figure 4. Test-Trace-Isolate-Quarantine (TTIQ) can prevent presymptomatic transmission. Panels 1 to 3 as in Figure 3 above. 4) Rapid quarantining of the contacts - i.e. reducing the time duration of the situation depicted in panel 3 as much as possible - will prevent ongoing presymptomatic transmission.

False positives

A so-called "false positive" denotes a result indicating the presence of a certain condition, when in reality the condition is not present. In the context of digital proximity tracing, it is essential to differentiate between multiple types of false positives.

The first type of false positive is with respect to the presence of an infection following exposure from an index case. These false positives are thus contacts that, despite being exposed to an index case, did not get infected. It is important to realize that this is a very common phenomenon in contact tracing generally, and in COVID-19-related contact tracing in particular. The majority of contacts identified through traditional, person-based contact tracing do not develop symptoms. In epidemiological literature, the fraction of contacts that get infected, following exposure to an index case, is called the secondary attack rate. Multiple studies have shown that the secondary attack rate is typically in the single digit percentages (e.g. Bi et al. 2020,). In other words, the vast majority of people identified as contacts of an index case through traditional, person-based contact tracing, will not have been infected by the index case.

The second type of false positive is with respect to the presence of an epidemiologically defined contact; that is recording a contact according to a defined contact definition, when in reality, there was no such contact. Definitions of close contacts vary (see the policy brief on contact tracing), but the Swiss Federal Office of Public Health currently considers a contact to be at less than 2 meters distance for period of at least 15 minutes, in line with guidance from the ECDC. Thus, exposure to an infected person at this distance and time is expected to be strong enough to be considered a contact, and thus to warrant quarantine. As PT uses Bluetooth signal attenuation to estimate distance, there is a concern that PT could lead to many false positives with respect to the presence of an epidemiologically defined contact (e.g. less than 2 meters for at least 15 minutes[1]). This rate of false positives will depend on the algorithm that maps attenuation data received from the Exposure Notification API available on Android and iOS to a risk score that warrants triggering a notification on the phone. Experimental work is ongoing to parameterize this algorithm in such a way that the false positive rate is acceptable. The algorithm will be continuously refined and systematically assessed in accompanying research.

A particular concern with respect to the second type of false positives is that a Bluetooth-based PT app could register a contact when there is a clear physical separation (e.g. a wall, a plexiglass barrier, or a N95 mask) that will prevent infection. Thin barriers like plexiglass or protective masks are indeed impossible to detect as they will not measurable attenuate the Bluetooth signal. In these conditions, PT app users can temporarily turn off the tracing in the app during the time periods in which they are certain that no infection can occur. Walls typically attenuate the signal strength enough for the system to avoid registering room-to-room contacts across walls.

Follow up after an exposure notification through PT

PT users who receive an exposure notification are advised to call a hotline number of the Federal Office of Public Health. The purpose of this call is to perform a more detailed risk assessment if possible, to advise about appropriate next steps, and to forward the person to the cantonal health authorities that are doing the traditional, person-based contact tracing.

As indicated in the policy brief on contact tracing, from the epidemiological perspective, contacts should undergo quarantine. Quarantine is the ultimate goal of contact tracing. Any disincentive to undergo quarantine (social, economical, or otherwise) directly weakens the epidemiological effect of contact tracing. Thus, appropriate quarantine management - i.e. testing, continued salary during quarantine, possibility to go elsewhere in case of cohabitation with risk groups, regular interaction and counselling during quarantine, etc.) will be crucial in order to maintain compliance, even if the quarantined person remains non-symptomatic. For research purposes on the effectiveness of PT, it is essential that

[1] https://www.bag.admin.ch/bag/de/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/information-fuer-die-aerzteschaft/schutzmassnahmen.html

quarantine management knows how the person entered quarantine (person-based contact tracing, PT, or both - see also below).

The way forward: Assessing effectiveness of PT

In its initial version, the PT app - and the general concept of handling exposure notification and the following quarantine management - will need to work with some assumptions (e.g. regarding distance and duration of a contact) that are based on traditional contact tracing, but nevertheless remain untested as of now. It is therefore important to monitor the effectiveness of PT over time and to optimize it, if necessary. But due to the privacy-by-design approach of the PT app, it needs to be emphasized that such monitoring will intentionally not be possible using data from the app itself.

The privacy-preserving design of the underlying protocol of the PT app (DP3T) requires that a feasible plan and resources for accompanying research will have to be put in place. This research program should prioritize (but not be limited to) three questions.

1. *How many people who receive an exposure notification due to proximity tracing are also contacted by person-based contact tracing, i.e. what is the overlap between the two methods? And which method captures exposed contacts sooner?*

   Knowing the overlap and timing of contacts reached by person-based contact tracing and PT is indicative of whether PT generally fulfills its main function: to warn people earlier.

2. *How many people with contact to an index case (as determined by person-based contact tracing and/or PT) will test positive of COVID-19 or develop symptoms while in quarantine?*

   Knowing the attack rate of PT, and how it compares to person-based contact tracing, is ultimately crucial for social acceptance of the PT app, and a very important parameter to inform the eventual optimization of the PT algorithm. Research on those questions will also yield indications about the effectiveness of PT. It is essential that those organizations that manage the quarantine record whether a person has entered the quarantine through person-based contact tracing, PT, or both.

3. *How effective is PT in addition to person-based contact tracing in preventing transmission when compared to person-based contact tracing alone?*

   This question can only be addressed at the population level (which may not allow causal interpretations). Nevertheless, by studying infection and mortality data in relation to PT app uptake in a given region may yield indications whether PT app use is i) widely accepted, and ii) whether it ultimately has a protective effect for groups at risk for hospitalizations or death due to COVID-19 by improved containment of the epidemic.

To address these questions, existing data from different sources will need to be pooled (e.g. from federal statistics, cantonal health directorates, data from person-based contact tracing, etc.), and new data will need to be collected (e.g. representative surveys regarding the use of the PT app in Switzerland, stratified by demographics). Of note, the only information available from the PT system will be the daily number of hotline calls due to the exposure notifications.

Voluntary Use

As outlined above, voluntary use is a basic premise on which the Swiss PT app is based. Several reasons make voluntariness the appropriate choice.

First, digital technologies, like other technologies, ought to respect individual autonomy, and specifically informational autonomy. Although in the context of public health emergencies, some temporary limitations of individual freedom may be justified, this should only happen when there is a reasonable expectation of tangible health care benefit. PT apps are novel technologies that are being developed and tried out for the first time. There is still limited, if any evidence, of their effectiveness and therefore the risks they may carry in terms of privacy, false positives/negatives, perception of social surveillance etc. cannot not be clearly calculated.

Second, there is broad agreement that voluntary use of a technology can enhance public acceptance and trust. It is important to note that the recent history of data misuses by certain companies and others have left societies with concerns about their privacy and potential risks to individuals and social institutions. As data companies are collaborating closely with states for the development of PT programs, allowing people the option to use or not digital tools is critical. Currently polling of the population suggests willingness to use a PT app. Sustaining and improving the willingness of people to use the app will depend on several factors including the terms of use, transparency and effectiveness. Despite the commitment by the state to offer such an app on a voluntary basis, there is the possibility that organizations or closed communities may demand the use of the app from their members or for access to their services / premises on a non-voluntary basis. Organizations may for instance argue that they mandate the use of the app in order to protect their employees and by extension the viability of their business. This can lead to individuals having no option but using an app that they did not intend to use. These situations erode voluntariness and risk to put people in front of dilemmas that make them feel coerced. Furthermore, in case individuals do not comply they may be prevented from accessing certain goods or important services. If organisations consider mandatory use for these reasons, they should carefully weigh them against the risk of creating hostility against the use of the app, employees' fear of working under surveillance and the negative consequences in job satisfaction and performance. Implications of such consequences can be detrimental to the public's trust and overall the acceptance of PT

Independent oversight

As a novel digital public health measure, the PT system should be subject to independent oversight. The evolving efficacy of such a system, data security, the involvement of state and non-state actors, the consequences (intended, or not) on individual and public life need to be monitored closely. Furthermore, adjustment should be made to ensure the PT system is well integrated in the broader response strategy and continues to meet the ethical standards included these articulated by the National Advisory Commission on Biomedical Ethics[2]. The function of an independent oversight body should include beyond review and monitoring the power to set stopping rules for the PT system. The mandate and composition of an oversight body should be transparent.

Public engagement

In many countries including Switzerland, publics are polled by academics and governments to ascertain willingness to use PT apps. While polls can be informative, they play only a small part in engaging the public to a novel public health intervention. In times of crisis and under time pressure, it is difficult to develop fully fledged public engagement activities. However, engaging the public remains critical and has to be done. This can be achieved by creating opportunities for civil society to weigh in at the different stages of the development of the PT program and its relation to the contact tracing strategy; by activities that allow citizens to express their concerns or ideas about such measures and when possible to deliberate. Although in the early days of the epidemic and at the beginning of lockdowns measures were introduced without public engagement being a priority, these measures had an expiration date. As we are moving to a phase where citizens will be asked to live with certain measures (such as PT and person-based contact tracing) for an undetermined period of time it is critical to ensure that they have a saying in how this is going to be done, or at least that they can express their concerns are addressed. Engaging with the public should become an ongoing activity. It is important for public trust, it can improve the suitability of the approach taken and the overall efficacy of PT.

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