Ethics of digital contact tracing apps for the Covid-19 pandemic response

Summary

- There is a growing interest in contact tracing apps (CT apps) for pandemic management. These apps raise significant moral concerns. It is therefore crucial to consider ethical requirements before and while implementing such apps.
- Public trust is of major importance for population uptake of contact tracing apps. Hasty, ill-prepared or badly communicated implementations of CT apps will likely undermine public trust, and as such, risk impeding general effectiveness.
- In response to these demands, to meet ethical requirements and find a basis for justified trust, this background introduces an ethical framework for a responsible design and implementation of CT apps. However, even prudently chosen measures of digital contact tracing carry moral costs, which makes it necessary address different trade-offs.

This background paper aims to inform developers, researchers and decision-makers before and throughout the process of implementing contact tracing apps.

Context

Digital technologies are increasingly being discussed and implemented for Covid-19 pandemic management and as tools for easing restrictive measures, such as lockdowns (1, 2). Due to the high penetration rate of smartphones, there has been a huge interest in mobile phone data as a source for public health research and measures (3). To track the spread of the virus, in Europe and elsewhere, network operators share (anonymized and aggregated) phone location data. Apple and Google, two leading providers of smartphone operating systems, release data to show mobility trends in countries and selected regions (4, 5). In addition, a range of new mobile phone based applications ("apps"), sometimes lumped together under the term "COVID-19 apps", have been rolled out recently or are being under development by private as well as public actors (6–8).

These apps could serve a variety of functions: provide users with Covid-19-related information, monitor people in quarantine, trace movements, or give users rapid warning of potential exposure to SARS-CoV-2 (8, 9). Frequently, mobile phone apps are designed to fulfil more than just one purpose, e.g. symptom checkers could generate data which might also be used for epidemiological modelling, monitoring the virus spread or to evaluate public health measures. Available apps differ widely regarding data use (e.g. self-reported, geolocation data, proximity tracing), data sources (e.g. GPS, Bluetooth), data handling (decentralized or centralized approaches), as well as data protection (anonymization or pseudonymization) (7).

Proximity or *contact tracing apps* (CT apps) have gained notable attention so far. CT apps notify users if they have been in proximity to confirmed infected people and propose next steps (e.g. self-isolation, testing). Since analogous contact tracing is slow, resource intensive and lacks reliability, digital proximity tracing has been proposed as a complementary tool to indicate possible transmission chains that analogous contact tracing might miss or take a long time to identify. One study suggests that CT apps could, in theory, effectively decrease virus transmission by enabling targeted testing or quarantine, and thus avoid mass confinements or lockdowns (10). Identifying and informing potential spreaders early could reduce pre-symptomatic transmission, i.e. before an infected person shows symptoms. This might also support micromanagement after restrictive measures get lifted or during future infection waves. Until today, however, little is known about the effectiveness and efficiency of CT apps in real-world settings, and whether or not they could also be counterproductive for pandemic management, or expose individuals to ethical downsides, such as lack of data security.

CT apps are already being used in some countries (7, 11). Singapore pioneered in developing a Bluetooth based open-source technology named Bluetrace, which underpins *TraceTogether app* (12). In Europe, after a joint attempt to establish a pan-European "privacy-preserving approach" for CT (PEPP-PT) has seemingly failed, some countries such as Austria or Iceland have already rolled out proximity tracing apps on their own. Until recently, PEPP-PT and a centralized database was considered as the preferred framework for CT apps in Germany, until massive criticism (13) led to the announcement to opt for a decentralised app (14). However, European countries are divided on the question whether to rely on centralized (e.g. France, Poland) or decentralized (e.g. Germany, Austria) data management (7), making interoperability between different CT apps even more difficult.

Development of CT apps is not only promoted by public agencies but also relies on public-private partnerships with relevant corporate actors. Apple and Google are collaborating to develop a joint contact tracing framework which is also founded on decentralized data management (15). Such efforts are important to guarantee interoperability between different smartphone systems and allow building efficient CT apps. However, due to this dependency, commercial companies are gaining a wide-ranging influence on the national strategies for digital contract tracing; e.g. the Apple and Google framework is only of limited use for countries which have opted for a centralized architecture of CT apps like France (16). Furthermore, the use of the framework is restricted to only one tracing app per country (17).

Apart from the possible benefits associated with these developments, CT apps also raise significant concerns (18, 19). As part of the Covid-19 pandemic response, advisory bodies, NGOs, and expert initiatives have interrogated the ethical aspects of digital surveillance technologies, including CT apps (e.g. 20–25). The first ethical frameworks for digital tools in the context of Covid-19 have been proposed (1, 18, 19, 26–28), and the European Commission has drafted various recommendations and guidelines for digital contact tracing in the EU (e.g. 29).

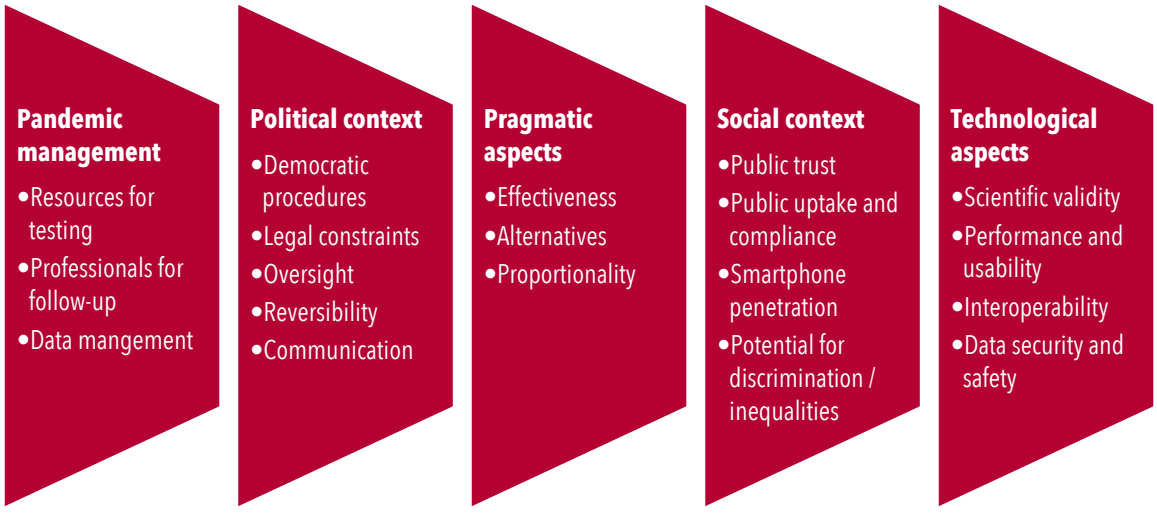
Objective

This background paper focuses on ethical considerations for responsible development, design and implementation of effective and justifiable digital public health measures. It provides a framework for ethical analysis of concrete proposals, and suggests issues that should be addressed by developers and decisions-makers prior to implementation.

The objective of this background paper is threefold. First, we will highlight the interconnection of social and political contexts, available measures of pandemic management, and a multi-layer assessment of CT apps. Then we will examine the role of trust in this process and point towards ethical concerns that should be taken into consideration on a policy level before allowing, endorsing, or implementing CT apps. Finally, we will discuss some trade-offs that arise from this perspective.

The Landscape of Justifying CT apps

Considering the wide variety of mobile applications being developed in the context of the Covid-19 pandemic, it is crucial to distinguish between different apps, their functions, purposes, and performance. An assessment of CT apps cannot focus on technological performance alone or the general desirability of technologies as such. The value of these tools essentially depends on specific pandemic contexts and factors such as the social and political environment, how CT apps are integrated into a comprehensive strategy of pandemic management, as well as possible and available alternatives:



Layers of assessment:
To assess CT apps, the interplay between technological aspects and socio-political contexts need to be considered.

Notably, the implementation of digital contact tracing always carries moral costs. In some countries, apps and other mobile based surveillance measures are imposed on people, leading to an infringement of privacy rights (23). Even without compulsion, CT apps can have severe consequences for social values: worries range from issues of data protection, to possible stigmatization of patients, social justice concerns, or function creep (7, 30).

Nevertheless, risks that cannot be easily mitigated or avoided could still be acceptable, considering the severity of a pandemic situation, the importance of effectiveness in contact tracing to manage it, and the scope of established measures to stop virus transmission. To assess whether a certain CT app is justified, its use needs to be compared to available alternative strategies. From this perspective, infringements associated with a possible loss of privacy and risks related to an effective CT app may appear justifiable in light of the enormous costs in terms of welfare, liberty and health outcomes of either letting the virus run its course or maintaining comprehensive restrictions or lockdowns.

To make a case in favour of a CT app, however, several conditions must be met. Sufficient societal need and potential effectiveness need to be demonstrated, and ethical risks sufficiently mitigated in order to demonstrate proportionality. In addition, such evaluation and decision-making needs to demonstrate procedural fairness, with transparency and opportunity for potentially concerned parties to voice concerns. Finally, the balance of reasons for and against needs to be superior to alternative solutions or strategies. Here, again, context matters. For a CT app scheme to be worth its costs and risks, a society needs to be in a pandemic stage, in which contact tracing is a priority. This may depend both on the pattern of (community) transmission, and the healthcare capacity of this country relative to the transmission pattern. If a society is not in such a state, no app will be able to promote better contact tracing.

In addition, the utility of CT apps largely depends on broader public health measures beyond digital technologies. For CT apps to be an effective contribution to public health strategies, sufficient staffing of public health services as well as reliable infrastructures (e.g. for testing and for quarantine) are needed. To avoid false positive self-reports, health departments or other institutions need to confirm infection status of users. There has to be an organization to take care of the data generated by the app in a meaningful and cost-effective way (from a public health perspective) in relation to a set of justified effective tracing actions that are thereby being facilitated (i.e. eased or made possible by the app data).

So far, there has been a striking lack of empirical evidence of the actual contribution of mobile technologies to reduce Covid-19 transmission. Effectiveness, however, does not only presuppose a favourable context in terms of a suitable pandemic stage and accompanying interventions, but also sufficient uptake. In turn, uptake depends on some level of trust in agencies responsible for development, marketing, and distribution of CT apps, further, in solving issues e.g. of data protection or stigmatization, but also in the usefulness and performance of digital proximity tracing itself. Since using CT apps could have severe consequences for individuals, e.g. by imposing isolation measures, demonstrated effectiveness and validity of CT apps will be a major factor for population uptake.

Public Trust

We witness a pragmatic dilemma regarding the factor of trust: on the one hand, the effectiveness of CT apps is uncertain. Even for countries with a high penetration rate of proximity tracing technologies such as Iceland, the contribution of CT apps to suppressing the pandemic has been questioned (31). On the other hand, digital proximity tracing essentially depends on population uptake and user adherence. Broad scepticism about the effectiveness of digital contract tracing could eventually become a self-fulfilling prophecy. For CT apps to offer a meaningful contribution to pandemic management, a large part of the population needs access to mobile technologies (e.g. smartphones or beacons), install and set up the app, and be willing and able to use tools correctly. This pragmatic dilemma must therefore also be incorporated into later ethical considerations. For if the probability of uptake and thus of effective pandemic control with the app is too small, the risks and moral costs of the app could be too high.

A study from the UK has estimated that around 80% of smartphone users (more than 50% of population overall) would have to use a CT app to stop the pandemic on its own (32), i.e. a user rate comparable to WhatsApp or Facebook Messenger in some European countries. So far the highest penetration rate of CT apps in the world has been reported from Iceland, where almost 40% of the overall population downloaded a CT app. For Singapore's much heralded CT app, less than a quarter of the population are using this tool (12). A lower adoption rate still has some positive effect for targeted testing and quarantine (33, 32). Nevertheless, population uptake is a bottleneck for success of these digital technologies.

Predicting future uptake of CT apps is difficult and depends on factors, such as the penetration range rate of digital technologies in a society, the credibility of institutions offering these solutions and credible solutions for ethical concerns such as data security. Recent surveys have been inconclusive about the possible uptake in different countries. A study showed a high level of support (around 80%) for CT apps in countries such as the UK, Germany, France and the US (34), while other surveys from the US and Germany came to a less optimistic conclusion (35, 36). The available data also show that some aspects could reduce the acceptability of CT apps: these include concerns about further continuation of surveillance after the pandemic and data security (35).

One way to increase uptake is, of course, to make CT app use mandatory (to some extent). This, however, adds ethical downsides of liberty restrictions that are seen as substantial in a liberal democratic context, and thereby complicates the justification of a CT app policy. Moreover, coercion may undermine public trust and create incentives for cheating (37), necessitating even more forceful steps to secure the benefits of the policy. However, then these benefits need to be even more pronounced and certified in order to create a potential for the policy to be proportional.

For this reason, CT app programs based on voluntary use with a good uptake is to be much preferable. But this assumes strong public trust in the apps and the program (28, 38).

Trust, however, must build on trustworthiness, and thus needs to be backed up by responsible design and corresponding policies. Such "well founded" credence (28) also remains a strong indicator that choices are self-determined and, thus, in line with democratic values.

Meanwhile, reports from China and other nations have already shown that digital measures utilised in the Covid-19 pandemic response have been used for mass surveillance (7, 23) and that there might be plans to massively extend the use of newly established apps even after pandemic (39). In some countries such as Sweden or the Netherlands, the launch of CT apps has been postponed or even cancelled due to weak data security and doubts about effectiveness as well as on the legality of apps that process sensitive personal information (40, 41). Such evidence might have already fuelled public mistrust in CT apps in other nations, especially in societies, in which trust in science and governance is limited. For countries like Germany, public outreach by the political representation regarding the introduction of different apps has created confusion (42). Internationally, CT apps have already become the subject of conspiracy theories, fake news, and scams.

The importance of trustworthiness of technologies and policies for earning sustainable public trust also means that it is important to prevent false expectations. For instance, simplistic "solutionism", i.e. the belief that pandemic challenges could be managed by technological fixes alone, must be avoided. Transparency is of paramount importance to the building of a trusting relationship between the state, its citizens and commercial actors. Therefore, the functions, goals, possible chances, and risks associated with specific CT apps must be communicated clearly, as well as the measures taken to mitigate the risks. The same goes for disclosure of conflicts of interest and the procedural management of state-business relationships linked to commissions of technological development and procurement of technical products.

This last aspect becomes extra important if the decision is to adopt one particular national CT app solution and policy, meaning that private developers will be in serious competition to win the race for a state contract. To increase app uptake, focusing efforts on one single CT app with just one (or a limited number of) clearly defined purpose(s) and broad support from political and health institutions may be crucial. To prevent confusion and loss of trustworthiness, there may then be good reasons to restrict privately offered CT apps, or to institute mandatory quality assurance authorisation in order to ensure that pandemic management is not undermined by business ventures.

Public decision-making on pandemic policies including decision making on CT apps, requires a structured framework to work through these ethical considerations. Such a framework can play a vital role in increasing transparency of made decisions, as well as the trustworthiness of (and trust in) policies and technical solutions.

Ethical framework for decision-making on the use of CT apps

The viability of CT apps as a useful pandemic-response measure, depends on a complex interplay of criteria, such as pragmatic assumptions about effectiveness, the likelihood of public health benefit, technological specifications etc. These aspects need to be scrutinized together with ethical values. To minimise the risk of adverse outcomes, ethical standards should be fulfilled together with technological requirements, throughout the process of development (ethics by design). The same is true for the implementation, use, and evaluation of CT apps. Rather than asking general questions on the moral acceptability of CT apps, the crucial question is: "*What specific interventions, if any, may be justified under what conditions?"* Inspired by ethical frameworks for big data in health and research, developed by the SHAPES initiative (43), and other normative frameworks (44), we propose relevant substantive values (which estimate the outcome of measures) and procedural values (which guide decision-making) as well as corresponding questions, which should be considered in response to these demands.

Substantive values	**Guiding questions**
Public health benefit	– Is a CT app an effective and efficient means to serve the purpose? – Is the considered use of the specific CT app likely to be beneficial in achieving desirable goals for pandemic policy? – Is the pool of potential users who are willing to use a CT app large enough for epidemiological effectiveness? – Is the cost-effectiveness of the CT app positive compared to alternative pandemic management strategies? – Are social, moral and financial costs of CT apps proportionate to the threat?
Harm minimisation	– Are CT apps the least harmful way of obtaining the desired benefits? – Are CT apps easy to use and do they minimise confusion or stress by design? – Has the risk of self- and social stigma effects, implicated by an elevated focus on one's or others' health status been considered and mitigated? – Are safeguards in place to mitigate the vulnerability of and harm to marginalized groups from CT apps and related public health and security measures? – Are potential, harmful social effects related to the app (widespread anxiety, ineffective quarantines etc.) adequately considered?
Privacy	– Are measures in place for data protection and against data loss or misuse? – Are data security authorities involved? – Is data parsimony guaranteed and access to non-essential personal data minimised? – Are the most privacy-preserving solutions (e.g. no real-time data, anonymization) prioritised? – Is collection of the tracing-data temporary (e.g. will it be deleted after a certain, specified amount of time)? – Is data sharing for other purposes excluded? – Are appropriate cyber-resilience measures in place?

Justice	– Has accessibility and availability been maximised? – Are benefits and burdens of CT apps equally distributed among population? – Are there measures to safely include marginalized groups or 'digital immigrants', without the exacerbation of their vulnerability? – Will resulting scientific knowledge and insights be freely shared for the public good? – Will discrimination of certain groups be prevented? – Are different levels of digital literacy considered in app design?
Liberty/autonomy	– Are CT apps used voluntarily? – Are users able to withdraw consent? – Is there proper user consent for data use? – Are users informed about possible consequences of CT app use? – Are CT apps the least liberty-compromising measures compared to alternative strategies to pandemic management? – Do the CT apps promote the user's health literacy? – Are there alternatives for those who will or cannot participate in CT apps?
Solidarity	- Are the measures to avoid negative effects on solidarity, e.g. by not imposing overly disproportionate burdens on specific groups? - Has consideration been given too whether negative attitudes towards people who do not use the app may feed into practices of victim blaming?
Stewardship	– Are effects of CT app on existing infrastructure considered (e.g. encourage or strengthen power asymmetries, or market monopolies)? – Are safeguards against function creep, i.e. the use beyond the purpose of the technology, in place? – Are there strategies against malicious, fake CT apps? – Are measures and policies reversible? – Are CT apps embedded in robust regulatory frameworks? – Are safeguards and oversight mechanisms in place?
Procedural values	**Guiding questions**
Transparency	– Are technological solutions and frameworks sufficiently transparent (e.g. open-source)? – Are purposes, objectives, as well as limitations of CT apps and measures clearly named and communicated? – Are actors and possible stakes behind the CT apps transparent? – Can CT apps be subject to an audit?
Trustworthiness	– Are democratic procedures in place to guide decision making? – Can population uptake be assumed? – Do stated objectives of CT apps align with proposed measures?
Reasonableness	– Is the proposed solution epidemiologically sound? – Are the underlying considerations and models scientifically valid? – Is there sufficient evidence that the CT app meets technical standards of reliance? – Is the pandemic situation of a stage that makes contact tracing a priority from a public health standpoint?

	– Is there a contact tracing system in which the CT app is likely to contribute beneficial added value if it is embedded? – Is the CT app effectively embedded into such a contact tracing system? – Is the app embedded in a robust public health strategy with sufficient resources to test, trace and treat?
Accountability	– Is it clear who can be held to account in the case of adverse outcomes, such as harm, infringements of rights or lack of effectiveness? – Is there oversight of CT apps by legitimate governmental agencies and independent oversight bodies?
Consistency	– Are CT measures and policies based on the same legal and ethical standards as other accepted measures of pandemic management? – Are policies consistent with legal frameworks?
Engagement	– Are there possibilities for the broader public to participate in decision making? – Has input from relevant stakeholders (e.g. public authorities, health departments) been considered?
Reflexivity	– Are there alternative strategies of contract tracing prepared if CT apps turn out to be inefficient? – Have the potential effects of CT apps on power asymmetries and data monopolies be considered in decision making. – Are there research initiatives in place to evaluate the efficiency of CT apps? – Are strategies in place to limit duration and end measures (sunset provisions)?

The list of considerations provides a sketch of the complex set of criteria relevant to assessing CT apps as ethically justifiable public health tools. We neither claim that the list is complete, nor do we think that a responsible policy-making process should necessarily address all of them. On the contrary, it is highly unlikely that a solution would satisfy all these demands. Not only is there is a significant lack of available data and real-world experience of CT technologies, *all* pandemic management strategies will involve several trade-offs. We will briefly discuss two of the most significant trade-offs in the implementation of CT apps, which will require appropriate political decisions.

Effectiveness vs. Privacy

Little is known about the effectiveness of contact tracing apps in the real-world setting (45). The implementation of an ineffective app has opportunity costs, wasting time and resources, undercutting other solutions and leading to wrong political decisions. This may result in a sub-optimal approach to the pandemic, resulting in higher morbidity and mortality and greater economic damage.

It is important to note that the less open to identification of specific people, the less useful will data be for contact-tracing purposes. It is also crucial to view the value of a CT app in

regards to the quality of information produced by it: the more it will rely on user-generated subjective information, the more it is likely to produce false predictions that will affect particular tracing policies. This concerns both positives and negatives. As such, incorrect information will rather compromise than support particular public health measures, as well as health care systems more generally, and scarce resources may be wasted, or used suboptimally.

By contrast, CT apps that appear to be effective in tracing individuals, may raise serious privacy concerns. It has been reported from South Korea, where multi-source tracing and tracking technologies are being used (8), that information was so detailed as to allow re-identification of individuals (46). Hence, the values of effectiveness and privacy need to be carefully balanced in public health measures. For example, while infringements on individual rights or liberties could be justified to secure health benefits, measures always need to be proportionate and aim for careful balance between competing values and considerations.

Liberty vs. population uptake

From the perspective of effectiveness, all measures that increase population uptake of CT apps seem desirable. Hence, a mandatory use of disease surveillance tools and possible moral obligations to comply with them are being discussed (19, 28, 47). Both opposing poles, a fully voluntary and informed use of CT apps on the one side and a strict enforcement by the state on the other side, raise significant problems. The first option, i.e. fully informed choice, can hardly be achieved, given the complexity of the subject and the limited knowledge regarding the functionality and technical aspects of CT measures in the general population. The latter option, i.e. compulsive measures would significantly undermine liberal values. Furthermore, oversight of adherence and enforcement of a mandatory use of CT apps are hardly feasible, given the nature of digital technologies.

In practice, most measures to increase compliance will find themselves somewhere between the two poles: e.g. nudges (e.g. opt-out rather than opt-in clauses), positive incentives (e.g. free mobile data or tax relief), or negative incentives (e.g. prohibition to enter public spaces). From the perspective of liberal values, citizens should ideally support CT apps because they have (justified) faith in public health measures and, thus, freely choose to utilise disease surveillance technologies. This, however, does not rule out some measures to increase population uptake (37): encouragement, campaigning, and even some forms of incentives could be justified to increase adoption rates. Possible benefits should be equally accessible for most citizens without disproportionate burdens, and negative incentives must not be so severe as to render CT apps de facto compulsory, e.g. by limiting access to essential infrastructures (19, 27). Incentives can also create new risks, e.g. owing to users' psychological responses to the information regarding user-surroundings and related health risks disclosed by a particular app. A privacy infringing, unfair or burdensome app may trigger negative responses, particularly if it is perceived as being imposed upon the public.

Recommendations

Based on our analysis, we conclude the following points for consideration:

- The Covid-19 pandemic cannot be solved by technological means alone. Digital proximity tracing is not a panacea in the Covid-19 pandemic response, but could become a valuable component in a comprehensive strategy. Thus, it is imperative to have appropriate public health measures and infrastructures in place before implementing CT apps.

- To ensure population uptake, there should only be a limited number of CT apps or, ideally, only one platform. Reducing the functionality of apps, i.e. only one clear objective per app, seems advisable. At the same time, local and national demands and strategies for pandemic management differ and, as such, prevent a comprehensive one-size-fits-all approach. While a joint, pan-European platform, allowing interoperability between different CT apps is warranted, diverging requirements need to be considered.

- Given the inevitable risks for privacy and the potential impact on individual liberty, there should be a reasonable expectation of population benefit of CT apps prior to their large-scale applications. Effectiveness and benefits must be evaluated alongside the first implementation.

- The ubiquitous presence of risks necessitates a thorough and prudent approach. A particular focus on temporary measures is warranted. While science and policy have been confronted with deep uncertainty during the Covid-19 pandemic, strategies must be carefully chosen, risks mitigated and measures reversible. Uncertainties on the benefits of digital CT limit the set of legitimate pandemic response policies and actions. Without clear evidence of effectiveness, jeopardizing the rights or liberties of (some parts of) the population can hardly be justified.

- Trust is essential in public health decision-making in general, and Covid-19 CT apps in particular. Policies, recommendations and public health measures should be part of a broader endeavour to win and maintain trust in public health measures. Well-founded trust requires taking seriously the ethical complexities relating to the implementation of CT apps as well as being transparent about the inevitable trade-offs that are being made. Communicating goals and functions as well as possible benefits, risks, and limitations of CT apps clearly and early can play a crucial role in preventing squandering trust and misconceptions.

References

1. Mello MM, Wang CJ (2020) Ethics and governance for digital disease surveillance. Science, 368(6494), 951-954. 29 May 2020. DOI: 10.1126/science.abb9045
2. Ting DSW, Carin L, Dzau V, Wong TY (2020). Digital technology and COVID-19. Nature Med 26:459–461. 27 March 2020. https://www.nature.com/articles/s41591-020-0824-5 [accessed 04.06.20]

3. Oliver N, Letouzé, E, Sterly H, Delataille S, De Nadai M, Lepri B et al. (2020) Mobile phone data and COVID-19: Missing an opportunity? arXiv preprint. arXiv:2003.12347. https://arxiv.org/abs/2003.12347 [accessed 04.06.20]
4. Apple (2020) Mobility trends reports https://www.apple.com/covid19/mobility [accessed 04.06.20]
5. Google (2020) Covid-19 Community Mobility Report. 3 Mar 2020. https://www.google.com/covid19/mobility/ [accessed 04.06.20]
6. Privacy International (2020) Tracking the Global Response to COVID-19. https://www.privacyinternational.org/examples/tracking-global-response-covid-19 [accessed 04.06.20]
7. Woodhams S (2020) COVID-19 Digital Rights Tracker. 20 Mar 2020, updated 12 May 2020. https://www.top10vpn.com/news/surveillance/covid-19-digital-rights-tracker/ [accessed 04.06.20]
8. GDPRhub (2020). Projects using personal data to combat SARS-CoV-2. Updated 15 May 2020. https://gdprhub.eu/index.php?title=Projects_using_personal_data_to_combat_SARS-CoV-2 [accessed 04.06.20]
9. Rimpiläinen S, Thomas J, Morrison C (2020) Global Examples of COVID-19 Surveillance Technologies: Flash Report. 15 Apr 2020. https://strathprints.strath.ac.uk/72028/ [accessed 04.06.20] https://doi.org/10.17868/72028
10. Ferretti L, Wymant C, Kendall M, Zhao L, Nurtay A, Abeler-Dörner L, et al. (2020) Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing. 8 May 2020. Science. 364(6491): eabb6936. DOI: 10.1126/science.abb6936
11. Howell O'Neill P, Ryan-Mosley T, Johnson B (2020). A flood of coronavirus apps are tracking us. Now it's time to keep track of them. MIT Tech Review. 7 May 2020. https://www.technologyreview.com/2020/05/07/1000961/launching-mittr-covid-tracing-tracker/ [accessed 04.06.20]
12. TraceTogether (2020) TraceTogether - an overview. 9 Apr 2020. https://bluetrace.io/policy/ [accessed 04.06.20]
13. [Multiple signatories] (2020) Joint Statement on Contact Tracing: Date 19th April 2020. https://drive.google.com/file/d/1OQg2dxPu-x-RZzETlpV3lFa259Nrpk1J/view [accessed 04.06.20]
14. Busvine D, Rinke A (2020) Germany flips to Apple-Google approach on smartphone contact tracing. Reuters. 26 Apr 2020. https://www.reuters.com/article/us-health-coronavirus-europe-tech/germany-flips-to-apple-google-approach-on-smartphone-contact-tracing-idUSKCN22807J [accessed 04.06.20]
15. Apple, Google (2020) Contact Tracing Bluetooth Specification Preliminary - Subject to Modification and Extension. Apr 2020. https://covid19-static.cdn-apple.com/applications/covid19/current/static/contact-tracing/pdf/ContactTracing-BluetoothSpecification.pdf [accessed 04.06.20]
16. Scott M, Braun E, Delcker J, Manacourt V (2020) How Google and Apple outflanked governments in the race to build coronavirus apps. Politico. 15. May 2020. https://www.politico.eu/article/google-apple-coronavirus-app-privacy-uk-france-germany/ [accessed 14.06.20]
17. Gurman M, De Vynck, G (2020) Apple, Google Covid-19 Tool to Be Limited to One App Per Country. Bloomberg. 4. May 2020. https://www.bloomberg.com/news/articles/2020-05-04/apple-google-covid-19-tool-to-be-limited-to-one-app-per-country [accessed 14.06.20]
18. Gasser U, Ienca M, Scheibner J, Sleigh J, Vayen E (2020) Digital tools against COVID-19: Framing the ethical challenges and how to address them. https://arxiv.org/pdf/2004.10236.pdf [accessed 04.06.20]

19. Lucivero F, Hallowell N, Johnson S, Prainsack B, Samuel G, Sharon T (2020). COVID-19 and Contact Tracing Apps: Technological Fix or Social Experiment? 10 Apr 2020. https://ssrn.com/abstract=3590788 [accessed 04.06.20]
20. AlgorithmWatch (2020) Automated decision-making systems and the fight against COVID-19 – our position. 2 Apr 2020. https://algorithmwatch.org/en/our-position-on-adms-and-the-fight-against-covid19/ [accessed 04.06.20]
21. Amnesty International et al. (2020) Joint civil society statement: States use of digital surveillance technologies to fight pandemic must respect human rights. 2 Apr 2020. https://www.amnesty.org/download/Documents/POL3020812020ENGLISH.pdf [accessed 04.06.20]
22. Chaos Computer Club (2020). 10 Prüfsteine für die Beurteilung von „Contact Tracing"-Apps. 6 Apr 2020. https://www.ccc.de/de/updates/2020/contact-tracing-requirements [accessed 04.06.20]
23. Human Rights Watch (2020) Mobile location data and Covid-19: Q&A. 13 May 2020. https://www.hrw.org/news/2020/05/13/mobile-location-data-and-covid-19-qa [accessed 04.06.20]
24. Swiss National Advisory Commission on Biomedical Ethics (2020) Contact tracing as an instrument for pandemic control: Central considerations from an ethical perspective. Opinion no. 33/2020. Bern, 6 Apr 2020. https://www.nek-cne.admin.ch/inhalte/Themen/Stellungnahmen/en/NEK-stellungnahme-EN_Contact_Tracing.pdf [accessed 04.06.20]
25. WHO (2020) Ethical considerations to guide the use of digital proximity tracking technologies for COVID-19 contact tracing. Interim guidance. 28 May 2020. https://apps.who.int/iris/bitstream/handle/10665/332200/WHO-2019-nCoV-Ethics_Contact_tracing_apps-2020.1-eng.pdf [accessed 04.06.20]
26. Kahn, Jeffrey, editor; Johns Hopkins Project on Ethics and Governance of Digital Contact Tracing Technologies (2020) Digital Contact Tracing for Pandemic Response: Ethics and Governance Guidance. Baltimore: Johns Hopkins UP, 2020. https://muse.jhu.edu/book/75831/pdf [accessed 04.06.20] DOI:10.1353/book.75831
27. Morley J, Cowls J, Taddeo M, Floridi L (2020) Ethical guidelines for COVID-19 tracing apps. Nature. Jun 2020; 582(7810):29-31. DOI: 10.1038/d41586-020-01578-0
28. Parker MJ, Fraser C, Abeler-Dörner L, Bonsall D (2020) Ethics of instantaneous contact tracing using mobile phone apps in the control of the COVID-19 pandemic. J Med Ethics. Preprint 4 May 2020. DOI: medethics-2020. 10.1136/medethics-2020-106314.
29. European Commission (2020) Commission Recommendation of 8.4.2020 on a common Union toolbox for the use of technology and data to combat and exit from the COVID-19 crisis, in particular concerning mobile applications and the use of anonymised mobility data. https://ec.europa.eu/info/sites/info/files/recommendation_on_apps_for_contact_tracing_4.pdf [accessed 04.06.20]
30. Hart V, Siddarth D, Cantrell B, Tretikov L, Eckersley P, Langford J, et al. (2020) Outpacing the Virus: Digital Response to Containing the Spread of COVID-19 while Mitigating Privacy Risks. 3 Apr 2020. https://drive.google.com/file/d/1vIN2AX-DDNW-S0aHq8xs0RJ2jkR_CckX/view?usp=sharing [accessed 04.06.20]
31. Johnson B (2020) Nearly 40% of Icelanders are using a covid app – and it hasn't helped much. MIT Tech Review. 11 May 2020. https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing/ [accessed 04.06.20]

32. Hinch R, Probert W, Nurtay A, Kendall M, Wymant C, Hall M et al. (2020) Report - Effective configurations of a digital contact tracing app: A report NHSX. 16 Apr 2020. https://github.com/BDI-pathogens/covid-19_instant_tracing/blob/master/Report%20-%20Effective%20Configurations%20of%20a%20Digital%20Contact%20Tracing%20App.pdf [accessed 04.06.20]
33. Howell O'Neill P (2020) No, coronavirus apps don't need 60% adoption to be effective. MIT Tech Review. 5 June 2020. https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/ [accessed 15.06.20]
34. Milsom L, Abeler J, Altmann S, Toussaert S, Zillessen H, Blasone R (2020) Survey of acceptability of app-based contact tracing in the UK, US, France, Germany and Italy. 26 Mar 2020. https://osf.io/7vgq9/ [accessed 04.06.20]
35. Anderson M, Auxier B (2020) Most Americans don't think cellphone tracking will help limit COVID-19, are divided on whether it's acceptable. 16 Apr 2020. https://www.pewresearch.org/fact-tank/2020/04/16/most-americans-dont-think-cellphone-tracking-will-help-limit-covid-19-are-divided-on-whether-its-acceptable/ [accessed 04.06.20]
36. COVID-19 Snapshot Monitoring (COSMO) (2020). Ergebnisse aus dem wiederholten querschnittlichen Monitoring von Wissen, Risikowahrnehmung, Schutzverhalten und Vertrauen während des aktuellen COVID-19 Ausbruchsgeschehens. Updated 2 Jun 2020. https://projekte.uni-erfurt.de/cosmo2020/cosmo-analysis.html#11_tracing-app [accessed 04.06.20]
37. Floridi L (2020) Mind the app - considerations on the ethical risks of COVID-19 apps. 18 Apr 2020 https://thephilosophyofinformation.blogspot.com/2020/04/mind-app-considerations-on-ethical.html [accessed 04.06.20]
38. Ienca M, Vayena E (2020). On the responsible use of digital data to tackle the COVID-19 pandemic. Nat Med 26, 463–464. 27 Mar 2020. https://doi.org/10.1038/s41591-020-0832-5
39. Davidson, H (2020) Chinese city plans to turn coronavirus app into permanent health tracker. The Guardian. 26 May 2020. https://www.theguardian.com/world/2020/may/26/chinese-city-plans-to-turn-coronavirus-app-into-permanent-health-tracker [accessed 04.06.20]
40. Wassens R (2020) Ministerie test corona-app regionaal. 29 May 2020. https://www.nrc.nl/nieuws/2020/05/29/ministerie-test-corona-app-regionaal-a4001318 [accessed 04.06.20]
41. Hagberg, S (2020) Folkhälsomyndigheten ratar smittspårning via app. Omni. 3 May 2020 https://omniekonomi.se/folkhalsomyndigheten-ratar-smittsparning-via-app/a/y32gVr [accessed 04.06.20]
42. Barker, T (2020) Germany's Angst Is Killing Its Coronavirus Tracing App. Foreign Policy. 8. May 2020. https://foreignpolicy.com/2020/05/08/germany-coronavirus-contract-tracing-pandemic-app/ [accessed 04.06.20]
43. Xafis V, Schaefer GO, Labude MK, Brassington I, Ballantyne A, Lim HY et al. (2020) An ethics framework for big data in health and research. Asian Bioethics Review. 2019 Sep; 11(3):227-254. doi: 10.1007/s41649-019-00099-x
44. Marckmann, G (2020) Ethische Fragen von Digital Public Health. Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz. Jan 2020, 63(2):199-205. DOI: 10.1007/s00103-019-03091-w
45. Anderson R (2020) Contact tracing in the real world. 12 April 2020. https://www.lightbluetouchpaper.org/2020/04/12/contact-tracing-in-the-real-world/ [accessed 04.06.20]

46. Zastrow M (2020) South Korea is reporting intimate details of COVID-19 cases: has it helped? 18 Mar 2020. https://www.nature.com/articles/d41586-020-00740-y [accessed 04.06.20] doi: 10.1038/d41586-020-00740-y
47. Schaefer GO, Ballantyne A (2020) Downloading COVID-19 contact tracing apps is a moral obligation. 4 May 2020. https://blogs.bmj.com/medical-ethics/2020/05/04/downloading-covid-19-contact-tracing-apps-is-a-moral-obligation/ [accessed 04.06.20]

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