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Trust & Privacy Expectations during Perilous Times of Contact Tracing

Habiba Farzand

University of Glasgow, UK
habiba.farzand@glasgow.ac.uk

Florian Mathis

University of Glasgow, UK
florian.mathis@glasgow.ac.uk

Karola Marky

University of Glasgow, UK
karola.marky@glasgow.ac.uk

Mohamed Khamis

University of Glasgow, UK
mohamed.khamis@glasgow.ac.uk

Abstract—Contact Tracing Apps (CTAs) have been developed and deployed in various parts of the world to track the spread of COVID-19. However, low social acceptance and the lack of adoption can impact CTA effectiveness. Prior work primarily focused on the privacy and security of CTAs, compared different models, and studied their app design. However, it remains unclear (1) how CTA privacy is perceived by end-users; (2) what reasons behind low adoption rates are, and (3) what the situation around the social acceptability of CTAs is. In this paper, we investigate these aspects by surveying 80 participants (40 from Australia, 40 from France). Our study reveals interesting results on CTA usage, experiences, and user perceptions. We found that privacy concerns, tech unawareness, app requisites, and mistrust can reduce the users' willingness to use CTAs. We conclude by presenting ways to foster public trust and meet users' privacy expectations that in turn support CTA's adoption.

I. INTRODUCTION

"While nations around the world are working at pace to develop and deploy new digital technologies, they also need to address the issue of public trust and how that too can be built at speed".

Anna Brown, 2020 [44]

Restricting the spread of COVID-19 remains a significant challenge for most parts of the world. In an attempt to gain control over the pandemic, many countries developed and deployed Contact Tracing Apps (CTAs) that help identifying chains of infection and warning contact persons. To be effective, CTAs need to be installed by a specific share of the population. Yet, current installation rates show that people are rather reluctant to use CTAs [5], [40]. Privacy was identified as one of the main concerns when it comes to using CTAs and a key reason why users are reluctant to adopt them [8]. In this paper, we investigate privacy concerns from users' perspectives in more depth as well as means to address them leading to improving the effectiveness of CTAs. We further investigate social acceptability of CTAs to provide authorities a better understanding of user's privacy expectations and enable them to build CTAs that consider users' privacy concerns which in turn has the potential to increase adoption and social acceptability.

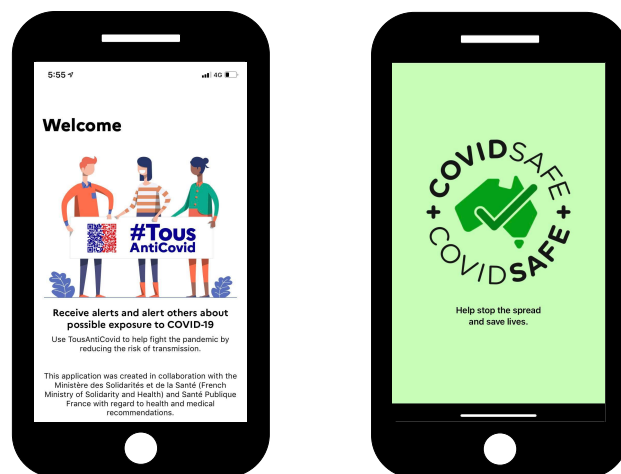


Fig. 1. The figure shows a app preview of Contact Tracing Apps used for this study. Participants from France and Australia were surveyed for the usage, experience, and perceptions of CTAs. Left: Tous Anti Covid [17], [19] used in France. Right: COVIDSafe [31], [32] used in Australia.

In this paper, we investigate the following Research Questions:

- RQ1:** How are CTAs perceived by end-users?
- RQ2:** What are the reasons behind the low adoption rates?
- RQ3:** What is the situation around social acceptability of CTAs?

To answer these, we conducted an online study (N=80) with participants from two countries, France and Australia. Our results show that participants from both countries consider the usage of CTAs as a social responsibility and expressed willingness to use them for self-protection. Social responsibility and willingness to self-protect, however, is impacted by specific concerns about data sharing, data collection practices, and digital legacy. Further, unawareness about CTA functionality and app requisites reduced CTA adoption. Overall, participants from both countries favoured government-made CTAs as the government is, according to our participants, less interested in making a profit compared to renowned companies and can offer better protection of personal data. However, participants also mentioned believing that the government lacks development expertise for building CTAs. To this end, we present eight ways to strengthen public trust and meet users' expectations that improve CTA's adoption.

Contribution Statement: This paper contributes an online survey (N=80) from two countries (Australia and France). We collected their CTA usage, perceptions, and experiences resulting in the social acceptability of CTAs. In the light of results, we present recommendations for ethical use of CTAs for future pandemics that bring more social acceptability and hence, better effectiveness of contact tracing technology.

II. BACKGROUND & RELATED WORK

We build on prior work on (1) social acceptability of CTAs, and (2) privacy concerns of CTAs.

A. Social Acceptability of CTAs

Contact tracing works on a similar principle as surveillance, where the contacts between individuals are being traced and observed constantly. Selinger and Rhee argue that surveillance brings along vulnerabilities [38]. Developed and advanced tech countries may have strict privacy measures in action, but in other less developed and low tech countries, surveillance could be felt like a "sword of Damocles waiting to drop" [38].

Before the availability of CTAs, Altmann et al. [3] conducted a study in five countries (France, the US, UK, Germany, and Italy) to measure the acceptability of CTAs after they become available. They observed huge support across all countries. Overall, 74.8% of respondents opted for installing CTA voluntarily, while 67.7% said they would keep the app on their phone in case CTAs are installed automatically. Despite the positive feedback, these findings do not translate into actual CTA adoption as the participants were asked before the availability of CTAs. What happened after the introduction of CTAs was the complete opposite of the results.

With the introduction of CTAs, many social acceptability and privacy issues were raised. In South Korea, the alerts triggered by the CTA revealed the private life of the people, which was a cause of the public's outcry [20]. The alerts along with the information about the movement of a positive case also revealed personal information which formed the basis of social stigma as the information included embarrassing information. A high number of privacy invasion cases were reported, such that the media in South Korea called it "more scary than Coronavirus" [20].

Georgieva et al. [18] list key factors impacting the social acceptability of technological tracking in the COVID-19 context through an extensive study of literature. The adoption of the population to the idea of tracking is the first factor listed. This factor can be further decomposed into the voluntary or forced nature of tracking and people's acceptance of tracking. The second factor listed is given by digital inequalities. The use of technology varies as we move across age, types of devices, and other factors. For example, not everyone is an owner of a smartphone which is a prerequisite for CTAs. The third factor states that tracking at risk communities will be hard, which can result in marking out some parts of the population.

Workaround efforts to increase CTA adoption include studying the role of incentives and proposing new models for contact tracing. Carli et al. [15] presented the new model for CTAs, which they call *WeTrace* as a solution towards privacy

protection of users. However, their study is not backed by user evaluation, and hence, acceptability cannot be guaranteed. Fast and Schnurr [16] investigated the effect of different incentives to increase the usage of the German CTA. They found that monetary incentives were three times more effective in improving the installation of CTAs and app usage after 14 days than without incentives. Further, they found that immediate compensation was more favoured as compared to delayed compensation. Does the question arise that do we need a "new" model for contact tracing? Is the "model" of CTA the issue behind low adoption, or is it the privacy concern linked with "tracing"? Secondly, not every government can afford to provide incentives to the whole population. The limited budget and unavailability of the budget is a limitation of the solution. This directs towards targeting the core problem behind low adoption from the perspective of the users.

The work by Chan and Saqib [8] highlights privacy concerns as the reason behind the unwillingness to use contact tracing apps. However, their work only focuses on concerns around governmental intervention into personal privacy. Other factors such as the effectiveness of contact tracing from users' perspectives remain unexplored. Morley et al. [27] expressed the concern that the general public may not accept an app that violates privacy, equality, and fairness. The unacceptability would result in a wastage of time and resources used to develop the app. In the efforts to develop an ethical and acceptable app, Morley et al. [27] presented sixteen questions for designers, developers, and evaluators as ethical guidelines for CTAs. They formulated questions around the necessity of the app and requirements. However, it remains unclear if the highlighted questions are representative of users' concerns and what are the basics of the formulations. In summary, the above-mentioned work allowed us to gather data from users' perspectives on the social acceptance of CTAs, voluntary compared to the forced use of CTA, the effectiveness of CTA, the role of the app developer, and recommendation of CTAs to others.

B. Privacy Concerns of Contact Tracing Apps

Privacy is an essential component for human growth as it provides breathing space [11]. With new technologies involving surveillance, privacy and liberties are at risk [38]. The team around Anna Brown at Massey University emphasized the need to gain public trust to make new digital technologies successful [44]. We find similar views for social acceptability as well. For example, Georgieva et al. [18] state that guaranteeing the highest level of non-disclosure of the data is central to the large-scale social acceptability of tracking measures. Privacy concerns are widespread and most significant in forming people's opinion about CTAs [8], [41], [42].

Several studies focusing on the US population have studied CTAs from the user perspective. For example, Li et al. [26] conducted a nationwide survey in the US to study the effects of app design choices and individual preferences on CTAs adoption. They found that privacy concerns, COVID-19 risk perceptions, and technology readiness played a bigger role than app models, such as centralized or decentralized. Calloway et al. [7] investigated risk perceptions around data use in health crises. They targeted a representative population of the US and presented participants with scenarios, and asked questions related to data use and sharing in the specific scenario. They

found that people are not comfortable in sharing their personal data even during health crises and the decision is dependent on the use, recipient, and devices used for compilation. Studies from other countries include the work by Cho et al. [8] who studied the privacy considerations and trade-offs of the Singapore CTA "TraceTogether". A study by Utz et al. [45] explored privacy concerns and user acceptance of a representative sample in the US, Germany, and China. Following similar line of research, Eran Toch [41], [42] studied Israel's CTA adoption and concerns. According to Eran Toch's study in Israel [41], [42], 59% of Israelis believed that CTAs collect sensitive information, and 43% were highly concerned about privacy. The impermanence of COVID-19 is a factor most people consider when opting for CTAs. The majority (53%) of Israelis did not trust the government to delete the data after the crisis is over [41], [42]. Approximately 35% of Israelis were commiserating to people leaving their phones at home to circumvent tracking, and about 42% reported having privacy concerns because of the cellular tracking technology [41], [42].

Privacy has been the core reason for declining to accept the wearable device for contact tracing proposed in, for example, digital wristbands by Hong Kong and South Korea [48]. It is also one of the significant reasons for low willingness to download contact tracing apps [8].

Buchanan et al. [6] reviewed various approaches to the CTA model in use across the world. Ahmed [1] also reviewed and compared different CTA models identifying user privacy concerns. Gvili et al. [21] performed a security analysis on the proposed CTA model by Apple and Google. Baumgartner et al. [4] also explored security and privacy threats to Google and Apple's joint proposal of a decentralized model of CTAs. A study by Oliver et al. [33] presented various ways in which mobile data can help to target and design improved measures to control the spread of COVID-19. Ali et al. [2] studied 47 CTAs from 28 countries and evaluated them from a security and privacy perspective. Similarly, Levi and Stewart [25] reviewed 152 CTAs. With a similar goal, Wen et al. [47] investigated the documentation and binary code of 41 released CTAs, running on iOS and Android. They found that some apps revealed identification information that can lead to the tracing of users. Hence, raising security and privacy concerns. However, the outlined work focused on the developer and organizational perspective. Whereas, the problem of low social acceptability lies at the user end. To improve social acceptability, the user side needs more focus and careful examination.

In summary, prior work focused on privacy analysis and considerations of CTAs [6], [47], security risks [4], [21], comparisons of different models [1], and app design [26]. What is missing is what privacy means from the user's perspective in the context of CTAs. How well do the privacy concerns highlighted by experts translate into users' privacy concerns?

In this paper, we investigate usage and perceptions around CTAs in Australia and France by asking our participants how they perceive privacy when it comes to CTAs. If privacy concerns are handled, the number of CTA users would likely increase i.e., social acceptability would increase. We complement the work on user concerns found in the US, UK, Germany, and China by exploring other countries: France and Australia.

III. METHODOLOGY

In this work, we chose to study two countries: France and Australia. We aimed to explore the underlying users' privacy concerns of both countries and shed further light on social acceptability and users' perceptions of CTAs.

A. Sampling and Questionnaire

We chose an online survey as the research method and deployed it on the recruitment platform Prolific [34] to reach out to users from the two different countries. Participants were rewarded £2.50 for their time. We used the survey provider Qualtrics [35] to build the questionnaire. The questionnaire consisted of two sections: users' use of CTAs - eliciting social acceptability, and their privacy perceptions. Some questions were inspired by a study targeted at Israelis by Eran Toch [41], [42]. We added a subset of their questions to our questionnaire. The study guide used for this study can be found in the Appendix A.

5-point Likert Scale statements (1=Strongly Disagree, 5=Strongly Agree) were used to present questions to the participants, followed by an open-ended question to provide reasoning. The study was approved by the Ethics Committee at our institute. After indicating consent, participants were presented with the questionnaire.

B. Participants

We recruited a representative sample of N=80 users (N=40 from France, N=40 from Australia) in September 2020. Participants from France (male=20, female=20) were on average 35 years (Min= 22, Max= 58, SD= 7.76). The minimum education achieved was upper secondary education with an average household income of \$31,304 per year. Participants from Australia (male=21, female=19) were on average 35 years (Min=22, Max=59, SD=8.0). The minimum education acquired was upper secondary education and the average household income was \$32,759 per year. These stats were chosen following the population statistics of France [13], [30] and Australia [12], [29] to ensure our sample's characteristics match that of the respective population.

C. Data Analysis

We conducted thematic analysis [36] on the responses received. In the first step, a codebook was developed by two researchers. One researcher open coded the full data set while the second researcher coded a subset (approx. 50% of the full data set). The two researchers then discussed their disagreements and agreed on a final codebook. Next, one researcher applied the codebook to the complete data set. The second researcher coded two randomly selected subsets to calculate Cohen's kappa and ensured inter-rater reliability. We achieved a Cohen's kappa of 0.879 for the first and 0.920 for the second subset, which shows high agreement between coders [23], [24]. We then performed selective coding. We present the themes that emerged from the codes in Section V.

IV. LIMITATIONS & FUTURE WORK

Like other online surveys, our study results have several limitations based on self-reported data, social desirability [43],

availability bias, and wrong self-assessments. In our study, we captured the age, gender, education, and household income of the participants. However, we did not capture their technical expertise and privacy perceptions. Since privacy perceptions and experiences vary as we move across levels of tech knowledge and different socioeconomic groups [37], future work should investigate these aspects in the context of CTAs. Our study targeted two developed countries (France, Australia) where technical knowledge is likely to be higher than in developing countries. Hence, our results might not be representative of all countries. Consequently, further work is needed to investigate the usage, experience, and perceptions of CTAs worldwide. In this study, we qualitatively explored the CTAs in Australia and France and detailed its usage, experience, and perceptions. Since our work is explorative and qualitative, quantitative conclusions cannot be made. Prior work has studied various aspects of CTAs, however, the user-centred design of CTAs remain unexplored. Our participants highlighted many issues in the design of CTAs that hindered the adoption of CTAs. Thus, we propose future work to focus on the user-centred design and specifically the usability aspect of CTAs to overcome the issues highlighted.

V. RESULTS

Communication between stakeholders and the population plays a key role in gaining social acceptability. Through our study, we contribute towards understanding social acceptability and perceptions around contact tracing from a representative population of two countries; France and Australia.

Whenever meaningful, we provide how often a specific aspect was mentioned by the participants to give the reader an indication of frequently. This should, however, not be considered as quantitative analysis.

A. Understanding of How Contact Tracing Apps Function.

We first checked participants' knowledge around the CTA used in their respective countries by asking the name of the CTA being used in their country. 30% Australia and 45% France participants were not aware of the CTA.

Participants were asked about their knowledge on how they think the CTA in their respective country functions. Among Australia participants, the use of Bluetooth (N=16 mentions) was a common understanding, but apart from this, users appeared to have no proper understanding. They reported features ranging from working in the background (N=7), recording of data (N=9), issuing alerts (N=5), being used by public health officials only (N=4), "6 feet and 15 minutes" (N=3), requiring registration (N=2), tracing locations (N=2), and using unique IDs (N=2). France participants reported features like data storage (N=2) and people involved (N=2).

B. Reasons to Discontinue & Factors Stopping from Downloading CTAs.

At the time of this study, only 25% France and 42.5% Australia participants reported being active users of CTAs. Some participants indicated that they have discontinued the use of CTAs. They were asked to explain their answer. Australia participants listed several reasons including no cases, improper

working, having Bluetooth constantly activated, ineffectiveness, the infrequency of use, pre-requirements of use, lack no scientific basis, and uselessness. Our France sample indicated reasons like their unfamiliarity with the technology, that the use of the app is restricted to borders, that there are fewer users and fewer cases, issues with the design of the app, and privacy concerns.

The group of participants who indicated that they have not yet downloaded a CTA was also asked to provide reasoning for their decision. Australia participants mentioned ineffectiveness (N=5), issues with the government (N=5), no cases (N=4), phone/app issues (N=4), improper working (N=3), laziness (N=3), unavailability of pre-requirements for CTA (N=2), privacy concerns (N=2), not going outdoors (N=2), and safety of data (N=2). France participants also voiced concerns: privacy concerns (N=10), uselessness/being unneeded (N=7), mistrusting the government (N=5), design of the app (N=5), unawareness (N=4), low number of users (N=3), and low number of cases (N=2).

Only 22.5% Australia participants and 25% France participants held the view that the app will reduce their chances of getting infected by the coronavirus. Participants were also found to be neutral on the role of CTAs in overcoming the spread of the virus. 42.5% participants from France and 54.5% participants from Australia believed that the app will assist in overcoming the spread of the coronavirus. Figure 3 showcases the privacy concerns in adopting CTAs of Australia and France participants. 60% France and 37.5% Australia participants were worried about the information collected by the app.

France participants mentioned more factors causing hindrance in adopting CTAs (N=18) as compared to Australia participants (N=7). Australia participants mentioned not preferring to share whereabouts, improper use, inefficient, no use of data, untrustworthy app, mistrust in government, and "covid-care fatigue". Whereas, France participants mentioned limited users, privacy concerns, mistrust in government, data security, unwillingness, and ineffective/inaccurate. France participants also asked for some confirmations (N=8) before they would start using the CTA that included: researching before downloading the app, security required for personal information, the guarantee of data security, anonymity and security of the app, privacy ensured, confirmation on the effectiveness, and the majority of the population should be using the app.

Participants from both countries; Australia (N=11) and France (N=10) listed some conditions to be fulfilled before accepting the use of CTAs. Australia participants mentioned open-source, more users, the possibility of reverse engineering, the guarantee of effectiveness, understanding of working, and if it does not revert to social contact. Participants from France mentioned they will use the app if they have been in contact with the virus, if the use of a CTA is made mandatory, depends on a personal judgement about the app, if it helps in reducing the spread, more people use it, more efficient it becomes, if anonymity and security of information gathered are guaranteed and if a trial of the app is provided.

For the statement "The app can collect sensitive information", 62.5% Australia participants and 67.5% France participants agreed. Sharing of information with other organizations through the app was also seen as a concern by 72.5% Australia

participants and 77.5% France participants.

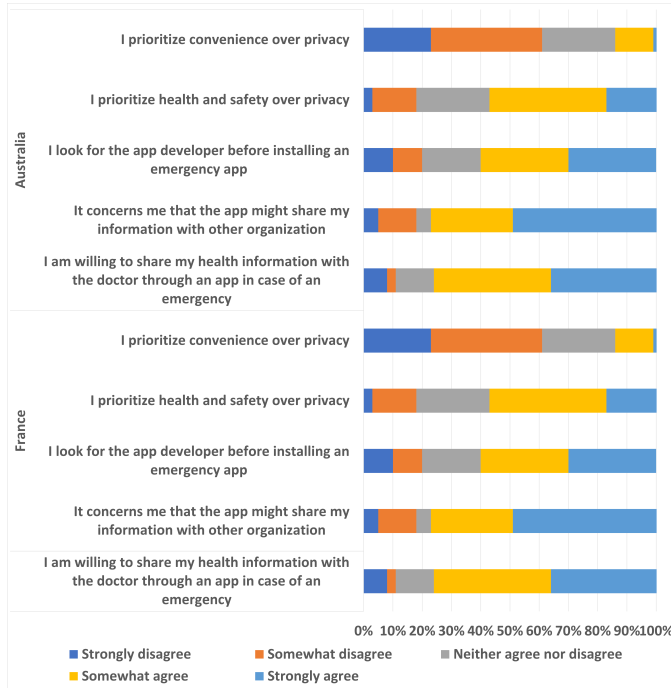


Fig. 2. The figure shows attitude towards CTAs from Australia and France. C. Motivational Factors to Use CTAs.

65% Australia and France participants expressed willingness to use CTA to help the government overcome the spread of the virus. Participants from both countries considered CTA as an important tool (N=4) to control the spread of the virus (N=3), especially in worst conditions (2) to control the transmission (N=3) and communicated inclination to use CTAs for self-protection (N=2). Participants voiced that they consider the usage of CTAs as everyone’s communal responsibility (N=7) as it serves the purpose of everyone’s protection (N=6). Contact tracing was marked as “efficient” (N=2) and “helpful” (N=2), providing a quick alerting mechanism (N=2) and “a way to return to normal life” (N=1).

D. Recommending Others to Use CTAs.

60% Australia participants and 42.5% France participants expressed their willingness to recommend CTAs to friends and family. Participants from both countries voiced that it is the individual’s choice (N=17) whether to install or not to install CTA. However, they also expressed reasons to not recommend CTA to friends and family. France participants revealed more concerns (N=25) as compared to Australia participants. France participants mentioned data collection and misuse of data, privacy concerns and uncertainty. Australia participants mentioned that privacy and security protection is needed, unsure about the working, ineffective, mistrust government, phone issues, issues with the app, and privacy concerns.

However, a group of participants from both countries favoured recommending CTA to friends and family, Australia participants were found to be in favour (N=14) because they understand the importance of CTA as it is helpful and everyone’s responsibility. More users would result in better

protection. Some participants also mentioned recommending it in the state of the outbreak and if the spread of the virus is widespread. France participants also mentioned similar reasons including more users more protection, which seems reasonable to do, tracing as a good idea, everyone’s safety, rising concern, and individual responsibility,

E. Government-Made vs. Company-Made CTAs.

Feedback from our participants indicated that they “trust government” (N=8). Other reasons (N=9) included: “government would do a better job”, “government already holds lots of data”, “safer with government as the government has better privacy protections”, and hence can offer better protection of personal data. Only 25% Australia participants preferred company-made CTAs, and only 10% France participants expressed they favour company-made CTAs. Company-made CTAs were preferred (N=10) mainly because they are considered to be the tech masters (N=5), and trust (N=3).

Participants also voiced issues in the company made CTAs. Australia participants mentioned distrust (N=7), collection of a lot of data (N=5), and economic interests (N=4). Whereas, our France participants mentioned mistrust (N=3), economic interest (N=3), and reselling of data (N=2). Participants from both countries mentioned privacy concerns (N=28), mistrust in government (N=7), ineffectiveness (N=4), and poor UX (N=2). Moreover, Australia participants mentioned the security of data (N=6), incompetent government (N=3), improper working (N=3), phone/battery issues, and malfunctioning of the app (N=9).

F. Users’ Interpretation of Privacy.

Privacy has been looked upon by security and privacy researchers in the past. However, it remains unclear what privacy concepts people link to the usage of CTAs. It has been observed that it is hard to agree on how privacy can be best defined and defended [39]. As the context changes, the meaning of privacy also changes. What does privacy mean from the user’s perspective? What do the users expect in terms of privacy from the developers of CTAs? To answer this, we asked participants to define what data privacy means to them. “Important and private” (N=13), “protection of data” (N=17), “use of data” (N=18), “No selling or sharing of data” (N=12), “informed use of data” (N=8), “consented data collection” (N=5), “no tracking” (N=1), control over data (N=5), and “no misuse of data” (N=2) were commonly used by our participants to define privacy. Some participants also defined privacy as the “protection of ethical issues” (N=11) and the “transparency in data collection” (N=3). Accountability (N=3), informed use of data (N=8), and deletion of data (N=2) were other meanings given to privacy. Some specific information like “Name, address, phone number” was linked to the concept of data privacy. All these meanings lay the foundation of gaining trust, which is as important and crucial as developing new technology [44].

G. User’s Understanding of CTA Models.

In France, only 25% of participants answered that they are aware of what is meant by a centralized and decentralized model. Only 17.50% Australia participants voiced that they

knew what is meant by a centralized CTA and 22.50% answered that they knew what is meant by a decentralized CTA. Australia participants defined centralized approach (N=15) as “control by one entity” (N=1), “match notification by AI” (N=1), “manual uploading of data by user” (N=1), “centralized infrastructure and databases” (N=2), “stats anonymity” (N=2), “centralized server” (N=2), “logging of location” (N=1) and similar. The responses indicated that our participants had no clear idea of how a centralized approach works. Many answers were opposite to the functioning of a centralized approach. France participants defined centralized approach (N=14) as “central server” (N=3), “data storing at one place”, “easy to hack” (N=1), “easy to trace back” (N=1), and similar.

Further, Australia participants defined decentralized approach (N=14) as “data uploaded to server” (N=1), “ad-hoc tracing and notification” (N=1), “no brand manufacturer” (N=1), “localized tracing” (N=1), “alerts broadcasted for dangerous users/location” (N=1), “list of other devices” (N=1), and similar. The broad mixed range of irrelevant answers clearly show the level of understanding among users. France participants defined decentralized approach (N=20) as “anonymization”, “fragmentation of data” (N=2), “peer to peer system” (N=2), “not hosted on server” (N=1) and similar.

Although Australia had a higher CTA adoption rate compared to France [40], people were still not aware of what these terms mean. It is important to deliver these key information in the simplest terms so that they can be widely understood, the trust of users can be gained and hence, the adoption rate can be increased.

H. Impact of CTA on Users’ Behavior.

Participants were asked how they would adapt to CTAs if the government makes the usage mandatory. While some participants from both countries expressed willingness to accept (N=45), some Australia participants mentioned opting for alternatives to avoid CTA (N=8) while France participants mentioned that they will avoid the pre-requirements of using CTAs (N=6) (e.g., turning off the Bluetooth or phone) and will make arrangements for use (N=4). Participants also mentioned the concern that not everyone owns a smartphone (N=4), hence, the law will not apply to the entire population. Moreover, Australia participants also mentioned that the adaption depends on what information the app collects (N=1), no reduction on free movement (N=1), and also dependent on how the law is made (N=1).

12.5% Australia and 7.5% France participants expressed that they are likely to leave their cellphones at home to avoid contact tracing. However, the other group of participants conveyed the unlikelihood of leaving a cellphone home because they believe that contact tracing is important (N=16). They also mentioned that the phone has other uses (N=18) and will instead adjust pre-requisites (N=5). 35% Australia participants and 20% France participants voiced they believe others are likely to leave their cellphones at home to avoid contact tracing because of their non-seriousness (N=13), for freedom (N=5), and data privacy concerns (N=4). On the opposite, 50% Australia and 47.5% France participants believe that some others are unlikely to leave their cellphones home as needing

the device for other purposes too (N=20) and mentioned that others are likely to avoid pre-requisites of the app (N=9), or opt for other ways to avoid installing CTAs (N=6).

I. Users’ Perceptions of the Effectiveness & Assistance of CTAs.

55% Australia participants and 42.5% France participants hold the opinion that CTAs is effective in overcoming the spread of the virus. Arguments included the hopefulness (N=12) that the app is effective with contact tracing (N=5), early notification (N=3), and in reducing the spread of the virus (N=3). On the contrary, France participants mentioned several reasons for CTAs’ ineffectiveness (N=36) including awareness requirement (N=7), uncertain (N=4), privacy concerns (N=3), fewer users (N=8), limited followers of the alerts (N=6), and inefficient/ineffective (N=8). Australia participants also mentioned that success depends on the number of users (N=6).

Participants were further asked if they consider that the app will reduce their chances of getting infected. 22.5% Australia participants 25% France participants believe that the app will assist in reducing the chances of getting self infected. Participants believed that CTAs contribute to early self-isolation (N=7), slow down the transmission (N=7), rapid contact tracing (N=2), and early notification (N=2). However, other participants raised the issue of app drawbacks (N=17), fewer users (N=8), and limited benefits of the app (N=11) as obstacles in achieving the purpose of CTAs.

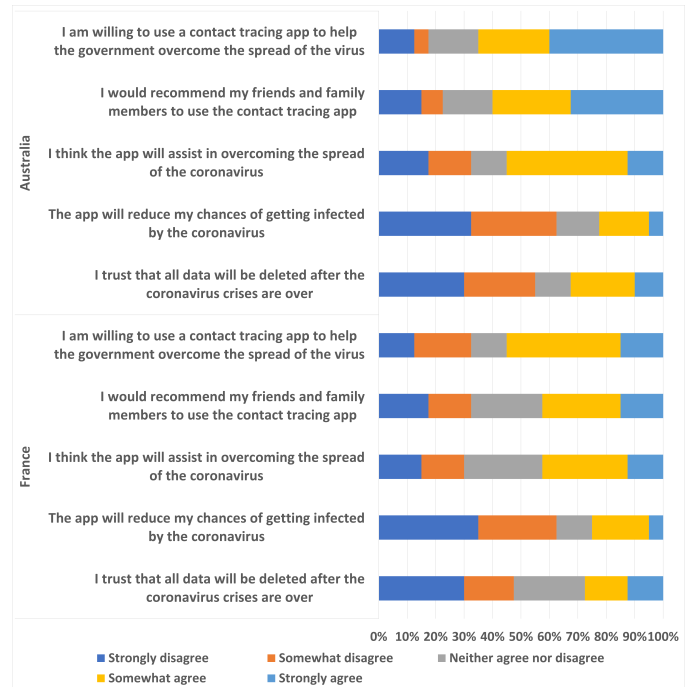


Fig. 3. The figure shows Privacy concerns in adopting CTAs from Participants of Australia and France.

J. Trust, Concerns & Thoughts on Data Collection.

Only 22.5% Australia participants and 27.5% France participants were found to be of the view that data will be deleted after the pandemic is over. France (N=7) and Australia (N=12) participants seemed to trust in the good use of the CTAs. For example, participants voiced that the code of their CTA has

been reviewed by professionals and that they believe data will be deleted afterwards. Australia participants also expressed trust in the government (N=4). However, some participants from both countries expressed distrust in government (N=17) and strongly believed in the concept of digital legacy (N=10). Participants also mentioned misuse of data (N=6) for other purposes (N=6), and privacy concerns (N=4).

When asking participants about their opinion on requiring to use CTAs in public spaces (e.g., malls, public transport) 45% Australia participants conveyed agreement. Reasons by France participants included "useful and hopeful" (N=7) while the Australia participants indicated that the idea would assist in the fight against COVID-19 (N=8) since more users are required (N=3), the strong interaction among people in crowded places (N=3). This way everyone's safety will be taken care of (N=2). On the contrary, participants from both countries also mentioned reasons for not making CTAs mandatory for public spaces. France participants expressed more concerns (N=39) as compared to Australia participants (N=26). France participants voiced that it should be free will (N=11), following of SOPs and awareness is more important (N=8), not everyone owns a smartphone (N=6), unhelpful (N=5), loopholes in the app (N=4), pre-requirements of the app as a hindrance (N=4), and less trustworthiness of the app (N=1). The Australia participants mentioned "freedom of choice (N=8)", privacy concerns (N=5), not everyone owns a smartphone (N=4), and app issues/improper working of the app (N=6).

While some participants expressed their concerns over sensitive data collection, a small group of participants from both countries considered that the app does not collect sensitive data (N=6). 37.5% Australia and more than half (60%) of our France participants were worried about the information collected by the app because of, for example, past experiences of mishandling data (N=2). Participants from both countries mentioned privacy concerns due to social tracking (N=24), mistrust in government (N=10). Furthermore, Australia participants expressed app developer issues (N=2) and wanted to know more about the app's functioning.

The other group of participants from Australia that seemed to be satisfied over the data collection by CTAs identified trust in government (N=3), minimal data collection (N=2) and that they trust in the CTA developers as the reasons to use CTAs (N=5). They also mentioned that they have nothing to hide (N=10) and so are satisfied with the information collected by the app. France participants identified "trust in government" (N=3), "open source code" (N=1), "anonymized process" (1), "government confirmation on no location tracking" (N=1), and "nothing to hide" (N=1) as the cause of satisfaction and conveyed confidence in the good use of it (N=2). In line with this finding, 65% Australia and 60% France participants reported that they take a look at the corresponding app developers before downloading and using it. The majority of our participants prioritized health and safety over privacy. Additionally, participants from both countries showed a willingness to share health information with the doctor through an app. However, they did not prefer convenience over privacy. This shows that if participants are presented with well-developed and secure CTAs, the number of users can be increased; hence the primary goal of CTAs can be achieved. Figure 2 shows the attitude of Australia and France participants towards CTAs.

VI. DISCUSSION

Whether it is the US, UK, China, Europe, or Australia, user concerns are prevalent and consistent when it comes to CTAs. Among the plethora of possible concerns, there exists a subset of privacy concerns that needs to be addressed to encourage and motivate people to adopt CTAs. In times of pandemics, especially with the still ongoing COVID-19 pandemic, the government, companies, and the general public should work together to overcome the spread of the virus.

A. Willingness to Help

The intention to help is seen across continents. A study based in the US showed that at least 67% of Americans are willing to install an app to assist in slowing the spread of COVID-19 [22]. While our participants voiced that they are willing to use CTAs, they also mentioned significant privacy concerns. The concerns are mainly situated around the data collection and the lack of transparency resulting in few users using CTAs. Our work revealed that one significant issue of low adoption rates lies in the users' distrust of the government. Our participants mentioned that they find it challenging to trust the government, which then leads to privacy concerns. It is important to ensure that the population is aware of the benefits of CTAs. It is equally important that the users' data is only used for purposes they agreed on. Further, trust can indeed play an important role in users' adoption of CTAs [44].

Our participants appeared to have similar views for themselves and others when recommending the use of CTAs as they believe it is a matter of freedom and individual choice. This is one reason why the majority of our participants were not positive about mandatory CTAs, which shows that if a government tries to make CTAs mandatory to gain more users, people are likely to find ways to avoid using CTAs.

B. The Choice Between Government & Company-Made CTAs

Privacy concerns are closely linked to trust [46]. Selinger and Rhee [38] argue that many government agencies and big tech companies are regarded as "untrustworthy". They further argue that a notice-and-consent regime does not perform well on a large scale. The mistrust in governments and big tech companies was also reflected in our participants' responses. Although users expressed concerns over government-made CTAs, they still preferred those over company-based CTAs.

Our study revealed that users' preference could be drawn back to their perception of the government as empathetic and caring for the public, whereas worrying that tech companies are interested in profit-making only. Along with tech expertise, governments also need to earn trust. To do so, it is essential to better understand what privacy means to users and also how to increase the transparency of data usage. Our study revealed that participants define privacy in the context of CTAs as the authorized use of data, clear explanation, and transparent use of data. All these definitions and meanings lay the foundation of gaining trust, which is as important and crucial as developing new technology [44].

While there has been debate and shift by many governments in choosing the centralized or decentralized model for CTAs [9], [10], [14], [28] as it is perceived that decentralized

is more privacy-preserving, participants from both countries mentioned problems in understanding the differences between centralized and decentralized CTAs. There is, indeed, research on how the systems work [1], [6] but the end-user is unaware of it. When users are not aware of the functionality of a system, it's hard to trust it with their data. This underlines the need to simplify the expert concepts and make them tangible and accessible for everyone to gain a clear understanding and hence, to minimize the privacy concerns. The insignificance of the CTA model from the user's perspective was also seen in the study by Li et al [26] that focused on US citizens and concluded that other factors such as individual preferences weigh a lot more than app models.

Moreover, the majority of our participants did not know the name of the CTA used in their country but they were aware that a CTA is being recommended for use. Similarly, they were unaware of its functionality and handling of personal data. This directs us towards properly and actively marketing and advertising CTAs to the general population to increase awareness about CTAs. The more awareness is spread, the more users are likely to adapt CTAs.

With technology-assisted solutions come technology-accessible issues. As highlighted by our participants, not everyone owns a smartphone. This brings a huge limitation to the functionality and goal of CTAs. Even if all smartphone owners start using the app, there will still be a small group of people without smartphones and hence, without the app. For example in 2018, 95% of people in South Korea owned a smartphone but only 66% of people did in Japan [27]. Within the smartphone owner group of people, there exists a subset of outdated OS which do not support the requirements of CTAs which further limits the goal associated with CTAs. This finding complements one of the two factors impacting social acceptability by Georgieva et al [18] i.e. digital inequalities. Governments should consider this issue when developing an application such as CTA as it is not only about smartphones but also what kind of smartphone. A possible solution could be to consider the minimal specifications of smartphones.

C. Lessons Learned for Use of CTAs in Future Pandemics

Considering the results of our user study, we present the following lessons learned that are useful when seeking tech assistance in future pandemics. These lessons not only direct towards ethical CTAs but also form the basis of earning public trust, which is as crucial as developing new technology [44].

- 1) **Communicate the importance and necessity of the emergency app to users in non-technical words.** This is important as people likely do not have a complete understanding of technical words, such as centralized or decentralized infrastructures (see Section IV.A, IV.G and [26]).
- 2) **Provide evidence on the effectiveness and accuracy of the app.** As elicited by users, awareness about the effectiveness and accuracy can lead to the adoption of CTAs (see Section IV.B, IV.D and IV.I).
- 3) **Set a time-frame or conditions of use of the app.** The absence of cases and infrequency of use has been a reason for discontinuing the use of CTAs. Knowing this sort of information in the forefront will encourage users in a way that the use of the app is limited (see Section IV.B).

For example, when the infection rate falls under a certain threshold, users may opt to stop using the app.

- 4) **Indicate voluntary/forced use with user consent required for the use of the app.** Mandating the use of CTAs may not work as well as expected as people are inclined to opt for other ways to avoid CTAs. Instead, voluntary/forced use of CTA with user consent would give them space. Moreover, informed, consented data collection, and transparency in data collection are the meanings of privacy according to users (see Section IV.H and IV.F).
- 5) **Ensure anonymity and confidentiality of the collected information.** Privacy is a core reason for distrust and low adoption of CTAs. A leak of confidentiality can result in disasters (see Section IV.B and [20]).
- 6) **Make the app open source.** Supporting open source could lead to improved software and also increases the transparency of data collection practices, which in return improves trust (see Section IV.B and IV.J).
- 7) **Determine other purposes of data (such as future predictions of diseases) and deletion of data.** Digital legacy is one of the highlighting user concerns. Educating the users about other purposes of data and the time frame for the deletion of data will assist in gaining users' trust (see Section IV.J).
- 8) **Incorporate a user-centred app design.** Poor app design and app issues are reasons to discontinue the use of CTAs. Following a user-centred app design would assist users in continuing using CTA smoothly (see Section IV.E and IV.B).

VII. CONCLUSION

We investigated two countries; Australia and France by surveying 80 participants (40 from Australia, 40 from France) to understand social acceptability better and if and how privacy impacts the adoption of contact tracing apps. We found that users' privacy concerns reduce their willingness to use CTAs and recommend CTAs within their social circle. Despite the privacy concerns, our participants have seen government-made CTAs more appropriate than company-made CTAs as they seem to be less likely to be interested in profit-making. In addition to privacy concerns, app requisites and tech unawareness further reduce users' willingness to adopt CTAs. Our work showed that the functionality of a decentralized compared to a centralized CTA often remains unclear to users. Hence, an increase in the adoption rate is challenging to achieve without proper handling of the privacy concerns of the users. We conclude by presenting recommendations to foster public trust when seeking tech assistance.

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APPENDIX

A. User's Use of Contact Tracing Apps

- 1) What is the name of the Contact Tracing App used in the country you are currently residing in?
- 2) Are you currently using the contact tracing app?
- 3) How does the app work? Please provide as much detail as you can.
- 4) Have you used the contact tracing app before?
- 5) Why did you discontinue using it?
- 6) What stopped you from installing and using the app?
- 7) For the statement "I am willing to use a contact tracing app to help the government overcome the spread of the virus" you:
 - a) Please provide reasons for your choice in the last question.
- 8) For the statement "I would recommend my friends and family members to use the contact tracing app", you:
 - a) Please provide reasons for your choice in the last question.
- 9) For the statement "I think the app will assist in overcoming the spread of the coronavirus", you:
 - a) Please provide reasons for your choice in the last question.
- 10) For the statement "The app will reduce my chances of getting infected by the coronavirus", you:
 - a) Please provide reasons for your choice in the last question.
- 11) For the statement "I am worried about the information which will be collected by the app", you:
 - a) Please provide reasons for your choice in the last question.
- 12) For the statement "The app can collect sensitive information", you:
 - a) Please provide reasons for your choice in the last question.
- 13) For the statement, "People who enter malls or public transport should be required to install the contact tracing app", you:
 - a) Please provide reasons for your choice in the last question.
- 14) For the statement "I trust that all data will be deleted after the coronavirus crises are over", you:
 - a) Please provide reasons for your choice in the last question.
- 15) For the statement "I am likely to leave my cellular phone at home to avoid contact tracing", you:

- a) Please provide reasons for your choice in the last question.
- 16) For the statement "Other people are likely to leave their cellular phones home to avoid contact tracing", you:
 - a) Please provide reasons for your choice in the last question.
- 17) For the statement "I'm more willing to use a Contact Tracing app by Apple/Google than by Government Authorities", you:
 - a) Please provide reasons for your choice in the last question.
- 18) What are your main concerns about using the Contact Tracing App developed by your government?
- 19) If the government makes the Contact Tracing App mandatory for all citizens and residents to use, how would you adapt to the new app?
- 20) Any other thoughts about the contact tracing app?

B. Privacy Perceptions

- 21) What does data privacy mean to you?
- 22) Do you know what is meant by a centralized app?
- 23) How do you think a centralized approach for contact tracing app would work? (Please note, there are no right or wrong answers. Kindly make sure your answer reflects your understanding)
- 24) Do you know what is meant by a decentralized app?
- 25) How do you think a decentralized approach for contact tracing app would work? (Please note, there are no right or wrong answers. Kindly make sure your answer reflects your understanding)
- 26) "I prioritize health and safety over privacy"
- 27) "I prioritize convenience over privacy"
- 28) "I am willing to share my health information with the doctor through an app in case of an emergency"
- 29) "It concerns me that the app might share my information with other organizations"
- 30) "I look for the app developer before installing an emergency app"