Deciding If and How to Use a COVID-19 Contact Tracing App: Influences of Social Factors on Individual Use in Japan

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Contact tracing apps have been suggested as a promising approach towards containing viral spread during pandemics, yet their actual use in the COVID-19 pandemic has been low. While researchers have examined reasons for or against installing contact tracing apps, we have less understanding of their ongoing use and how they interact with everyday pressures related to work, communities, and mental well-being. Through a survey of 153 working people in Japan and 15 follow-up interviews, we investigated attitudes toward installing and using Japan's national contact tracing app, COCOA, and how these related to respondents' daily lives, work structures, and general attitudes about the pandemic. We found that motivations about installing the app differed from those related to ongoing usage. Specifically, we identified ways that people navigate uncertain norms of behaviour during the pandemic, and how people consider individual risks such as COVID-related stigmas, anxiety, and financial precarity when deciding if and how to use COCOA. In light of these, we discuss the tension between COCOA's design and desires to protect oneself by selective controlling disclosures. We note that perceived risks are closely tied to respondents' local contexts, and based on our analysis, we identify ways to address these challenges and tensions through design interventions at multiple scales.

CCS Concepts: • **Human-centered computing → Computer supported cooperative work**; • **Applied computing → Health informatics**.

Additional Key Words and Phrases: Contact tracing, COVID-19, public health, stigmatization, technology adoption

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1 INTRODUCTION

Public health crises are complex challenges that require coordination among many parties to serve the public good. Understanding how people understand and use technologies in these contexts can help us prepare for future crises. The COVID-19 pandemic emerged in late 2019, and at the time of writing, the disease has killed almost three million people [26] and efforts to contain the pandemic have impacted billions. As most of the world awaits wide distribution of vaccines, containment

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measures including social distancing, travel restrictions, testing, and contact tracing remain crucial [16, 68, 87, 89].

Digital contact tracing apps have been regarded as a particularly important tool for managing public health crises, since they can contribute to the rapid identification and notification of exposures to the disease [32]. The effectiveness of these apps is proportional to the number of people who use them. An influential simulation study found that "the epidemic can be suppressed with 80% of all smartphone users using the [contact tracing] app, or 56% of the population overall" [44]. Many regions have thereby targeted an adoption rate of approximately 60%, though even with lower levels adoption, contact tracing apps can contribute to a reduction of COVID-19 cases and deaths [83]. Early in the pandemic, survey research reported that a strong majority of the population, well above 60%, was willing to install a hypothetical contact tracing app [8, 56]. However, actual adoption has been considerably lower, with installation rates below 10% of the population of nearly all countries where apps have been deployed [17, 84].

Accordingly, there is a need to understand why contact tracing apps have not been as popular as anticipated. This is not only significant for addressing the COVID-19 pandemic, but also for understanding how to design technologies for public health as well as other large, collective challenges in the future. Researchers have shown that willingness to use these apps is shaped by a range of factors, such as perceived effectiveness of the apps [30, 110], privacy risks from disclosing contact, health, and location data [65, 92], and practical concerns such as battery drain and mobile data costs [92]. Additionally, as we deploy digital technology to fight the spread of COVID-19, it is important to consider technology could either reinforce or reduce existing inequities related to representation, access to resource, and stigmatization [51]. Patterns and perspectives related to inequity, effectiveness, and privacy are situated in the local contexts in which the technology is being used. In the present study we focus on contact tracing in Japan, where stigmatization of infected people has been particularly strong [25, 50, 82].

A significant barrier for contact tracing app adoption is that people are urged to make an individual choice (using an app on their personal smartphone) to serve a collective good of containing the pandemic. Further, the collective utility of contact tracing technology to suppress the spread of viruses depends not only on the adoption of contact tracing apps but also on their continued use. In particular, registering infections is important so they can be tracked and communicated to others, as is responding appropriately in the event that one is notified of contact with an infected person. However, registering infection may involve personal risks, or more precisely, people may *perceive* it as posing a personal risk even if the feature does not retain the ability to identify an individual. Indeed, research have shown that people's risk assessments vary in relation to different functions of contact tracing, such as identifying contacts, sending notifications, and monitoring systems [65]. In addition to such personal risks entailed in the use of contact tracing apps, research about other health tracking smartphone apps (which are predominantly personal informatics) has found that sustained use has different motivations than initial adoption [20, 29, 63]. Based on these observations, we address a gap in research about how contact tracing apps integrate into individuals' everyday lives on an ongoing basis, with particular attention to how they contribute to personal benefits and risks that vary significantly depending on one's social context.

We conducted a survey of 153 working people in Japan, as well as 15 follow-up interviews, to investigate behaviours and intentions to use Japan's contact tracing app, COCOA. We investigated general pandemic attitudes and practices alongside adoption of the app, which illuminated ways that the app fits (and does not fit) into the context of respondents' everyday lives. We used quantitative analysis to identify overall patterns in the responses and drew from qualitative interpretation to explain these patterns and to illuminate personal risks that shape individuals' approach to using the app.

Three research questions guided our analysis:

(RQ1) What factors shape people's attitudes about installing and using a contact tracing app?

(RQ2) What sort of personal risks do participants encounter during the pandemic, and how does COCOA relate to these?

(RQ3) How do participants navigate risks identified in RQ2?

By "personal risks" in RQ2, we refer to risks besides infection itself. Specifically, we are interested in personal risks as potential barriers to using COCOA. By doing so, we address the potential for technical solutions to cause or worsen harms, which has been identified as a vital consideration for HCI research [14]. Particularly, we look for ways in which a contact tracing app may exacerbate existing personal risks and social inequities.

Participants described high installation and compliance with COCOA, but doubted that others would comply and thus were skeptical of COCOA's utility. Additionally, our findings demonstrate that local contexts are important for shaping attitudes toward adopting technologies. We identify ways that people's overall behaviours and intentions during the COVID-19 pandemic were shaped by their communities, workplaces, and other social factors, and that they impact decisions about initial installation and ongoing use of a contact tracing app. Notably, we found that technical decisions supporting anonymity are regarded as insufficient in small communities, and thus alleviating privacy concerns is more nuanced than has been accounted for. The results of this study illuminate ways that local contextual and social factors shape ongoing usage as well as potential harms arising from technology.

2 BACKGROUND

2.1 Digital contact tracing

Digital (app-based) contact tracing methods were identified as a promising tool to contain the spread of COVID-19 because the disease spreads too rapidly to be contained by manual contact tracing [32]. In brief, digital contact tracing uses mobile technologies that help identify when an infected person has been in close proximity to someone else, which helps trace and contain infections. A variety of implementations exist for digital contact tracing, with significant differences about how much information is collected, considerations of privacy, and integration with other systems [6]. Some major architectural differences are whether an app uses centralized or decentralized storage, identifies contact by using location data (e.g., using a Global Positioning System (GPS) signal, or by using Bluetooth to record proximity between devices), and whether any identifying information is collected [64].

In most regions, contact-tracing apps are optional. There are exceptions, such as China's *Health Code* app being required for entry to many public spaces [73] and apps being mandatory for subsets of the population in Singapore [27] and India [19]. For those regions where apps are optional, the actual adoption rate has been as low as 10%, which is considerably lower than the ideal adoption rate, which is above 60% [17, 84]. Because the effectiveness of contact tracing apps is reliant on their widespread adoption, many studies have investigated what factors affect people's intentions to use them. Prior literature has identified barriers to adoption of contact tracing apps. A significant challenge is that the main benefit of contact tracing apps operates at a collective scale, with minimal immediate individual benefit. Research investigating contact tracing app use in Germany reported that people are less likely to be motivated by commitments to the common good than they are by individual incentives [74]. Privacy has been identified as an especially significant factor for people's attitudes towards contact tracing apps [8], and motivated many of the architectural differences across app designs [31]. In large part, efforts to address privacy concerns in digital contact tracing

have focused on fears about surveillance and data breaches, and thus employed mechanisms such as limiting the amount of data collected, encrypting and decentralizing data storage, and using anonymous identifiers [92, 97]. For example, literature shows that members of marginalized populations are more vulnerable to negative outcomes if their privacy is breached [35, 51].

Attitudes around sharing information for the purpose of contact tracing are complex, shaped by with whom and in what contexts information is shared as well as what information is shared. Hargittai et al. [42] found that willingness to install a contact tracing app varied based on the distributor (e.g., the government, a technology company), using contextual integrity theory [80] to argue this was due to viewing some distributors as less appropriate than others. Lu et al. [65] compared attitudes toward human contact tracing and digital contact tracing, finding significant differences in attitude based on factors such as privacy, convenience, emotional reassurance, and accessibility.

Because adoption of contact tracing technology for COVID-19 has generally been low, research has primarily reported on people's attitudes toward the technology and decision-making around adoption. We extend this work to investigate the influence of these attitudes toward both adopting and using digital contact tracing, studying COCOA in Japan as a case study given the broader level of adoption and emphasis on the app as a key part of the national approach to COVID-19 containment. Although COCOA use is higher than many other contact tracing apps worldwide, the optional nature of the app leads people to make decisions about when and how to use or not use it. The rationales behind these decisions point to important implications for the use of digital contact tracing during pandemics worldwide.

2.2 COVID-19 pandemic in Japan

Japan's first COVID-19 case was reported on January 16th, 2020, and there have been multiple waves of infections over the course of the pandemic. As of April 8, 2021, Japan had reported 492,860 cases of COVID-19 and 9,286 deaths [26]. Among the measures taken to combat the spread of COVID-19 were closing Japan's borders, requesting companies to increase remote working and take various other precautions, and mandating that schools close and nightlife establishments reduce their hours in heavily affected areas. Many measures have involved non-compulsory restrictions of movement, which have been successful at significantly reducing social contacts [111], though these have been balanced against campaigns to boost restaurant and tourism industries [9, 34]. Alongside the devastation of COVID-19 itself, the pandemic has had severe effects on economic stability and mental health. Globally, pandemic-related economic hardship has disproportionately affected younger people and women were more likely to have lost their jobs or had their income reduced [4]. Research about Japan has found that younger and middle-aged people, women, and those with precarious employment have disproportionately experienced mental health problems compared to the rest of the population [101, 104].

An additional consideration for understanding the pandemic in Japan is the role of stigmatization. Like in many countries [5, 72, 103] people who have been infected with COVID-19 [10, 50] and healthcare workers [98] have faced discrimination. For example, staff and students at schools where infections were reported were mocked on social media and the institutions themselves reported receiving threats [114]. Additionally, healthcare workers have reported being unwelcome at some restaurants or being asked to leave parks [10]. The Associated Press reported that this is related to norms about purity and cleanliness that extend through Japan's cultural history [10]. The Japanese Association for Disaster Medicine expressed the severity of this stigmatization in a report claiming that healthcare workers who responded to a cruise-ship outbreak early in the pandemic faced "being treated as 'germs' in the workplace, being bullied, being asked by their children's nursery schools

and kindergartens to refrain from attending school, and being asked by workplace managers to apologize for their activities in the field." [52]

On the other hand, pressure to conform to social norms has been identified as the most prominent motivator for wearing masks in Japan [77]. Similarly, stigma against going out during Japan's state of emergency was identified as contributing to safe pandemic practices, such as staying at home [57]. These patterns highlight that stigmatization has multiple effects on the pandemic context. Negatively, stigmatization is a clear threat to mental health and well-being. Furthermore, in other disease outbreaks, stigma has hampered contact tracing apps when infected people were motivated to hide their illness [12]. Given the strength of stigmatization in Japan during the pandemic, it is important to understand how this could encourage or discourage safe practices.

2.2.1 COCOA. On June 19, 2020, the Japanese government launched a contact tracing app called COCOA (COVID-19 Contact Confirming Application). COCOA's app store description reads, "This app notifies you of close contact with COVID-19 positive users to help the government and healthcare organizations contain the spread of COVID-19"[1].

COCOA is built using the Exposures Notification API built by Google and Apple for Android and iOS smartphones. COCOA is designed to run in the background and does not involve frequent user interaction. Relative to other implementations of contact tracing [e.g., 93], COCOA prioritizes individuals' privacy through decisions including: (1) Bluetooth is used to measure when two devices are in close proximity to one another, and GPS or other location data are not collected; (2) An encrypted log of recorded encounters is stored on individuals' smartphones, not on a central server, and is deleted after 14 days, and (3) people can withdraw informed consent at any time, at which point their data gets erased [76]. COCOA measures close contact as spending 15 minutes or longer within 1 meter of another person. If an individual tests positive for COVID-19, they are given a code to register their case to the system. Then, anyone with whom they have been in close contact in the past 14 days is sent a notification informing them that they may have been exposed to COVID-19.

As of March 2021, COCOA had been downloaded 26,530,000 times [71]. If each of those downloads represented a unique person, then COCOA's adoption rate is about 21% of Japan's population.

2.3 Crisis Informatics Research in HCI

There has been increasing HCI and CSCW research examining how people respond and use ICT systems during crises. A large body of crisis informatics literature studies on natural (physical) and manmade disasters, such as bombings [47], floods [109], and hurricanes [91], focusing on topics such as information seeking and transmission [66], sharing locally-useful information [62] and collectively making sense of the crisis [43]. Studies on these natural crises are often conducted through social media analysis, due to the risk and hazard of these events.

Recent research has examined public health crises, which are characterized by extreme uncertainty, often lacking scientific understanding of the transmission and prevention mechanisms, and often have insufficient public communication. For instance, during the 2016 Zika outbreak, individuals had to assess and make sense of the situation through engaging with social media content [38, 39]. Other studies examined people's perceptions and information sources during COVID-19 pandemic [13, 94] and the types of risks they perceived, including illness, secondary illness, economic, social behaviors risks [90].

While these studies provide useful insights into people's perceptions and behaviors during public health crises, most of them were conducted over social media, and relatively few studied technologies that are specifically designed to contain the crisis. To our best knowledge, this study

is one of the first examining the adoption and use of a digital contact tracking app in a real-world setting. Thus, it provides useful insights to understand the benefits, risks and the challenges experienced by the real users.

2.4 Adoption and use of health technologies

While understanding intent to install a technology is important, continued or proper usage is not guaranteed. This is particularly important for technologies like digital contract tracing whose utility is contingent on keeping the app installed, registering if one becomes infected, and responding appropriately to exposure notifications. Research has found that people abandon healthcare technologies for a variety of reasons, including mismatches between user expectations and technology designs and requiring too much effort [36]. Continued use of digital contract tracing has many of the same motivations as for self-tracking technologies, since both types of technologies can collect data in the background, which can then be interpreted and acted upon [65]. Research about abandonment of self-tracking technologies has identified that decisions to keep using or abandon self-tracking apps are shaped by many factors including fit with one's routine, ongoing usefulness of data, emotional discomfort with revealed data, and costs (e.g.,social) of having data or sharing it with others [11, 20, 29, 63]. Considering that ongoing use of technologies is motivated differently than initial adoption, it is important to investigate reasons that people may abandon or fail to appropriately use technologies that could be vital in a crisis.

For the most part, people adopt personal health technologies for their own benefit or for the benefit of people close to them. For example, self-tracking is generally focused on self-improvement through improved diet, exercise, or habits [61]. Additionally, some health tracking tools serve small collective contexts such as caregiver relationships [113] and collaborative tracking among patients and providers or in small groups [28]. There is some research about using technologies to encourage individuals to contribute to disease surveillance. For example, researchers have studied *Flu Near You* [99], a crowd-sourcing platform for tracking influenza outbreaks, and found its data was reasonably matched to that from official sources as long as usage was sufficiently high. Yet little research explores people's motivations for using personal technologies to tackle collective problems. Particularly, individuals may have different stakes when it comes to contributing to collective goods. Pre-existing social conditions put some people at greater risk of harm during crisis situations [15, 54, 55, 55], and technologies or interventions introduced to address crises may fail to meet the needs of those vulnerable groups[48] and even worsen inequality as a result [107].

3 METHODS

To investigate individuals' attitudes and intentions towards the national contact tracing app, COCOA, we conducted an online survey of 153 working people in Japan, followed by one-hour online interviews with 15 participants randomly invited from the survey respondents. The survey and interviews took place in December 2020. Both were conducted in Japanese and translated into English for analysis. Quantitative analyses of survey responses were used to identify patterns related to contact tracing app installation and ongoing use. Initial results were used to develop a guide for follow-up interviews. Because individuals' experiences are complex and varied, we used qualitative analysis of open-ended survey questions together with interview responses to investigate how intentions and behaviours were shaped by personal stakes situated within surrounding social and work structures. This study was reviewed and approved by our institutional review boards.

3.1 Survey

3.1.1 Survey Development. We designed the survey primarily to answer RQ1 and RQ2. Specifically, we designed the survey questions to understand how work conditions and infection control

measures under the pandemic, examine the relationship between these factors and COCOA installation/use, and understand any influence of demographics.

The survey questions started with questions about their demographics, attitudes and behaviours regarding the pandemic. Then, we offered a brief introduction of COCOA by explaining its goal and the basic features of the technology, followed by questions about their adoption and use of COCOA, and contextual information about their work and home life. The survey was a mix of 5-point Likert questions (from strongly agree to strongly disagree) as well as multiple-choice, Boolean and open-ended questions. The complete survey is made available in the supplementary materials.

To address RQ1, we asked intentions to use COCOA as well as attitudes about the app. COCOA use was measured across three dimensions: installing COCOA, intent to register one's case if infected, and how respondents intended to act if they receive an exposure notification from COCOA. For the third dimension, we asked respondents their intentions to take actions such as getting tested for COVID-19, telling their employer or boss, and self-isolating at home. We selected these actions to represent a range of diligent responses to reduce the risk of passing infection to other people. To understand attitudes about COCOA itself, we asked about respondents' performance expectancy, effort expectancy, and social influences to use the app. These questions were derived from UTAUT [108], which presents four main constructs to explain intentions to adopt a given technology: Performance expectancy, effort expectancy, social influence, and facilitating conditions. The survey includes the first three constructs, and we addressed facilitating conditions during interviews to provide an opportunity to unpack them as sociotechnical contexts. This model is important in that it takes into account both social and technical factors as influences on technology adoption, and has been validated in a variety of contexts, including adoption of health technologies [e.g. 45, 49, 60, 78]. Additionally, we asked about fears of information leaks because this dimension of privacy has been established as important in prior research about digital contact tracing [8, 31, 92, 97].

To understand how respondents' overall experiences during the pandemic related to COCOA use (RQ2), we asked about their worries and stress, as well as general measures taken to reduce the spread of corona virus. Stress questions were derived from the COVID Stress Scale [102] with additional questions about fear of discrimination and personal financial losses. Questions about general precautions were based on recommendations by Japan's Ministry of Health, Labour and Welfare [69] and the World Health Organization [88].

Finally, we included open-ended questions where respondents could identify some other action they would take that had not been covered in multiple choice questions, as well as a general question asking, "How do you think daily life is affected by installing COCOA?" Responses to these questions helped to address RQ2 by describing ways that individuals were impacted personally by the pandemic and COCOA, and RQ3 by offering respondents an opportunity to describe ways that they navigated personal risks.

3.1.2 Survey Participants. Participants were recruited on a crowdsourcing platform Lancers [1] where the study was advertised with the title *"Questionnaire on the COVID-19 contact-tracing application 'COCOA'"*. Altogether, 153 working people who resided in Japan completed the survey and were compensated for their time at a rate set by Lancers. Since we were interested in studying how the participants' working environment/condition shape their attitudes and intentions toward COCOA, we limited our participants to working people. Additionally, working people are more likely than others (e.g., retirees) to have physical contact or proximity with others, and so a contact tracing app is especially relevant to their daily lives. Survey recruitment was balanced to achieve a roughly equivalent ratio of people whose work involved contact–physical proximity or touching – with unspecified others (e.g., restaurant staff, bus drivers, beauty salon staff), to those whose work

[1] https://www.lancers.jp

did not involve such contact with unspecified others (e.g.,lawyer's assistant, call center staff). The purpose of this split was to evaluate how contact with the public through work shaped attitudes about contract tracing, as this sort of contact is frequently a conduit for infection. 46% (N =71) of respondents had jobs that involved contact with unspecified others (e.g.,customers or clients), 29% (N=44) had jobs that involved contact with specified others (e.g.,colleagues), and 25% (N=38) did not have close contact with others through their work (e.g.,working from home). 73% (N=111) of respondents identified as women, and 27% (N=42) identified as men. Respondents' mean age was 36.1, with a minimum age of 20 years old and a maximum of 62.

At the point of recruitment, 53.6% of respondents reported that they currently had COCOA installed (n=82), 9.8% had previously installed COCOA but since uninstalled it (n=15), and 36.7% had never installed COCOA (n=56). This is a significantly higher installation rate than the general Japanese population, which might be because people who had installed COCOA were more likely to want to participate in our web survey.

3.2 Interviews

3.2.1 Interview Protocol. Semi-structured interviews were conducted to help us probe more deeply into what factors shaped participants' attitudes and decisions about installing and using COCOA. We drafted an interview protocol based on an initial analysis of survey data (section 3.3.1). These added context to RQ1, and particularly served to address RQ2 and RQ3 by delving into participants' personal experiences. All interviewers followed the same protocol, starting with a question about the participant's daily routine, asking where and how they worked, whom and how frequently they interacted with other people. Then, we asked questions about their attitudes toward the pandemic, what measures they take, the rules and new routine at work, and how they perceive of others' attitudes. The follow-up questions were designed to elicit how their interaction with others (colleagues, customers, friends) had changed after the pandemic and their feelings about the change. Furthermore, to help us better understand what factors contributed or blocked them from using COCOA, we asked them their impressions on COCOA; the reasons for installing (or not installing) it; what advantages and disadvantages they see by using the app; and for those who actually installed the app, whether the use of app has affected their daily lives in any way. We also asked them to reflect, based on their own experiences, on what behaviors they might take when they get a notification from the app (e.g., who would you tell about the notification?), when they feel sick (e.g., what would you do when you get a fever?), when they test positive (e.g., whether they would register it to the app), and reasons behind their behavior. In sum, the interviews served to investigate how social norms, institutional rules, power relationships, and other structures, served as *facilitating conditions* [108] for COCOA adoption.

3.2.2 Interviewees. 15 interviewees were selected from the survey respondents and invited to a one-hour online interview. The selection of interviewees was stratified so approximately half of the interviewees had contact (physical proximity or touching) with unspecified others through work, and to include a mix of people who had and had not installed COCOA. Within those groups, selection was random. Out of the 15 interviewees, seven had jobs that involved contact with unspecified others, five had jobs that involved contact with specified others, and three did not have close contact with others through their work. Interviewees were between 22 and 62 years old, and the gender distribution was six men and nine women. Eight reported that they currently had COCOA installed and seven had never installed COCOA. All interviews were audio recorded and transcribed. All the Japanese transcripts were translated into English by an external professional translation service.

3.3 Analysis

We first conducted exploratory analysis on the survey data to identify patterns and themes related to COCOA installation and use, as well as general pandemic behaviours. Based on this preliminary analysis, we focused our investigation as described in the remainder of this section. In large part, quantitative analyses were used to identify patterns, which we sought to explain through reference to qualitative findings. However, when qualitative findings suggested patterns that were not apparent in the first stages of quantitative analysis, we adopted an integrative approach, adding additional quantitative analyses to find validate those patterns.

3.3.1 Quantitative analysis. We used Multivariate Regression models to identify variables associated with COCOA adoption. The dependent variables for these analyses were: (1) If the respondent had installed COCOA, (2) Intentions to register one's case to COCOA if infected with COVID-19, (3) Intentions to respond to notifications of potential exposures. For the purpose of this analysis, we reduced these measures as follows. First, we reduced three categories of installation (currently installed, previously installed, and never installed) into a single dummy category measuring whether the respondent had ever installed COCOA. This is because the number of people who had previously installed COCOA but since uninstalled it was too small for our statistical models. Second, we reduced the five questions about responding to notifications (get a PCR test, tell employer/boss, tell family/friends, self-isolate at home, and monitor my condition and if nothing changes let it go) to one factor––labelled *notification response*––which indicates intentions to actively and diligently respond to notifications and which explains 91% of variance from those questions. The following measures indicated these questions were appropriate for factor-analysis: Cronbach's α = 0.77; Kaiser-Meyer-Olkin measure of sampling adequacy = 0.72; and Bartlett's test of sphericity χ^2= 223.251, p<0.001. We created a polychoric correlation matrix of these variables, then performed factor analysis on the correlation matrix.[2]

Since the dependent variables were of different types, we used the following types of regression:

- Whether respondents had installed COCOA (Boolean): Logistic regression.
- Intentions to register positive COVID-19 case to COCOA (5-point Likert): Ordered logistic regression.
- Notification response (Continuous factor variable): Linear Regression.

Due to the relatively small sample size, we used the Firth procedure in our logistic regression model to remove potential parameter estimation bias [22, 33]. These analyses were performed in Stata/IC 15.1.

3.3.2 Qualitative analysis. We analyzed both the semi-structured interviews and the open-ended questions in the survey using inductive qualitative methods. Two researchers individually analyzed the quotes and sorted them into meaningful categories while identifying relationships between the themes as well as looking for salient themes that could help explain the quantitative findings. The initial themes include: others' judgement and stigmatization, anxiety, social norms, financial risk and responsibility to others. The full research team met every other week to discuss the themes. The discussion also revealed patterns that were not evident in the quantitative findings, which led the first author to conduct additional quantitative analysis to verify those patterns observed in qualitative analysis, such as identifying correlations among attitudinal variables. Most notably, interview participants expressed worry about being discriminated against if anyone else found they were infected with COVID, which influenced us to pay greater attention to quantitative measures related to discrimination fear and anxiety. This led us to find a small positive association

[2]The polychoric correlation matrix was produced using Stas Kolenikov's 'polychoric' package for stata - http://staskolenikov.net/stata/

between believing that COCOA increased anxiety and stress about being discriminated against if one were infected with COVID-19 (rho = 0.24, p = 0.003), which shaped our interpretation of respondents' beliefs about COCOA's relationship with anxiety. The findings below emerged from this collaborative analysis.

3.4 Limitations

As contact tracing apps have been launched around the world, both the apps themselves and the social, cultural, and technical environment in which they are encountered vary significantly. Since we focus on one contact tracing app in a particular context, the results of this study may not be generalizable to digital contact tracing in different circumstances, including different cultural norms, social structures, and number and severity of COVID-19 cases. Especially given our interest in respondents' workplaces, it is worth recognizing that Japan's work culture is characterized by long hours, long-term or lifetime employment, traditional gender roles, and a high level of group cohesion [85], which is different from many other countries. Additionally, attitudes toward contact tracing apps have shifted over time. Notably, shortly after our data collection, a bug was revealed that had caused COCOA to fail to send exposure notifications to Android users for approximately four months [2]. It is likely that had we conducted this study after this bug became public knowledge, opinions of COCOA's effectiveness would have been more negative. Given that contact tracing apps have experienced similar bugs in other countries [e.g., in Canada: 23], it would be valuable to follow-up to better understand how technical failures impact public opinion, however this was beyond the scope of our analysis.

The sample of survey and interview participants includes some biases that impact generalizability. Recruitment focused on working people, and thus we can not claim the findings to extend to people who are not employed. For example, focusing on employed people means the median age of survey respondents (36.1) is lower than that of Japan's general population (48.4)[3], since our sample excludes retirees. Older adults in prior studies have expressed hesitance around adopting contact tracing technology [65], suggesting that our sample may be more positive towards COCOA than a more representative sample. Additionally, the gender ratio among our respondents is skewed toward women. Past research has not identified significant differences about contact tracing app adoption based on gender [8, 74], but there is a possibility our sample includes gender-related biases toward other variables. Notably, Japan has a large gender wage gap and women are much more likely than men to work part-time [112]. Additionally, as noted in Section 2.2, women are more likely to have experienced pandemic-related mental health problems than men. Accordingly, the large portion of women among our respondents limits the generalizability of this study toward Japan's overall population, while drawing our focus toward challenges and beliefs that may disproportionately be experienced by women.

Regarding our measures of COCOA adoption, respondents reported whether they had installed COCOA in the past, while ongoing usage was reported as intentions for future behaviours. Past research has found that intention and behaviour measures are not perfectly correlated, but instead are correlated with coefficients between about 0.3 and 0.6 [7]. One factor is that self-report measures are subject to socially desirable responding, where respondents are likely to present themselves favourably [105]. Accordingly, responses indicating strong agreement that one would take a specific action should not be interpreted as meaning the respondent would definitely take that action, but they are nonetheless more likely to take that action than someone who expressed a lower level of agreement.

[3]https://www.worldometers.info/world-population/japan-population/

Finally, the sample size (N=153) may have resulted in our quantitative analyses being under powered to some extent. This could result in both false positives and false negatives when identifying relationships in our quantitative models. We have reduced the risk of false positives through our mixed methods approach, since we triangulate findings across both quantitative and qualitative analyses. However, we acknowledge that some relationships with small effect sizes might have required a larger population to be statistically significant, and thus are absent from our findings.

4 FINDINGS

In this section, we report results from the survey and interview analysis. Section 4.1 summarizes respondents' stressors and behaviours during the pandemic, providing a foundation from which to address our research questions.Section 4.2 addresses RQ1 by describing COCOA adoption patterns and identifying beliefs and other factors associated with installation and use. We then address RQ2 in Section 4.3 where we explain how individuals perceived various personal risks related to using COCOA, and RQ3 in Section 4.4, where we identify ways that respondents worked to reduce risks.

4.1 The pandemic context

This section summarizes respondents' experiences, worries, and behaviours during the pandemic. Describing the context in which respondents encountered COCOA provides a grounding for our analysis.

Respondents described feeling stressed about potential personal impacts of the pandemic, including infection, losing income, and being discriminated against. Figure 1 summarizes the extent to which respondents agreed that they experienced a variety of worries related to the pandemic. Participants' main concerns related to the direct impact of the pandemic on themselves and their families through infection (63.4% strongly agree; 26.1% agree) and loss of income (56.9% strongly agree, 27.5% agree). Many also expressed fear of being discriminated against if infected (48.4% strongly agree, 28.8% agree). Concerns about stores running out of essentials (a measure of societal economic stability); stress behaviours such as compulsive information checking or losing the ability to focus, and xenophobic stress about being infected by foreigners were relatively less prominent.

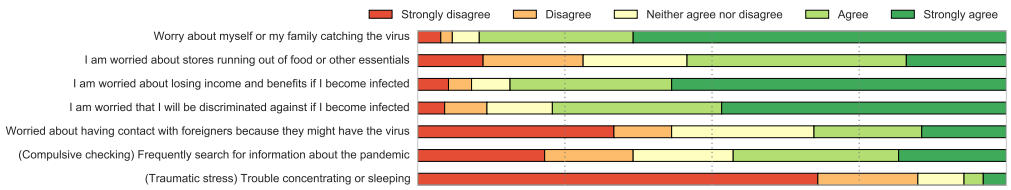

Fig. 1. Summary of respondents' agreement that they experienced a variety of worries related to the pandemic.

In general, respondents indicated that they followed most of the recommended COVID-19 precautions, such as wearing masks, social distancing, washing hands, and improving ventilation [70, 86], although there was some variation, as presented in Figure 2. Specifically, mask-wearing was close to ubiquitous (92.8% strongly agree; 6.5% agree), and frequent hand washing (77.8% strongly agree, 19.0% agree), staying home when sick (66.0% strongly agree, 20.9% agree), and improving ventilation (58.8% strongly agree, 29.4% agree) were also practiced by a large majority. By contrast, fewer participants reported following social distancing guidelines (34.6% strongly agree, 35.3% agree) or avoiding non-essential outings (41.8% strongly agree, 30.1% agree).

The measures participants most commonly took to contain the pandemic tended to be those which were visible to others or had a performative element, such as mask-wearing or frequent

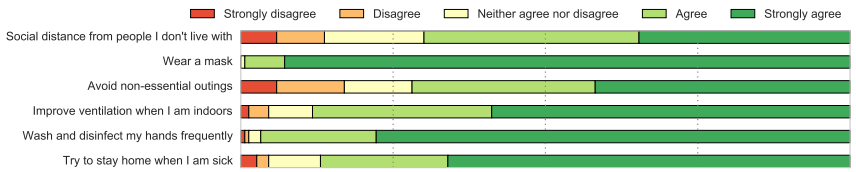

Fig. 2. General measures taken to contain the spread of COVID-19.

disinfecting. This was most obvious regarding decisions made by businesses to reassure customers and clients of their responsibility. A business owner reported telling his staff to wear a mask and to wash their hands in front of customers because *"showing is very important"* (P11-I). Participants who worked with the public described new pressures to visibly demonstrate cleanliness:

> *The standards upon which you are called a 'good salesperson' have changed since the pandemic. For example, are you wearing your mask correctly? Are you just handing over a pen from your own pocket to have contracts signed, or are you wiping it down first with sanitizers? [...] I sense that our awareness levels are being assessed.* (P61-I)

However, participants expressed uncertainty and disagreement about how to act during the pandemic, particularly about social and professional obligations to meet in person, although also related to the most commonly taken measures such as mask-wearing. Participant 61, who works in the bridal business, observed very different attitudes among her clients:

> *We have two distinct groups of clients: those who postpone or cancel their ceremonies, and those who are determined to go ahead because they say, "you can't predict the future no matter how long you wait."* (P61-I)

In addition to different behaviors among clients, some described disagreements about socializing among their friends:

> *It feels that my friends became divided into two groups who criticize each other. [...] Some of them scheduled an event in the past year, but some people declined. The people who scheduled the event said, "If you really wanted to go, then you'd go no matter what others would say" [while the others criticized back,] "You still go out even during this situation?"* (P37-I)

Such differences in attitudes and decisions about social interaction seemed impact the impressions that participants had of others. For example, Participant 103 described herself as cautious during the pandemic because her mother is at-risk, but encountered strikingly different values at her workplace, which inevitably changed her view on her owner:

> *Regarding the public uproar over the pandemic, he keeps saying, "What are they making a fuss about?" and thinks that I am way too cautious just going to work in a mask. [...] He doesn't wear a mask except in front of customers, and refuses to take precautions. [...] the difference in values has changed how I sees the owner. Now I feel somewhat patronizing about him.* (P103-I)

The two main structures we identified in people resolving these tensions about how to behave were the introduction of institutional rules, largely in workplaces, and social stigmatization of behaviours regarded as irresponsible. In particular, respondents indicated they complied with workplace rules. At one workplace, staff were told not to sit at the same table or socialize during their meal break:

> *Although we live in [rural area] where the cases are low, we are warned about the COVID-19 virus. When we eat lunch at the employee cafeteria, we are not allowed to have more than one person sitting at a table. We are also not allowed to talk. If we talk while eating, we are scolded.* (P40-I)

Another participant explained that he would follow strict rules about reporting illness to his university, but may not report to his part-time job since a similar rule was not clearly defined there:

> *[If you get sick] you now have to report it to the infirmary or somewhere like that at the university. [...] There isn't this kind of rule for the cram school [where I work], so although I should tell them this, I try to interpret it in a selfish way and I'd feel less inclined to tell them.* (P133-I)

Participant 61, who described her wedding clients above, noted that many wanted to treat weddings as an exception when it came to pandemic safety, and this was discouraged through contractual obligations:

> *We get requests like, "We don't want masks because they look bad in photos." We try to persuade them that the wedding will be held at considerable risk. [...] But still many couples don't want to compromise on the wedding ceremony. In such cases, the company I work for makes clients sign an indemnity, which says that the venue may claim damages if infections emerge. Then most clients will give in and accept masks and other measures.* (P61-I)

Through these examples, it is evident that formal structures provided by workplaces and other institutions, were often used to resolve uncertainty or disagreements about how to act during the pandemic.

In many contexts, people who did not follow norms of pandemic prevention were met with stigmatization. This was especially evident regarding highly visible behaviours, such as mask-wearing. Consistent with past research, stigmatization against perceived irresponsible behaviour was effective at driving pandemic safety [77], but also increased social discord and stress about discrimination. For example, an interview participant reflected on being one of a few to not wear a mask:

> *Recently, I've started wearing a mask because so many people are wearing it. In the end, it was sort of inevitable. [...] I went to Kyoto station and I'd realize that every single person as far as I could see, except myself, was wearing a mask. I felt like I looked like some kind of dubious character. [...] Other people's eyes are the most terrifying thing, not the virus itself.* (P95-I)

Another participant acquiesced to social pressure not to visit his parents in the countryside because he lives in Tokyo, and his parents' neighbours feared he could bring infection:

> *My hometown is in the rural part of Fukushima Prefecture, and my parents live there. I was planning to visit my parents in the summer, but decided not to. The neighbors indirectly said to my parents they preferred that I not come back during the summer. This is discrimination against people living in an urban area, and I felt very sad.* (P35-I)

In sum, many participants were worried about personal impacts of the pandemic, related to infection, loss of income, and discrimination. Respondents generally reported following general pandemic prevention measures, although some were lax regarding social distancing and avoiding unnecessary outings. In many cases, there was disagreement and uncertainty about how to behave, which were moderated by institutional rules, largely from the workplace, and the threat of stigmatization. These perspectives on pandemic behaviors form the background for decisions around the use or non-use of COCOA.

4.2 COCOA: Usage and attitudes

This section addresses RQ1, which asked "What factors shape people's attitudes about installing and using COCOA?" First, we summarize the rate of COCOA installation and usage reported by respondents. We then identify adoption patterns related to respondents' age, gender, and physical proximity or contact with other people through their jobs. Following this we describe attitudes about COCOA's efficacy, ease-of-use, potential harms, and motivations for adoption. We conclude by identifying associations between those attitudes and reported installation and use.

Table 1. Respondent demographics and COCOA usage

				COCOA install status			If get COVID*	If notified of potential exposure by COCOA*				
	Category	N	%	Current	Former	Never	Register to app	Get test	Self isolate	Tell employer	Tell family/ friends	Only monitor
	All respondents	153	100%	54%	10%	37%	85%	82%	82%	72%	84%	29%
Gender	Man	42	27%	52%	14%	33%	86%	81%	79%	71%	74%	24%
	Woman	111	73%	54%	8%	38%	85%	82%	84%	72%	87%	31%
Age	18-24	27	18%	56%	11%	33%	89%	78%	81%	70%	78%	37%
	25-34	47	31%	64%	11%	26%	96%	83%	81%	79%	87%	32%
	35-44	41	27%	41%	7%	51%	76%	78%	83%	68%	83%	24%
	45-54	27	18%	52%	7%	41%	70%	89%	85%	70%	85%	22%
	55-64	11	7%	55%	18%	27%	100%	82%	82%	64%	82%	27%
Work contact	Specified others	44	29%	61%	9%	30%	91%	80%	75%	80%	82%	27%
	Unspecified others	71	46%	49%	11%	39%	80%	80%	83%	73%	80%	30%
	No work contact	38	25%	53%	8%	39%	87%	87%	89%	61%	92%	29%

*These columns show the percentage of respondents who selected 'agree' or 'strongly agree' to these questions

Table 1 reports overall COCOA installation and use, and differences among demographic groups. Across all respondents, the rate of installation was well above the national average. Additionally, a strong majority of respondents agreed that they intend to register to COCOA if infected and would respond diligently if COCOA sends them an exposure notification.

In terms of COCOA usage, we expected we might observe higher adoption and usage of COCOA among respondents who have physical contact or proximity with unspecified others through work (i.e. customer-service and other public-facing jobs), since these people are at a relatively high risk of coming into contact with an infected person. In fact, a lower percent of these respondents reported that they intend to register to COCOA if infected than the overall sample. However, multivariate regression analyses did not show a significant relationship between gender, age, or work contact type and installing or using COCOA (in all cases, $p > 0.05$). Thus, we find that neither demographic variables nor respondents' contact with other people through work were significant factors in shaping decisions about if and how to use COCOA.

4.2.1 Attitudes and beliefs about COCOA. We next turned to understanding respondents' attitudes and beliefs about COCOA, as summarized in Figure 3. First, most respondents expressed confidence that they could use COCOA easily, although 33.3% expressed agreement that COCOA was difficult to install, and 31.4% stated that they do not know how to use the app. Respondents expressed some confusion around how they should respond to COVID notifications, as 49.7% strongly expressed agreement that they were unsure about what to do if COCOA notified them of a potential exposure. Furthermore, 43.8% of respondents expressed agreement that they were worried about COCOA leaking information to a third-party.

Opinions about COCOA's performance were generally mixed. Some were concerned about COCOA's general effectiveness. 41.8% expressed agreement that using COCOA would not help

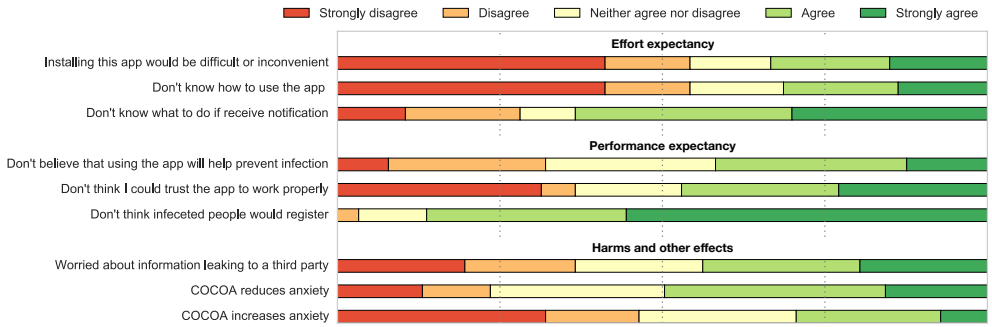

Fig. 3. Respondents' attitudes toward COCOA

prevent infection, and 47.1% that they do not trust COCOA to work. But the more significant pattern was that 86.3% of respondents strongly agreed or agreed that they did not trust that other people with COCOA installed would register their case to the app if infected. Reasons for this skepticism varied. Some respondents characterized not registering positive cases to the app as a moral failing: *"I think irresponsible people will act as innocent"* (P131-S). Others identified the threat of discrimination as a deterrent for other people: *"I guess few people would register because of fear of reputational damage"* (P150-S). And a small number of respondents suggested that infected people may simply not remember to register during a time of crisis:

> *I have doubts about the way the reporting is done when there is a positive case. [...] If you get contacted, you would probably think it was terrible enough to go and get tested, but I wonder if people are really capable at the time of thinking "I have to report this to COCOA." And what about health centers? Would they ask you to register with COCOA?* (P103-I)

We also observed mixed opinions about COCOA's effect on anxiety. 49.7% expressed agreement that using COCOA decreased or would decrease one's anxiety. This is generally consistent with past research that found that downloading COCOA was associated with decreased psychological distress, even though it was not associated with overall worry about COVID-19[58, 95]. Explanations for why COCOA could reduce anxiety generally took two forms. First, a lack of exposure notifications could provide relief that one had not been infected: *"Sometimes I go to Tokyo, and after that, for a few days, I often check COCOA. It's reassuring to see that there was no close contact with an infected person"* (P22-S). Second, some respondents described that receiving exposure notifications would help equip them to take action if exposed to coronavirus:

> *I'll know if I had close contact with an infected person and maybe I can get guidance about what I should do in that case, for example by calling the health centre to get information.* (P61-I)

However, 29.4% reported that COCOA actually increased their anxiety. Although this is a minority, it was meaningful for understanding adoption, as described further in Section 4.2.2.

On the positive side, respondents reported several different motivations for using COCOA, summarized in Figure 4. When asked questions about what COCOA was most useful for, most respondents' answers focused on protecting other people. 68.0% expressed agreement that COCOA could protect their family, friends, and colleagues, followed by 57.6% who agreed that using COCOA helped fulfill one's responsibility to their community. Finally, 32.7% strongly agreed or agreed that COCOA could protect their own health.

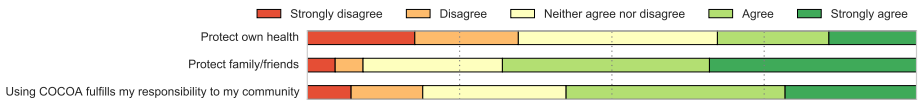

Fig. 4. Respondents' motivations for using COCOA

4.2.2 Factors associated with COCOA installation and use. Table 2 presents multivariate regression models about COCOA installation (Model 1), registering to the app if infected (Model 2), and responding to notifications (Model 3). We found two types of associations in Model 1. First, respondents were less likely to have installed the app if they responded that COCOA is difficult to install (odds ratio = 0.04, 95% CI = 0.004, 0.324) or that they do not know how to use it(odds ratio = 0.093, 95% CI = 0.011, 0.801). Second, participants who knew at least one other COCOA user were more likely to have installed the app (odds ratio = 18.389, 95% CI = 4.031, 83.882). Related to this, perceived lack of COCOA use by others was a deterrent for installing the app:

> *I feel very strongly that there would be no point unless everyone uses it. Looking at the TV and internet, and from what I've heard from people around me, not that many people are using it so there's not much point.* (P37-I)

The wide 95% confidence intervals for these results suggest that the odds ratios may be exaggerated. This could result from a lack of statistical power, particularly since some categories are sparsely populated (e.g. there were only 5 respondents who knew someone else who uses COCOA but had not themselves installed the app). However, these results are generally consistent with prior findings that effort expectancy is related to contact tracing app adoption [30], and with our qualitative findings about social influence, presented shortly.

Models 2 and 3 explained significantly less variance than Model 1 (pseudo R^2 and R^2), indicating that they represent smaller effect sizes. Nonetheless, they surfaced two significant variables related to ongoing COCOA use. People who reported that COCOA increased anxiety were less likely to indicate that they would either register infections (odds ratio = 0.021, 95% CI = 0.0039, 0.1158) or respond diligently to exposure notifications (coef = 0.1901, 95% CI = -0.3050,-0.0751). Of note, none of the variables associated with having installed COCOA had statistically significant associations with these measures of use. We elaborate on findings related to anxiety in Section 4.3, since they relate closely to individuals' personal contexts, social risks, and mental well-being.

4.3 Personal risks

This section addresses RQ2: "What sort of personal risks do participants encounter during the pandemic, and how does COCOA relate to these?" Based on the findings reported in Section 4.2, we paid particular attention to the relationship between COCOA and anxiety, since this was a consistent factor shaping both dimensions of ongoing COCOA usage. Below, we provide findings from qualitative analysis of interviews and open-ended survey responses.

Although many respondents said that COCOA decreases anxiety, some felt that adopting COCOA could also lead to more stress and anxiety, mostly related to registering infections and responding to notifications. First, some people felt COCOA caused or would cause them to think about the pandemic more than they already did, and that this would increase anxiety but cause no benefit. A participant who had not installed COCOA noted,

> *[If I installed COCOA] I would be always be afraid about not being able to live a normal life. What if I find out that I have been in contact with someone who has tested positive*

Table 2. Regression results for COCOA installation and use.

	(1) Installed COCOA	(2) Register infection	(3) Notification response
I don't believe that using the app will help prevent infection	-0.8708 (-0.71)	-0.00980 (-0.01)	-0.0471 (-0.75)
I don't think I could trust the app to work properly	-0.2959 (-0.35)	1.1695 (1.89)	-0.00689 (-0.15)
Installing this app would be difficult or inconvenient	-3.3020** (-2.97)	-0.4530 (-0.61)	0.0326 (0.55)
I don't know how to use the app	-2.3764* (-2.16)	0.0416 (0.06)	-0.0509 (-0.85)
Using COCOA fulfills my responsibility to my community	0.8228 (0.60)	-0.4178 (-0.51)	-0.0031 (-0.05)
Respondent knows at least one person who uses COCOA	2.9117*** (3.76)	0.7424 (1.64)	0.0472 (1.28)
I'm worried about information leaking to a third party	-1.4455 (-1.34)	0.3414 (0.48)	0.1004 (1.79)
I believe using COCOA increases anxiety	-1.9111 (-1.64)	-3.8493*** (-4.46)	-0.1901** (-3.27)
Having physical proximity or contact with unspecified others through work	-0.2258 (-0.31)	-0.7082 (-1.39)	-0.0092 (-0.23)
Area cases per capita	0.9320 (1.05)	0.8788 (1.37)	0.0991 (1.95)
Female	0.3397 (0.44)	0.1825 (0.37)	0.0462 (1.21)
If I am infected and can't work, I will:			
Lose my job	2.9851 (1.75)	-0.8668 (-0.86)	0.0908 (1.02)
Receive no income or benefits	2.2896 (1.90)	0.0729 (0.11)	0.0354 (0.71)
Receive reduced income and benefits	0.5203 (0.44)	-0.1653 (-0.23)	0.0476 (0.85)
Receive full income and benefits	-0.7004 (-0.74)	-0.1009 (-0.14)	0.0509 (0.96)
Observations	152	152	152
R^2			0.168
Pseudo R^2	0.689	0.149	

Models 1 & 2: z statistics in parentheses. Model 3: t statistics in parentheses
Model 1: Logistic regression with Firth procedure; Model 2: Ordered logistic regression; Model 3: Linear regression
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

> *somewhere I don't know or don't remember? Or if a close relative or myself is notified that I have tested positive?* (P90-S)

Desires to avoid COCOA because it would increase anxiety reflected perceptions of other media. For example, Participant 91 already felt he was exposed to too much pandemic information from TV, and did not want to get it from his smartphone too:

> *I do not want to install COCOA because I would end up being so worried about this disease when I constantly get information about it. [...] I'm worried that we have more information than is necessary, with it constantly being a topic of television programs and with news about it coming constantly to my cell phone.* (P91-I)

Some feared that being infected with COVID-19 or receiving exposure notifications through COCOA could lead to them losing income or even their job. For example, one survey respondent wrote, *"I'm a little worried [about getting a notification] because I see in the news that people will lose their job when they disclose to the workplace"* (P15-S). Concern about this sort of risk was mediated by individuals' job security, as indicated by a different survey respondent who wrote, *"Given I presently work for a big company, I feel secure in my job. If I get a notification, I would first of all report it to my boss and seek advice on what measures I should take."* (P87-I). In addition to fears for job security, many respondents were worried about discrimination if they became infected with COVID-19 or associated with infection (e.g., by receiving an exposure notification). Participants frequently expressed fears about being subject to *"the discriminating public eye"* (P88-S) or *"being identified and getting excluded from work"* (P141-S) if infected. Despite COCOA's privacy-focused design, respondents often expressed concern that the app would leak information to people nearby, and thus create risk of judgement. Respondents identified different ways that information could spread, such as other people happening to see an exposure notification on one's smartphone screen. Another respondent noted that, even anonymous notifications of potential exposure could be identifying in sparsely populated areas, where stigma about COVID-19 was regarded as particularly severe:

> *Since I live in the countryside, people will immediately identify who I am and the rumors after infection will be very serious. [...] I am more afraid of social obliteration than illness. I don't know how anonymous this app is. It is not a problem in urban areas, but I don't think it will be [anonymous] in depopulated areas.* (P84-S)

This resonated with another respondent's comment that

> *I think there are some people who don't want to register because there is corona discrimination. If it was contact with strangers, perhaps it's not a big deal, but if it was contact with acquaintances or close people, they would recognize it immediately. So, I think some people would be reluctant to register.* (P118-S)

In other cases, respondents did not explain *how* they thought other people could find out if they received a notification, but nonetheless expressed concerns that this could happen:

> *I don't want other people to know if I get a notification [...] I think that people have quite a negative image of COVID, and that people would think I'd been slack in my own precautions or that I'd perhaps caught it from being careless, and then I'd be embarrassed and not want other people to know this.* (P133-I)

And similarly, some described simply using COCOA as potentially resulting in being blamed: *"If I become an infected person, I'm afraid that I will be blamed if people find out that I'm using the app"* (P112-S).

In summary, although some participants believed that installing COCOA would decrease their anxiety, most participants perceived that individual risks would result from registering to COCOA

if infected or receiving and exposure notification, such as reduced job security, being discriminated against, and privacy concerns. However, the risks of using COCOA were not experienced universally – they varied based on participant's social and economic circumstances.

4.4 Navigating risks

This section addresses RQ3: "How do participants navigate risks identified in RQ2?" In general, participants perceived the risks identified in the previous section as resulting from disclosing information to others, intentionally or otherwise. In large part, we focus on how participants navigated these risks in the context of the pandemic more generally, not just in terms of using COCOA. This is because in the more general context, people can exercise types of control that are not accounted for in a particular design.

The main tactic participants used to mitigate risks from disclosing infection information was to hide that information from others. Where respondents were willing to go to great lengths to hide from others, this often extended to avoiding installing COCOA altogether. For example, Participant 95 described that, if one person at his workplace became sick and missed work, their pay would be cut, so it might be better to continue working and potentially infect others because *"it would end up being the company's decision to close the plant and then we will probably still get paid to a certain extent,"* and he later explained,

> *I definitely don't want to spread COVID into the world at large, but installing [COCOA] would not bring a single advantage for me, so I don't feel like I'm going to install it. If I install it and get a notification, I will have to make my own decision to take days off, or if I notify my company, most likely, I'd be told to come to work if it's just a slight fever. Either way, the app doesn't benefit me in any way.* (P95-I)

Some respondents who had COCOA installed reported that they would not use it as directed because of external pressures (e.g.,financial). For example Participant 46 did not intend to get tested if she received an exposure notification, and explained, *"Due to a labor shortage of my workplace, I am told not to go to the hospital even if I get physical symptoms."* Similarly, Participant 100 explained that "*Whether or not to register my infection with COCOA would depend on my symptoms and affordability at the time of infection.*" Thus, strong motivations to hide infection information could result in choosing not to install COCOA, or installing COCOA but not being willing to register if infected.

Many individuals did not express a desire to wholly hide if they were infected with COVID-19 or received an exposure notification, but instead wanted to be selective about to whom they disclosed this information and how. In many cases, respondents identified that they would tell others if infected or if they received a COCOA notification, but only those with whom they had been in contact and may have infected

> *[If I were infected,] I would inform the people I'd definitely been in contact with because they might want to go get a test. I don't think I would say anything to my friends whom I'm not in contact with. [...] Even after I myself had fully recovered, I wouldn't disclose to my friends because they might be hesitant to meet me if they knew I was infected.* (P37-I)

> *If I had close contact with an infected person, I would undergo a PCR*[4] *test [to detect infection] and tell my family and work clients about it and isolate as much as possible. I don't dare tell anyone I did not have potential contact with, such as friends* (P37-S)

Such perspectives are matched by COCOA's design, where notifications are only shared based on having close contact.

[4]Polymerase Chain Reaction

In other instances, decisions about to whom to disclose were shaped by relational factors. For example, respondents were more worried about COCOA reporting to people they know than to strangers:

> *I have no problem with my infection being known to people I don't know. such as people who were on the same train. But for certain places, like places I went to, like the restaurants I usually go, I don't. For example, say an infected person appears in this restaurant. With COCOA installed, the fact that the infected person went to that restaurant would probably be made known. I'd worry that it might cause trouble for the people in the restaurant.* (P37-I)

Finally, some respondents reported a desire to control *how* disclosures took place. For example, fearing that others could see her screen, Participant 31 carefully avoided opening COCOA in public: *"I was afraid of people's eyes around me in case I got notifications, so I never opened the app in public places."* Additionally, there were many respondents who intended to tell others if infected, but were not willing to register their case to the app and/or did not have COCOA installed: *"I would communicate it verbally [if I were infected], but I don't know if I would communicate through COCOA"* (P3-S).

Based on these findings, we conclude that in the general context of the pandemic, participants who were more concerned about negative personal impacts if others found out about their infection often intended to hide infection information from others. In some cases, this was a matter of totally hiding or avoiding disclosure, but in others it entailed decision-making about disclosing to certain people and not others.

5 DISCUSSION

We aimed to investigate why adoption of contact tracing apps has been lower than anticipated, as well as how people actually use the app in their everyday lives. Overall, over half of our respondents had installed COCOA, and the majority indicated that they would intend to use the app by registering their case if infected and responding to notifications diligently. This is consistent with prior research reporting that a strong majority was willing to install a contact tracing app [8]. We anticipated there may be significant differences between public-facing and other jobs, but found no significant difference in adoption patterns between these groups. Instead, decisions about COCOA installation and use were shaped by complex personal and social factors, including knowing other COCOA users, effort expectancy, financial risk, anxiety, and fear of consequences like discrimination.

Our study revealed that people's behaviors toward using a digital contact tracing app are embedded and situated in the larger social cultural context in which use occurs. For example, participants felt pressure to demonstrate responsible behaviour by wearing masks and handwashing in front of others, and simultaneously wanted to hide if they were infected from others. Fear of stigmatization was shaped by factors such as financial precarity and community structures, so was not experienced the same by everyone, though at least some fear of discrimination was nearly ubiquitous. Since respondents associated COCOA with exposing infection, but not visibly demonstrating responsible behaviour, people most at risk of negative consequences were apprehensive that COCOA could cause problems for them. Further, even among those who indicated that COCOA would not have negative effects on them personally, there was deep skepticism that others would install COCOA and report positive cases. These findings suggest that the design of digital contact tracing apps should be co-examined with social factors that shape people' behaviors during global health pandemics.

Even though the adoption rate among respondents was higher than among the general population, they reported a lot of concerns with installation and use of COCOA such as being discriminated against and facing financial risks. We suspect that these concerns would be even more prevalent among the general public, and have implications for using and improving future contact tracing technology. Thus, in the remainder of this paper, we consider ways to address the personal risks reported in this study, both to improve uptake of contact tracing apps, and more generally to mitigate harms that could arise from public health and other crisis informatics. Section 5.1 reflects on how COCOA's complex relationship with respondents' anxiety impacts technology adoption. Section 5.2 uses Nissenbaum's [80] contextual integrity theory to unpack respondents' privacy concerns and considers ways to align contact tracing designs with norms about disclosure and pandemic precautions. Section 5.3 revisits the challenge of enlisting individuals to contribute to a collective goal, and identifies opportunities to surmount these challenges by intervening at a community scale.

5.1 Designing with anxiety in mind

COCOA had a complex relationship with respondents' anxiety. Some respondents expressed that if they became infected, COCOA would help them understand what to do, which is consistent with COCOA's promise to "[provide] guidance to protect your health" [1]. Others reported that the absence of notifications provided welcome assurance that one had not been exposed to COVID-19. This could provide relief to pandemic-related anxiety, though this reassurance may have been spurious given the fact that people could be exposed to COVID-19 through someone who does not use COCOA.

By contrast, a sizable minority of respondents claimed that COCOA would increase their anxiety. This was clearly connected to stress and anxiety in other aspects of participants' lives. In response to P91-I's explanation that he was already exposed to too much COVID-19 information on TV and so did not want to get it through COCOA as well, we note that COCOA actually sends almost no information except for (hopefully rare) exposure notifications. Thus, this perspective was not rooted in features of COCOA's design, but instead extended from experiences elsewhere. Perceived risks of discrimination or other negative consequences were another source of anxiety, and were similarly born from respondents' experiences and social context.

Health technologies are typically encountered in situations that are already highly stressful and can simultaneously alleviate and reinforce stress in complex ways [21]. This can both result in immediate harm and also fuel distrust and resistance toward adopting future healthcare technologies or interventions [46]. Not only could this drive down overall adoption, but where negative experiences extend from different social contexts, this could lead to some groups becoming under-represented by future technologies. As a result, we need to exercise particular caution toward existing causes of stress when designing and deploying such technologies.

5.2 Privacy in context

Our results highlighted an under-researched dimension of privacy in relation to contact tracing apps. In large part, privacy preserving approaches to contact tracing have been oriented around limiting what information is shared with governments and app developers and preventing unauthorized data access [6]. By contrast, respondents were concerned about social consequences if people around them learned (or even falsely believed) that they were infected. COCOA's design partially accounts for this risk by using anonymous identifiers when sending exposure notifications. However, anonymity could be relative to the context in which a notification is distributed. We use Nissenbaum's [80] theory of privacy as contextual integrity to unpack this. According to this framework,

> Privacy requires the appropriate flow of information, which means flow that meets legitimate expectations. Legitimate expectations, in turn, are characterized by context-specific norms of information flow that not only are entrenched in the practices and conventions of a given context (for example, health care, education, religious practice, etc.), but that also support important ethical and contextual values. [79].

In general, COCOA defines the context of information flow as between an infected person and people with whom they have been in physical proximity or contact . However, for many respondents, *people with whom one has been in close contact* is not a unified group. Even where people wanted to disclose to others so they could get tested and stop the spread of the pandemic, anonymity was not ensured in contexts such as the sparsely populated countryside. Further, the risks of transgressing contextual norms are not equally distributed. In the Japanese context, stigmatization of illness is generally greater than in western countries [37, 67] and within Japan, those of lower social and economic standing or who are simply surrounded by people who would discriminate against them if infected risk more than others. Some who feared significant negative impacts, such as losing income, were willing to go to great lengths to prevent certain people from finding out if they were infected.

To navigate privacy risks in multiple contexts, respondents wanted to carefully select to whom they disclose illness information. However, COCOA's minimal design includes no options for controlling or even viewing the scope of disclosures through registering infections. As a result, people who fear negative outcomes from registering infections to were generally left with a binary choice: Either opt-in and accept the risks, or opt-out altogether. Offering individuals greater control over their disclosures would more match their decision-making in other aspects of life and may increase overall uptake. For example, in sparsely populated regions, it may be desirable to report that potential exposure occurred during a 72 hour period instead of reporting a more precise time. Alternately, people who do not want others to see a notification on their screen, such as Participant 31, could be given an option to schedule notifications to only occur at a time when they are not in public.

In raising this possible direction, we would like to address potential harms. The first is that providing individuals with options to limit disclosure of potentially lifesaving information is ethically fraught. If this leads to more people being willing to use a system, and/or sufficiently reduces harmful side-effects of the system, then such an exchange could be worthwhile. Future research may investigate if and how this type of configurability could affect overall adoption. A second dilemma is that too many options could cause confusion or inconsistent quality. Chen [18] reported that a myriad of privately operated contact tracing apps launched early in the pandemic in New Zealand had inconsistent privacy, accessibility, and user experience. For an approach where contextual tailoring is provided through a choice among multiple apps, one solution could be a government body that sets minimum standards, including interoperability.

5.2.1 Visibility. An additional consideration for understanding how flows of information relate to risks in various contexts is the concept of visibility. Respondents described that visible pandemic safety measures such as mask-wearing or disinfecting were motivated by social pressure. Taking part in those behaviours could demonstrate a commitment to working toward a collective goal of fighting the pandemic, and thus be rewarded with social acceptance. By contrast, participants' use of COCOA was overwhelmingly private. Participants rarely discussed using COCOA with others or used a lack of a positive case in COCOA as social proof of following safety precautions. As reported above, COCOA could make infection information visible in some undesirable circumstances, which could result in discrimination or other harms. However, it typically did not illuminate when people were acting responsibly by virtue of using it. For example, Participant 133 worried that people

would judge him as having been careless if he received a notification, even though using COCOA itself could be an example of being careful.

Increasing visibility of contact tracing technology could be used to demonstrate responsible safety practice. For example, New Zealand's NZ COVID Tracer app includes a feature where people can scan QR codes to record visits to businesses and other spaces [3]. As well as providing an additional layer of tracking, this creates an opportunity to visibly perform pandemic safety by scanning the code. However, for people who fear heavy discrimination related to COVID infection, this could place an additional burden on individuals to demonstrate their responsibility in public, but not convey responsibility to friends, colleagues, or people whose negative judgement could be particularly meaningful.

Thus, rather than creating new forms of visibility, we consider how visible demonstrations of responsibility could be incorporated into existing disclosures. For example, respondents often reported that their decisions about whom to disclose would be shaped by the same logic that COCOA uses – i.e., notifying people with whom they have been in contact – however, there were still many concerns about registering cases. One possibility is that, if the recipient of a notification would be able to infer its source, an exposure notification could be too impersonal. Oeldorf-Hirsch and Novak [81] studied which media people choose for various types of disclosures. When disclosing about sensitive subjects, such as telling someone they had contracted a sexually transmitted disease, appropriateness was the most significant factor for media selection, which meant preferring unmediated forms of communication (e.g.,face-to-face). Although face-to-face disclosure would be decidedly inappropriate for reporting that one has COVID-19, communicating by telephone or direct message would offer an opportunity to demonstrate care and responsibility when disclosing to others. Thus, in contexts where someone believes that an anonymous exposure notification will be identifying, they may prefer to disclose themselves rather than through an impersonal means. Thus, while we considered above that decreasing visibility of disclosures could be beneficial in certain contexts, there are also cases where expanding visibility to demonstrate that one is acting responsibly and with consideration could increase the appropriateness of disclosure.

5.3 Individual and collective interests

Digital contact tracing apps encounter a fundamental challenge of attempting to mobilize individuals toward a collective good of controlling the pandemic. Respondents generally distrusted that other people would use COCOA appropriately, and this undermined their faith that the app could achieve that collective benefit.

As discussed in Section 4.2.1, some respondents did identify personal benefits that could arise from installing COCOA and receiving (or better still, not receiving) exposure notifications. However, perceived personal benefits were overshadowed by personal risks, especially from registering infections or receiving exposure notifications.

Accordingly, COCOA use, and particularly actions that involve disclosure, resembles a tragedy of the commons as described by Hardin [41], wherein everyone benefits from mutual contributions, but there is a lack of individual incentive. In this situation, "free-riders" can reap the benefits of the system while refusing to contribute, but if too many people take that path, the system as a whole will not work. Hardin's recommendations for addressing this problem call for an external authority to either mandate or incentivize certain behaviours. When workplaces required COCOA usage, it was an example of an authority-driven mandate, however this was relatively uncommon, and ultimately piecemeal when considered at a societal scale. Conversely, social pressure to wear masks was an example of incentivizing collectively beneficial behaviour. Both approaches have significant limitations. Large scale authority-driven solutions, such as if the government made it mandatory for everyone to install COCOA, would dramatically conflict with commitments to

personal freedom and democracy, which are deeply held in many regions including Japan. On the other hand, relying on personal incentives can harm those who are already disadvantaged, especially when those incentives are punitive measures such as stigma. We have shown throughout this study that stigmatization can be effective for visible behaviours, but also lead people to hide infection information, thus undermining people's trust that other people can be relied upon to pursue the collective goal.

In sum, many of the risks we observed originated from communities, and so cannot be addressed only at an individual scale. This reflects observations within the CSCW/HCI research community that the costs of opting into collectively (and even personally) beneficial healthcare treatments technologies are not evenly distributed, and individual healthcare decisions depend on the availability of social support networks [e.g., 59, 75]. Thus, rather than deferring to authority mandates or relying on individuals, we believe that interventions at a community scale could address factors such as discrimination, stigmatization, and financial precarity that create risks if infection becomes visible to others, and thereby create pressure to hide. In this recommendation, we draw from Veinot et al. [106], who argued that individual-scale health interventions are "less effective for marginalized groups [...] than those that target the context in which behaviour occurs." Based on this proposition, they argue that "upstream" interventions may be better suited for tackling inequality, and additionally may be more effective at "reaching large numbers of people due to their lack of dependence upon individual patient/consumer action for uptake." Drawing from their review of promising approaches, we suggest that interventions at a community-scale could supplement individually-oriented contact tracing apps, for example by: documenting experiences of marginalized groups [40], detecting norms and attitudes [24] and bias and discrimination [53] in communities, or creating community-scale games to promote healthy behaviour [96]. By supporting a contact tracing app with complementary interventions at community and other scales, policymakers and designers could create conditions in which individuals face fewer risks and can see more benefits from adopting a contact tracing app. More broadly, we affirm arguments for a "long view of crisis" that recognizes and addresses ways that social life produces vulnerabilities that lead to crisis [100].

6 CONCLUSION

In this paper, we reported on factors shaping decisions to install and use a contact tracing app among 153 working people in Japan. By investigating the integration of digital contact tracing into people's everyday lives, we identified that their decisions are shaped by social factors. People's decision-making is often informed by social stigmatization and lack of trust in professional, community, and personal contexts, pointing to challenges when scaling interventions which require high levels of adoption. Given our focus on a specific context, it is not wise to generalize specific patterns to global contexts (e.g., concerns about discrimination are rooted in the context of Japanese society, and given that they affected some participants differently from others, are likely shaped by the demographic bias of our sample). Instead, this study has demonstrated that broadly distributed technologies such as contact tracing apps should be designed with consideration for local contexts, since needs vary considerably. We suggested ways to improve the fit of such technologies with individuals' everyday lives by enabling greater control over actions like disclosure, which could more closely match ways that people navigated socially embedded challenges in other aspects of life. We identified a need to support individual-scale technologies with interventions at community, as well as at other scales from which social pressures originate. Amid growing attention to large social challenges, such as public health crises and global sustainability, we unpack some strategies about how to design interventions to serve those goals while accounting for individuals' lived experiences, though challenges remain around scale and cultural fit. Finally, the limited capacity

to generalize about attitudes toward contact tracing apps illuminates an opportunity for future research, such as meta-analysis, to investigate how attitudes toward contact tracing apps change across time, space, and cultures, especially in a rapidly shifting situation such as the pandemic.

REFERENCES

[1] [n.d.]. COCOA - COVID-19 Contact App. https://play.google.com/store/apps/details?id=jp.go.mhlw.covid19radar&hl=en&gl=US

[2] 2021. Japan's COVID-19 Contact Tracing App for Android Not Working for 4 Months: Ministry. *Mainichi Daily News* (Feb. 2021). https://mainichi.jp/english/articles/20210204/p2a/00m/0na/005000c

[3] 2021. NZ COVID Tracer App. https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-resources-and-tools/nz-covid-tracer-app

[4] Abi Adams-Prassl, Teodora Boneva, Marta Golin, and Christopher Rauh. 2020. Inequality in the Impact of the Coronavirus Shock: Evidence from Real Time Surveys. *Journal of Public Economics* 189 (Sept. 2020), 104245. https://doi.org/10.1016/j.jpubeco.2020.104245

[5] Dickson Adom and Jephtar Adu Mensah. 2020. *The Psychological Distress and Mental Health Disorders from COVID-19 Stigmatization in Ghana.* SSRN Scholarly Paper ID 3599756. Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.3599756

[6] Nadeem Ahmed, Regio A. Michelin, Wanli Xue, Sushmita Ruj, Robert Malaney, Salil S. Kanhere, Aruna Seneviratne, Wen Hu, Helge Janicke, and Sanjay Jha. 2020. A Survey of COVID-19 Contact Tracing Apps. *IEEE Access* 8 (2020), 134577–134601. https://doi.org/10.1109/ACCESS.2020.3010226 arXiv:2006.10306

[7] Icek Ajzen. 2011. The Theory of Planned Behaviour: Reactions and Reflections. *Psychology & Health* 26, 9 (Sept. 2011), 1113–1127. https://doi.org/10.1080/08870446.2011.613995

[8] Samuel Altmann, Luke Milsom, Hannah Zillessen, Raffaele Blasone, Frederic Gerdon, Ruben Bach, Frauke Kreuter, Daniele Nosenzo, Severine Toussaert, and Johannes Abeler. 2020. *Acceptability of App-Based Contact Tracing for COVID-19: Cross-Country Survey Evidence.* SSRN Scholarly Paper ID 3590505. Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.3590505

[9] Asami Anzai and Hiroshi Nishiura. 2021. "Go To Travel" Campaign and Travel-Associated Coronavirus Disease 2019 Cases: A Descriptive Analysis, July–August 2020. *Journal of Clinical Medicine* 10, 3 (Jan. 2021), 398. https://doi.org/10.3390/jcm10030398

[10] Associated Press. 2020. In Japan, Pandemic Brings Outbreaks of Bullying, Ostracism : The Asahi Shimbun. *The asahi shimbun* (2020). http://www.asahi.com/ajw/articles/13362712

[11] Christiane Attig and Thomas Franke. 2020. Abandonment of Personal Quantification: A Review and Empirical Study Investigating Reasons for Wearable Activity Tracking Attrition. *Computers in Human Behavior* 102 (Jan. 2020), 223–237. https://doi.org/10.1016/j.chb.2019.08.025

[12] Ron Barrett and Peter J. Brown. 2008. Stigma in the Time of Influenza: Social and Institutional Responses to Pandemic Emergencies. *The Journal of Infectious Diseases* 197, Supplement_1 (Feb. 2008), S34–S37. https://doi.org/10.1086/524986

[13] John M. Barrios and Yael Hochberg. 2020. *Risk Perception Through the Lens of Politics in the Time of the COVID-19 Pandemic.* Technical Report w27008. National Bureau of Economic Research. https://doi.org/10.3386/w27008

[14] Eric P.S. Baumer and M. Six Silberman. 2011. When the Implication Is Not to Design (Technology). In *Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems - CHI '11.* ACM Press, Vancouver, BC, Canada, 2271. https://doi.org/10.1145/1978942.1979275

[15] Lisa Bowleg. 2020. We're Not All in This Together: On COVID-19, Intersectionality, and Structural Inequality. *American Journal of Public Health* 110, 7 (May 2020), 917–917. https://doi.org/10.2105/AJPH.2020.305766

[16] CDC. 2020. Social Distancing - Keep a Safe Distance to Slow the Spread. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html

[17] Stephanie Chan. [n.d.]. COVID-19 Contact Tracing Apps Reach 9% Adoption In Most Populous Countries. https://sensortower.com/blog/contact-tracing-app-adoption

[18] Andrew Tzer-Yeu Chen. 2021. How Fragmentation Can Undermine the Public Health Response to Covid-19. *Interactions* 28, 2 (March 2021), 64–69. https://doi.org/10.1145/3448413

[19] Andrew Clarance. 2020. Aarogya Setu: Why India's Covid-19 Contact Tracing App Is Controversial. *BBC News* (May 2020). https://www.bbc.com/news/world-asia-india-52659520

[20] James Clawson, Jessica A. Pater, Andrew D. Miller, Elizabeth D. Mynatt, and Lena Mamykina. 2015. No Longer Wearing: Investigating the Abandonment of Personal Health-Tracking Technologies on Craigslist. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15).* Association for Computing Machinery, New York, NY, USA, 647–658. https://doi.org/10.1145/2750858.2807554

[21] Mayara Costa Figueiredo, Clara Caldeira, Elizabeth Victoria Eikey, Melissa Mazmanian, and Yunan Chen. 2018. Engaging with Health Data: The Interplay Between Self-Tracking Activities and Emotions in Fertility Struggles. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (Nov. 2018), 40:1–40:20. https://doi.org/10.1145/3274309

[22] Joseph Coveney. 2021. FIRTHLOGIT: Stata Module to Calculate Bias Reduction in Logistic Regression. Boston College Department of Economics. https://ideas.repec.org/c/boc/bocode/s456948.html

[23] Thomas Daigle. 2020. Federal COVID Alert App Wasn't Working for Some Users for Much of November | CBC News. https://www.cbc.ca/news/technology/covid-app-alert-vulnerability-1.5826808

[24] Munmun De Choudhury, Sanket Sharma, and Emre Kiciman. 2016. Characterizing Dietary Choices, Nutrition, and Language in Food Deserts via Social Media. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*. ACM, San Francisco California USA, 1157–1170. https://doi.org/10.1145/2818048.2819956

[25] Simon Denyer and Akiko Kashiwagi. 2020. In Japan, Coronavirus Discrimination Proves Almost as Hard to Eradicate as the Disease. *Washington Post* (Sept. 2020). https://www.washingtonpost.com/world/asia_pacific/japan-coronavirus-discrimination/2020/09/13/e82e5aa4-eea0-11ea-bd08-1b10132b458f_story.html

[26] Ensheng Dong, Hongru Du, and Lauren Gardner. 2020. An Interactive Web-Based Dashboard to Track COVID-19 in Real Time. *The Lancet Infectious Diseases* 20, 5 (May 2020), 533–534. https://doi.org/10.1016/S1473-3099(20)30120-1

[27] Melissa Eigen and Urs Gasser. Mon, 07/20/2020 - 20:34. *Country Spotlight: Singapore's TraceTogether Program |*. Technical Report. Berkman Klein Center for Internet & Society at Harvard University. https://cyber.harvard.edu/story/2020-07/country-spotlight-singapores-tracetogether-program

[28] Daniel A. Epstein, Clara Caldeira, Mayara Costa Figueiredo, Xi Lu, Lucas M. Silva, Lucretia Williams, Jong Ho Lee, Qingyang Li, Simran Ahuja, Qiuer Chen, Payam Dowlatyari, Craig Hilby, Sazeda Sultana, Elizabeth V. Eikey, and Yunan Chen. 2020. Mapping and Taking Stock of the Personal Informatics Literature. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 4, 4 (Dec. 2020), 126:1–126:38. https://doi.org/10.1145/3432231

[29] Daniel A. Epstein, Monica Caraway, Chuck Johnston, An Ping, James Fogarty, and Sean A. Munson. 2016. Beyond Abandonment to Next Steps: Understanding and Designing for Life after Personal Informatics Tool Use. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. Association for Computing Machinery, New York, NY, USA, 1109–1113. http://doi.org/10.1145/2858036.2858045

[30] Imane Ezzaouia and Jacques Bulchand-Gidumal. 2021. A Model to Predict Users' Intentions to Adopt Contact-Tracing Apps for Prevention from COVID-19. In *Information and Communication Technologies in Tourism 2021*, Wolfgang Wörndl, Chulmo Koo, and Jason L. Stienmetz (Eds.). Springer International Publishing, Cham, 543–548. https://doi.org/10.1007/978-3-030-65785-7_51

[31] Robert A. Fahey and Airo Hino. 2020. COVID-19, Digital Privacy, and the Social Limits on Data-Focused Public Health Responses. *International Journal of Information Management* 55 (Dec. 2020), 102181. https://doi.org/10.1016/j.ijinfomgt.2020.102181

[32] Luca Ferretti, Chris Wymant, Michelle Kendall, Lele Zhao, Anel Nurtay, Lucie Abeler-Dörner, Michael Parker, David Bonsall, and Christophe Fraser. 2020. Quantifying SARS-CoV-2 Transmission Suggests Epidemic Control with Digital Contact Tracing. *Science* 368, 6491 (May 2020). https://doi.org/10.1126/science.abb6936

[33] David Firth. 1993. Bias Reduction of Maximum Likelihood Estimates. *Biometrika* 80, 1 (March 1993), 27–38. https://doi.org/10.1093/biomet/80.1.27

[34] Yoshito Funashima and Kazuki Hiraga. 2020. *Where to Go: The Japanese Government's Travel Subsidy during COVID-19*. SSRN Scholarly Paper ID 3746114. Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.3746114

[35] Rachel Benchaya Gans, Jolien Ubacht, and Marijn Janssen. 2020. Self-Sovereign Identities for Fighting the Impact of COVID-19 Pandemic. *Digital Government: Research and Practice* 2, 2 (Dec. 2020), 16:1–16:4. https://doi.org/10.1145/3429629

[36] Trisha Greenhalgh, Susan Hinder, Katja Stramer, Tanja Bratan, and Jill Russell. 2010. Adoption, Non-Adoption, and Abandonment of a Personal Electronic Health Record: Case Study of HealthSpace. *BMJ* 341 (Nov. 2010), c5814. https://doi.org/10.1136/bmj.c5814

[37] Kathleen M. Griffiths, Yoshibumi Nakane, Helen Christensen, Kumiko Yoshioka, Anthony F. Jorm, and Hideyuki Nakane. 2006. Stigma in Response to Mental Disorders: A Comparison of Australia and Japan. *BMC Psychiatry* 6, 1 (May 2006), 21. https://doi.org/10.1186/1471-244X-6-21

[38] Xinning Gui, Yubo Kou, Kathleen H. Pine, and Yunan Chen. 2017. Managing Uncertainty: Using Social Media for Risk Assessment during a Public Health Crisis. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. Association for Computing Machinery, New York, NY, USA, 4520–4533. https://doi.org/10.1145/3025453.3025891

[39] Xinning Gui, Yue Wang, Yubo Kou, Tera Leigh Reynolds, Yunan Chen, Qiaozhu Mei, and Kai Zheng. 2017. Understanding the Patterns of Health Information Dissemination on Social Media during the Zika Outbreak. *AMIA ... Annual Symposium proceedings. AMIA Symposium* 2017 (2017), 820–829.

[40] Alisse Hannaford, Madeleine Lipshie-Williams, Joanna L. Starrels, Julia H. Arnsten, Jessica Rizzuto, Phillip Cohen, Damon Jacobs, and Viraj V. Patel. 2018. The Use of Online Posts to Identify Barriers to and Facilitators of HIV Pre-Exposure Prophylaxis (PrEP) Among Men Who Have Sex with Men: A Comparison to a Systematic Review of the Peer-Reviewed Literature. *AIDS and behavior* 22, 4 (April 2018), 1080–1095. https://doi.org/10.1007/s10461-017-2011-3

[41] Garrett Hardin. 1968. The Tragedy of the Commons. *Science* 162, 3859 (1968), 1243–1248.

[42] Eszter Hargittai, Elissa M. Redmiles, Jessica Vitak, and Michael Zimmer. 2020. Americans' Willingness to Adopt a COVID-19 Tracking App. *First Monday* (Oct. 2020). https://doi.org/10.5210/fm.v25i11.11095

[43] Thomas Heverin and Lisl Zach. 2012. Use of Microblogging for Collective Sense-Making during Violent Crises: A Study of Three Campus Shootings. *Journal of the American Society for Information Science and Technology* 63, 1 (2012), 34–47. https://doi.org/10.1002/asi.21685

[44] Robert Hinch, Will Probert, Anel Nurtay, Michelle Kendall, Chris Wymant, Matthew Hall, Katrina Lythgoe, Ana Bulas Cruz, Lele Zhao, Andrea Stewart, Luca Ferretti, Michael Parker, Ares Meroueh, Bryn Mathias, Scott Stevenson, Daniel Montero, James Warran, Nicole K Mather, Anthony Finkelstein, Lucie Abeler-Dörner, David Bonsall, and Christophe Fraser. 2020. *Effective Configurations of a Digital Contact Tracing App: A Report to NHSX.* Technical Report. https://www.pepp-pt.org

[45] Rakibul Hoque and Golam Sorwar. 2017. Understanding Factors Influencing the Adoption of mHealth by the Elderly: An Extension of the UTAUT Model. *International Journal of Medical Informatics* 101 (May 2017), 75–84. https://doi.org/10.1016/j.ijmedinf.2017.02.002

[46] Ruey-Lin Hsiao. 2003. Technology Fears: Distrust and Cultural Persistence in Electronic Marketplace Adoption. *The Journal of Strategic Information Systems* 12, 3 (Oct. 2003), 169–199. https://doi.org/10.1016/S0963-8687(03)00034-9

[47] Y. Linlin Huang, Kate Starbird, Mania Orand, Stephanie A. Stanek, and Heather T. Pedersen. 2015. Connected Through Crisis: Emotional Proximity and the Spread of Misinformation Online. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15)*. Association for Computing Machinery, New York, NY, USA, 969–980. https://doi.org/10.1145/2675133.2675202

[48] Jina Huh, Jejo Koola, Alejandro Contreras, Alanah KP. Castillo, Melissa Ruiz, Keely G. Tedone, Melissa Yakuta, and Melody K. Schiaffino. 2018. Consumer Health Informatics Adoption among Underserved Populations: Thinking beyond the Digital Divide. *Yearbook of Medical Informatics* 27, 1 (Aug. 2018), 146–155. https://doi.org/10.1055/s-0038-1641217

[49] P. Ifinedo. 2012. Technology Acceptance by Health Professionals in Canada: An Analysis with a Modified UTAUT Model. In *2012 45th Hawaii International Conference on System Sciences*. 2937–2946. https://doi.org/10.1109/HICSS.2012.556

[50] Yuri Imamura. 2020. Japan Survivors of COVID-19 Say They Face Stigma, Have 'aftereffects' : The Asahi Shimbun. *The asahi shimbun* (Aug. 2020). http://www.asahi.com/ajw/articles/13649395

[51] H. V. Jagadish, Julia Stoyanovich, and Bill Howe. 2021. COVID-19 Brings Data Equity Challenges to the Fore. *Digital Government: Research and Practice* 2, 2 (March 2021), 24:1–24:7. https://doi.org/10.1145/3440889

[52] Japanese Association for Disaster Medicine. 2020. *Statement against wrongful criticisms to healthcare workers responding to novel coronavirus infection [in Japanese].* Technical Report. https://www.jadm.or.jp/sys/_data/info/pdf/pdf000121_1.pdf

[53] Adam J. Joseph, Neeraj Tandon, Lawrence H. Yang, Ken Duckworth, John Torous, Larry J. Seidman, and Matcheri S. Keshavan. 2015. #Schizophrenia: Use and Misuse on Twitter. *Schizophrenia Research* 165, 2-3 (July 2015), 111–115. https://doi.org/10.1016/j.schres.2015.04.009

[54] Ehsan Jozaghi, Russ Maynard, Dave Hamm, and Samona Marsh. 2020. COVID-19 and People Who Use Drugs: A Call for Action. *Canadian Journal of Public Health* 111, 3 (June 2020), 401–402. https://doi.org/10.17269/s41997-020-00326-1

[55] Neeta Kantamneni. 2020. The Impact of the COVID-19 Pandemic on Marginalized Populations in the United States: A Research Agenda. *Journal of Vocational Behavior* 119 (June 2020), 103439. https://doi.org/10.1016/j.jvb.2020.103439

[56] Gabriel Kaptchuk, Daniel G. Goldstein, Eszter Hargittai, Jake Hofman, and Elissa M. Redmiles. 2020. How Good Is Good Enough for COVID19 Apps? The Influence of Benefits, Accuracy, and Privacy on Willingness to Adopt. (May 2020). arXiv:2005.04343 http://arxiv.org/abs/2005.04343

[57] Yuya Katafuchi, Kenichi Kurita, and Shunsuke Managi. 2020. COVID-19 with Stigma: Theory and Evidence from Mobility Data. *Economics of Disasters and Climate Change* (Sept. 2020). https://doi.org/10.1007/s41885-020-00077-w

[58] N Kawakami, N Sasaki, R Kuroda, K Tsuno, and K Imamura. 2021. The Effects of Downloading a Government-Issued COVID-19 Contact Tracing App on Psychological Distress During the Pandemic Among Employed Adults: Prospective Study. *JMIR Mental Health* 8, 1 (Jan. 2021), e23699–e23699. https://doi.org/10.2196/23699

[59] Elizabeth Kaziunas, Michael S. Klinkman, and Mark S. Ackerman. 2019. Precarious Interventions: Designing for Ecologies of Care. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (Nov. 2019), 113:1–113:27.

https://doi.org/10.1145/3359215

[60] Boonchai Kijsanayotin, Supasit Pannarunothai, and Stuart M. Speedie. 2009. Factors Influencing Health Information Technology Adoption in Thailand's Community Health Centers: Applying the UTAUT Model. *International Journal of Medical Informatics* 78, 6 (June 2009), 404–416. https://doi.org/10.1016/j.ijmedinf.2008.12.005

[61] Young-Ho Kim, Jae Ho Jeon, Bongshin Lee, Eun Kyoung Choe, and Jinwook Seo. 2017. OmniTrack: A Flexible Self-Tracking Approach Leveraging Semi-Automated Tracking. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 1, 3 (Sept. 2017), 67:1–67:28. https://doi.org/10.1145/3130930

[62] Marina Kogan, Leysia Palen, and Kenneth M. Anderson. 2015. Think Local, Retweet Global: Retweeting by the Geographically-Vulnerable during Hurricane Sandy. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15)*. Association for Computing Machinery, New York, NY, USA, 981–993. https://doi.org/10.1145/2675133.2675218

[63] Amanda Lazar, Christian Koehler, Theresa Jean Tanenbaum, and David H. Nguyen. 2015. Why We Use and Abandon Smart Devices. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15)*. Association for Computing Machinery, New York, NY, USA, 635–646. https://doi.org/10.1145/2750858.2804288

[64] Jinfeng Li and Xinyi Guo. 2020. COVID-19 Contact-Tracing Apps: A Survey on the Global Deployment and Challenges. *arXiv:2005.03599 [cs]* (May 2020). arXiv:2005.03599 [cs] http://arxiv.org/abs/2005.03599

[65] Xi Lu, Tera L Reynolds, Eunkyung Jo, Hwajung Hong, Xinru Page, Yunan Chen, and Daniel A. Epstein. 2021. Comparing Perspectives Around Human and Technology Support for Contact Tracing. (2021), 15.

[66] Wendy Macias, Karen Hilyard, and Vicki Freimuth. 2009. Blog Functions as Risk and Crisis Communication During Hurricane Katrina. *Journal of Computer-Mediated Communication* 15, 1 (Oct. 2009), 1–31. https://doi.org/10.1111/j.1083-6101.2009.01490.x

[67] Akihiko Masuda, Steven C. Hayes, Michael P. Twohig, Jason Lillis, Lindsay B. Fletcher, and Andrew T. Gloster. 2009. Comparing Japanese International College Students' and U.S. College Students' Mental-Health-Related Stigmatizing Attitudes. *Journal of Multicultural Counseling and Development* 37, 3 (2009), 178–189. https://doi.org/10.1002/j.2161-1912.2009.tb00101.x

[68] Ministry of Foreign Affairs of Japan. 2021. Border Enforcement Measures to Prevent the Spread of Novel Coronavirus (COVID-19). https://www.mofa.go.jp/ca/fna/page4e_001053.html

[69] Ministry of Health, Labour and Welfare. [n.d.]. Preventing COVID-19 (Novel Coronavirus) and Stopping Its Spread. https://www.c19.mhlw.go.jp/covid-19-en.html

[70] Ministry of Health, Labour and Welfare. 2020. Q & A on Coronavirus Disease 2019 (COVID-19). https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/dengue_fever_qa_00014.html

[71] Ministry of Health, Labour and Welfare. 2021. (COCOA) COVID-19 Contact-Confirming Application. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/cocoa_00138.html

[72] Aya Mostafa, Walaa Sabry, and Nayera S. Mostafa. 2020. COVID-19-Related Stigmatization among a Sample of Egyptian Healthcare Workers. *PLOS ONE* 15, 12 (Dec. 2020), e0244172. https://doi.org/10.1371/journal.pone.0244172

[73] Paul Mozur, Raymond Zhong, and Aaron Krolik. 2020. In Coronavirus Fight, China Gives Citizens a Color Code, With Red Flags. *The New York Times* (March 2020). https://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html

[74] Simon Munzert, Peter Selb, Anita Gohdes, Lukas F. Stoetzer, and Will Lowe. 2021. Tracking and Promoting the Usage of a COVID-19 Contact Tracing App. *Nature Human Behaviour* (Jan. 2021), 1–9. https://doi.org/10.1038/s41562-020-01044-x

[75] Elizabeth L. Murnane, Tara G. Walker, Beck Tench, Stephen Voida, and Jaime Snyder. 2018. Personal Informatics in Interpersonal Contexts: Towards the Design of Technology That Supports the Social Ecologies of Long-Term Mental Health Management. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (Nov. 2018), 127:1–127:27. https://doi.org/10.1145/3274396

[76] Ichiro Nakamoto, Ming Jiang, Jilin Zhang, Weiqing Zhuang, Yan Guo, Ming-Hui Jin, Yi Huang, and Kuotai Tang. 2020. Evaluation of the Design and Implementation of a Peer-To-Peer COVID-19 Contact Tracing Mobile App (COCOA) in Japan. *JMIR mHealth and uHealth* 8, 12 (Dec. 2020), e22098. https://doi.org/10.2196/22098

[77] Kazuya Nakayachi, Taku Ozaki, Yukihide Shibata, and Ryosuke Yokoi. 2020. Why Do Japanese People Use Masks Against COVID-19, Even Though Masks Are Unlikely to Offer Protection From Infection? *Frontiers in Psychology* 11 (2020). https://doi.org/10.3389/fpsyg.2020.01918

[78] P. Ndayizigamiye and M. Maharaj. 2016. Mobile Health Adoption in Burundi: A UTAUT Perspective. In *2016 IEEE Global Humanitarian Technology Conference (GHTC)*. 613–623. https://doi.org/10.1109/GHTC.2016.7857342

[79] Helen Nissenbaum and Heather Patterson. 2016. Biosensing in Context: Health Privacy in a Connected World. In *Quantified*, Dawn Nafus (Ed.). The MIT Press, 79–100. https://doi.org/10.7551/mitpress/9780262034173.003.0005

[80] Helen Fay Nissenbaum. 2010. *Privacy in Context: Technology, Policy, and the Integrity of Social Life.* Stanford Law Books, an imprit of Standford University Press, Stanford, California.
[81] Anne Oeldorf-Hirsch and Kristine L. Nowak. 2018. There Is Something I Need to Tell You: Balancing Appropriateness and Efficiency in Modality Choice for Interpersonal Disclosures. *Communication Studies* 69, 2 (March 2018), 125–144. https://doi.org/10.1080/10510974.2017.1417878
[82] Noriko Okada. 2020. Coronavirus Sufferers Face Anger and Prejudice. https://www3.nhk.or.jp/nhkworld/en/news/backstories/1273/
[83] Patrick Howell O'Neill. 2020. No, Coronavirus Apps Don't Need 60% Adoption to Be Effective. https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/
[84] Patrick Howell O'Neill, Tate Ryan-Mosley, and Bobbie Johnson. 2021. A Flood of Coronavirus Apps Are Tracking Us. Now It's Time to Keep Track of Them. https://www.technologyreview.com/2020/05/07/1000961/launching-mittr-covid-tracing-tracker/
[85] Hiroshi Ono. 2018. Why Do the Japanese Work Long Hours? *Japan Labor Issues,* 2, 5 (2018), 35–49.
[86] World Health Organization. [n.d.]. Coronavirus. https://www.who.int/westernpacific/health-topics/coronavirus
[87] World Health Organization. 2020. Tracking COVID-19: Contact Tracing in the Digital Age. https://www.who.int/news-room/feature-stories/detail/tracking-covid-19-contact-tracing-in-the-digital-age
[88] World Health Organization. 2021. Advice for the Public on COVID-19 – World Health Organization. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public
[89] World Health Organization. 2021. An Update on Testing Strategies for COVID-19. https://www.who.int/docs/default-source/coronaviruse/risk-comms-updates/updates46-testing-strategies.pdf?sfvrsn=c9401268_6
[90] Kathleen H Pine, Myeong Lee, and Samantha A Whitman. 2021. Making Sense of Risk Information amidst Uncertainty: Individuals' Perceived Risks Associated with the COVID-19 Pandemic. (2021), 15.
[91] Claire H. Procopio and Steven T. Procopio. 2007. Do You Know What It Means to Miss New Orleans? Internet Communication, Geographic Community, and Social Capital in Crisis. *Journal of Applied Communication Research* 35, 1 (Feb. 2007), 67–87. https://doi.org/10.1080/00909880601065722
[92] Elissa M. Redmiles. 2020. User Concerns 8 Tradeoffs in Technology-Facilitated COVID-19 Response. *Digital Government: Research and Practice* 2, 1 (Nov. 2020), 6:1–6:12. https://doi.org/10.1145/3428093
[93] Mark Ryan. 2020. In Defence of Digital Contact-Tracing: Human Rights, South Korea and Covid-19. *International Journal of Pervasive Computing and Communications* 16, 4 (Jan. 2020), 383–407. https://doi.org/10.1108/IJPCC-07-2020-0081
[94] Ali Salimi, Hassan ElHawary, Nermin Diab, and Lee Smith. 2020. The North American Layman's Understanding of COVID-19: Are We Doing Enough? *Frontiers in Public Health* 8 (2020). https://doi.org/10.3389/fpubh.2020.00358
[95] Natsu Sasaki, Reiko Kuroda, Kanami Tsuno, and Norito Kawakami. 2020. Workplace Responses to COVID-19 Associated with Mental Health and Work Performance of Employees in Japan. *Journal of Occupational Health* 62, 1 (2020), e12134. https://doi.org/10.1002/1348-9585.12134
[96] Christopher L. Schaefbauer, Danish U. Khan, Amy Le, Garrett Sczechowski, and Katie A. Siek. 2015. Snack Buddy: Supporting Healthy Snacking in Low Socioeconomic Status Families. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. ACM, Vancouver BC Canada, 1045–1057. https://doi.org/10.1145/2675133.2675180
[97] Tanusree Sharma, Hunter A. Dyer, and Masooda. Bashir. 2021. Enabling User-Centered Privacy Controls for Mobile Applications: COVID-19 Perspective. *ACM Transactions on Internet Technology* 21, 1 (Jan. 2021), 26:1–26:24. https://doi.org/10.1145/3434777
[98] Jun Shigemura, Robert J. Ursano, Mie Kurosawa, Joshua C. Morganstein, and David M. Benedek. 2020. Understanding the Traumatic Experiences of Healthcare Workers Responding to the COVID -19 Pandemic. *Nursing & Health Sciences* (Oct. 2020), nhs.12766. https://doi.org/10.1111/nhs.12766
[99] Mark S. Smolinski, Adam W. Crawley, Kristin Baltrusaitis, Rumi Chunara, Jennifer M. Olsen, Oktawia Wójcik, Mauricio Santillana, Andre Nguyen, and John S. Brownstein. 2015. Flu Near You: Crowdsourced Symptom Reporting Spanning 2 Influenza Seasons. *American Journal of Public Health* 105, 10 (Aug. 2015), 2124–2130. https://doi.org/10.2105/AJPH.2015.302696
[100] Robert Soden and Leysia Palen. 2018. Informating Crisis: Expanding Critical Perspectives in Crisis Informatics. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (Nov. 2018), 162:1–162:22. https://doi.org/10.1145/3274431
[101] Takanao Tanaka and Shohei Okamoto. 2020. Suicide during the COVID-19 Pandemic in Japan. *medRxiv* (Dec. 2020), 2020.08.30.20184168. https://doi.org/10.1101/2020.08.30.20184168
[102] Steven Taylor, Caeleigh A. Landry, Michelle M. Paluszek, Thomas A. Fergus, Dean McKay, and Gordon J.G. Asmundson. 2020. Development and Initial Validation of the COVID Stress Scales. *Journal of Anxiety Disorders* 72 (May 2020), 102232. https://doi.org/10.1016/j.janxdis.2020.102232

[103] Steven Taylor, Caeleigh A. Landry, Geoffrey S. Rachor, Michelle M. Paluszek, and Gordon J. G. Asmundson. 2020. Fear and Avoidance of Healthcare Workers: An Important, under-Recognized Form of Stigmatization during the COVID-19 Pandemic. *Journal of Anxiety Disorders* 75 (Oct. 2020), 102289. https://doi.org/10.1016/j.janxdis.2020.102289

[104] Michiko Ueda, Andrew Stickley, Hajime Sueki, and Tetsuya Matsubayashi. 2020. Mental Health Status of the General Population in Japan during the COVID-19 Pandemic. *Psychiatry and Clinical Neurosciences* 74, 9 (Sept. 2020), 505–506. https://doi.org/10.1111/pcn.13105

[105] Thea F. van de Mortel. 2008. Faking It: Social Desirability Response Bias in Self-Report Research. *Australian Journal of Advanced Nursing, The* (June 2008). https://search.informit.org/doi/abs/10.3316/INFORMIT.210155003844269

[106] Tiffany C. Veinot, Jessica S. Ancker, Heather Cole-Lewis, Elizabeth D. Mynatt, Andrea G. Parker, Katie A. Siek, and Lena Mamykina. 2019. Leveling Up: On the Potential of Upstream Health Informatics Interventions to Enhance Health Equity. *Medical Care* 57 (June 2019), S108–S114. https://doi.org/10.1097/MLR.0000000000001032

[107] Tiffany C. Veinot, Hannah Mitchell, and Jessica S. Ancker. 2018. Good Intentions Are Not Enough: How Informatics Interventions Can Worsen Inequality. *Journal of the American Medical Informatics Association: JAMIA* 25, 8 (Aug. 2018), 1080–1088. https://doi.org/10.1093/jamia/ocy052

[108] Viswanath Venkatesh, Michael G Morris, Gordon B Davis, and Fred D Davis. 2003. User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly* 27, 3 (2003), 425–478.

[109] Sarah Vieweg, Amanda L. Hughes, Kate Starbird, and Leysia Palen. 2010. Microblogging during Two Natural Hazards Events: What Twitter May Contribute to Situational Awareness. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*. Association for Computing Machinery, New York, NY, USA, 1079–1088. https://doi.org/10.1145/1753326.1753486

[110] Michel Walrave, Cato Waeterloos, and Koen Ponnet. 2020. Ready or Not for Contact Tracing? Investigating the Adoption Intention of COVID-19 Contact-Tracing Technology Using an Extended Unified Theory of Acceptance and Use of Technology Model. *Cyberpsychology, Behavior, and Social Networking* (Oct. 2020). https://doi.org/10.1089/cyber.2020.0483

[111] Takahiro Yabe, Kota Tsubouchi, Naoya Fujiwara, Takayuki Wada, Yoshihide Sekimoto, and Satish V. Ukkusuri. 2020. Non-Compulsory Measures Sufficiently Reduced Human Mobility in Tokyo during the COVID-19 Epidemic. *Scientific Reports* 10, 1 (Oct. 2020), 18053. https://doi.org/10.1038/s41598-020-75033-5

[112] Kazuo Yamaguchi. 2019. Impediments to the Advancement of Women in the Japanese Employment System: Theoretical Overview and the Purpose of This Book. In *Gender Inequalities in the Japanese Workplace and Employment: Theories and Empirical Evidence*, Kazuo Yamaguchi (Ed.). Springer, Singapore, 1–45. https://doi.org/10.1007/978-981-13-7681-8_1

[113] Naomi Yamashita, Hideaki Kuzuoka, Keiji Hirata, Takashi Kudo, Eiji Aramaki, and Kazuki Hattori. 2017. Changing Moods: How Manual Tracking by Family Caregivers Improves Caring and Family Communication. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. Association for Computing Machinery, New York, NY, USA, 158–169. https://doi.org/10.1145/3025453.3025843

[114] Takashi Yoshioka and Yohei Maeda. 2020. COVID-19 Stigma Induced by Local Government and Media Reporting in Japan: It's Time to Reconsider Risk Communication Lessons From the Fukushima Daiichi Nuclear Disaster. *Journal of Epidemiology* 30, 8 (2020), 372–373. https://doi.org/10.2188/jea.JE20200247

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