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# COVID-19: Privacy and Confidentiality Issues with Contact Tracing Apps

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## Abstract

*Contact tracing has been a main topic of conversation in the COVID-19 pandemic. While implementation of app-based contact tracing can be beneficial, it raises concerns of privacy and confidentiality. To better understand how these issues were addressed, a qualitative study was conducted which analyzes the current status of contact tracing apps from Iceland, Italy, Germany, India, Singapore, Japan, and four states within the United States. The comparisons made amongst the contact tracing apps will be surveyed across numerous criteria. The results show contact tracing apps are able to assist in the COVID-19 caseloads by determining self-isolation periods. Future developments can change these apps into a tool for returning to normalcy that may require more user information disclosure, but limited protections of privacy and confidentiality issues have not been addressed at a worldwide level.*

## 1. Introduction

Contact tracing is a non-pharmaceutical method of controlling infectious diseases through means of seeking and testing contacts of infected individuals [1]. This method, having origins as far back as sixteenth century Europe, has been effective for addressing localized disease outbreaks [2]. The typical process of contact tracing involves a workforce made of community health care workers or volunteers who begin with interviewing the infected person (index case) for diagnosis, gaining knowledge of their actions, and identifying other individuals who are at risk of infection through close proximity [3]. At-risk individuals are then notified of their exposure to the disease and given further instructions, which may include discussing possible symptoms and directions to self-quarantine [4]. A follow-up is conducted to investigate changes in condition, aside from notification of release for self-monitoring or quarantine [4].

Klikenberg et al. [5] explains two types of tracing forms occur: single-step tracing and iterative tracing. Single-step tracing happens once all identified close contacts of a symptomatic index case are quarantined and tracing resumes only when an unknown infected case is identified during the quarantine period. The more common form of contact tracing is an iterative form, where each infected individual from an index case is considered a new index case and their identified close contacts become quarantined. While both forms are concluded to be equal in effectiveness, “capacity issues may reduce the effectiveness of iterative tracing if effort is directed towards secondary contactees prior to primary contactees” [5].

### 1.1 Advantages of Conventional Contact Tracing

Contact tracing is by no means a perfect or single solution to breaking the chain of infectious disease transmission, as it works in combination with a testing regimen and quarantine [3]. Before contract tracing commences, testing could occur for “cases of endogenous infection (cases of infection caused by transmission from individuals in the population) or for cases of exogenous infection (e.g. among immigrants, visitors from other countries, and travelers returning from vacation)” [1]. Armbruster & Brandeau noted that the benefits of contact tracing and testing together outweigh the benefits of performing them separately as cost-effectiveness varies on the amount of testing conducted and vice versa [1]. A result of sufficient testing contributes to knowledge of individuals who need to self-isolate and who is unaffected. In order to deem testing measures as adequate, positivity rates (the inverse number of positive tests per case) are set as benchmarks [6].

The process of contact tracing is advantageous for “targeting of control, at the cost of effort spent on finding at-risk individuals” [7]. Tracing efforts can consist of random checking or contact tracing, to identify infected individuals [8]. Random checking is usually associated with public health surveillance

programs, much like the WHO's Sentinel Surveillance Program, whose purpose of to obtain high-quality data for a certain disease, which is unobtainable through a passive system [9]. The final step of completing preventative plans is to self-isolate which may seem simplistic, but it is dependent on the individual's safety, comfort, and adequate resources to do so.

## 1.2 Disadvantages of Conventional Contact Tracing

Although a stable infrastructure and application is vital, there is a possibility for missed potential exposures. A significant reason is contributed to inaccurate memory recollection and false, incomplete or missing documentation [10]. Conventional contact tracing is limited to who the index case is able to identify, as most people don't have constant situational awareness or contact information for every person encountered. Along with incomplete or missing documentation, the margin of error has since grown through the reluctance of disclosing personal information due to concerns of stigma, privacy, government surveillance, and scams. An occasional obstacle for contact tracing is the inability to interview individuals who are too sick to participate, in which case proxy interviews are allowed but jeopardizes patient confidentiality [11][12].

## 2. Contact Tracing for COVID-19

To highlight the importance of contact tracing, it is at the forefront of combating the present-day COVID-19 illness as there is no vaccine or effective treatments, as of July 2020. The workforce in many areas are inadequately staffed to deal with the magnitude of this caseload [13]. At a lower estimate of nine COVID-19 incidences daily, the CDC recommends that states should have 30 contact tracers for every 100,000 residents [12]. Depending on the resources available and severity of caseload, states are handling the matter through different means such as "recruiting volunteers, deploying the National Guard, hiring or reassigning of government employees, contracting with outside vendors, and utilizing technology" [13].

In the event workforce scalability is met, conventional means of contact tracing are laborious. Given the time between onset of symptoms ranging from 2-14 days following viral exposure, further supports the need for faster identification of an index case's close contacts as well as testing [14]. Scarcity in testing at the beginning of the outbreak in the USA in February-March 2020, allowed only those who met certain conditions to be tested, leading to an over

overemphasized positivity rate [6]. Currently in May 2020, WHO advised governments that positivity rate should be 10% or less for adequate testing guidelines and should remain at 5% or lower for two weeks prior to reopening [15].

### 2.1 Contact Tracing in Hawaii

Hawaii has one of the lowest COVID-19 caseloads in the US with 1 death per 100,000 people and as of July 10, 2020 there has been 19 deaths [16]. The state has established a 14-day self-quarantine for arrivals to assist in keeping numbers at bay [17]. Besides contact tracing and testing, the Hawaii Department of Health uses a Sentinel Surveillance Program that will evaluate disease movements by collecting nasal swab samples from patients who meet certain criteria and performing random tests in an attempt to locate unnoticed viral transmission [18]. Since the beginning of the program, it has discovered 28 cases of COVID-19 amid 1,876 specimens (1.6%) from a dated week 22 report [19].

### 2.2 Contact Tracing in Mainland US

On July 10, 2020 the highest amount of COVID-19 cases were occurring in New York, California, Texas, Florida, and New Jersey [20]. A month prior to this news, only three of the 50 states have committed to using the Apple & Google API: Alabama, North Dakota, and South Carolina [21]. Many states aren't using apps for contact tracing but instead looking to expand their workforce for conventional contact tracing. States who have deployed app-assisted contact tracing have had low usage. For example: Utah's Healthy Together app was only downloaded by 1.4% of state's residents in late May, 2020 [22].

### 2.3 Contact Tracing Outside the US

Based on Oxford's COVID-19 Government Response Tracker, contact tracing outside the United states has become more comprehensive in comparison to the limited tracing in the US [23]. Many countries have resorted to using app-based technology to assist in decreasing COVID-19 prevalence and have had a higher adoption rate. One of the first countries to use Bluetooth technology in contact tracing was Singapore when news reported in April that "one in five people have downloaded the app" [24].

## 3. Technological Implementation

Whilst contact tracing apps don't compensate for deficiency of personal protective equipment, quicker

testing, and the absence of effective treatment, technological implementation offers effective outbreak management and affordability. Contact Tracing apps can be based on centralized or decentralized models, which has various trade-offs on privacy and security vulnerabilities [25]. The processing of both models is initiated in the same way: when users install the app on their smartphones and activate Bluetooth or Location Services, their apps will generate unique private keys [26]. Once in close contact, which the CDC has defined to be 6 feet and duration of roughly 15 minutes, the apps will exchange and record the anonymized keys [12].

A decentralized model, preferred by Apple and Google, will store that information locally on the devices and with user permission test results can be uploaded only to notify other app users [26]. Thus, this API and apps allows more control over personal information by storing it on the phone, and offers a higher degree of privacy [25]. In the centralized model, the app will report that information to a central server controlled by a designated entity [25].

Even with technological implementation, some proximity communication protocols may have drawbacks, such that “physical interactions obtained by Bluetooth aren’t a complete picture of the interaction history, it does represent a large portion of interactions” [8]. The benefits of contact tracing app usage results in accelerating the step of identifying close contacts of an index case, reducing the probability of viral spread to at-risk individuals. Apps will be inefficient in isolation, so participation and a high adoption rate is needed. Researchers at Oxford University in the UK conducted a study that found if 60% of a country’s population or region used an app it could prevent a virus from spreading, adding a positive outlook for lower amounts of app users with an estimation that one infection can be avoided for every one to two users [27].

#### 4. Methodology

The overall objective of this analysis is to understand concerns and issues that occur due to the implementation of technology in contact tracing through apps. The initial process consisted of forming a sample of contact tracing apps from diverse continental locations: US, Europe, and Asia. Further review was required to identify similarities and differences in app characteristics.

In order to discover a range of concerns and issues, the contact tracing apps were selected based on differing characteristics and available documentation. The unit of analysis was the contact tracing apps of

each country. To analyze confidentiality and privacy, the following categories were established: voluntary/mandatory use, age requirement, retention period, deletion ability/period, local storage, central storage, adoption rate, protocol of app, personal information disclosure, data controller, and the ability for user to be identified due to usage.

An examination of contact tracing apps reveals that a majority are available on both Apple and Google stores with the ability to run on iOS and Android phones. Secondary steps performed a qualitative analysis on privacy policies, FAQs, the contact tracing apps, and other available documentation. To ensure reliability and validity of data, information was collected from available documentation on official websites, Apple store download pages, and actual use of selected apps. These contact tracing apps are subject to change.

#### 5. Contact Tracing Apps in Europe

Table 1: Analysis of European apps.

CRITERIA	EUROPEAN APPS		
	Iceland	Italy	Germany
Age Requirement (Years)	4+*	18†	16†
Data Controller	Healthcare	Healthcare	Healthcare
Immediate Deletion	YES‡	YES‡	YES‡
Retention Period (Days)	14	14	14-21
Amt of Info Needed For Registration	1	2	0
Local Storage	Location records	Random IDs	Random IDs
Central Storage	Phone #	Region, Province	0
Voluntary Use	YES	YES	YES
Allow For Identification?	NO	NO	NO
Protocol	Location	AGEN Bluetooth	AGEN Bluetooth

\*Apple Store age rating

†Parental consent needed for younger ages.

‡Deletion dependent on retention period.

§Changes to use since introduction. [28]–[31].

Here, the term data controller is defined as an entity “who decides why and how personal data will be processed” which is much more prevalent outside the United States (see Table 1) [32]. European countries declare data controllers as compliance to the General Data Protection Regulation (GDPR) [32]. The contact tracing apps selected in the Europe are offered for voluntary use and have explicit healthcare entities

as data controllers: Italy- Ministry of Health, Iceland - Department of Civil Protection and Emergency Management, Germany – Robert Koch Institute, an independent public health institute [28]–[30]. All apps are only available for use within their respective countries. Although some processes have a small difference, these countries protect user data under the GDPR and none store any information that allow for identification of individuals and their devices [32].

## 5.1. Iceland

Of the three European apps, Iceland's Rakning C-19 app does not provide an official age requirement. The Apple Store displays an age rating of 4 years old and above, which is defined as having "no objectionable material" [33]. Rakning C-19 requires the input of a user's phone number which becomes stored into the app's database and triggers an SMS text message from the country's health authority. The entry of the 6-digit code from the SMS text message into the app signifies the user's agreement to terms. Rakning C-19 uses location data, which is encrypted and stored locally for 14 days. A user may choose to delete the app from their phones at any time which will disable and remove location data.

When an individual receives a positive test result for infection, the Department of Civil Protection and Emergency Management's Contact Tracing Team will use the app to send a request for access of location data. An app user agrees to disclosure by selecting the button on the screen and (if applicable) entering their Icelandic national ID number for verification purposes. Location data is forwarded to the Contact Tracing Team's database upon verification and stored in their database for 14 days after upload. Phone numbers that were entered for acceptance of terms will be deleted when after contact tracing is no longer required. Iceland's adoption rate of the app is about 40% of their population [28].

## 5.2. Italy

Whereas Italy's Immuni app states that users must be at least 18 years old, requiring parental or guardian consent is needed for users between 14-18 years of age. Initial app configuration requires the user to select the region and providence of residency. The app uses Apple and Google's Exposure Notification API allowing Bluetooth communication with other app users. It doesn't collect any geolocation data, including GPS. When someone tests positive for COVID-19, a healthcare professional will enter the date of symptom onset or swab test (if the user is asymptomatic) into the Italian Ministry of Health's

system. If the individual is an Immuni app user, they are able to access the one-time password (OTP) generation function from the app and provide the 10-digit OTP code to the healthcare operator for upload authorization, which prevents any false reports. After receiving confirmation from healthcare operator, the user is able to upload their random codes to the server to notify others of exposure.

Immuni will store the following encrypted information locally: providence of residency, indicators of the App's operation status, temporary codes, receipt of exposure notification, date of last risk contact, Temporary Exposure Key (TEK), previous contact risk indicators, OTP code, and date of symptom onset or swab test. Data retention may vary depending on the type of information. However, all data is subject to deletion on 12/31/2020. In addition to the GDPR, the data is also processed in accordance with Articles of the Italian Personal Data Protection Code [29]. Despite the June 2020 introduction of limited app availability in four regions, it has garnered 8 million downloads out of Italy's 60 million population [34].

## 5.3. Germany

Similar to Italy, Germany's Corona-Warn-app requires legal guardian agreement for users below the age of 16 years and uses the same Apple and Google Exposure Notification with Bluetooth communication. However, it does not need any personal information. The app functionality allows for two ways to report a verified, positive test result. One of the methods works in the same way as Italy's Immuni app, communication with a healthcare operator provides the app user with a TeleTAN (Tele Transaction Number) and entry of TeleTAN will request the upload of diagnosis keys. Another method involves the optional scanning of a custom-QR code received at the testing facility, that becomes hashed and matched with the user's test results.

The app's test retrieval functionality offers the option to share the results once available. Data deletion may vary for certain features, such as 14 days for exposure logging, 21 days for test registration-positive results, 14 days for test result sharing and 21 days for TeleTANS and TANS stored on server. Currently, the app is available for European countries listed in their documentation. Pending availability for other countries will occur after proper legal compliance is ensured [30].

## 6. Contact Tracing Apps in Asia

**Table 2: Analysis of Asian contact tracing apps.**

CRITERIA	ASIAN APPS		
	India	Japan	Singapore
Age Requirement (Years)	4*	4+*	13+*
Data Controller	Gov	Healthcare	Healthcare
Immediate Deletion	NO‡	YES	NO
Retention Period (Days)	45-60	14	25
Amt of Info Needed For Registration	6	0	3-4
Local Storage	Location Records & unique ID	Random IDs	Random IDs
Central Storage	8 pieces of information	0	Phone Number, Personal Info, User ID
Voluntary Use	NO§	YES	YES§
Allows For Identification?	YES	NO	YES
Protocol	Bluetooth, GPS	AGEN Bluetooth	Bluetrace, Bluetooth

\*Apple Store age rating

†Parental consent needed for younger ages.

‡Deletion dependent on retention period.

§Changes to use since introduction. [31], [35]–[37].

As seen in Table 2, The Ministry of Health for both Japan and Singapore are listed as data controllers for their voluntary apps, which operate with Bluetooth for proximity communication [37][36]. Local storage for both apps consists of randomized Bluetooth IDs. In contrast, India has opted for the Government to oversee the information for their country’s mandatory app that operates proximity communication combination of Bluetooth and GPS [35].

Close contact for all three apps is considered to be within the Bluetooth range: 6 feet for India, 1 meter for Japan, and 2 meters for Singapore [35]–[37]. Age requirements for usage are not specified in the available documentation. Japan and India are assumed to follow the Apple’s age rating of 4 years and above that deems they have no objectionable material [33]. Singapore’s TraceTogether displays an age rating of 13 and above. Of these three, only Japan’s COCOA app excludes any identification of an individual or device.

### 6.1. India

In comparison to other apps in the analysis, India’s Aarogya Setu app has a comprehensive list and retention period for information. Registration information requires a user’s name, phone number, age, gender, profession, and travel history in the last 30 days, which will be retained for the entirety of the account’s existence. Once registered, a unique digital ID (DiD) becomes assigned to the user and location details are captured. All registration information, DiD, and location details will be stored on app’s server.

Data retention periods differ on health status. Uploaded information for healthy individuals will be purged from the server after 45 days. Recovered individuals will have their information removed from the server after 60 days. Bluetooth and GPS are to be enabled at all times. Local data storage contains time, proximity, location, duration, and digital signature of interaction between users. Other locally stored data includes a location record that captures user location at 30 or 15 minutes, depending on the epidemic’s severity, which is only uploaded to the server with the DiD if the user tests positive for infection.

When an individual is positive for infection, the testing lab discloses results to the Indian Council of Medical Research (ICMR). ICMR shares the list of infected individuals to the app’s server, eliciting updates to a user’s status. The risk of infection is calculated for other app users and notifies them of exposure, which can be displayed on their home screen in four classifications: green, yellow, orange, and red [35]. Due to mandatory nature of this app, the adoption rate has been affected.

### 6.2 Singapore

TraceTogether documentation states that in order to complete app registration, the user will need a valid National Registration Identity Card (NRIC), Foreign Identification Number (FIN), or valid document of current stay in Singapore, a compatible phone, and disclosure of mobile phone number [38]. Further examination of the app reveals that a user is provided with six profile options: NRIC, FIN-Work Pass, FIN-Dependent’s Pass, FIN-Student’s Pass, FIN-Long Term Visit Pass (LTPV), and “I’m Visiting Singapore.” All profile options involve entry of name in addition to previously noted information. Specifically, the NRIC profile involves sharing date of birth. The latter option, “I’m Visiting Singapore”, will also require entry of date of birth, nationality, and passport number. User’s mobile number, random anonymized user ID, and identification details are stored in a secure server prohibiting any public access.

Local storage data consisting of anonymized Bluetooth data is retained for up to 25 days. No GPS location, Wi-Fi, or mobile network data is collected. Instead of the Apple and Google Exposure Notification used by other apps, TraceTogether uses the BlueTrace protocol resulting in more reported phone encounters for Android users as less than a quarter of phone encounters are made with iOS-to-iOS phones. Users may request for deletion of identification data through email only if they have not been infected. The process will remove mobile number, identification details, and user ID from the server.

If an individual receives a positive test result, they can expect contact from a healthcare official by phone. Only the Ministry of Health has the ability to “decrypt the shared encounter history to obtain and use personally-identifiable information to filter for close contacts and contact potentially infected users”, which is made possible with the mobile numbers used for app registration [39]. There is no need for users to upload any information. The app plans to be in service until the need for contact tracing ceases. No specific laws are mentioned to protect user data. However the BlueTrace protocol, made by their Government Technology Agency, declares implementation of privacy safeguards [36]. As of July 5, 2020, 2.1 million people have downloaded the app [40].

### 6.3. Japan

App registration for COCOA includes agreement to terms of use, enabling of contact detection, and confirmation of proximity communication function (Bluetooth). Encrypted, locally stored data is comprised of contact codes, changed every 10 minutes, and daily keys, changed every 24 hours. Data deletion transpires automatically after 14 days. Alternatively, users have the ability to delete records for the previous two weeks by stopping app usage and deleting the app [37]. Japan’s Ministry of Health has used technology made by Apple and Google for this familiar exposure notification process [31].

When a user tests positive for infection, the healthcare organization will record the test result into “The Health Real-time Information-sharing System on COVID-19” and provide a temporary, randomly-issued processing number via phone number or email that allows an individual to voluntarily register their test results in the app. Close contact app users within the past two weeks will receive an alert [37]. Japan’s COCOA app received more than 4 million downloads in its first week of launching announced by news reports in late June 2020 [41].

## 7. Contact Tracing Apps in US

Unlike Europe, the United States has no national privacy law similar to that of the GDPR, which affect much of the criteria for the apps (see Table 3)[42]. US contact tracing apps have a wide range of differences among them and aren’t currently operable at a national level. The following apps were selected for analysis: CARE-19, Healthy Together, NOVID, and Pathcheck (former known as SafePaths). Contact Tracing Apps would assist in the manual process for the United States, but a structured framework and protections need to be arranged for inter-state operability.

**Table 3: Analysis of US contact tracing apps.**

CRITERIA	UNITED STATES			
	CARE19	Healthy Together	NOVID	Path check
Age Requirement (Years)	18*	18†	4+*	16*†
Data Controller	Developer	Developer	Developer	Developer
Immediate Deletion	YES	YES	YES	YES
Retention Period (Days)	14	30-60	NA	14
Amt of Info Needed For Registration	2	3	0	0
Local Storage	Location records	Location & Random IDs	Random IDs	Location records
Central Storage	Location Data	6 types of information	0	0
Voluntary Use	YES	YES	YES	YES
Allow For Identification?	NO	YES	NO	NO
Protocol	Location	Bluetooth, GPS	Ultrasound, Bluetooth	AGEN Bluetooth, GPS

\*Apple Store age rating

†Parental consent needed for younger ages.

‡Deletion dependent on retention period.

§Changes to use since introduction. [31], [43]–[46].

Those marked as having no objectionable material with an age rating of 4+ in the Apple Store are NOVID and Pathcheck, amid Pathcheck stating in their App Privacy Policy that children under 16 aren’t allowed to use service [46][45]. Consequently, not requiring any personal information for registration and storing unidentifiable information locally. On the other hand, CARE-19 and Healthy Together have explicit age requirements, both labeled for use by individuals 18 years and older [44][43]. Healthy Together allows an exception for those between the ages of 13 and 17 on

the condition there is parental review and agreement to terms of service [44].

The processing of data is at the discretion of the developer or other 3rd parties mentioned in the documentation. Due to either of these not classified as a healthcare provider or other covered entity, HIPAA laws do not apply [44]. CARE19 states compliance with California Consumer Privacy Act (CCPA) yet is not available for use in California [43]. CCPA allows consumers the control what information the company has of the individual and provides the ability to request deletion [47]. An inference could be made that the developer is attempting to prove responsible data handling or a 3rd party site for data processing is located in California. All data collected from apps allow deletion at any time through uninstallment or email request. Though all, except NOVID, are subject to retention periods noted in Privacy Policies. The various technologies are used to collect information such as location; GPS, Wi-Fi, cellular, Bluetooth, and IP address; Bluetooth and Ultrasound; and Bluetooth, respectively [43]–[46]. NOVID is currently the only app within this analysis using ultrasound technology, which acquires obtain more accurate proximity measurements [48].

## 8. Comparative Analysis

The age criteria as shown in the first row of each of the above Tables 1, 2 and 3, many of the contact tracing apps either allow for underage usage with parental or guardian consent or display a low age rating in the Apple Store. While COVID-19 does not affect an individual of a lower age group as much as those ages 65 years and older, any preventative measures to contain the spread will be beneficial as schools return to in-person learning operations and common travel routines resume [49]. Overall, the apps have considered underage usage for minors.

When comparing data controllers, the European and Asian apps display healthcare authorities in charge of the information received, with an exception of India whose government is listed as the data controller. Due to this, the assumption can be made that there is a level of trust with the app user and the listed entity to responsibly process the data collected. Compared to the United States, the title of data controllers is not explicitly mentioned in the app documentation. Data processing for the apps is handled at the discretion of the app developer.

Unsurprisingly, all apps from the United States are voluntary and allow for immediate deletion of information upon uninstallment or email request. While other countries provide the option for deletion,

some information either acquired at registration or upon server upload may be retained as stated in their documentation. The standard retention period for apps using technology from Apple and Google, listed with protocols of “AGEN”, is 14 days. Additional retention of data can be caused by test registration, as well as the sharing and outcome of test results. Contact tracing apps that retain information for longer periods, have more information stored whether it be centrally or locally.

Apps that were initially voluntary in early 2020 are now looking to create exceptions for people who are visiting from other countries. Singapore’s TraceTogether app was deemed voluntary, but news in June of 2020 reports that the Ministry of Manpower required foreign workers to have app installed [40][50]. Based on this information, the two expectations can be made that usage for contact tracing apps may be required to permit entry into other countries and to resume normal activities such as work and schooling. In contrast, India’s contact tracing app has always been mandatory. As of May 20, 2020, individuals under 14 years old in India are not mandated to use the app [51]. This change in requirement shows user concerns over mandates that may cause privacy issues, especially for children.

The obvious connection exists that the amount of personal information needed for initial registration increases the likelihood of being able to personally identify a person or device. In the same way, data controllers are looking to learn more from the information with the core intention to perform conventional contact tracing as a more comprehensive approach. Complementarily, apps who require no information for registration purposes are assuming that app usage will mainly allow an individual to determine when it is necessary to self-isolate, which may influence a higher amount participation from users to self-report test results for others to do the same.

Apps labeled as “AGEN Bluetooth” have Apple and Google Exposure Notification implemented into the app. As a result, those apps will not have mandatory usage and adopt a decentralized model [24]. Whereas apps, whose protocols are made without the use of Apple Google technology, have an opportunity to change protocols if the need arises. Overall, the prevalence of contact tracing apps has spurred innovation amongst various countries. This is an evolving issue with Covid-19 and hopefully will lead to better contact tracing apps and methodologies during the near decade.

## 9. Privacy and Confidentiality Issues and Concerns

One of the main concerns with contact tracing apps is privacy, which can be defined as “the claim of individuals, groups and institutions to determine for themselves when, how, and to what extent information about them is communicated to others” [52]. Some apps have addressed the issue by allowing voluntary use, storing of personal information locally, choosing a decentralized model, requiring no personal information, and providing immediate deletion of information. Correspondingly, the issue of confidentiality defined as “the respectful handling of information disclosed within relationships of trust, especially as regards to further disclosure”, was addressed by allowing for users to self-report test results, encrypting personal information obtained, periodical generation of new randomized keys, and prohibiting public access [11].

While laws and policies exist for public health information handling in the United States, such as the Health Insurance Portability and Accountability Act (HIPAA), none are robust to address the potential for data abuse with the use of contact tracing apps. To tackle the issue, on June 1, 2020 US Senators Cantwell, Cassidy, and Klobuchar have introduced the Exposure Notification Privacy Act, a bipartisan bill, that sets federal rules to ensure that data collected by contact tracing apps would not be used for commercial purposes [53]. The bill discusses: “voluntary participation, user consent, right to data deletion at any time, diagnoses verification, strict restrictions on data use, and strong enforcement provisions” [53]. Likewise in spite of India’s Personal Data Protection bill, an epidemic is considered grounds for processing personal data without consent and holds no mention in the documentation of how it plans to regulate children’s personal data [54].

Individuals may be skeptical to use technology that allows for interactions or locations to be recorded due to a fear of government surveillance or data abuse. In the US, the Fourth Amendment, known to “protect individuals against reasonable search and seizure by the government”, does not apply to electronic searches [42]. Until the previously mentioned Exposure Notification Privacy Act is passed, Americans are lacking privacy from government surveillance when using contact tracing apps [53]. Whilst countries within the European Union/European Economic Area are covered by the GDPR, others are plagued with the same issue. India is rampant with government surveillance being that the nation’s surveillance program launched in 2013 [55][54] and Singapore

ranks just as high with the amount of CCTVs within the country [56].

## 10. Conclusion

It is apparent that these apps were made with the intention to combat the current pandemic caseload by determining self-isolation periods and a means for individuals to assist in decreasing infectious spread. Despite reopening phases barely within reach for most countries, changes can be made to have contact tracing apps as a tool for returning to normalcy. However, international or interstate usage of these apps has not been addressed due to varying levels of governmental trust and laws concerning data processing and protection. For globalization and re-opening purposes, contact tracing apps should consider how to best ensure protection, privacy and confidentiality for user data on a worldwide level.

## 11. References

- [1] B. Armbruster and M. L. Brandeau, “Contact tracing to control infectious disease: When enough is enough,” *Health Care Manag. Sci.*, vol. 10, no. 4, pp. 341–355, 2007, doi: 10.1007/s10729-007-9027-6.
- [2] L. O. Gostin and J. G. Hodge, “Piercing the Veil of Secrecy in HIV/AIDS and Other Sexually Transmitted Diseases: Theories of Privacy and Disclosure in Partner Notification,” *Duke J. Gend. Law Policy*, no. 5 (1), pp. 9–88, 1998.
- [3] Swiss National COVID-19 Science Task Force, “Contact Tracing Strategy (26 April 20 - EN),” 2020. [Online]. Available: <https://ncs-tf.ch/en/policy-briefs/contact-tracing-strategy-26-april-20-en>.
- [4] A. De La Garza, “What Is Contact Tracing? Here’s How It Could Be Used to Help Fight Coronavirus,” Apr. 2020. <https://time.com/5825140/what-is-contact-tracing-coronavirus/>.
- [5] D. Klinkenberg, C. Fraser, and H. Heesterbeek, “The Effectiveness of Contact Tracing in Emerging Epidemics,” *PLoS One*, vol. 1, no. 1, pp. 1–7, 2006, doi: 10.1371/journal.pone.0000012.
- [6] Johns Hopkins University, “Which U.S. States Meet WHO Recommended Testing Criteria?,” 2020. <https://coronavirus.jhu.edu/testing/testing-positivity>.
- [7] T. House and M. J. Keeling, “The Impact of Contact Tracing in Clustered Populations,” *PLoS Comput. Biol.*, vol. 6, no. 3, 2010, doi: 10.1371/journal.pcbi.1000721.
- [8] K. Farrahi, R. Emonet, and M. Cebrian, “Epidemic Contact Tracing via Communication Traces.,” *PLoS One*, vol. 9, no. 5, pp. 1–11, May 2014,

[9] [Online]. Available: <http://10.0.5.91/journal.pone.0095133>.

[10] World Health Organization, "Immunization, Vaccines and Biologicals. Sentinel Surveillance," 2017. [http://www.who.int/immunization/monitoring\\_surveillance/burden/vpd/surveillance\\_type/sentinel/en/](http://www.who.int/immunization/monitoring_surveillance/burden/vpd/surveillance_type/sentinel/en/).

[11] T. R. Hellmich *et al.*, "Contact tracing with a real-time location system: A case study of increasing relative effectiveness in an emergency department," *Am. J. Infect. Control*, vol. 45, no. 12, pp. 1308–1311, 2017, doi: 10.1016/j.ajic.2017.08.014.

[12] W. W. Lowrance, *Privacy, confidentiality, and health research*. 2012.

[13] CDC, "HEALTH DEPARTMENTS: Interim Guidance on Developing a COVID-19 Case Investigation & Contact Tracing Plan," 2020, [Online]. Available: <https://www.cdc.gov/coronavirus/2019-ncov/downloads/case-investigation-contact-tracing.pdf>.

[14] United States of CARE, "State of COVID-19 Contact Tracing in the U. S. Contact Tracing in States," 2020. <https://unitedstatesofcare.org/covid-19/covid-19-contact-tracing/> (accessed Jun. 10, 2020).

[15] Mayo Clinic, "Coronavirus Disease 2019," 2020. <https://www.mayoclinic.org/diseases-conditions/coronavirus/symptoms-causes/syc-20479963?p=1>.

[16] World Health Organization, "Public health criteria to adjust public health and social measures in the context of COVID-19. Annex to Considerations in adjusting public health and social measures in the context of COVID-19," 2020. [Online]. Available: <https://www.who.int/publications/item/public-health-criteria-to-adjust-public-health-and-social-measures-in-the-context-of-covid-19>.

[17] The New York Times, "Hawaii Coronavirus Map and Case Count," 2020. <https://www.nytimes.com/interactive/2020/us/hawaii-coronavirus-cases.html>.

[18] Hawaii Governor's Office, "NEWS RELEASE – GOV. IGE ORDERS MANDATORY 14-DAY QUARANTINE FOR ALL INDIVIDUALS ARRIVING OR RETURNING TO THE STATE OF HAWAI'I," Honolulu, Mar. 21, 2020.

[19] H. H. Youn, "The Scoop on Sentinel Surveillance Testing," *Hawaii Daily News Digest*, 2020. <https://hawaiicovid19.com/the-scoop-on-sentinel-surveillance-testing/>.

[20] HAWAII STATE DEPARTMENT OF HEALTH DISEASE OUTBREAK CONTROL DIVISION, "Influenza / Respiratory Disease Surveillance Report - Morbidity and Mortality Weekly Report (MMWR)," 2020. [Online]. Available: [https://health.hawaii.gov/docd/files/2019/10/Combined\\_2019-20.pdf](https://health.hawaii.gov/docd/files/2019/10/Combined_2019-20.pdf).

[21] The New York Times, "Coronavirus in the U.S.: Latest map and case count," *The New York Times*, 2020. <https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html> (accessed Jul. 07, 2020).

[22] A. Holmes and H. Langley, "Apple and Google's ambitious COVID-19 contact-tracing tech can help contain the pandemic if used widely. But so far only 3 states have agreed — and none has started to use it .," *Business Insider*, 2020. <https://www.businessinsider.com/apple-google-coronavirus-contact-tracing-tech-states-dont-plan-using-2020-6> (accessed Jun. 10, 2020).

[23] T. Sonnemaker, "Utah reportedly spent nearly \$3 million on a contact tracing app that less than 2% of the state's population has downloaded," *Business Insider*, 2020. <https://www.businessinsider.com/utahs-275-million-contact-tracing-app-few-downloads-report-2020-5> (accessed Jun. 05, 2020).

[24] T. Hale, S. Webster, A. Petherick, T. Phillips, and B. Kira, "Which countries do COVID-19 contact tracing?," *Oxford COVID-19 Government Response Tracker, Blavatnik School of Government*, 2020. <https://ourworldindata.org/grapher/covid-contact-tracing>.

[25] A. Aravindan and S. Phartiyal, "Bluetooth phone apps for tracking COVID-19 show modest early results," *Reuters*, 2020.

[26] K. Larson and A. Berke, "Contact Tracing Technologies : Methods and trade-offs Contact Tracing Technologies : Methods and trade-offs," *MIT Media Lab*, 2020, [Online]. Available: [https://damprod.media.mit.edu/x/2020/05/19/contact\\_tracing\\_tech-1\\_V5.pdf](https://damprod.media.mit.edu/x/2020/05/19/contact_tracing_tech-1_V5.pdf).

[27] Cristina Criddle and Leo Kelion, "Coronavirus contact-tracing: World split between two types of app," *BBC*, 2020. <https://www.bbc.com/news/technology-52355028>.

[28] Fraser Group Oxford - University's Big Data Institute, "Digital contact tracing can slow or even stop coronavirus transmission and ease us out of lockdown," *Univ. Oxford*, 2020, [Online]. Available: <https://www.research.ox.ac.uk/Article/2020-04-16-digital-contact-tracing-can-slow-or-even-stop-coronavirus-transmission-and-ease-us-out-of-lockdown>.

[29] Directorate of Health and The Department of Civil Protection and Emergency Management, "Rakning C-19." <https://www.covid.is/app/en>.

[30] Italian Ministry of Health, "Immuni." <https://www.immuni.italia.it>.

[31] Corona-Warn-App Authors, "Corona-Warn-App Open Source Project," 2020. <https://www.coronawarn.app/en/>.

[32] B. Howell O'Neill, Patrick; Ryan-Mosley, Tate; Johnson, "A flood of coronavirus apps are tracking us. Now it's time to keep track of them," *MIT Technol. Rev.*, pp. 1–16, 2020, [Online].

Available:  
<https://www.technologyreview.com/2020/05/07/1000961/launching-mittr-covid-tracing-tracker/>.

[32] B. Wolford, "What is GDPR, the EU's new data protection law?", 2019. <https://gdpr.eu/what-is-gdpr/> (accessed Jun. 23, 2020).

[33] Apple Inc., "App Ratings," 2020. <https://help.apple.com/app-store-connect/#/dev269f11291>.

[34] A. Amante and E. Pollina, "Italians embrace coronavirus tracing app as privacy fears ease," *Reuters*, Rome, pp. 1–9, Jun. 11, 2020.

[35] Government of India, "Aarogya Setu," 2020. <http://www.aarogyasetu.gov.in>.

[36] Team Tracetogther, "TraceTogether," 2020. <https://www.tracetogther.gov.sg>.

[37] Japan Ministry of Health Labour Welfare, "COCOA," 2020. [https://www.mhlw.go.jp/stf/seisakunitsuite/english/\\_rk\\_00031.html](https://www.mhlw.go.jp/stf/seisakunitsuite/english/_rk_00031.html).

[38] Western Union - Singapore, "FAQ Registration," 2000. <https://www.westernunion.com/sg/en/frequently-asked-questions/faq-registration.html>.

[39] J. Bay *et al.*, "BlueTrace : A privacy-preserving protocol for community-driven contact tracing across borders," 2020. [Online]. Available: [https://bluetrace.io/static/bluetrace\\_whitepaper-938063656596c104632def383eb33b3c.pdf](https://bluetrace.io/static/bluetrace_whitepaper-938063656596c104632def383eb33b3c.pdf).

[40] B. S. Asher, "Coronavirus : Why Singapore turned to wearable contact-tracing tech," *BBC*, Singapore, Jul. 05, 2020.

[41] Reuters, "Japan's COVID-19 app reaches 4 million downloads in first week," pp. 19–20, Jun. 27, 2020.

[42] Subscript Law, "Legal Landscape : Government Electronic Surveillance."

[43] ProwdCrowd LLC, "Care19." <https://www.care19.app/Privacy> (accessed Jun. 16, 2020).

[44] Twenty Holdings Inc., "Healthy Together," 2020. <https://www.healthytogether.io> (accessed Jun. 15, 2020).

[45] Expii Inc, "NOVID," 2020. <https://www.novid.org> (accessed Jun. 15, 2020).

[46] Pathcheck Foundation, "Pathcheck," 2020. <https://pathcheck.org>.

[47] B. Freed, "On data privacy, state AGs say they're following California's lead," *StateScoop News Group*, Jan. 30, 2019.

[48] P. Loh, "Accuracy of Bluetooth-Ultrasound Contact Tracing : Experimental Results from NOVID iOS Version 2 . 1 Using Five-Year-Old Phones," 2020.

[49] CDC Covid-19 Response Team, "Severe Outcomes Among Patients with Coronavirus Disease 2019 (COVID-19) — United States, February 12–March 16, 2020," *Morb. Mortal. Wkly. Rep.*, vol. 69, no. 12, pp. 343–346, 2020, doi: 10.15585/mmwr.mm6912e2.

[50] N. Meah, "Migrant workers learn to use apps for contact tracing , health reporting before they can resume work," *Today Online*, 2020. <https://www.todayonline.com/singapore/migrant-workers-learn-use-apps-contact-tracing-health-reporting-they-can-resume-work> (accessed Jun. 14, 2020).

[51] National Herald India, "AAI issues SOP for domestic flights ' resumption; Aarogya Setu not mandatory for children below 14," no. May, May 21, 2020.

[52] A. F. Westin, *Privacy and Freedom annotated*. 1967.

[53] M. Cantwell, B. Cassidy, and A. Klobuchar, *Exposure Notification Privacy Act Full Text*. US Senate and House of Representatives, 2020.

[54] A. Burman, "Will India's Proposed Data Protection Law Protect Privacy and Promote Growth?," 2020. [Online]. Available: [https://carnegieendowment.org/files/Burman\\_Data\\_Privacy.pdf](https://carnegieendowment.org/files/Burman_Data_Privacy.pdf).

[55] A. Litton, "The State of Surveillance in India: The Central Monitoring System's Chilling Effect on Self-Expression," *Washingt. Univ. Glob. Stud. Law Rev.*, vol. 14, no. 4, 2015, [Online]. Available: [https://openscholarship.wustl.edu/cgi/viewcontent.cgi?article=1556&context=law\\_globalstudies](https://openscholarship.wustl.edu/cgi/viewcontent.cgi?article=1556&context=law_globalstudies).

[56] P. Bischoff, "Surveillance Camera Statistics: Which City has the Most CCTV Cameras?," *Comparitech*, p. 1, 2019, [Online]. Available: <https://www.comparitech.com/vpn-privacy/the-worlds-most-surveilled-cities/>.