EVIDENCE SYNTHESIS BRIEFING NOTE

TOPIC: QUICK RESPONSE (QR) CODES AS AN APPROACH TO CONTACT TRACING FOR COVID-19

Information finalized as of November 18, 2020.[a]

This Briefing Note was completed by the Evidence Synthesis Unit (Research, Analysis and Evaluation Branch, Ministry of Health) based on a literature search, as well as information provided by members of the COVID-19 Evidence Synthesis Network. Please refer to the Methods section for further information.

Purpose: Contact tracing is a process that is used to identify, educate, and monitor individuals who have had close contact with someone who is infected with a virus, such as coronavirus disease 2019 (COVID-19); these individuals are at a higher risk of infection and transmission. Contact tracing can help individuals understand their risk and limit further spread of the virus. Quick response (QR) codes, barcodes that can be scanned by smartphones, are a type of location-based digital contract tracing approach. This briefing note provides a summary of the evidence and jurisdictional experiences using QR codes as contact tracing approaches to contain the COVID-19 pandemic.

Key Findings:

- Limited research evidence was identified on the use of QR codes as an approach to contact tracing.
  - Some research findings suggest that QR codes may be effective with sufficient population uptake and usage and/or when they are used in combination with other strategies. They are easy to deploy and have high locational accuracy. They may be most effective when they are required to be used by all patrons of a specific location or service and tied to a specific exchange (e.g., ticket to enter a venue, fare for public transport).
  - Potential limitations associated with the use of QR codes primarily relate to user adoption, for example: users may not be comfortable with an application that tracks their real-time location; users may become fatigued over time from having to scan multiple entry/exit points and choose to discontinue or be dissuaded from participating at the onset; and failures to regularly scan and log codes can lead to false negatives.
- Jurisdictional information was identified on Australia, China, Israel, Netherlands, New Zealand, Singapore, and Taiwan, who use QR codes as part of their case management and contact tracing strategies for COVID-19.
  - **Method**: In Australia (New South Wales [NSW]), China, Netherlands, New Zealand, and Singapore, users scan QR codes with their smartphones at entry/exit checkpoints to keep track of places visited and/or to verify permission to enter public venues based on their low- or high-risk COVID-19 profile. In Israel, four stationary testing centres in major metropolitan areas and eight drive-in testing centres use QR codes to identify patients. In Taiwan, travelers flying to Taiwan have to complete a COVID-19 health declaration form when arriving at airports by scanning a QR code.
  - **Mandatory/Voluntary Use**: Mandatory in Australia, China, Singapore, and Taiwan, and voluntary in New Zealand.
  - **Locations Used**: Ranges from: office buildings, shopping centres, transportation systems (e.g., taxis, buses, trains, airports), hospitality sector, schools/universities, parks, hospitals, and testing centres.
  - **Information Collected**: Ranges from: name, phone number, email, home address, self-reported health status, travel history, relationship to confirmed or suspected cases, and date of visit to public venue.
  - **Governance**: Governments authorize and oversee the contract tracing approach, often in partnership with technology companies who developed the QR code applications.
  - **Privacy**: Singapore abides by their personal data protection act, and New Zealand's system was developed in consultation with the privacy commissioner, has password authentication protocols, enables automatic deletion of information, and requires users' permission to share information with the government.

[a] This briefing note includes current available evidence as of the noted date. It is not intended to be an exhaustive analysis, and other relevant findings may have been reported since completion.

Date: 25-Nov-2020; Version: 2.0

Context and Terminology

A study (May 27, 2020) on digital contact tracing for coronavirus disease 2019 (COVID-19) described traditional and digital contact tracing approaches, including the use of QR codes:

- **Traditional Contact Tracing**: Public health officials interview an infected individual, identify contacts, and advise exposed contacts to self-monitor for symptoms, self-quarantine, or obtain medical evaluation and treatment. This approach has had success in reducing infection transmission in many epidemics, including severe acute respiratory syndrome-associated coronavirus (SARS-CoV) and Ebola. However, limitations have become apparent during the COVID-19 pandemic. For example, traditional contact tracing is labour- and time-intensive, making it challenging to scale.
- **Digital Contact Tracing**: Electronic information has the potential to address limitations of traditional contact tracing, such as scalability, notification delays, recall errors, and contact identification in public spaces.
    - Bluetooth-Based Approaches: Most COVID-19 contact tracing apps use Bluetooth signal strength to infer distance and define exposure status based on distance from and duration of proximity to an individual subsequently identified as infected.
    - Location-Based Approaches: These contact tracing approaches do not require Bluetooth. Instead, they use cell phone network data, Global Positioning System (GPS), Wi-Fi signals, and other smartphone sensors to identify the geolocations of users and proximity to infected individuals.
        - *QR Codes*: These are barcodes that can be scanned by phones and can be placed in public spaces (e.g., bus doors, store entrances), allowing users to log visited locations.[1]

Example of a QR Code

Supporting Evidence

Table 1 below summarizes the scientific evidence and jurisdictional experiences regarding use of QR codes as an approach to contact tracing during the COVID-19 pandemic. In terms of jurisdictional experience, information is presented on China, Israel, New Zealand, Singapore, and Taiwan. Additional details about use of QR codes in these jurisdictions are provided in Table 2 in the Appendix. No information was identified about Ontario or other Canadian jurisdictions.

Table 1: Summary of Scientific Evidence and Jurisdictional Experiences on Using QR Codes as an Approach to Contact Tracing for COVID-19

Scientific Evidence	• While QR codes may be easy to deploy, six studies identified a number of challenges associated with their use in contact tracing approaches: ○ A research commentary (June 29, 2020) indicated that mobile phone solutions for quarantine enforcement can be bypassed if individuals leave their quarantine location without their devices. Self-reported surveys, such as those used in QR code systems, only work when individuals are symptomatic and report their symptoms accurately. However, these technological innovations could provide benefits when used in combination with other strategies.[2] ○ A study (June 15, 2020) suggested that QR code-based apps have merit where they are required to be used by all patrons of a specific location or service – for instance, when these apps are managed by individual service providers and can be tied to some specific exchange (e.g., fare for public transport, ticket to enter a venue). They do not

	appear well-suited to population-based systems spanning multiple activities and locations. Bluetooth-based apps appear better suited to population-based systems where participation is optional.[3] ○ A preprint systematic review (May 28, 2020) assessed 15 automated or partially-automated contact tracing approaches, one of which included a modelling study (April 7, 2020) of a Bluetooth-based smartphone app that scans QR codes at checkpoints. No evidence was identified on the effectiveness of automated contact tracing. However, four of seven included modelling studies found that controlling COVID-19 requires high population uptake of automated contact tracing apps (estimates from 56%-95%), typically alongside other control measures. Automated contact tracing has the potential to reduce transmission with sufficient population uptake and usage, but there is a need for well-designed effectiveness evaluations.[4] ▪ The modeling study (April 7, 2020) indicated that the primary concern with using QR codes is user adoption. Users may not be comfortable with an application that tracks their real-time location. Users may also become fatigued over time from having to scan entry/exit points and choose to discontinue or be dissuaded from participating at the onset. Under normal circumstances, these hurdles might deter most users; however, due to the impact of the pandemic, users may be motivated to overlook these inconveniences in light of alternative, more-invasive location tracking measures.[5] ○ A report (May 15, 2020) from the School of Geographical Sciences and Urban Planning Spatial Analysis Research Center (Arizona State University) indicated that while QR code systems have high locational accuracy, the lack of automated detection can cause problems if users do not regularly scan codes, such as extensive false negatives.[6] ○ A preprint study (April 27, 2020) noted that although QR codes are relatively easy to deploy, manual scanning of QR codes can become tiresome if an individual has to scan many times a day at different places. Without service personnel stationed at each QR code location, people may skip scanning the code.[7]
International Scan	• China, Israel, New Zealand, Singapore, and Taiwan use QR codes as part of their case management and contact tracing strategies for COVID-19: ○ **Purpose**: Ranges from: expanding case management and testing capacity (e.g., supporting manual contact tracing efforts), controlling people's movements in public places, and notifying people if they contacted with infected people.[8,9,10,11] ▪ In addition to their use in supporting the response to public health emergencies (e.g., COVID-19) in China, personal QR codes have also been adapted to support the self-management of health conditions, health care services provision, and organizing major public events.[12] ○ **Method**: ▪ In Australia, China, Netherlands, New Zealand, and Singapore, users scan QR codes with their smartphones at entry/exit checkpoints of public venues to keep track of places visited and/or to verify permission to enter public venues based on their low- or high-risk COVID-19 profile.[13, 14,15,16,17] ▪ In Israel, four stationary testing centres in major metropolitan areas and eight drive-in testing centres use QR codes to identify patients.[18] ▪ In Taiwan, travelers flying to Taiwan must complete a COVID-19 health declaration form upon arrival at an airport by scanning a QR code. Those with low-risk

	accelerate immigration clearance and those at high-risk must quarantine at home and are tracked through their mobile phone.[19] ○ **Locations Used**: Ranges from: office buildings, shopping centres, transportation systems (e.g., taxis, buses, trains, airports), schools/universities, parks, hospitality sector (e.g., hotels, restaurants), hospitals, funeral homes, places of worship, and testing centres.[20,21,22,23] ▪ China and Singapore seem to have implemented comprehensive QR coding systems in almost all public settings across the country.[24,25] ○ **Information Collected**: Ranges from: name, national registration IDs, phone number, home address, email, self-reported health status, travel history, relationship to confirmed or suspected cases, and date of visit to public venue.[26,27,28, 29] ▪ China and Taiwan use big data analytics for case management and contact tracing.[30,31] China's QR code database is derived from users' self-reported information, government databases, and data from other sources across sectors (e.g., banking, public transportation, telecommunications). China's government is also promoting the timely incorporation of nucleic acid and serum antibody test results and other population data in the QR code database.[32] Taiwan integrated its national health insurance and immigration/customs databases with QR code scanning and online reporting of travel history and health symptoms.[33] ○ **Mandatory/Voluntary Use**: Mandatory in Australia (within the hospitality sector), [34] China,[35] Singapore,[36] and Taiwan,[37] and voluntary in Netherlands[38] and New Zealand[39] Unknown for Israel. ○ **Governance**: Governments authorize and oversee the contract tracing approach, often in partnership with technology companies who developed the QR code applications (e.g., Alibaba Group Holding and Tencent Holdings in China, Rush Digital in New Zealand).[40,41,42] ○ **Privacy**: Singapore's QR code system abides by the personal data protection act. New Zealand's system was created in consultation with the Privacy Commissioner, has two-factor authentication, enables automatic deletion of information after 31 days, and enables sharing of information with government only after the user's permission.[43] In the Netherlands, the QR codes help track interactions with no unique identifier assigned to any individual user or their app. This decentralized infrastructure is designed to ensure users privacy, as the entire system is based on locally stored random numbers that cannot be traced back to individual users.[44] In New South Wales, when COVID app data is downloaded from the National COVIDSafe Data Store by a state or territory health authority, it retains its status as COVID app data under the Privacy Act.[45] Businesses and organizations that are required to collect customer details must: keep the name and mobile number or email address of the customer/visitor for at least 28 day.[46] No information on privacy measures was identified for the other countries. ○ **Challenges**: ▪ In China and New Zealand, reported challenges include: people's lack of willingness to sign up for contact tracing apps or share private health data, inconsistent data compilation, lack of audible prompts for visually impaired users, inability to record in locations that do not use QR codes, and/or incomplete contact tracing mechanisms if too few businesses opt into hosting QR code posters in voluntary systems.[47,48]

	▪ A study (May 27, 2020) noted that tracking based on QR codes is being used in China, but familiarity with QR codes is high due to their use in mobile payments. However, it is unclear whether the strategy could be adopted for Europe and North America.[49]
Canadian Scan	• No information identified.
Ontario Scan	• No information identified.

Methods

Individual peer-reviewed articles and review articles were identified through PubMed, the Cochrane Library, and Google Scholar. Grey literature was identified through Google and relevant government websites. The search was limited to English sources and therefore may not capture the full extent of initiatives in non-English speaking countries. Full-text results extracted were limited to those available through Open Access or studies made available to the Ministry by our partners.

The COVID-19 Evidence Synthesis Network is comprised of groups specializing in evidence synthesis and knowledge translation. The group has committed to provide their expertise to provide high-quality, relevant, and timely synthesized research evidence about COVID-19 to inform decision makers as the pandemic continues. The following members of the Network provided evidence synthesis products that were used to develop this Evidence Synthesis Briefing Note:

- Bhatia, D., Morales-Vazquez, M., Song, K., Roerig, M., Allin, S., & Marchildon, G. (May 2020). COVID-19 Case and Contact Tracing: Policy Learning from International Comparisons. *Toronto: North American Observatory on Health Systems and Policies. Rapid Review (No. 30)*.
- Wang Q, Wilson MG, Waddell K, Lavis JN. (June 26, 2020) COVID-19 rapid query response #2: What is known from evidence and experiences in China about the use of QR codes in contact tracing for COVID-19? *Hamilton: McMaster Health Forum*.

This is version 2.0 of this Evidence Synthesis Briefing Note; the previous version was completed in July, 2020.

For more information, please contact the Research, Analysis and Evaluation Branch (Ministry of Health).

APPENDIX

Table 2: Using Quick Response (QR) Codes as an Approach to Contact Tracing for COVID-19 across Jurisdictions

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
Australia – New South Wales **COVID Safe Check-in**	**Purpose** • By signing in to the COVID Safe app with contact details when visiting a pub, restaurant, place of worship, or other business, the app helps make contact tracing more efficient and aids in the prevention and transmission among the community. • Some business such as those in the hospitality sector (e.g., pubs, registered clubs, bars, restaurants, cafes, casinos) are required to keep a record of all staff, patrons, and contractors visiting their premises. **Method** • When a customer arrives at a venue, they hover their phone camera or QR code reader over the code. The smartphone reads the code and one of two things will happen:	• Name • Contact details (date, a phone number, entry time) for every person including staff, patrons, and contractors entering the premises.[52]	• Pubs • Restaurants • Places of worship • Other businesses and organizations[53]	• It is mandatory to register as COVID Safe under the Public Health Orders for the following businesses/organizations: • Gyms • Hospitality venues (restaurants, cafes, pubs, clubs, small bars, cellar doors, breweries, distilleries, karaoke bars, and casinos) • Funeral homes and crematoria • Places of public worship • Other businesses and organizations	• Businesses and organizations that are required to collect customer details must: ○ Keep the name and mobile number or email address of the customer/visitor for at least 28 days ○ Store the information confidentially and securely. [55] • COVID app data is 'personal information' for the purposes of the Privacy Act. • When COVID app data is downloaded from the National COVIDSafe Data Store by a state or territory health authority, it retains its status as COVID app data under the Privacy Act.[b] State and territory health authorities must therefore comply with	• No information identified.

[b] The Digital Transformation Agency (DTA) was appointed as the National COVIDSafe Data Store Administrator under the Privacy Act 1988 to manage the data collected by the COVIDSafe app. The National COVIDSafe Data Store is the storage for information collected or generated through the use of COVIDSafe (Australian Government, 2020).

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
	○ The customer will be asked to download the Service NSW app. ○ If they already have the app they will be taken to the check in.[50] • If any customers are unable to use the QR code, businesses should have an alternative check in method available, such as an SMS service or manual check in with a staff member.[51]			are encouraged to register as COVID Safe to show their customers and visitors that they are keeping up the highest standards to prevent COVID-19 transmission.[54]	the Privacy Act when handling COVID app data. However, information collected by a state or territory health authority from a source other than directly from the National COVIDSafe Data Store will not be 'COVID app data'. For example, when a diagnosed individual provides to a contact tracing team the names and mobile phone numbers of other individuals with whom they have recently come into contact, this will not be considered 'COVID app data', even if some or all of the same information is also held in the National COVIDSafe Data Store.[56]	
China – Health Code	**Purpose** • To measure the risk level of any person and control their movement (e.g., qualified to enter public spaces, travel, or resume work)[57,58] • To notify users if they have come into contact with infected people[59]	• Name • National identity card number • Phone number • Home address • Self-reported health status • Travel history	• Public checkpoints, including: ○ Office buildings ○ Shopping centres/markets ○ Bus and train stations ○ Airports	• Mandatory[73]	• No information identified	• As of May 18, 2020, over 700 million people are using Health Code[74] • Potential challenges to QR code use include, among others: people's lack of willingness to share health data, the possibility of public sharing of health data, inconsistent data formats

	Method • On February 11, 2020, Hangzhou (capital of East China's Zhejiang province) was the first city in China to launch a health QR code system for COVID-19 ○ Since then, China's national integrated online government service platform and many provincial and municipal governments introduced various color-based health code systems[60] • A colour-code app generally uses three colors (guidelines for QR codes systems may vary slightly across the country): ○ **Green**: Allows unrestricted movement ○ **Yellow**: Requires seven days of quarantine ○ **Red**: Determines user to be either a confirmed case of COVID-19 or a close contact, requiring isolation[61,62] • Users are required to scan signs displaying QR codes at public checkpoints with their phones and wait for their devices to display a colour-coded signal to permit entry[63] • The colored-rating algorithm is based on self-reported information from users, data derived from COVID-19	• Relationship to confirmed or suspected cases[68,69] • New national criteria being developed will enable collection of four types of information: ○ Personal information (name, gender, nationality, type of ID, ID number, address, phone number, and medical history) ○ Personal health information (temperature, symptoms, history of living or travelling in high-risk areas, contact with confirmed or suspected cases, and date that health information was recorded); ○ Travel history (cities travelled to and itinerary verification) ○ Health certificates, documenting health risks and testing history (including when and where the test was done and the results)[70]	○ Communities/ villages ○ Schools ○ Parks ○ Hotels ○ Hospitals ○ Universities[71,72]			across different systems, and the lack of mutual recognition of codes across regions[75] • Recent policies for and proposals about using QR codes include: ○ On May 8, 2020, the government began promoting the implementation of health-related QR codes and the adoption of a uniform code system across the country ▪ The government is also promoting the timely incorporation of the results of nucleic acid and serum antibody test results and other important information about key populations in the QR code database, as well as the use of QR codes for people entering China ○ On June 25, 2020, the government recommended that people with a history of living or travelling in high-risk areas must have a negative nucleic acid test certificate or be able to present a 'green' QR code indicating proof of a negative nucleic acid test

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	databases set up by government authorities, and data held by sources in the banking, public transportation, and telecommunication sectors[64] • Mobile cell data is used to determine close contacts and personal information, and the app can ask its users additional questions (e.g., health status, travel history)[65] • Those who do not have smartphones, including children and the elderly, can still use valid paper documents[66] **Governance** • With the authorization of China's government, the country's two 'internet giants' (Alibaba Group Holding Ltd. and Tencent Holdings Ltd.) host the health code systems on their smartphone apps (Alibaba's mobile payment app Alipay and Tencent's messaging app WeChat), which are used by hundreds of millions of people in China and therefore provide wide access to health QR codes • On April 29, 2020, China's State Administration for Market Regulation and					within seven days before reaching the destination ▪ Those in low-risk areas can move freely with a 'green' code and appropriate personal protection equipment ○ In addition to their use in supporting the response to public-health emergencies (e.g., COVID-19), personal QR codes have also been adapted to support the self-management of health conditions, health care-services provision, and organizing major public events[76]

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
	Standardization Administration of China released a series of national guidelines for personal health information codes[67]					
Israel – Model Name not Identified	**Purpose** • To expand case management and testing capacity[77] **Method** • On March 17, 2020, four stationary testing centres in major metropolitan areas and eight drive-in testing centres were established ○ Non-quarantined individuals were directed to these centres to undergo testing ○ The centres used QR codes to identify patients and manage flow[78] **Governance** • The system was initially established by Magen David Adom (MDA), Israel's emergency medical services organization[c] • The testing system has been decentralized and moved to Israel's four national Health	• Patient identification[80]	• Major metropolitan areas • Eight drive-in testing centres[81]	• No information identified	• No information identified	• According to MDA data reported on May 5, 2020, a total of 245,460 Israelis have been sampled by MDA teams, with 96,065 individuals sampled at drive-in facilities, 88,272 sampled in their homes, and 61,123 sampled in long-term care[82] • Between April 1 and May 7, 2020, Israel was reported to perform an average of 8,000 to 10,000 diagnostic tests per day[83]

[c] The MDA is staffed with 2,500 salaried workers and 24,000 volunteers (NAO, May 2020).

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
	Maintenance Organizations and associated clinics[79,d]					
Netherlands - Zwaai App	**Purpose** • Zwaai was developed by several members of the Interdisciplinary Hub for Security, Privacy and Data Governance (iHub) at Radboud University Nijmegen in the Netherlands.[84] **Method** • A user of the Zwaai app can establish links in two ways: ○ In a personal meeting, where one person's phone scans a QR-code shown on the phone of others. In doing so two random numbers are exchanged between the phones. These random numbers are stored locally, for a limited period, together with the time of the exchange.[85] **Method** • Upon entering a space, like a shop, work floor, train coupe, or bus, a QR-code is scanned. The Zwaai app then connects to a server and exchanges random numbers. Upon leaving the	• Location[88]	• Personal meetings • Entering a space[89]	• Voluntary[90]	• QR code that helps keep track of what interactions a given app user has had, in a privacy-preserving way as there is no unique identifier assigned to any individual user or their app. • This decentralized infrastructure has been designed to ensure users' privacy, as the entire system is based on locally stored random numbers that cannot be traced back to individual users. It also gives public health authorities insight into possible 'heat zones' where new clusters of infections may be taking place.[91]	• No information identified.

[d] Coverage for health services in Israel is supplied by four Health Maintenance Organizations (also referred to as Kupat Holim or "sick funds" in Hebrew), which are regional semi-public insurance organizations: Clalit, Maccabi, Meuhedet, and Leumit. Health care in Israel is universal and Israeli residents are required to be registered with one of the four Health Maintenance Organizations by law (NAO, May 2020).

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	space, the Zwaai user can check out on their phone. The check-out also happens automatically, after a certain period, or upon entering another space.[86] • In effect, each app user can be thought of as being subscribed to a central server. If an individual receives a positive diagnosis for COVID-19, a responsible party, such as a public health physician, can then publish this information to the server with the approval of the diagnosed user. Individual users' apps routinely ping the server looking for matches between the set of locally stored random numbers, and those that correspond to a positive diagnosis. If a match is found, regardless of whether it was via a 'wave' or if a user has visited a 'contaminated' building such as a supermarket, the system will automatically notify the user that they may have been in contact with a confirmed case of COVID-19 and can provide additional advice, such as to get tested or to undergo 14-day self quarantine.[87]					

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
New Zealand – NZ COVID Tracer	**Purpose** • To support manual contact tracing conducted by public health units and the National Close Contact Service[92] **Method** • Creates a digital diary of the places users visit when users scan QR code posters that contain information about the name and location of businesses • Users can sign up for contact alerts to let them know if they have checked into a location at the same time as a confirmed or probable case of COVID-19 • If a user is identified as a confirmed or probable case of COVID-19, a contact tracer will provide advice on self-isolation and check on their health via a phone call ○ The contact tracer will ask for information about the places visited and the people seen, prompting users to review their digital diary ○ Users can voluntarily share their digital diary with the Ministry of Health, but it is up to the user to decide whether to do so or not[93]	• Personal information • Contact details • Home address[95]	• Businesses • Organizations[96]	• Voluntary - all citizens, businesses, and organizations are encouraged to use the app or display QR code posters[97,98]	• The Ministry of Health consulted with the Privacy Commissioner • Two-factor authentication (2FA) is used to provide an extra layer of security ○ The app supports 2FA through the use of Time-Based One Time Passwords (TOTPs) • Personal information and contact details used to register are provided to the Ministry of Health so contact tracers can quickly get in touch ○ Any further information recorded by users (e.g., locations) is stored securely on users' phone and automatically deleted after 31 days • Any information (excluding anonymous statistical information) provided to the Ministry will not be shared with other government agencies, except when directly	• A study (June 15, 2020) noted that the diaries may prompt infected individuals to recall encounters that would otherwise be missed. • The study noted that adoption of the app has been mixed. While official data is not available, by May 25, 2020, an estimated 380,000 users had downloaded it. Business adoption has been "quite low". • The study identified several limitations: ○ If too few businesses opt in, it will be both less appealing for individuals to download the app and less useful as a diary of movements[100] ○ The requirement for businesses to maintain comprehensive logs of visitor activity regardless of opting into the app means that many have already adopted apps based on QR codes provided by private sector suppliers (e.g., Rippl) ▪ The marginal benefit of adopting the app to a business already using alternative apps is negligible. Individuals will be required to scan

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
	Governance • App was developed for the Ministry of Health by New Zealand company Rush Digital, and relies in part on the Amazon Web Services platform[94,e]				involved in the COVID-19 pandemic ○ Data will never be used for enforcement purposes • At any time, users can delete their digital diary by uninstalling the app from their phone ○ It is not possible to delete an individual location from the digital diary[99]	two systems, potentially inducing 'scanning fatigue' and confusion (e.g., scanning out using the wrong code, leading to incomplete data) ○ Movement logs may create an "information overload" which could overwhelm contact tracers ○ Too many individuals could be identified, increasing the resources required to identify those who have actually contracted the virus ○ Visually-impaired users have voiced dissatisfaction with the lack of audible prompts and confirmations. ○ Reports of the inconvenience of holding a phone at all times have emerged, along with concerns about the inability to record contacts in locations that are not businesses[101]
Singapore – SafeEntry App	**Purpose** • On May 9, 2020, the Ministry of Health implemented the SafeEntry	• Names • National Registration Identification	• Entrances and exits of: ○ Government offices	• Mandatory[110, 111]	• Businesses are required to abide by the Singaporean personal data	• As of May 9, 2020, there were 16,000 venues in which SafeEntry was deployed[113]

[e] An All-of-Government cloud services agreement with Amazon Web Services (AWS) has been in place since 2017. AWS services and infrastructure were reviewed as part of the procurement process and are regularly tested against third-party assurance frameworks (NZ Ministry of Health, June 28, 2020).

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	QR code system to public venues that have resumed economic activity to enable identification of contacts[102] **Method** • Visitors scan the QR code displayed at venues' entry/exit points using their smartphones or venues' staff scan visitors' identification cards that have a barcode (e.g., driver's licence, student pass, work permit)[103,104] **Governance** • App developed and overseen by GovTech[105,f]	Cards/Foreign Identification Numbers[g] • Mobile numbers • Date of visit • Time-window of visit[106]	○ Workplaces of essential services ○ Businesses ○ Public venues in which individuals would be in close proximity for a prolonged time or in enclosed or high-traffic spaces[107,108] • It is expected that SafeEntry will be rolled out in offices, factories, schools, health care facilities, community care facilities, malls, supermarkets, hotels, and taxis, among others[109]		protection act in handling collected data[112]	• As of May 18, 2020, the government reports that 40,000 sites are using the app[114]
Taiwan – Entry Quarantine System	**Purpose** • Launched on February 14, 2020 to help monitor people with travel history[115] **Method** • Travelers flying to Taiwan had to complete a health	• Passport number • Name • Nationality • Flight number • Presence of specific symptoms in past 14 days (e.g., fever, cough,	• Airports[121]	• Mandatory[122]	• All hospitals, clinics, and pharmacies in Taiwan have access to patient travel histories[123]	• A research report (March 3, 2020) highlighted that Taiwan leveraged its national health insurance database and integrated it with its immigration and customs database for big

[f] GovTech is a Singapore government agency that develops technology-driven approaches to governance. The agency was created by the Smart Nation and Digital Government Group, situated in the Prime Minister's Office, as part of Singapore's Smart Nation initiative (NAO, May 2020).

[g] Personnel identifiers used by the Singapore Payroll System, where National Registration Identification Card (NRIC) is used among Singapore citizens and Foreign Identification Number (FIN) is used among permanent residents of Singapore (NAO, May 2020).

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
	declaration survey when arriving at Taiwan's airports • Travelers with mobile phone numbers provided by national telecom operators can complete the survey via phone to accelerate immigration clearance ○ The mobile form consists of scanning a QR code and filling out a COVID-19 health declaration form[116] ○ Persons with low risk (no travel to level 3 alert areas) were sent a health declaration border pass via SMS to their phones for faster immigration clearance; those with higher risk (recent travel to level 3 alert areas) were quarantined at home and tracked through their mobile phone to ensure that they remained at home during the incubation period[117] • If travelers do not have a local mobile number, they are advised to apply for a SIM card at the airport and health staff will dial the phone number on-site to ensure it is valid and the person is reachable[118]	runny nose, limb weakness) • Personal mobile number • Landline number • Address of home/hotel where the individual will be under mandatory quarantine[120]				data collection and analytics. ○ The system generated real-time alerts during a clinical visit based on travel history and clinical symptoms to aid case identification. ○ It used QR code scanning and online reporting of travel history and health symptoms to classify travelers' infectious risks based on flight origin and travel history in the past 14 days.[124]

Jurisdiction & Name of Model	Purpose, Method, and Governance	Information Collected	Locations Used	Mandatory or Voluntary	Privacy	Reported Outcomes
	Governance • Central Epidemic Command Center[119]					

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