Riyadh Global
Digital Health
Summit
11-12 August, 2020

Global Strategic Partnerships in Digital Health to Fight Pandemics

Emerging Surveillance Technologies

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Digital Epidemiology

Emerging Surveillance Technologies

Modern Epidemiology

1854

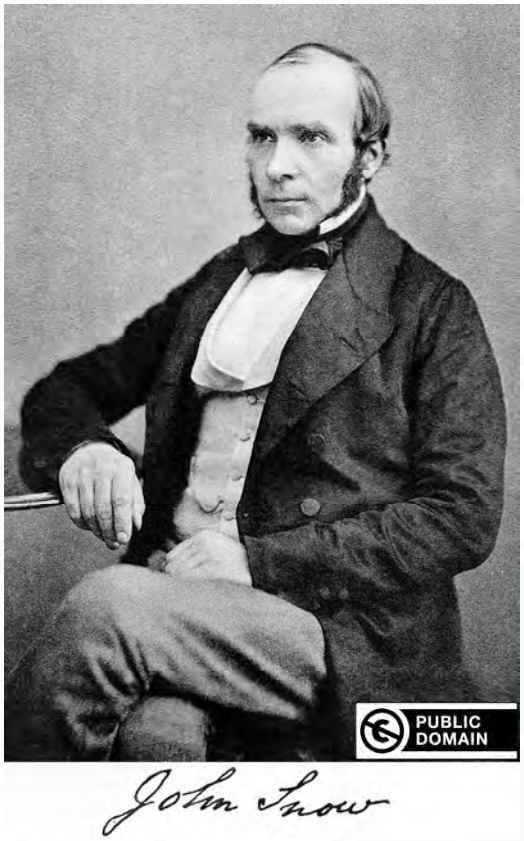
Broad Street
Cholera Outbreak

A COURT FOR KING CHOLERA.

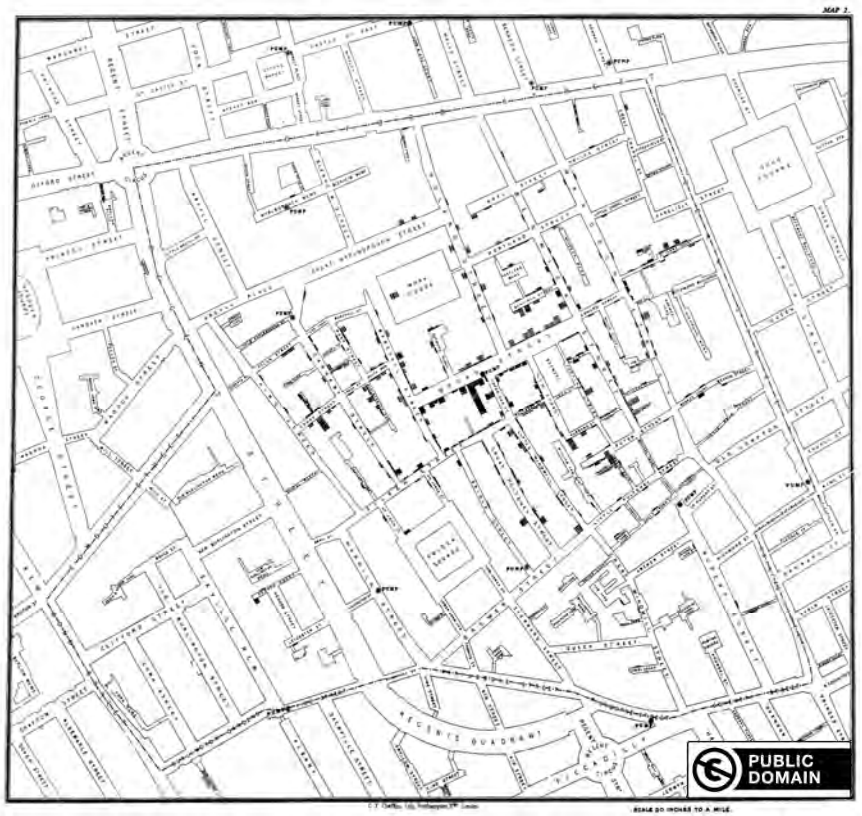
Modern Epidemiology

John Snow

Epidemiologist



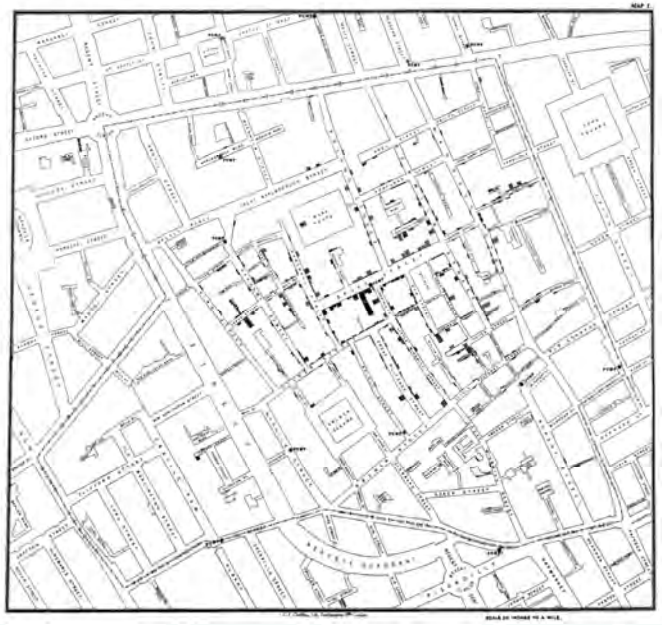
Modern Epidemiology



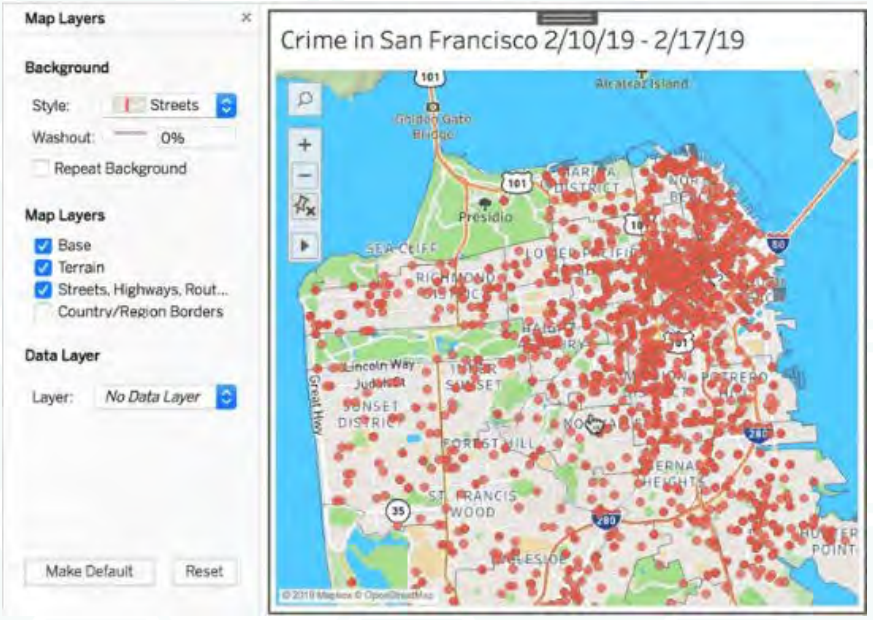
Source: https://lookup.london/john-snow-water-pump/

Precursor to Geographical Information Systems

1854



2019



Source: https://gisuser.com/2019/05/tableau-2019-2-introduces-new-mapping-capabilities/

Verity of Digital Health Solutions

Digital Twin of the Person

Health Passport

Web Applications

Mobile Apps

Bluetooth Low Energy Beacon

Smart Dust

Ultra-wide Bandwidth Communication

Business Intelligence

Blockchain

Internet of Things

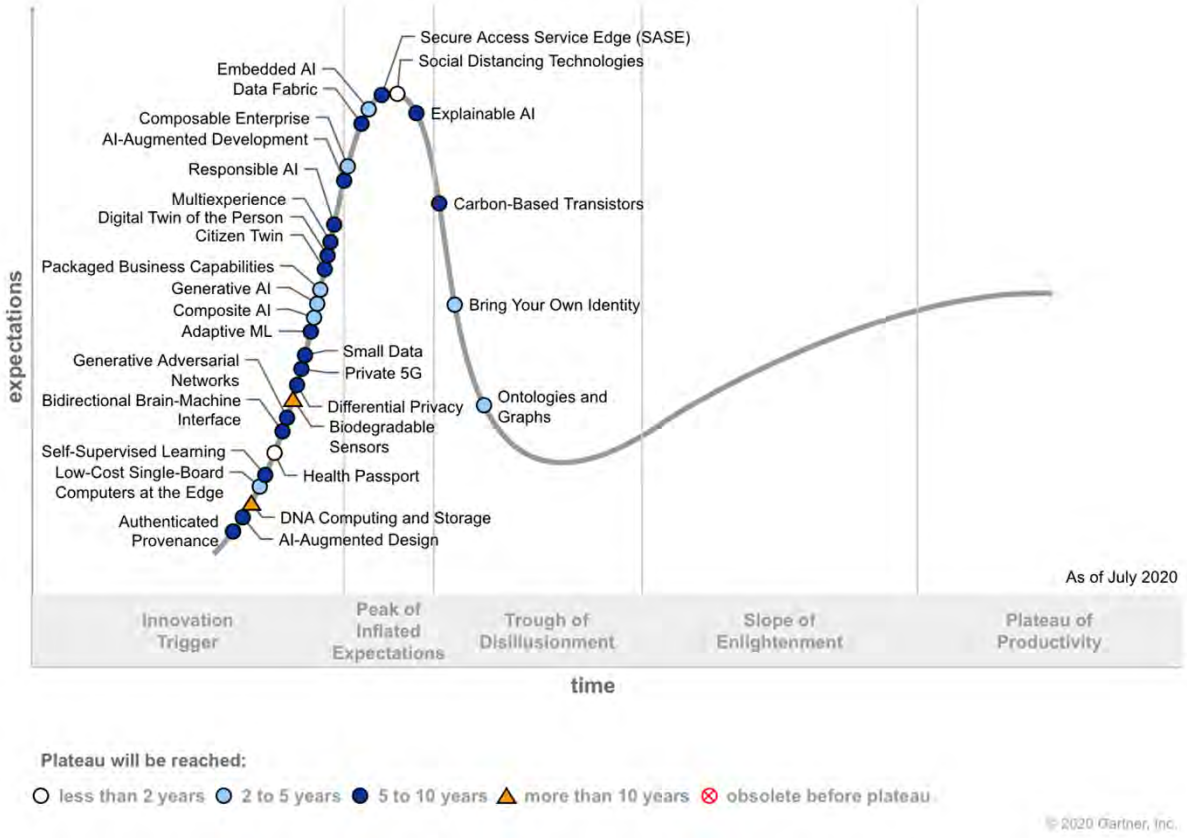
Artificial Intelligence

Big Data

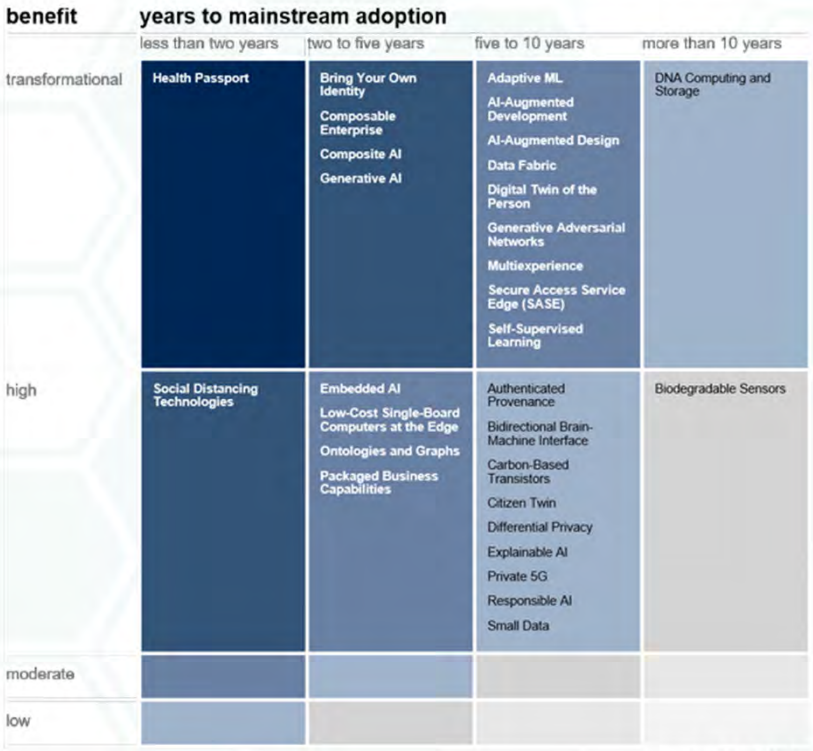
Radio Frequency Identification

Wearable Devices

Emerging Technologies, 2020



Priorities Matrix for Emerging Technologies, 2020



Source: Gartner
ID: 450415

Key Emerging Technologies in the Fight against Pandemics

Table 1 | Digital technologies and their impact on public-health strategies

	Digital technology			
Public-health measures	**IoT**	**Big data**	**AI**	**Blockchain**
1. Monitoring, surveillance, detection and prevention of COVID-19 (directly related to COVID-19)	+++	+++	++	+
Examples	1. Real-time tracking and live updates in various online databases in the USA, UK and China	1. Modeling of disease activity, potential growth and areas of spread	1. Detection of COVID-19 from chest imaging (X-ray) (Beijing Hospital)	1. Manufacturing and distribution of COVID-19 vaccines once they are available
	2. Live tracking of the at-risk vicinity in Korea (Coronamap.live; Wuhanvirus.kr)	2. Modeling of the preparedness and vulnerability of countries in fighting a disease outbreak	2. Prognostication of disease progression via clinical data, imaging and AI	2. Insurance claims from COVID-related illness and death

The likely impact of digital technologies on (1) disease monitoring, surveillance, detection and diagnosis, and (2) mitigation of impact: +, low (no clear example yet in either official government website); ++, moderate (one clear example); +++, high (two or more examples). Gray shading indicates potential applications that are not described in the literature thus far but should be considered by technology companies or research groups worldwide to help battle against COVID-19. Additional examples beyond those mentioned in the text are included in this table. *https://www.form.gov.sg/#!/5e33fa3709f80b00113b6891.

Ting, D.S.W., Carin, L., Dzau, V. *et al.* Digital technology and COVID-19. *Nature Medicine* **26,** 459–461 (2020). https://doi.org/10.1038/s41591-020-0824-5

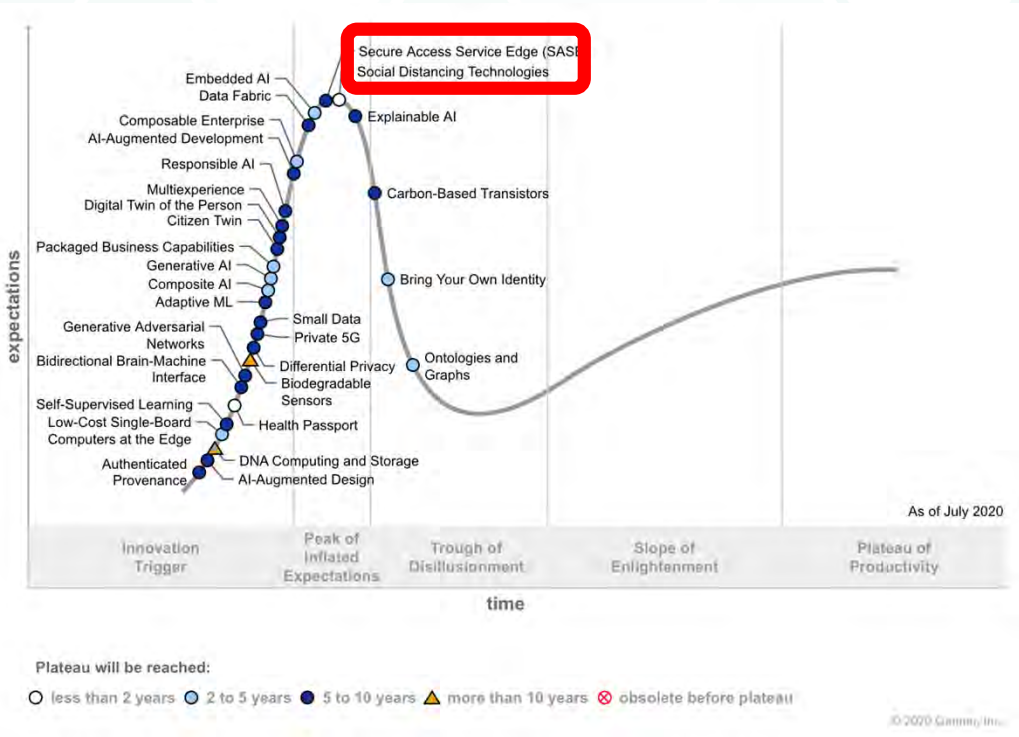
Surveillance Types

- Accelerated Disease Control – National Active
- National Passive
- Sentinel

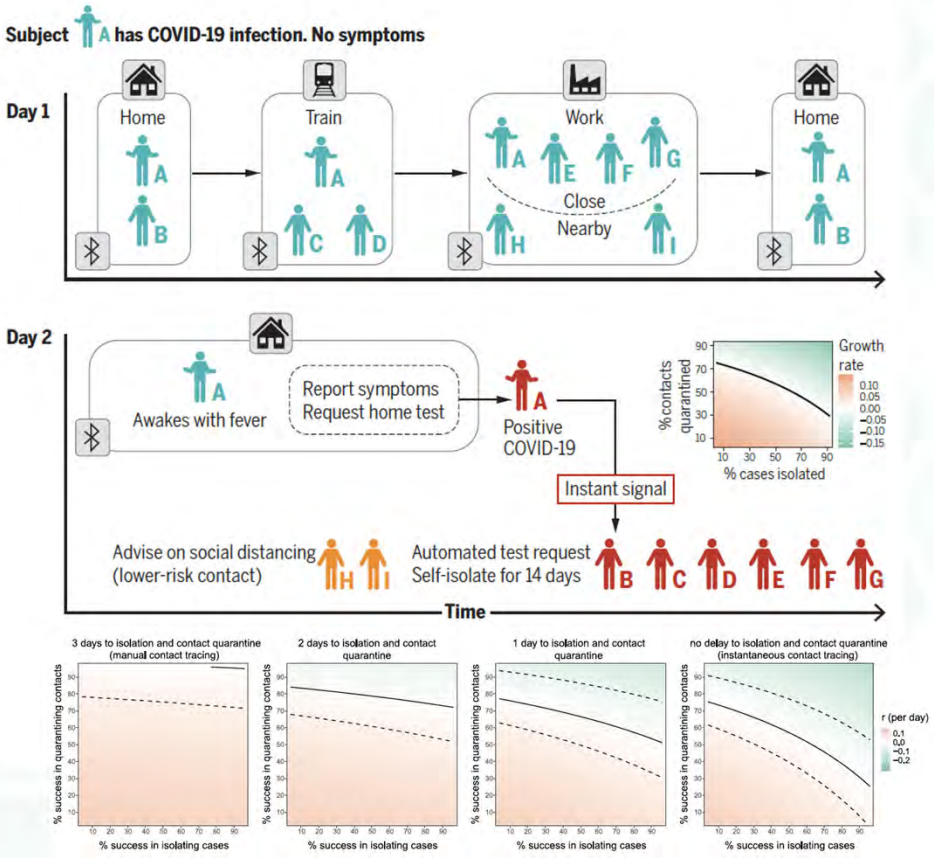
Source: WHO, https://www.who.int/immunization/monitoring_surveillance/burden/vpd/surveillance_type/en/

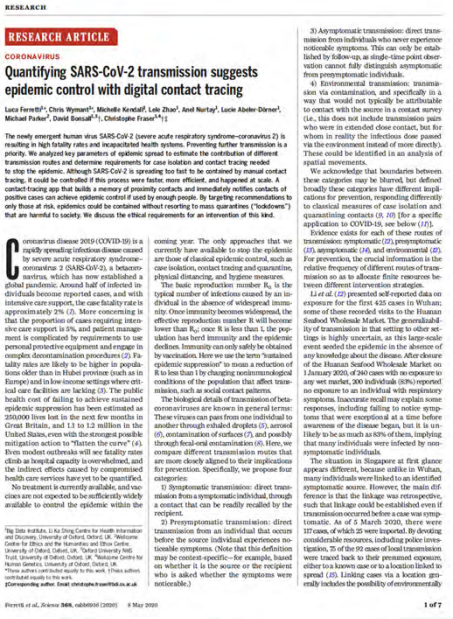
Social Distancing Technologies

- Accelerated Disease Control – National Active
- Encourage individuals to maintain a safe distance from each other
- Could also include contact tracing
- Platform:
  - Mobile App
  - Dedicated/generic wearable device
  - Video analytics



Effectiveness of Instant Contact Tracing





RESEARCH

RESEARCH ARTICLE

CORONAVIRUS

Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing

Luca Ferretti[1]*, Chris Wymant[1]*, Michelle Kendall[2], Lele Zhao[2], Anel Nurtay[2], Lucie Abeler-Dörner[1], Michael Parker[2], David Bonsall[1,2]†, Christophe Fraser[1,4]†‡

The newly emergent human virus SARS-CoV-2 (severe acute respiratory syndrome–coronavirus 2) is resulting in high fatality rates and incapacitated health systems. Preventing further transmission is a priority. We analyzed key parameters of epidemic spread to estimate the contribution of different transmission routes and determine requirements for case isolation and contact tracing needed to stop the epidemic. Although SARS-CoV-2 is spreading too fast to be contained by manual contact tracing, it could be controlled if this process were faster, more efficient, and happened at scale. A contact-tracing app that builds a memory of proximity contacts and immediately notifies contacts of positive cases can achieve epidemic control if used by enough people. By targeting recommendations to only those at risk, epidemics could be contained without resorting to mass quarantines ("lockdowns") that are harmful to society. We discuss the ethical requirements for an intervention of this kind.

Coronavirus disease 2019 (COVID-19) is a rapidly spreading infectious disease caused by severe acute respiratory syndrome–coronavirus 2 (SARS-CoV-2), a betacoronavirus, which has now established a global pandemic. Around half of infected individuals become reported cases, and with intensive care support, the case fatality rate is approximately 2% (*1*). More concerning is that the proportion of cases requiring intensive care support is 5%, and patient management is complicated by requirements to use personal protective equipment and engage in complex decontamination procedures (*2*). Fatality rates are likely to be higher in populations older than in Hubei province (such as in Europe) and in low-income settings where critical care facilities are lacking (*3*). The public health cost of failing to achieve sustained epidemic suppression has been estimated as 250,000 lives lost in the next few months in Great Britain, and 1.1 to 1.2 million in the United States, even with the strongest possible mitigation action to "flatten the curve" (*4*). Even modest outbreaks will see fatality rates climb as hospital capacity is overwhelmed, and the indirect effects caused by compromised health care services have yet to be quantified.

No treatment is currently available, and vaccines are not expected to be sufficiently widely available to control the epidemic within the coming year. The only approaches that we currently have available to stop the epidemic are those of classical epidemic control, such as case isolation, contact tracing and quarantine, physical distancing, and hygiene measures.

The basic reproduction number R_0 is the typical number of infections caused by an individual in the absence of widespread immunity. Once immunity becomes widespread, the effective reproduction number R will become lower than R_0; once R is less than 1, the population has herd immunity and the epidemic declines. Immunity can only safely be obtained by vaccination. Here we use the term "sustained epidemic suppression" to mean a reduction of R to less than 1 by changing nonimmunological conditions of the population that affect transmission, such as social contact patterns.

The biological details of transmission of betacoronaviruses are known in general terms: These viruses can pass from one individual to another through exhaled droplets (*5*), aerosol (*6*), contamination of surfaces (*7*), and possibly through fecal-oral contamination (*8*). Here, we compare different transmission routes that are more closely aligned to their implications for prevention. Specifically, we propose four categories:

1) Symptomatic transmission: direct transmission from a symptomatic individual, through a contact that can be readily recalled by the recipient.

2) Presymptomatic transmission: direct transmission from an individual that occurs before the source individual experiences noticeable symptoms. (Note that this definition may be context-specific—for example, based on whether it is the source or the recipient who is asked whether the symptoms were noticeable.)

3) Asymptomatic transmission: direct transmission from individuals who never experience noticeable symptoms. This can only be established by follow-up, as single-time point observation cannot fully distinguish asymptomatic from presymptomatic individuals.

4) Environmental transmission: transmission via contamination, and specifically in a way that would not typically be attributable to contact with the source in a contact survey (i.e., this does not include transmission pairs who were in extended close contact, but for whom in reality the infectious dose passed via the environment instead of more directly). These could be identified in an analysis of spatial movements.

We acknowledge that boundaries between these categories may be blurred, but defined broadly these categories have different implications for prevention, responding differently to classical measures of case isolation and quarantining contacts (*9*, *10*) [for a specific application to COVID-19, see below (*11*)].

Evidence exists for each of these routes of transmission: symptomatic (*12*), presymptomatic (*10*), asymptomatic (*13*), and environmental (*8*). For prevention, the crucial information is the relative frequency of different routes of transmission so as to allocate finite resources between different intervention strategies.

Li *et al.* (*12*) presented self-reported data on exposure for the first 425 cases in Wuhan; some of these recorded visits to the Huanan Seafood Wholesale Market. The generalizability of transmission in that setting to other settings is highly uncertain, as this large-scale event seeded the epidemic in the absence of any knowledge about the disease. After closure of the Huanan Seafood Wholesale Market on 1 January 2020, of 240 cases with no exposure to any wet market, 200 individuals (83%) reported no exposure to an individual with respiratory symptoms. Inaccurate recall may explain some responses, including failing to notice symptoms that were exceptional at a time before awareness of the disease began, but it is unlikely to be as much as 83% of them, implying that many individuals were infected by non-symptomatic individuals.

The situation in Singapore at first glance appears different, because unlike in Wuhan, many individuals were linked to an identified symptomatic source. However, the main difference is that the linkage was retrospective, such that linkage could be established even if transmission occurred before a case was symptomatic. As of 5 March 2020, there were 117 cases, of which 25 were imported. By devoting considerable resources, including police investigation, 75 of the 92 cases of local transmission were traced back to their presumed exposure, either to a known case or to a location linked to spread (*15*). Linking cases via a location generally includes the possibility of environmentally

Big Data Institute, Li Ka Shing Centre for Health Information and Discovery, University of Oxford, Oxford, UK. *Wellcome Centre for Ethics and the Humanities and Ethox Centre, University of Oxford, Oxford, UK. †Oxford University NIHR Trust, University of Oxford, Oxford, UK. ‡Wellcome Centre for Human Genetics, University of Oxford, Oxford, UK.
*These authors contributed equally to this work. †These authors contributed equally to this work. ‡Corresponding author. Email: christophe.fraser@bdi.ox.ac.uk

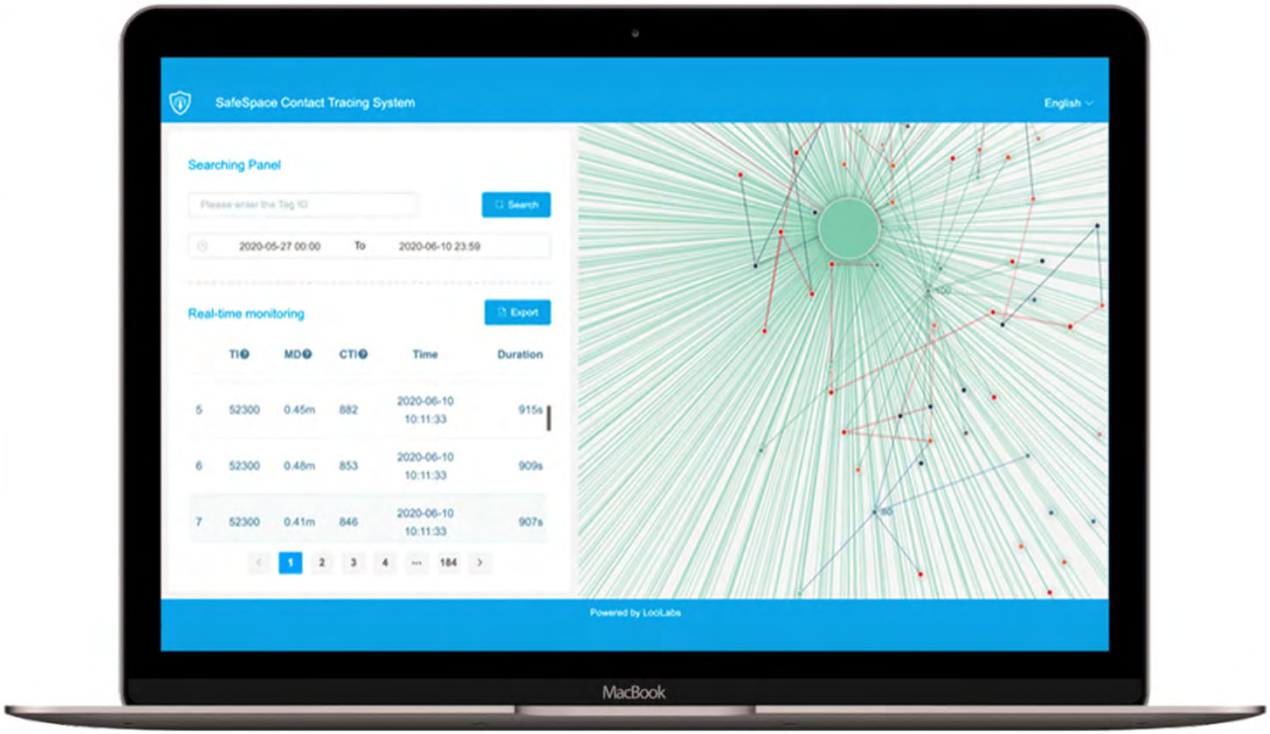
Luca Ferretti, Chris Wymant, Michelle Kendall, Lele Zhao, Anel Nurtay, Lucie Abeler-Dörner1, Michael Parker, David Bonsall1, Christophe Fraser, Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing, Science, Vol 368, Issue 6491, 08 May 2020

Internet of Things (IoT)

- Wearable Devices
- Radio Frequency (RF)
- Affordable

Internet of Things (IoT)

- Contact Tracing
- Ideal in:
  - Office Workspaces
  - Hospitals
  - Factories
  - Shopping Malls
  - Retail stores
  - Conferences



Internet of Things (IoT)

- Smart Watch
- Pros:
  - Varity of sensors
  - Effective Communication
  - Practical
- Cons:
  - Costly
  - Standard device

© Samsung

Internet of Things (IoT)

- Amazon Distance Assistant
  - Social Distancing (6’ apart)
  - Contact Tracing
  - Simple and affordable to deploy
  - Deployed in a few Amazon warehouses, as a pilot test[1]

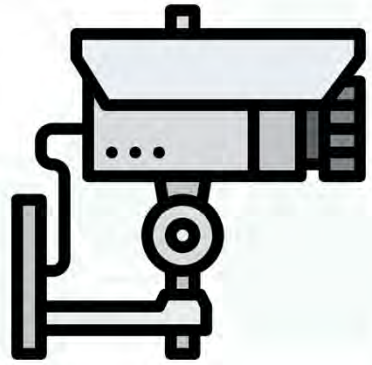
[1] **Source:** https://blog.aboutamazon.com/operations/amazon-introduces-distance-assistant

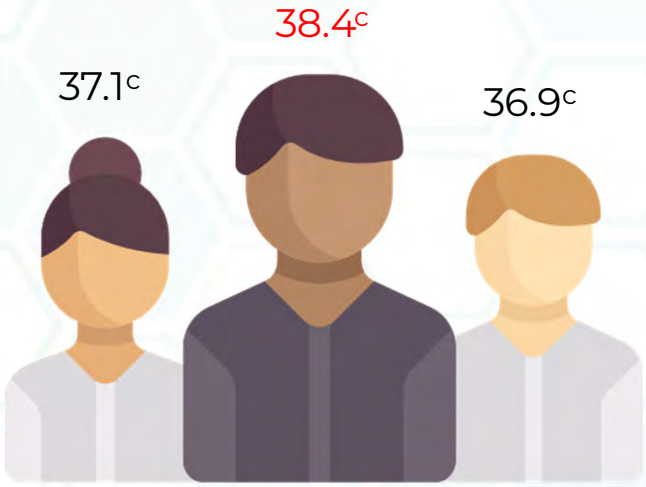
Internet of Things (IoT)

- Amazon Distance Assistant
  - Open Source
  - Commodity Hardware
  - Cameras and depth sensors
  - Artificial Intelligence
  - Robot Operating System (ROS) as the underlying framework for runtime, launch, and configuration

Internet of Things (IoT)

- Thermal Cameras
  - Passive Surveillance
  - Access Enforcement





Health Passport

- Accelerated Disease Control – National Active
- Mobile App that controls access to public and private services
- Health Index
- Contact, travel, health record, and other data
- Combination of UWB, Mobile App, Big Data and AI

China’s Experience

- Named “Health Code”
- First Launched in February 2020
- Technology applied in all of China’s 23 provinces, as well as municipalities and autonomous regions[1]

[1] https://www.wired.co.uk/article/china-coronavirus-health-code-qr

China's Experience

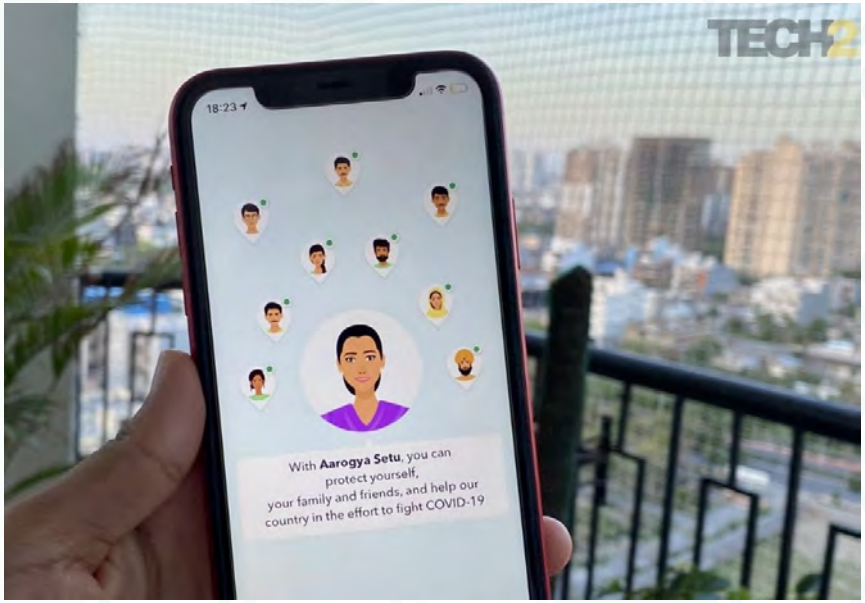
- Very common in public and private places
- Color coding[1]:
  - **Red**, is confirmed Covid-19 infection
  - **Yellow**, should be in quarantine
  - **Green**, means no restrictions

People scanning a QR code on their phones while volunteers check their temperatures before entering a market in Kunming, in China's southern Yunnan Province. **Credit: Wong Campion/Reuters**

[1] https://www.gartner.com/document/3987951?ref=solrAll&refval=258217044

India’s Experience

- Aarogya-Setu Mobile App
- Open Source[1], to mitigate privacy issues
- Travelers must be marked "safe" on the app for travel by rail and air[2]
- Reach challenge – only 35% of cell phones are smart in India[3]

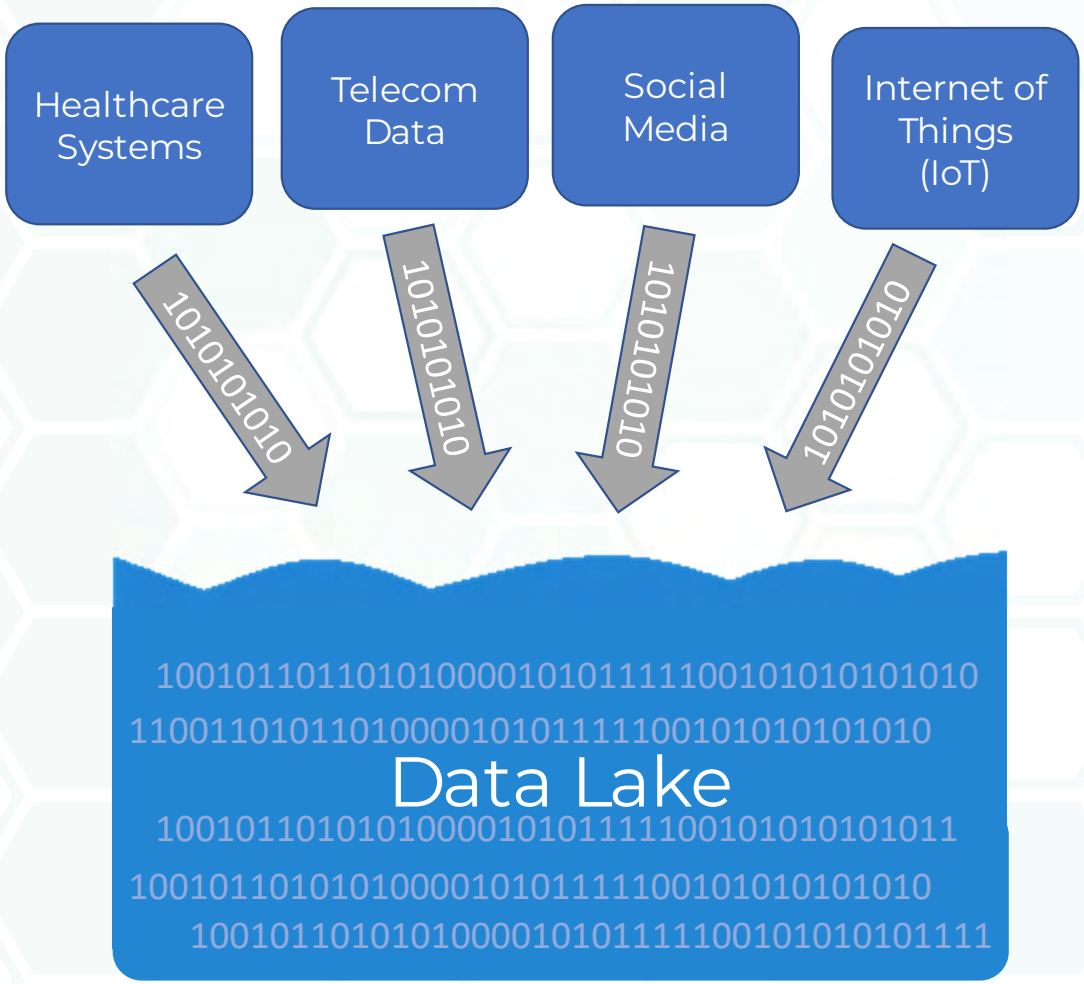


Source: https://www.firstpost.com/tech/news-analysis/aarogya-setu-indias-contact-tracing-app-goes-open-source-8412191.html

[1] Dhar, Tripti, Aarogya Setu - Carrying Your Privacy in Your Hands? (May 29, 2020). Available at SSRN: https://ssrn.com/abstract=3614506 or http://dx.doi.org/10.2139/ssrn.3614506
[2] https://www.gartner.com/document/3987951?ref=solrAll&refval=258217044
[3] Transactions of the Indian National Academy of Engineering (2020) 5:157–161 https://doi.org/10.1007/s41403-020-00109-7

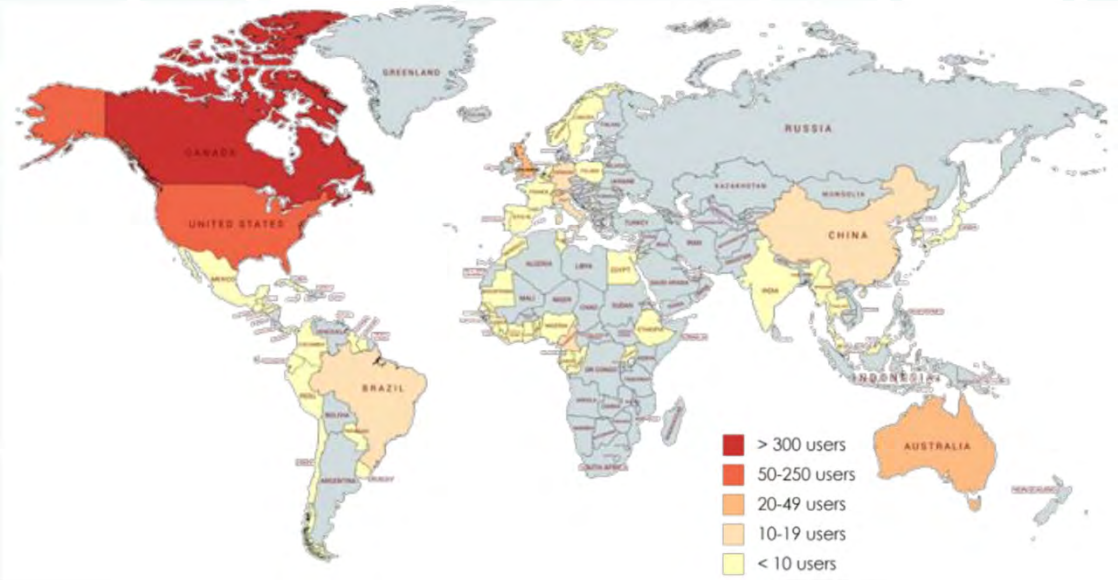
Data Lake

- Passive Surveillance
- Unstructured data
- Big Data
- Global, national, and local implementation



Global Public Health Intelligence Network

- Started in 1997
- Collaboration project between Canada Public Health Agency and WHO
- Event-based multilingual early-warning system
  - Biological
  - Chemical
  - Radiological
  - Nuclear
- Mostly utilized in Canada



Source: https://www.who.int/docs/default-source/eios-gtm-2019-presentations/tanguay-phac---eios-gtm-2019.pdf?sfvrsn=8c758734_2

ProMED Mail

- Launched in 1994
- International Society for Infectious Diseases
- Teams are located across 32 countries
- Identify unusual health events

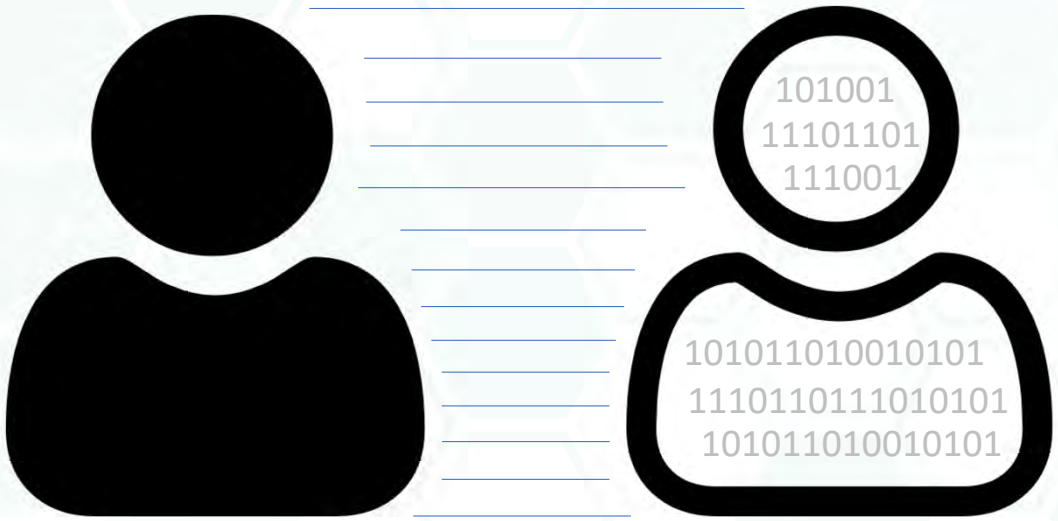
HealthMap

- Developed by Boston Children's Hospital in 2006

- Aggregates data from:
  - ProMED Mail
  - WHO
  - GeoSentinel
  - EuroSurveillance
  - Google News
  - Baidu News
  - SOSO Info

Digital Twin of the Person (DToP)

- Citizen Twin
  - Singapore experience
- Digital replica of the patient
  - Demographics
  - Health
  - Genetic
  - Financial
  - Social



Digital Twin of the Person (DToP)

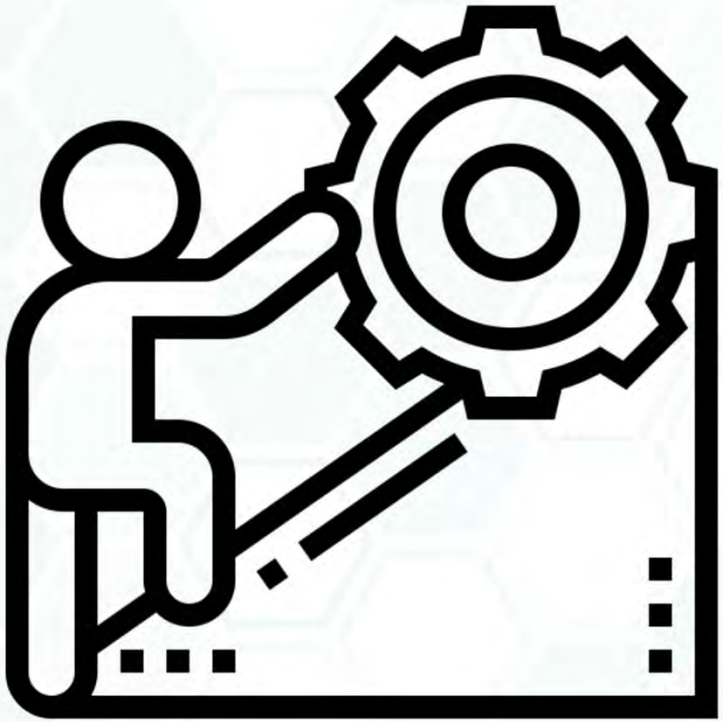
- Data-driven simulation
- High-variability activities
- Powered by AI, IoT, Wearables and Big Data
- Enables:
  - Real-time actions
  - Accurate forecasts

Small Data

- Emerging pandemics have small data
- AI models require a lot of data
- Small data technologies are in early development stage
- Available in 5 to 10 years

Challenges

- Cost
- Practicality
- Accuracy
- IT Infrastructure
- User participation
- Immature solutions
- Privacy



Privacy Concerns

- Consumers and Data Privacy Perceptions: Consumer Preferences & Behaviors on Data Sharing & Privacy

- University of Southern California

Are you concerned about data privacy?					
	Gen Z	Millennials	Gen X	Baby Boomers	Total
Not concerned at all	9%	9%	6%	2%	6%
Slightly concerned	20%	25%	20%	16%	20%
Neutral	18%	16%	12%	8%	14%
Somewhat concerned	25%	22%	28%	26%	25%
Very concerned	28%	29%	35%	47%	35%

n = 1,002

Source: University of Southern California (USC Dornsife); March 26 to April 11, 2019 (https://s3.amazonaws.com/factual-content/marketing/downloads/Factual-Consumers-Data-Privacy-Perceptions-Report.pdf)

Mitigation of Ethical Issues: Inform and Engage

- Any privacy impact to be minimized[1]
- High standards of data security, protection and oversight would be in place[1]
- There will be transparency about proposed and actual data uses[1]
- Other layers of protection would also be implemented, i.e. non-discrimination[1]
- Capture the findings not the identities from the Edge

Current controversy

OPEN ACCESS

Ethics of instantaneous contact tracing using mobile phone apps in the control of the COVID-19 pandemic

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ABSTRACT

In this paper we discuss ethical implications of the use of mobile phone apps in the control of the COVID-19 pandemic. Contact tracing is a well-established feature of public health practice during infectious disease outbreaks and epidemics. However, the high proportion of pre-symptomatic transmission in COVID-19 means that standard contact tracing methods are too slow to stop the progression of infection through the population. To address this problem, many countries around the world have deployed or are developing mobile phone apps capable of supporting instantaneous contact tracing. Informed by the on-going mapping of 'proximity events' these apps are intended both to inform public health policy and to provide alerts to individuals who have been in contact with a person with the infection. The proposed use of mobile phone data for 'intelligent physical distancing' in such contexts raises a number of important ethical questions. In our paper, we outline some ethical considerations that need to be addressed in any deployment of this kind of approach as part of a multidimensional public health response. We also, briefly, explore the implications for its use in future infectious disease outbreaks.

INTRODUCTION

Learning from China

As we write this paper, Europe is at the epicentre of the COVID-19 pandemic. The pandemic has its origins in the emergence, late in 2019, of a novel coronavirus in the Chinese city of Wuhan, which has a population of around 11 million. It is estimated that between the official confirmation of the outbreak and the imposition of a lockdown, around 5 million people left the city. The vast majority went to other parts of China.[1] The epidemiological implication of this is that the Chinese population outside Wuhan came into contact with many more people infected with COVID-19 than did the world outside China. Despite this, as of 14 April 2020, around 3 months later, China's total number of cases is 83 306, and its daily case rate is close to zero. By contrast, the global total of cases is now approaching 2 million and doubling every few days in many places.[2] Compared with other countries, China has been very successful at controlling the spread of COVID-19.[3]

There are a number of features of China's response to COVID-19 that would be unlikely to be effective or acceptable in other countries. This does not mean that there are not important lessons to learn from China's success. One element of the approach adopted by China and by several other countries in East and South East Asia that has been highly successful in reducing cases is the use of mobile phone data combined with intensive testing programmes. There is evidence to suggest that the use of this kind of approach might be successfully transferable to other settings with different political and cultural systems.[3 4]

Effective, rapid contact tracing is the cornerstone of effective public health response in the face of infectious disease outbreaks. Its success depends on identifying cases (usually people with symptoms) quickly, gathering information from them about recent contacts and following up and quarantining those contacts to interrupt further transmission of the disease. COVID-19 presents a problem for contact tracing as usually practiced because around 50% of transmissions happen early in infection, before symptoms start, and before test results can be acted on. This means that COVID-19 moves too quickly through the population to be amenable to standard contact tracing methods. The use of a mobile phone app that captures 'proximity events'—events in which two mobile phones have been close enough for sufficient time for the risk of infection to be high—offers the potential for instantaneous contact tracing from the moment the infection is confirmed.[4a] This has the potential to stop the pandemic.

The modelling for the use of a mobile phone app in COVID-19 and a more detailed description of how this might work have been published elsewhere.[3] A number of different approaches are currently under development by health systems in many countries around the world. In this paper, our aim is to set out a number of ethical considerations relevant to the use of mobile phone apps to enable rapid contact tracing. These issues will emerge in different ways in different settings.

ETHICAL QUESTIONS

Benefits and harms

Any consideration of the ethical questions arising in the context of the COVID-19 pandemic has to place great importance on the moral significance of its international spread and the massive scale

[1]There is debate about the accuracy of the figures coming out of China but broad agreement about the success of their intervention in reducing the number of infections.

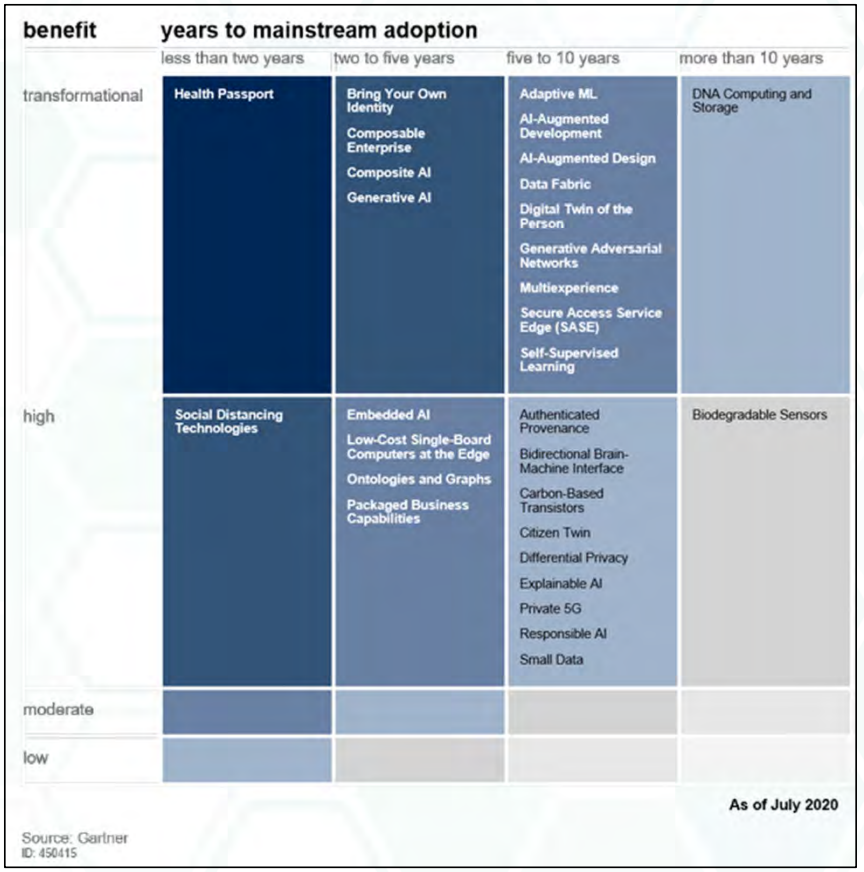
"The effectiveness and reach of any implementation of the app in democratic societies will inevitably be affected by varying configurations of state-citizen relationships, as well as by the roles of civil society groups and non-governmental actors.

"The question of what constitutes adequate information about infection status for a population effect may be answered differently by different systems, ranging from self-reported symptoms through to clinically validated test results.

[1] Parker MJ, Fraser C, Abeler-Dörner L, et al. J Med Ethics, 2020;46:427–431

Preparation for Future Pandemics

- Digitization
  - Global, National and Healthcare Systems
- Data Integration
  - Global and National
- Data Sharing
  - Global and National
- Investment in Emerging Technologies
  - Early Warning Solutions
  - Real-time Alerts and Notifications
  - Accurate Reports and Predictions



THANK YOU

G20
SAUDI ARABIA 2020

وزارة الحرس الوطني - الشؤون الصحية
Ministry of National Guard - Health Affairs

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Saudi Center For International Strategic Partnerships

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