Australian Government
National Health and Medical Research Council

NHMRC

National COVID-19 Health and Research Advisory Committee*

Date of advice: 15 February 2021

New and novel methods for detection of COVID-19 cases

Focus

The Chief Medical Officer (CMO) asked the National COVID-19 Health and Research Advisory Committee (NCHRAC) to provide advice about new and novel methods of case detection that have been developed and their effectiveness.

Notes

This advice paper has been developed at a point in time and may need further review as more evidence is available. The key findings represent expert interpretation of relevant evidence as at 11 February 2021. In order to provide timely advice, a full systematic review process was not undertaken.

This advice paper was reviewed by NCHRAC members, Professor Brendan Crabb and Professor Michael Reade.

A glossary of key terms is provided in **Attachment 1**.

* NHMRC is providing secretariat and project support for the Committee, which was established to provide advice to the Commonwealth Chief Medical Officer on Australia's health response to the COVID-19 pandemic. The Committee is not established under the NHMRC Act and does not advise the NHMRC CEO.

Key findings

1. There are a range of new and novel technologies that have been developed, or are under development, for the detection of people with COVID-19 or the presence of SARS-CoV-2 in the environment.
2. Evidence is emerging about the application and effectiveness of these new and novel technologies, with the key limitation being the lack of currently available evidence and the lack of validation of many new and novel technologies.
3. Factors determining the practical application of new and novel technologies include the number of COVID-19 cases in the city/region/country, the level of restrictions to people movements and lockdown, the capacity of health systems, available technology and resources, and the level of community engagement and compliance with health directives.
4. There are numerous approaches being developed that seek to address these challenges. We recommend a close watching brief on these technologies, including developments of some (especially 'home-based' testing) that are not considered fit for purpose in Australia at this stage, but that may have uses in the future.
5. There are significant ethical, privacy, data security and/or legal issues associated with many of the new and novel technologies described in this advice paper.

Introduction

The purpose of this advice paper is to present the outcomes from an horizon scan of the available literature which seeks to provide information about new and novel methods for detection of people with COVID-19, or the presence of SARS-CoV-2 in the environment. For the purposes of this paper, new and novel methods include:

- newly developed and emerging technologies and non-technological methods of detection that differ from current SARS-CoV-2 testing technologies
- newly developed and emerging technologies and non-technological methods of detection that complement current SARS-CoV-2 testing technologies
- new or novel active strategies and measures that can aid in active or passive detection of COVID-19 cases.

In Australia, nucleic acid testing (NAT) of respiratory tract samples using reverse transcription polymerase chain reaction (RT-PCR) remains the gold standard for diagnosis of COVID-19. In Australia, point-of-care antigen tests that detect specific proteins from the virus are not currently considered suitable for extremely low prevalence settings like Australia. However, such tests are gaining traction in high prevalence settings and it may eventuate that with improving technology and/or changing circumstances in Australia there may be uses for such technology in the future. Serology does not currently have a role for diagnosis of COVID-19 during the acute illness but can be helpful for the diagnosis of past cases.[1,2] However, an 'acute-phase' point-of-care antibody test – based on the detection of dimeric IgA - is being developed at the Burnet Institute with funding from the Victorian state government.

Public Health Laboratory Network Emerging SARS-CoV-2 Testing Technologies Working Group

NCHRAC is aware of the work being undertaken by the Public Health Laboratory Network (PHLN) Emerging SARS-CoV-2 Testing Technologies Working Group (PHLN Working Group) to provide up-to-date advice on current testing technologies. Membership of the PHLN Working Group includes representatives from the Communicable Diseases Network Australia (CDNA) and the Department of Health.

The following areas are covered by the work of the PHLN Working Group and are out of scope for this advice paper:

- SARS-CoV-2 testing technologies, including their performance characteristics, that are approved, or are being considered, for use in Australia by the Therapeutic Goods Administration (TGA); including advice on how to apply the SARS-CoV-2 testing technologies (examples include all point-of-care tests, in-home tests, saliva tests, fingerprint tests)
- innovations related to currently used SARS-CoV-2 testing technologies
- wastewater surveillance.

This advice paper is intended to complement the work of the PHLN Working Group, with its scope determined in consultation with the PHLN Working Group.

Out-of-scope considerations

In-home antigen tests

NCHRAC notes that tests are being developed in Australia and elsewhere that are designed to provide an instant result without the need for laboratory analysis. The Burnet Institute is developing a rapid point-of-care test which they hope will allow people who have had COVID-19 return to work faster.[3] Ellume has recently announced that their in-home COVID-19 tests will soon be available for use without prescription in the USA.[4] The tests are designed to either be administered at home or at a point-of-care with little or no experience. NCHRAC considers that the applicability of these tests to the Australian pandemic response is worth monitoring.

The supply and advertising of COVID-19 tests for consumers to use in their homes is prohibited in Australia.[5] The Therapeutic Goods Administration (TGA) places additional conditions on rapid screening tests used at point-of-care including the involvement of a suitably qualified healthcare professional in the interpretation of the results.[5]

Further, the concern of the Public Health Laboratory Network (PHLN) is noted. PHLN advised that the use of in-home test kits and rapid antigen kits would introduce difficulties in ensuring that test results are reported appropriately into the relevant state and territory notifiable diseases processes and on to the Commonwealth's National Notifiable Diseases Surveillance System (NNDSS) and hence be available to inform the public health response.[6] Counterbalancing this valid concern is the potential for greater population uptake of point-of-care testing compared to the current exclusively laboratory-based RT-PCR strategy. A population-based comparative effectiveness study of the two approaches might be warranted.

Approach

A rapid evidence search was conducted between 23 November and 1 December 2020 to identify systematic reviews and other key literature, and relevant grey literature, published since May 2020. The search/identification strategies used included:

1. Pubmed search using specific terms (see **Attachment 2**)
2. MedRvix search using specific terms (see **Attachment 2**)
3. Google search using specific terms (see **Attachment 2**)
4. Searching of key information sources including the NSW Agency for Clinical Innovation website, the National Institute for Health and Care Excellence (NICE UK) website, World Health Organisation (WHO) website, and COVID-End website
5. Press releases and media alerts (Nature Briefing emails, WHO email updates, CSIRO media announcements etc)
6. Search of Australian and international patent databases (see **Attachment 2**).

A top-up search of the Pubmed database was performed on 7 January 2021 to cover the period between 1 December 2020 and 7 January 2021.

Evidence was included for further consideration if it addressed one or more of the following questions:

- What new and novel methods have been developed, or are being trialled, to detect individual COVID-19 cases?
- What new and novel methods have been developed, or are being trialled, to detect COVID-19 cases at the population level (other than wastewater surveillance)?
- What new and novel methods have been developed, or are being trialled, to detect evidence of SARS-CoV-2 in the environment (for example to detect surface contamination)?
- What active strategies and measures have been developed, or are being trialled, to aid in the active or passive detection of COVID-19 cases?

Well-established methods for testing and detection were excluded.

Evidence

The discussion of detection methods and technologies often results in a tendency to think about methods in isolation. Existing clinical and laboratory testing techniques for the detection of the SARS-CoV-2 virus can be complemented with automation, artificial intelligence and environmental testing technologies. Where the methods and technologies identified are designed to complement existing technologies or other innovations this is noted under ‘Application’. Detailed consideration and discussion of the benefits of bringing a range of methods together to improve detection is beyond the scope of this advice as few investigations have quantified the effectiveness of combining more than one technological approach in detecting COVID-19. However, the combination of technologies that in isolation have low sensitivity or specificity is theoretically attractive, and warrants further investigation.

The use of emerging technologies may be most useful in situations where the response to the COVID-19 pandemic is encumbered by lockdowns and/or travelling restrictions, a high infection rate and continuous increase of COVID-19 cases which overwhelm health systems[7], or when the manifestations of COVID-19 infection are modified by prior vaccination, such that a greater proportion of infected individuals are not aware of their infected status. The discussion below is complemented by a recent review by Mbunge *et al.* at **Attachment 3**.[7]

Artificial intelligence and big data analytics

Advances in data analysis, data linkage abilities and computer learning techniques have led to advances in disease detection and diagnostic abilities. Artificial intelligence (AI) (including machine learning, deep learning, artificial neural networks and nature-inspired computing) (see glossary; **Attachment 1**), and big data analytics can be employed to enhance, support or complement:

- existing methods for identification of people with COVID-19, and potential cases for subsequent assessment by a healthcare professional
- clinical decision-making to identify people with COVID-19 following transfer of data/information to health-based systems such as the electronic health records and electronic decision support tools
- syndromic surveillance
- existing testing technologies and detection systems.

Advantages include:

- easing of the burden on the health system
- support for clinical decision making
- low cost, fast, simple (image analysis); for some methods, cost may be high initially with significant decrease over time leading to lower cumulative costs
- available 24 hours a day, seven days a week compared to limited hours of conventional human labour
- little/no contact between persons, which significantly decreases the possibility of transmission of the virus
- remote detection of potential SARS-CoV-2 infection in vulnerable people who are considered high risk, with subsequent alert to carers, family members, health professionals
- identification of cases that may be missed by established population-surveillance systems that typically rely on health-related data from laboratories, notifications of cases diagnosed by clinicians and syndromic surveillance networks
- minimisation of potential incorrect diagnoses, particularly given the breadth of clinical manifestations observed in COVID-19 and the need for differentiation between SARS-CoV-2 infection and other infections (e.g. viral, bacterial and mycoplasma pneumonia).

Disadvantages and issues include:

- quantity and quality of datasets, with artificial-intelligence and big data approaches being only as good as the source empirical datasets
- selection bias
- over-interpretation of findings
- lack of integration with official national surveillance that report established surveillance metrics
- lack of validation for some methods with many digital technologies not yet peer-reviewed, lacking rigorous testing or not having been evaluated by digital health-evidence frameworks
- legal, ethical and privacy concerns; e.g. associated with the sharing and use of personal data such as diagnosis reports, CT scans, daily activities and GPS location.

Method	References	Reported accuracy/ effectiveness	Application
Deep learning algorithms and neural network models for classification and analysis of chest computed tomography (CT) scan and X-ray images to detect COVID-19 pneumonia (distinguish between COVID-19, pneumonia due to another reason and no infection within the lungs).	7-14	**CT:** Accuracy: 82.9%–99.68% Specificity: 80.5%–97.6% Sensitivity: 84.98%–93.3% **X-ray:** Accuracy: 87%–99% Specificity: 87.84% Sensitivity: 90%–98.3%	• Detection of individual cases. • Most useful in situations where the health system and radiologists' time are overwhelmed, or where there is no access to CT and MRI for chest imaging (e.g. rural and remote communities). • Minimises the need for interpretation of chest CT and X-rays by specialists. • There are few reports about the accuracy of AI models compared to that of radiologists. Bai et al[10] reports that, when compared to results for radiologists, an AI model had higher test accuracy (96% vs 85%, $P < 0.001$), sensitivity (95% vs 79%, $P < 0.001$), and specificity (96% vs 88%, $P = 0.002$). In addition, with AI assistance, the radiologists achieved higher average accuracy (90% vs 85%, $P < 0.001$), sensitivity (88% vs 79%, $P < 0.001$), and specificity (91% vs 88%, $P = 0.001$). [10] • To support clinical decision making (e.g. when combined with patient history and clinical data; using automated systems such as Intelligent clinical decision support system [SADC]).
Collection, analysis and interpretation of clinical data collected from COVID-19 patients and potential patients.	*General information applicable to all technologies outlined in this section:* • Can be fully or partially automated, for storage in electronic health records where they can be easily shared and rapidly transferred when needed.		

Method	References	Reported accuracy/ effectiveness	Application
	• Detection of individual cases and to support clinical decision-making.		
Examples:	*Additional information relevant to the specific example:*		
1. Analysis of clinical data collected by medical staff from patients in hospitals /clinics using personal digital assistants, tablets and similar equipment.	11	Not stated	• Diminishes infection risk and burdens imposed on medical staff to constantly gather, store, analyse and interpret data. • Most useful in situations where the health system are overwhelmed.
2. Video-imaging-based high-speed medical monitoring systems and motion-tracking algorithms for monitoring of signs (temperature, heart rate, respiratory rate, blood pressure, oxygen status).	11	Not stated	• Can provide large amount of factual information regarding vital signs (temperature, heart rate, respiratory rate, blood pressure, oxygen saturation) as well as status, condition severity, existing comorbidities, and patient discharge.
3. Data collected from patients' devices such as smartphones (e.g. record of coughs and sounds) and wearable devices (e.g. *Biovitals Sentinel* platform which includes clinical grade biosensor *Environ*, combined with cloud-based analytics platform, *Biovitals*).	12, 13	Not stated	• Early detection of cases in quarantine.
Linking between point-of-care rapid antibody testing and smartphones with	14, 15	Not stated	• Cellphone-based rapid-diagnostic-test (RDT) reader platform that can work with various lateral flow

Method	References	Reported accuracy/ effectiveness	Application
automatic readout through the use of image processing and machine-learning methods.			immuno-chromatographic assays and similar tests to sense the presence of a target analyte in a sample. The digital RDT reader attaches to the existing camera unit of a cellphone, where various types of RDTs can be inserted to be imaged in reflection or transmission modes under light-emitting diode (LED)-based illumination. Captured raw images of these tests are then digitally processed (within less than 0.2 secs per image) through a smart application running on the cellphone for validation of the RDT, as well as for automated reading of its diagnostic result. The same smart application then transmits the resulting data, together with the RDT images and other related information (e.g., demographic data), to a central server, which presents the diagnostic results on a world map through geo-tagging. This dynamic spatio-temporal map of various RDT results can then be viewed and shared using internet browsers or through the same cellphone application.[15] • Detection of individual cases. • Could allow mass testing to be linked with geospatial and patient information that is rapidly reported/notified to both clinical systems and public-health systems.

Method	References	Reported accuracy/ effectiveness	Application
			• For this method to work effectively, standardisation of data and integration of data into electronic health records are required. • Can be implemented in home, community or social-care settings.
Deep learning and neural network model to detect people with COVID-19 by feature selection and classification (see glossary) (e.g. Diagnosis module of *Artificial Intelligence-inspired Model for COVID-19 Diagnosis and Prediction for Patient Response to Treatment* [AIMDP]).	16, 17	Not stated	• Detection of individual cases.
AI to identify emerging risk of infection.	16	Not stated	• Population level - identification and tracking of the spread of SARS-CoV-2. For example, Canadian company, BlueDot (https://bluedot.global/) which claims to deliver bespoke, near-real-time intelligence to governments, hospitals and airlines, revealing COVID-19 movements and identify emerging risk of COVID-19.
Autonomous AI-enabled robots	16, 18	Not stated	• Autonomous AI-enabled robots can assist with monitoring and recording symptoms and are capable of collection of samples (e.g. throat swabs).

Method	References	Reported accuracy/ effectiveness	Application
			• Can be deployed in risky environments, or crowded public spaces such as customs, airports, ports, railways stations. • The mobile robot increases efficiency and coverage of COVID-19 screening.
Chatbots (artificial intelligence applications designed to simulate conversation with people)	14, 16	Not stated	• Virtual assistants that provide information to potential COVID-19 cases about symptoms and reduce the burden on non-emergency health-advice call centres. • Population level surveillance – following data transfer and analysis.
Non-contact sensing technologies, to support disease diagnosis and allow monitoring of patients without direct contact with the patients or devices physically touching the body.	*General information applicable to all technologies outlined in this section:* • Unlike currently available wearable devices for monitoring of vital signs and potential COVID-19 symptoms, these technologies can minimise contact between health-care providers and potentially infectious patients and thus reduce the risk of infection and spread of the disease. • All methods can be used with AI for processing of information collected from a patient to provide clinical decision support, or for direct analysis by clinicians, for diagnosis and/or monitoring of the patient and progression of disease.		
Examples:	*Additional information relevant to the specific example:*		
1. Camera technology and deep learning neural network model of	9	Accuracy: 83.7%–94.5%	• Deep learning neural network models can distinguish between different breathing patterns detected using camera technology (eupnea,

Method	References	Reported accuracy/ effectiveness	Application
depth images[†] to identify the tachypnoea breathing patterns observed in COVID-19 patients.			bradypnea, tachypnea, Biot's respiration, Cheyne – Stokes breathing and central apnea). • Detection of potential COVID-19 cases, particularly in vulnerable people who are considered high risk, with an alarm sent to carers, family members and/or health professionals when an irregular breathing pattern is detected. • Less expensive than CT and X-ray scanning.
2. Deep learning model with ultrasound technology to detect COVID-19 pneumonia and respiratory failure.	9	Accuracy: 89%	• AI used with ultrasound technology can be used in to distinguish the differences in COVID-19, pneumonia, and no infection within the lungs. • Ultrasound technology used to detect respiratory failure (through imaging of lung movements) can become contactless by using an ultrasound transmitter and receiver. Respiratory movement can then take place between the transmitter and receiver and creates a Doppler affect. This can then be used to create a contactless breathing monitor. • Can be performed using smartphones for the signalling and processing of ultrasound images, which would allow translation of ultrasound technology to the portable setting.

[†] A depth camera uses two sensors to allow distances/depth to be measured.

Method	References	Reported accuracy/ effectiveness	Application
			Disadvantage: • Patients must prepare themselves before an ultrasound can effectively create an image of the body.
3. Radar technology with AI models for monitoring vital signs of people within a home environment.	9	Accuracy: 94% (for detection of breathing rate); 80% (for detection of heart rate)	• Radar technology uses frequency-modulated continuous wave (FMCW) to observe the Doppler effect when a person moves. By applying AI models to give real-time classification of the Doppler images captured by the radar system, this technology can be used to monitor the fine movements such as those associated with breathing. • Remote monitoring of vital signs (e.g. breathing rate, heart rate) within a home environment (e.g. people in home quarantine) to enable a quick response if abnormalities are found that suggest COVID-19. Disadvantages: • High power requirements • High cost technology which may limit its use to hospital environments.
4. Radio frequency with AI to infer the breathing rate and/or respiratory pattern of the person.	9	Not stated	• Radio frequency (RF) signal sensing can detect the minute movements of the chest by collecting the channel state information (CSI), which can show

Method	References	Reported accuracy/ effectiveness	Application
			amplitudes of the RF signals while movement occurs between a RF transmitter and receiver. Systems have been developed (e.g. the Emerald system) that use RF signals to detect the breathing rate of COVID-19 patients and then uses AI to infer the breathing rate of the patient. • Allows monitoring of COVID-19 patients from a safe distance. • Monitors vital signs independent of the person's activities. • Can be implemented inexpensively within existing WiFi technology present within many homes; associated with less cost compared to camera or radar technology. Disadvantage: • RF signals can be vulnerable to other movements within the room, which can cause false readings.
5. Thermography	9	Not stated	• NOTE: Issues related to general screening for temperature outlined in NCHRAC Advice paper 'Thermal scanning'. • Can be used to detect irregular breathing patterns that are associated with COVID-19 using AI and deep learning. • Detection of potential cases in vulnerable people who are considered high risk, with subsequent

Method	References	Reported accuracy/ effectiveness	Application
			alarm to carers, family members, health professionals. Appropriate action can then be taken for more accurate tests and diagnosis.
6. Terahertz sensing technology with AI (deep learning) to detect changes in the motion of the chest created by changes in heart rate or respiratory pattern.	9	Not stated	• The use of terahertz waves (electromagnetic frequencies around 0.1–10 Terahertz) to detect COVID-19 will work similarly to the radar system, with AI being used to rapidly classify the images showing the Doppler effect of terahertz waves once an AI model has been fully trained. • Useful when seeking to avoid harmful effects of x-rays (radiation) because of non-harmful properties of terahertz sensing technology to living cells.
AI analysis of data/information about symptoms from crowdsourcing systems; e.g. Coronavirus (COVID-19) Symptom Checker (Australia), *InfluenzaNet* (Europe), *COVID Near You* (USA, Canada, Mexico), *COVID9 symptom - tracker* app (UK).	14, 19	Not stated	• Support for national syndromic surveillance. • Population level.
Nature-inspired computing (NIC) models for automated screening,	16	Not stated	• Nature-inspired computing (NIC) is an interdisciplinary domain that combines the branch of computing science with other knowledge

Method	References	Reported accuracy/ effectiveness	Application
diagnosis and prediction of COVID-19 cases.			disciplines from sciences, e.g., physics, chemistry, biology, mathematics and engineering, to allow for the development of new computational tools such as algorithms and hardware. • Purported to address some issues seen with AI-based technologies and big data analytics such as accuracy and reliability of source data/information, accuracy of classification of features, architecture for data sharing and merging, issues associated new learning. • NIC models have been applied to the diagnosis and prediction of COVID-19, and they have been used for X-ray image segmentation to identify features of COVID-19. • For detection of individual cases and for contact tracing. • NIC models have not been explored in the contact tracing algorithms for the COVID-19 pandemic. While NIC models have been applied in domains such as car tracking algorithms, similar studies for the COVID-19 pandemic could be the subject of further research.
AI-enabled smart toilet.	18, 20, 21	Not stated	• Involves the use of hardware and software for analysis of a user's excreta. Gadgets fitted to the bowl (e.g. motion sensors, molecular probes, dipsticks for detection of specific molecules and other technologies that can detect a range of

Method	References	Reported accuracy/ effectiveness	Application
			disease biomarkers in stool and urine) so that deposits in the bowl, including urine samples, are subjected to a physical and molecular examination. Each user of the toilet is identified through their fingerprint and the distinctive features of their anoderm, and the data are securely stored and analysed in an encrypted cloud server, for future rapid retrieval and reference in any electronic health record system. • Can be used for detection of biomarkers for conditions such as bladder or kidney infection, colorectal or urologic cancers. If used for detection of COVID-19 cases, system would analyse urine and stool for viral RNA. • Detection of individual cases and population level surveillance depending on site (e.g. in the home, at public venues).
AI and big data analytics using different sources of data; e.g. self-tracking devices, mobile health apps, social media posts with meta-data and tags, passenger lists, smartcards to metro, logs of a vehicle that people travel with and the use of credit card.	16	Not stated	• Contact tracing to identify potential individual COVID-19 cases • By determining features of importance from location meta-data/tag on social media to validate that a person was at a certain location at a certain time, although not accurate, can provide a tracking model that could trace people even if they do not have tracking equipment or mobile phones with them

Method	References	Reported accuracy/ effectiveness	Application
			• Support clinical decision-making.
Social media search indexes (SMSI) – analysis of key words including clinical symptoms such as cough, pneumonia, fever and chest distress.	16	Not stated	• To detect new cases (suspected or confirmed) • Posts on social media can help to identify any information relating to the perceived risk of contracting the infection • Advantage with approach using keywords: Health authorities can outline appropriate responses to create the needed alert mechanism Disadvantage: • Posts might not be accurate and reliable.

Mobile app technology

- There has been an increase in mobile application technology (apps) around the world as a means of digitising contact tracing and medical monitoring of COVID-19. Apps have been designed either to track the location of users, track a user's vital signs, record individuals who attend a specific venue or through recording interactions with others.
- In Australia, mobile app technology has been implemented by individual jurisdictions to allow individuals to check-in to businesses easily using Quick Response (QR) codes, creating a contactless log of who has attended the business.
- Other apps include the use of smart watch data which can be used to track individual's changes in biometrics such as heart rate or respiratory rate. This data can be shared with specific apps to identify and track individual and population-level viral illnesses, including COVID-19.
- Wearable tag based systems have been shown to be effective in clinical settings, this method involves asking individuals to wear a wrist monitor which is able to detect other monitors close by. Unfortunately, while effective, this method is not able to be practically implemented in the community setting due to high set up costs and difficulties enforcing the use of the tags in the community.[22]

Advantages of mobile app technology:

- Manual contact tracing is a labour intensive process which can help to identify those who may have been exposed to COVID-19 and relies on an individual's ability to both recall where they have been during an infectious period and their honesty.[23]
- Mobile app technology, such as QR codes, can assist in fast identification of close contacts and help to reduce the recall burden for an individual.[23]

Disadvantages of mobile app technology:

- Contact tracing apps and the use of QR codes both require public trust in the application developer, the third party collecting the data and the government to keep their data secure.
- The tracing apps and QR codes are only effective if widely adopted by the population.
- Ethical and safety concerns exist over the monitoring of peoples movements and the collection and storage of personal data.

Method	References	Reported accuracy/ effectiveness	Application
Automated contract tracing and location based risk assessment using GPS, Bluetooth and	23	Not stated	• Disease surveillance. • Rapid contract tracing. • Detection of disease spreading events.

Method	References	Reported accuracy/ effectiveness	Application
manual data entry applications.			
Code scanning/ Quick response (QR) codes utilised as a means of contactless check-in.	23	Not stated	• Disease surveillance • Rapid contact tracing for super spreader events.
A wearable tag-based real-time locating system.	22	96.9% sensitivity, 83.1% specificity (in a clinical setting)	• Surveillance of individual cases in a clinical setting. • Could be used in the community to augment other contact tracing methods.
Smart watch monitoring of biometrics such as heart rate or respiratory rate.	24, 25	Not stated	• Detection of individual cases. • Could be used to alert user to the need to present for point-of-care testing.

Detection of volatile organic compounds (Sniffer dogs, breath testing)

- Detection dogs are being trained to identify specific scents to detect COVID-19 positive individuals. These studies are currently being carried out around the world including Finland, Germany and Australia to determine the accuracy and sensitivity of dogs, with promising preliminary results.
- The University of Adelaide in collaboration with the Australian Border Force has commenced a feasibility study for the use of specially trained dogs to detect COVID-19, results will be published early 2021.[26]
- Breath testing for the detection of COVID-19 is still in the feasibility phase, however early studies indicate it may also be possible to rapidly detect COVID-19 through a breath test.[27, 28]
- Feasibility studies have been conducted in both the UK and Singapore.[27, 28]

Advantages include:

- Early results indicate dogs may be able to detect the virus prior to a PCR positive result and may be able to detect people who are pre-symptomatic.
- Sniffer dogs enable fast, real time screening for large groups of people.

- Breath testing would allow a rapid non-invasive method to detect the virus with a result provided in minutes.
- Breath testing would not require specialised laboratory staff but could be conducted by any health care professional.

Disadvantages:

- It is likely this method will have a high cost associated with training both dogs and handlers, limiting the ability for widespread use.[29]
- Detection accuracy varies between dogs and there is the potential that the use of sniffer dogs may create a false sense of security that COVID-19 is not present if only one dog with a lower level of accuracy is used.
- Sniffer dogs are not able to give a diagnosis of COVID-19 and additional testing is still required for those with suspected cases.
- Breath testing is still in the pilot phase.

Method	References	Reported accuracy/ effectiveness	Application
Dogs trained to detect a specific odour in sweat to detect positive COVID-19 cases.	30, 31	96.35% specificity (95% CI: 96.31–96.39%), 82.63% sensitivity (95% CI: 82.02–83.24%)	• Population level screening at specific checkpoint locations e.g. international arrivals or entrance to sporting match. • Non-invasive detection to inform the need for further testing. • Could be used to complement traditional testing methods.
COVID-19 detection via exhaled breath. Methods include testing for volatile organic compounds or using near-patient gas chromatography-ion mobility spectrometry.	27, 28	90% accuracy, 93% sensitivity and 95% specificity (based on limited data)	• Breath testing aims to detect whether COVID-19 is present through measurements of specific changes in volatile organic compounds (VOCs) in a person's exhaled breath. • Non-invasive. • Could be used as point-of-care testing.

Method	References	Reported accuracy/ effectiveness	Application
			• Could be used in high traffic areas such as air ports and dormitories to complement other testing efforts.

Detection of viral particles in the environment (excludes wastewater detection)

- A Canadian company (Kontrol Energy Group) has developed an air sampling and detection system, the BioCloud system that they claim can detect the presence of SARS-CoV-2 in the air.[32-34]
- The BioCloud system is claimed to continuously sample air in the room and contains a replaceable detection cassette. The developer provides little detail but states the presence of SARS-Cov-2 can be detected at a lower detection limit of 50 viral particles using a viral collider and chemical process to trap the virus and identifies the virus with a laser sensor.[35] If the presence of SARS-CoV-2 is detected an alert is sent via Wi-Fi or the cloud to the appropriate administrator who can then act on the alert. The detection cassette can be replaced and returned to the company for disposal.
- A distribution agreement which covers Australia has been entered into between Kontrol Energy Group and United Safety. It is not known when this product will be available on the Australian market.

Advantages:

- The system is designed to complement traditional test and trace methods.
- Non-invasive sampling of the air does not require active participation by members of the community.
- Could be used in schools or work places to provide an additional level of detection.

Disadvantages:

- Accuracy and effectiveness data could not be found. However, four patent applications have been filed in the USA to cover the invention. Kontrol Energy Group claims that the system has been independently tested by Western University (Canada).
- It is not known how close to the system, or for how long, an infectious person must be for the system to detect the presence of the virus.
- Detection cassette must be replaced after virus is detected.

Method	References	Reported accuracy/ effectiveness	Application
BioCloud – Real time air sampling and virus detection system.	32-34	Accuracy and effectiveness information could not been found. Patent applications have been filed in the USA and commercialisation arrangements have been announced.	• Static machine that is designed to regularly sample air and detect the presence of the SARS-CoV-2 virus in spaces where people gather such as classrooms, offices, public transport, etc. • The company claims the machine is designed to complement traditional test and trace methods already in place.

Other population based surveillance methods

- Drones are being considered by a range of groups, including an Australian Department of Defence and University of South Australia collaboration, for monitoring and detection of respiratory conditions, temperature, heart rate and other health indicators in open public spaces.[36, 37] The use of drones has also been suggested for social distancing controls, sanitising and patient monitoring in crowded places, ships, airlines and border crossing areas. The use of nano or low altitude drones is suggested for indoor monitoring.[38]
- Researchers at the University of South Australia have adapted previously developed software to allow drones to monitor heart rate, temperature and coughing and sneezing. Researchers state that heart rate can be measured from a distance of eight metres.

Advantages:

- Allows remote observation and monitoring of potential symptoms in the community.

Disadvantages:

- The software was being trailed in a town in the USA before the trial was stopped due to privacy concerns.[36]
- Drone control systems can be vulnerable to hacking, spoofing and jamming.[7]

Method	References	Reported accuracy/ effectiveness	Application
Drones used to detect body temperature, heart rate, coughing and sneezing; or to monitor adherence to social distancing and for disinfecting contaminated areas.	7, 36-38	Accuracy and effectiveness not reported.	• Population level screening in public spaces to allow early warning of possible infection. • There is no clear advice from the WHO on the use of drones in healthcare.[7]

Other out-of-scope considerations

In the course of developing this advice paper, NCHRAC identified the following considerations that were out of scope, but are important and related considerations:

- detailed concertation of the privacy and ethical concerns around new technologies, especially AI, apps and drones
- communication to individuals on how different tests are to be used and what the results of the test mean and how to gain follow-up testing (especially important for 'instant' tests used at home or at venues)
- communication with vulnerable populations for any new tests adopted (see: *NCHRAC Advice 5: Risks of resurgence and a potential 'second wave' of COVID-19 in Australia*)
- the validity of the technologies to the Australian community and the implications of a negative or normal result
- appropriate management of positive results; data management and communication to affected person.

Attachments

Attachment 1: Glossary

Attachment 2: Search strategy detail

Attachment 3: *A critical review of emerging technologies for tackling COVID-19 pandemic*.

References

1. Communicable Diseases Network Australia. *National Guidelines for Public Health Units, Coronavirus Disease 2019 (COVID-19)* 28 October 2020 2020.

2. Public Health Laboratory Network. *Guidance on laboratory testing for SARS-CoV-2 (the virus that causes COVID-19)*. 2 November 2020 2020.

3. Burnet Institute. *Global Health Diagnostics Development Group*. 2021 2021.

4. Ellume. Ellume COVID-19 home test, https://www.ellumehealth.com/products/consumer-products/covid-home-test (2021, accessed 4 February 2021).

5. Therapeutic Goods Administration. *Legal supply of COVID-19 test kits*. 5 November 2020 2020.

6. Department of Health. CDNA national surveillance case definition, https://www1.health.gov.au/internet/main/publishing.nsf/Content/cdna-casedefinitions.htm#c (2021, accessed 4 February 2021).

7. Mbunge, E., Akinnuwesi, B., Fashoto, S. G., Metfula, A. S. and Mashwama, P. A critical review of emerging technologies for tackling COVID-19 pandemic. *Hum Behav Emerg Technol* 2020 2020/12/29. DOI: 10.1002/hbe2.237.

8. Alsharif, M. H., Alsharif, Y. H., Chaudhry, S. A., Albreem, M. A., Jahid, A., et al. Artificial intelligence technology for diagnosing COVID-19 cases: a review of substantial issues. *Eur Rev Med Pharmacol Sci* 2020; 24: 9226-9233. DOI: 10.26355/eurrev_202009_22875.

9. Taylor, W., Abbasi, Q. H., Dashtipour, K., Ansari, S., Shah, S. A., et al. A Review of the State of the Art in Non-Contact Sensing for COVID-19. *Sensors (Basel)* 2020; 20 2020/10/08. DOI: 10.3390/s20195665.

10. Bai, Harrison X., Wang, Robin, Xiong, Zeng, Hsieh, Ben, Chang, Ken, et al. Artificial Intelligence Augmentation of Radiologist Performance in Distinguishing COVID-19 from Pneumonia of Other Origin at Chest CT. *Radiology* 2020; 296: E156-E165. 2020/04/27. DOI: 10.1148/radiol.2020201491.

11. Adly, A. S., Adly, A. S. and Adly, M. S. Approaches Based on Artificial Intelligence and the Internet of Intelligent Things to Prevent the Spread of COVID-19: Scoping Review. *J Med Internet Res* 2020; 22: e19104. DOI: 10.2196/19104.

12. Alsharif, W. and Qurashi, A. Effectiveness of COVID-19 diagnosis and management tools: A review. *Radiography* 2020. DOI: https://doi.org/10.1016/j.radi.2020.09.010.

13. Wong, C, Ho, D, Tam, A, Zhou, M, Lau, Y, et al. Artificial intelligence mobile health platform for early detection of COVID-19 in quarantine subjects using a wearable biosensor: protocol for a randomised controlled trial. *BMJ Open* 2020; 10: e038555. DOI: 10.1136/bmjopen-2020-038555.

14. Budd, J, Miller, B, Manning, E, Lampos, V, Zhuang, M, et al. Digital technologies in the public-health response to COVID-19. *Nature Medicine* 2020; 26: 1183-1192. DOI: 10.1038/s41591-020-1011-4.

15. Mudanyali, Onur, Dimitrov, Stoyan, Sikora, Uzair, Padmanabhan, Swati, Navruz, Isa, et al. Integrated rapid-diagnostic-test reader platform on a cellphone. *Lab on a chip* 2012; 12: 2678-2686. 2012/05/17. DOI: 10.1039/c2lc40235a.

16. Agbehadji, I., Awuzie, B., Ngowi, A. and Millham, R. Review of Big Data Analytics, Artificial Intelligence and Nature-Inspired Computing Models towards Accurate Detection of COVID-19 Pandemic Cases and Contact Tracing. *Int J Environ Res Public Health* 2020; 17 2020/07/30. DOI: 10.3390/ijerph17155330.

17. Siam, M. H. B., Nishat, N. H., Ahmed, A. and Hossain, M. S. Stopping the COVID-19 Pandemic: A Review on the Advances of Diagnosis, Treatment, and Control Measures. *J Pathog* 2020; 2020: 9121429. 2020/11/03. DOI: 10.1155/2020/9121429.

18. Yuan, X, Yang, C, He, Q, Chen, J, Yu, D, et al. Current and Perspective Diagnostic Techniques for COVID-19. *ACS Infectious Diseases* 2020; 6: 1998-2016. DOI: 10.1021/acsinfecdis.0c00365.

19. Healthdirect. Coronavirus (COVID-19) Symptom Checker, https://www.healthdirect.gov.au/symptom-checker/tool/basic-details (2020, 2021).

20. Park, SM, Won, D, Lee, B, Escobedo, D, Esteva, A, et al. A mountable toilet system for personalized health monitoring via the analysis of excreta. *Nature Biomedical Engineering* 2020; 4: 624-635. DOI: 10.1038/s41551-020-0534-9.

21. Thomas, L. 'Smart toilet' looks for signs of disease. *News-MedicalNet* 6 April 2020 2020.

22. Huang, Z., Guo, H., Lee, Y., Ho, E., Ang, H., et al. Performance of Digital Contact Tracing Tools for COVID-19 Response in Singapore: Cross-Sectional Study. *JMIR Mhealth Uhealth* 2020; 8: e23148. DOI: 10.2196/23148.

23. Wirth, F. , Johns, M., Meurers, T. and Prasser, F. Citizen-Centered Mobile Health Apps Collecting Individual-Level Spatial Data for Infectious Disease Management: Scoping Review. *JMIR Mhealth Uhealth* 2020; 8: e22594. 2020/10/20. DOI: 10.2196/22594.

24. Quer, G, Radin, J, Gadaleta, M, Baca-Motes, K, Ariniello, L, et al. Wearable sensor data and self-reported symptoms for COVID-19 detection. *Nature Medicine* 2020. DOI: 10.1038/s41591-020-1123-x.

25. Abbasi, J. Using Smartwatch Data to Detect COVID-19 Cases Early. *JAMA* 2020; 324: 2247-2247. DOI: 10.1001/jama.2020.23696.

26. Savage, C. COVID-19 DETECTOR DOG RESEARCH AND TRIALS UNDERWAY. The University of Adelaide, 2020.

27. Ruszkiewicz, D. M., Sanders, D., O'Brien, R., Hempel, F., Reed, M. J., et al. Diagnosis of COVID-19 by analysis of breath with gas chromatography-ion mobility spectrometry - a

feasibility study. *EClinicalMedicine* 2020; 29-30: 100609. DOI: https://doi.org/10.1016/j.eclinm.2020.100609.

28. Koh, D. NUS spin-off company develops one-minute breath test to detect COVID-19, https://www.mobihealthnews.com/news/asia-pacific/nus-spin-company-develops-one-minute-breath-test-detect-covid-19 (22 October 2020, accessed 06 January 2021).

29. Parliament of New South Wales. 0861 - POLICE DRUG DETECTION DOG COMPLAINTS AND COSTS. *Questions & Answers Paper No 54*. Parliament of New South Wales, 2016.

30. Jendrny, P., Schulz, C., Twele, F., Meller, S., von Köckritz-Blickwede, M., et al. Scent dog identification of samples from COVID-19 patients – a pilot study. *BMC Infectious Diseases* 2020; 20: 536. DOI: 10.1186/s12879-020-05281-3.

31. Else, H. Can dogs smell COVID? Here's what the science says. *Nature* 2020; 587: 530-531. News. DOI: https://doi.org/10.1038/d41586-020-03149-9.

32. Ghezzi, P. *Kontrol Enters into Exclusive Distribution Agreement with United Safety and Survivability Corporation for BioCloud Technology Distribution in North America, Australia and New Zealand*. 1 December 2020 2020.

33. Kontrol Energy Corp. *Kontrol to host BioCloud Event for Investors, Analysts and Media*. 11 December 2020 2020.

34. Kontrol BioCloud. What is BioCloud?, https://www.kontrolbiocloud.com/what-is-biocloud (2020, accessed 15 December 2020).

35. Kontrol BioCloud. *BioCloud REAL-TIME AIR SAMPLING FOR THE CAPTURE AND DETECTION OF SARS-COV-2*. 2020. Online.

36. Daly, N. *A 'pandemic drone' and other technology could help limit the spread of coronavirus and ease restrictions sooner, but at what cost?* 1 May 2020.

37. Gibson, C. *UniSA working on 'pandemic drone' to detect coronavirus*. 2020.

38. Kumar, A, Sharma, K, Singh, H, Naugriya, S G, Gill, S S, et al. A drone-based networked system and methods for combating coronavirus disease (COVID-19) pandemic. *Future Generation Computer Systems* 2021; 115: 1-19. DOI: https://doi.org/10.1016/j.future.2020.08.046.

39. CSIRO. Artificial intelligence, https://www.csiro.au/showcase/ai (2020, accessed 22 December 2020).

40. Singh, D. Data Science Glossary, https://www.datasciencecentral.com/profiles/blogs/data-science-glossary (2018, accessed 22 December 2020).

41. Anirudh, V. Artificial Intelligence, https://www.toolbox.com/tech/artificial-intelligence/tech-101/what-is-deep-learning-definition-framework-and-neural-networks/ (2019, 22 December 2020).

42. DeepAI. Neural Network, https://deepai.org/machine-learning-glossary-and-terms/neural-network (accessed 22 December 2020).

43. Ray, T. Demystifying Neural Networks, Deep Learning, Machine Learning, and Artificial Intelligence, https://www.stoodnt.com/blog/ann-neural-networks-deep-learning-machine-learning-artificial-intelligence-differences/ (2018, accessed 22 December 2020).

Attachment 1

Glossary

Term	Meaning as applied in the NCHRAC advice paper
Artificial intelligence (AI)	Any autonomous device (an ‘intelligent agent’) that is capable of perceiving its surroundings, processing this input using the experiences it has gained and taking rational and intelligent decisions that maximize its chance of success at some goal, without explicit human guidance; can engage in behaviours that humans consider intelligent. [16, 39, 40]
Artificial neural network	See ‘neural network’.
Big data	Large volume of data that cannot be processed by traditional data processing applications and may be analysed to generate valuable insights from the data. Major characteristic in big data include: • Volume – the amount of the data • Velocity – the speed at which the data is generated • Variety – the different types of data and data sources (e.g. heterogeneous sources).[16]
Chatbot	Artificial intelligence applications designed to simulate conversation with people.
Channel state information	properties of a communication link in wireless communications.
Deep learning (DL)	A subfield of machine learning that uses the power of neural network to accelerate the processing of algorithms to make computations on huge amount of data.[40] Deep learning algorithms differ from machine learning algorithms in their ability to learn from unstructured and unlabeled data. Usually, human help is required in machine learning to label the data and make it readable by the program, with ML algorithms dealing with structured, labeled data. However, deep learning algorithms can process this data accurately without the need for human labelling.[41]
Feature	The machine learning expression for a piece of measurable information about something. If you store the age, annual income, and weight of a set of people, you are storing three

Term	Meaning as applied in the NCHRAC advice paper
	features about them. (http://www.datascienceglossary.org/#machinelearning)
Machine learning (ML)	The process that uses data and statistics to learn and generate algorithms and models to perform intelligent action on previously unseen data.[40]
Nature-inspired computing (NIC)	An interdisciplinary domain that combines the branch of computing science with other knowledge disciplines from sciences, e.g., physics, chemistry, biology, mathematics and engineering, to allow for the development of new computational tools such as algorithms and hardware. • NIC intelligence is an optimization technique based on the behavior of living organisms. • An NIC model seeks to achieve an objective within a set of constraints to be satisfied and the optimal solution is measured by a performance index known as objective function. • The nature-inspired algorithm can explore and exploit the search space using the naturally endowed random hunting skills of animals to find a global optimal solution. NIC algorithms are mainly categorized into evolutionary algorithms and swarm intelligence-based algorithms. • Evolutionary algorithms are based on the evolutionary behaviour of natural systems, e.g., genetic algorithm (GA), whereas swarm intelligence mimics the collective behaviour of natural swarms, e.g. the ant colony algorithm (ACO), and the wolf, ANT, dung beetle, particle swarm optimization (PSO) and BAT algorithms, plus many more.[16]
Neural network	A computational learning system that uses a network of functions to understand and translate a data input of one form into a desired output, usually in another form. Neural networks are currently the *de facto* way to deploy deep learning solutions. The concept of the artificial neural network was inspired by human biology and the way neurons of the human brain function together to understand inputs from human senses. Neural networks are just one of many tools and approaches used in machine learning algorithms. The neural network itself

Term	Meaning as applied in the NCHRAC advice paper
	may be used as a piece in many different machine learning algorithms to process complex data inputs into a space that computers can understand.[41, 42]
Point-of-care tests	A diagnostic test performed by an experienced healthcare professional at a healthcare providers.
Terahertz sensing technology	The process of directing terahertz beams (electromagnetic frequencies around 0.1–10 Terahertz [THZ]) to a person's body to detect the motion of the chest created by a heart beating or lungs inhaling or exhaling breath.[9]

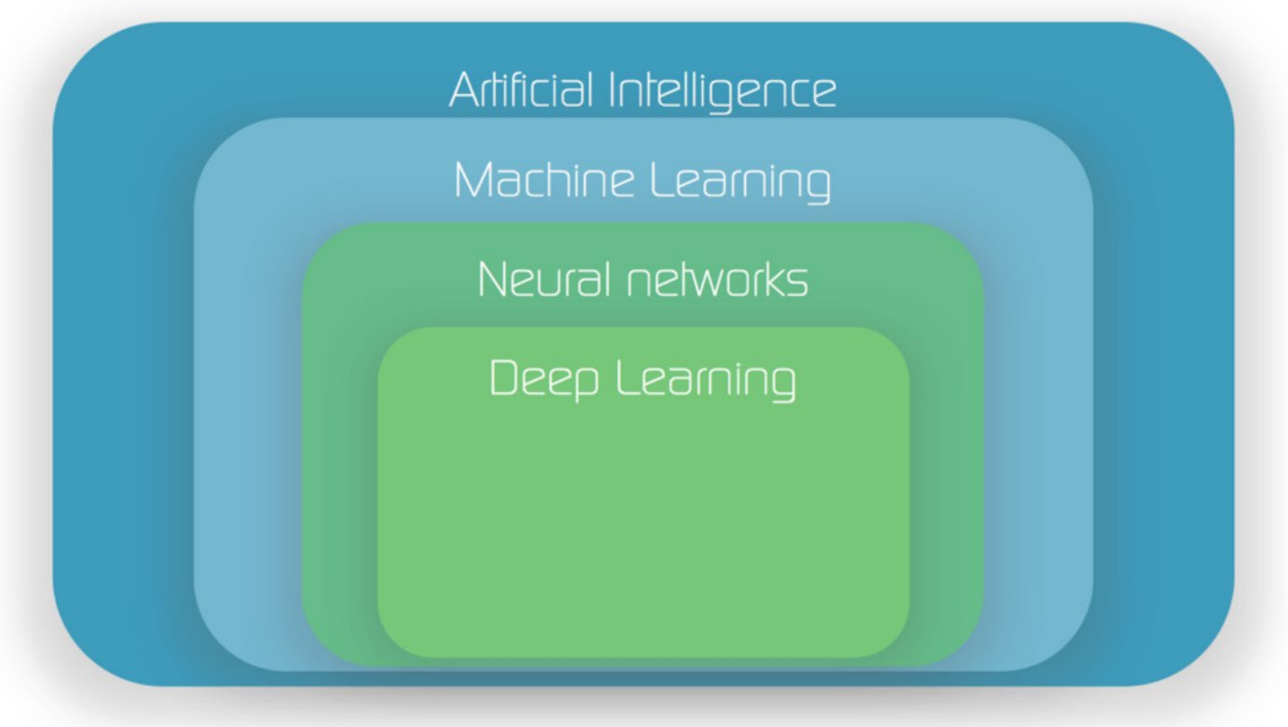

Figure taken from: Ray, T. Demystifying Neural Networks, Deep Learning, Machine Learning, and Artificial Intelligence, https://www.stoodnt.com/blog/ann-neural-networks-deep-learning-machine-learning-artificial-intelligence-differences/ (2018, accessed 22 December 2020).[43]

Attachment 2

Search strategy and results

1. PuBMed

1.1 Strategy

The search was guided by the question: *What new technologies or more active measures of case detection have been developed and how effective are they?*

A search of the PubMed database was conducted on 30 November 2020 using the following search terms:

COVID19 detection technology Filters: **Abstract, Free full text, Clinical Study, Clinical Trial, Comparative Study, Meta-Analysis, Randomized Controlled Trial, Review, Systematic Review, from 2020/5/1 - 2020/12/1** Sort by: **Most Recent**

("covid 19"[Supplementary Concept] OR "covid 19"[All Fields] OR "covid19"[All Fields]) AND ("detect"[All Fields] OR "detectabilities"[All Fields] OR "detectability"[All Fields] OR "detectable"[All Fields] OR "detectables"[All Fields] OR "detectably"[All Fields] OR "detected"[All Fields] OR "detectible"[All Fields] OR "detecting"[All Fields] OR "detection"[All Fields] OR "detections"[All Fields] OR "detects"[All Fields]) AND ("technology"[MeSH Terms] OR "technology"[All Fields] OR "technologies"[All Fields] OR "technology s"[All Fields])

Translations

- **COVID19:** "COVID-19"[Supplementary Concept] OR "COVID-19"[All Fields] OR "covid19"[All Fields]
- **detection:** "detect"[All Fields] OR "detectabilities"[All Fields] OR "detectability"[All Fields] OR "detectable"[All Fields] OR "detectables"[All Fields] OR "detectably"[All Fields] OR "detected"[All Fields] OR "detectible"[All Fields] OR "detecting"[All Fields] OR "detection"[All Fields] OR "detections"[All Fields] OR "detects"[All Fields]
- **technology:** "technology"[MeSH Terms] OR "technology"[All Fields] OR "technologies"[All Fields] OR "technology's"[All Fields]

A top-up search of the Pubmed database was performed on 7 January 2021 to cover the period between 1 December 2020 and 7 January 2021.

2. Additional evidence

2.1 Strategies

- MedRvix search using specific terms [title "COVID" (match all words) and abstract or title "detection test" (match phrase words) and posted between "08 Oct, 2020 and 09 Dec, 2020" on 9/12/20].
- Google search using the terms [“COVID-19 Detection”, “Case Detection Technology”, Case Detection Technology” and “UK”, “USA”, “Canada”, “Australia”, “Population”]
- Searching of key information sources including the NSW Agency for Clinical Innovation website, the National Institute for Health and Care Excellence (NICE UK) website, World Health Organisation (WHO) website, COVID-End website
- Press releases and media alerts (Nature Briefing emails, WHO email updates, CSIRO media announcements etc)
- Search of Australian patent database (https://www.ipaustral https://www.ipaustralia.gov.au/patents) on 7/12/2020 using the search term “COVID” returned 19 patents either filed or granted of which 2 were relevant. Search of the international patent database (https://patentscope.wipo.int/search/en/search.jsf) with the search terms: “COVID”, “detection” searching the front page of patents returned 107 patents of which 51 were relevant however insufficient information is provided in public summaries to be of use.

3.2 Results

MedRvix search: 1,202 Results – filtered first 50 results and screened the title – no relevant articles.

Grey literature search results:

Citation/Source and URL	Type of article	Key facts/Summary
Covid: New breath test could detect virus in seconds https://www.bbc.com/news/uk-wales-54718848	News article	Early trials of a new test for coronavirus open up the possibility of "rapid identification" for the disease in seconds rather than hours. The study, led by Loughborough University, evolved from the university's work on its toxi-triage project to help emergency services in civil disasters. The scientists concluded: "If shown to be reliable, it offers the possibility for rapid identification or exclusion of Covid-19 in emergency departments or primary care that will improve management of patients and safety of healthcare staff.

Citation/Source and URL	Type of article	Key facts/Summary
Rapid Research Information Forum – Monitoring wastewater to detect COVID-19 https://www.chiefscientist.gov.au/sites/default/files/2020-04/Monitoring%20wastewater%20to%20detect%20COVID-19_0.pdf	Rapid review	Wastewater-based epidemiology (WBE) techniques are used in routine surveillance for human pathogens and have provided valuable public health data. Developing similar WBE techniques for detection of SARS-CoV-2 is an active area of research and rapid improvements can be expected. Further understanding of SARS-CoV-2 infection biology and standardisation of WBE methods, along with improvements in their sensitivity and specificity, will enhance use of WBE tools to inform public health authorities of the prevalence of COVID-19 and management of its spread. Given the resolution of WBE techniques can facilitate the identification of communities in a given geographic location, there are concerns of stigmatisation of communities resulting from WBE. Careful thought must be given to research design and public release of data.
Karp DG, Cuda D, Tandel D, et al. Sensitive and Specific Detection of SARS-CoV-2 Antibodies Using a High-Throughput, Fully Automated Liquid-Handling Robotic System. SLAS TECHNOLOGY: Translating Life Sciences Innovation. 2020;25(6):545-552. doi:10.1177/2472630320950663 https://journals.sagepub.com/doi/full/10.1177/2472630320950663	Research article	As of July 22, 2020, more than 14.7 million infections of SARS-CoV-2, the virus responsible for Coronavirus Disease 2019 (COVID-19), have been confirmed globally. Serological assays are essential for community screening, assessing infection prevalence, aiding identification of infected patients, and enacting appropriate treatment and quarantine protocols in the battle against this rapidly expanding pandemic. Antibody detection by agglutination–PCR (ADAP) is a pure solution phase immunoassay that generates a PCR amplifiable signal when patient antibodies agglutinate DNA-barcoded antigen probes into a dense immune complex. Here, we present an ultrasensitive and high-throughput automated liquid biopsy assay based on the Hamilton Microlab ADAP STAR automated liquid-handling platform, which was developed and validated for the qualitative detection of total antibodies against spike protein 1 (S1) of SARS-CoV-2 that uses as little as 4 µL of serum. To assess the clinical performance of the ADAP assay, 57 PCR-confirmed COVID-19 patients and

Citation/Source and URL	Type of article	Key facts/Summary
		223 control patients were tested. The assay showed a sensitivity of 98% (56/57) and a specificity of 99.55% (222/223). Notably, the SARS-CoV-2–negative control patients included individuals with other common coronaviral infections, such as CoV-NL63 and CoV-HKU, which did not cross-react. In addition to high performance, the hands-free automated workstation enabled high-throughput sample processing to reduce screening workload while helping to minimize analyst contact with biohazardous samples. Therefore, the ADAP STAR liquid-handling workstation can be used as a valuable tool to address the COVID-19 global pandemic
M. Qjidaa et al., "Early detection of COVID19 by deep learning transfer Model for populations in isolated rural areas," 2020 International Conference on Intelligent Systems and Computer Vision (ISCV), Fez, Morocco, 2020, pp. 1-5, doi: 10.1109/ISCV49265.2020.9204099. https://ieeexplore.ieee.org/abstract/document/9204099	Research Article	To combat the spread of COVID 19, the World Health Organization suggests a large-scale implementation of COVID 19 tests. Unfortunately, these tests are expensive and cannot be provided and available for people in rural and remote areas. To remedy this problem, we will develop an intelligent clinical decision support system (SADC) for the early diagnosis of COVID 19 from chest x-rays which are more accessible for people in rural areas. Thus, we collected a total of 566 radiological images classified into 3 classes: a class of COVID19 type, a Class of Pneumonia type and a class of Normal type. In the experimental analysis, 70% of the data set was used as training set and 30% was used as the test set. After preprocessing process, we use some augmentation using a rotation, a horizontal flip, a channel shift and rescale. Our finale classifier achieved the best performance with test accuracy of 99%, f1score 98%, precision of 98.60% and sensitivity 98.30%
Diagnosis of COVID-19 by analysis of breath with gas chromatography-ion mobility spectrometry - a feasibility study	Research Article	There is an urgent need to rapidly distinguish COVID-19 from other respiratory conditions, including influenza, at first-presentation. Point-of-care tests not requiring laboratory- support will speed diagnosis and protect health-care staff. We studied the feasibility of using breath-analysis to distinguish these conditions with near-patient gas chromatography-ion mobility spectrometry (GC-IMS).

Citation/Source and URL	Type of article	Key facts/Summary
https://doi.org/10.1016/j.eclinm.2020.100609		Methods: Independent observational prevalence studies at Edinburgh, UK, and Dortmund, Germany, recruited adult patients with possible COVID-19 at hospital presentation. Participants gave a single breath-sample for VOC analysis by GC-IMS. COVID-19 infection was identified by transcription polymerase chain reaction (RT-qPCR) of oral/nasal swabs together with clinical-review. Following correction for environmental contaminants, potential COVID-19 breath-biomarkers were identified by multi-variate analysis and comparison to GC-IMS databases. A COVID-19 breath-score based on the relative abundance of a panel of volatile organic compounds was proposed and tested against the cohort data. Findings: Ninety-eight patients were recruited, of whom 21/33 (63.6%) and 10/65 (15.4%) had COVID-19 in Edinburgh and Dortmund, respectively. Other diagnoses included asthma, COPD, bacterial pneumonia, and cardiac conditions. Multivariate analysis identified aldehydes (ethanal, octanal), ketones (acetone, butanone), and methanol that discriminated COVID-19 from other conditions. An unidentified-feature with significant predictive power for severity/death was isolated in Edinburgh, while heptanal was identified in Dortmund. Differentiation of patients with definite diagnosis (25 and 65) of COVID-19 from non-COVID-19 was possible with 80% and 81.5% accuracy in Edinburgh and Dortmund respectively (sensitivity/specificity 82.4%/75%; area-under-the-receiver- operator-characteristic [AUROC] 0.87 95% CI 0.67 to 1) and Dortmund (sensitivity / specificity 90%/80%; AUROC 0.91 95% CI 0.87 to 1). Interpretation: These two studies independently indicate that patients with COVID-19 can be rapidly distinguished from patients with other conditions at first healthcare contact. The identity of the marker compounds is consistent with COVID-19 derangement of breath-biochemistry by ketosis, gastrointestinal effects, and

Citation/Source and URL	Type of article	Key facts/Summary
		inflammatory processes. Development and validation of this approach may allow rapid diagnosis of COVID-19 in the coming endemic flu seasons.
NUS spin-off company develops one-minute breath test to detect COVID-19, Mobi health news, 22 October 2020 https://www.mobihealthnews.com/news/asia-pacific/nus-spin-company-develops-one-minute-breath-test-detect-covid-19	News article	Breathonix's breath analysis technology works by detecting Volatile Organic Compounds (VOCs) present in a person's exhaled breath.
Bio-rad.com https://www.bio-rad.com/featured/en/covid-19-surveillance.html?tlp-link=%5bHeader%20Nav%5d%20%5bSurveillance	Webpage	Wastewater Testing Wastewater testing can be used to detect SARS-CoV-2 viral RNA shed in the stool of symptomatic and asymptomatic infected individuals, providing near real-time surveillance of SARS-CoV-2 viral spread at the community level. Wastewater testing provides a more complete snapshot of community spread than clinical testing and can serve as an early warning system for COVID-19 outbreaks. High levels of PCR inhibitors combined with low levels of virus complicate testing wastewater with traditional nucleic acid tests. Bio-Rad's SARS-CoV-2 ddPCR Assay overcomes these obstacles by providing an ultrasensitive, PCR inhibitor tolerant alternative. Bio-Rad's ddPCR technology is being used to predict and prevent COVID-19 community outbreaks
Digital technologies in the public-health response to COVID-19	Review article	Digital technologies are being harnessed to support the public-health response to COVID-19 worldwide, including population surveillance, case identification, contact tracing and evaluation of interventions on the basis of mobility data and

Citation/Source and URL	Type of article	Key facts/Summary
https://doi.org/10.1038/s41591-020-1011-4		communication with the public. These rapid responses leverage billions of mobile phones, large online datasets, connected devices, relatively low-cost computing resources and advances in machine learning and natural language processing. This Review aims to capture the breadth of digital innovations for the public-health response to COVID-19 worldwide and their limitations, and barriers to their implementation, including legal, ethical and privacy barriers, as well as organizational and workforce barriers. The future of public health is likely to become increasingly digital, and we review the need for the alignment of international strategies for the regulation, evaluation and use of digital technologies to strengthen pandemic management, and future preparedness for COVID-19 and other infectious diseases
This App Could Help Detect COVID-19 By Analyzing A Person's Speech https://spectrum.ieee.org/news-from-around-ieee/the-institute/ieee-member-news/this-app-could-help-detect-covid19-by-analyzing-a-persons-speech	IEEE Spectrum magazine	Speech contains inherent information about the physical, physiological, psychological, and emotional status of the speaker. Any variation in any of these is reflected in the person's speech. It generally isn't hard for a person to detect when someone is tired, happy, sad, angry, or sick just by listening to them speak. Using signal processing and AI, finer variations in speech characteristics, which may not even be perceived by the listener or the speaker, can be detected and used for diagnostic purposes. We are developing an app that can analyze an individual's speech to detect COVID-19 symptoms so that the person can be quarantined, tested, and provided with medical support at a much earlier stage.
Cough analysis app could detect COVID-19 by sound alone	News articles	AI-based framework by using smartphones to record cough and sound signals as input data to detect COVID-19

Citation/Source and URL	Type of article	Key facts/Summary
https://appleinsider.com/articles/20/10/31/cough-analysis-app-could-detect-covid-19-by-sound-alone Algorithm spots 'Covid cough' inaudible to humans https://www.bbc.com/news/technology-54780460		
A Systematic Review of Smartphone Applications Available for Corona Virus Disease 2019 (COVID19) and the Assessment of their Quality Using the Mobile Application Rating Scale (MARS) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7417101/	Systematic review	The global impact of COVID-19 pandemic has led to a rapid development and utilization of mobile health applications. These are addressing the unmet needs of healthcare and public health system including contact tracing, health information dissemination, symptom checking and providing tools for training healthcare providers. Here we provide an overview of mobile applications being currently utilized for COVID-19 and their assessment using the Mobile Application Rating Scale. We performed a systematic review of the literature and mobile platforms to assess mobile applications currently utilized for COVID-19, and a quality assessment of these applications using the Mobile Application Rating Scale (MARS) for overall quality, Engagement, Functionality, Aesthetics, and Information. Finally, we provide an overview of the key salient features that should be included in mobile applications being developed for future use. Our search identified 63 apps that are currently being used for COVID-19. Of these, 25 were selected from the Google play store and Apple App store in India, and 19 each from the UK and US. 18 apps were developed for sharing up to date information on COVID-19, and 8 were used for contact tracing while 9 apps showed features of both. On MARS Scale, overall scores ranged from 2.4 to 4.8 with apps scoring high in areas of functionality and lower in Engagement. Future steps should involve developing and testing of mobile

Citation/Source and URL	Type of article	Key facts/Summary
		applications using assessment tools like the MARS scale and the study of their impact on health behaviours and outcomes.
Wearable sensor data and self-reported symptoms for COVID-19 detection https://www.nature.com/articles/s41591-020-1123-x	Letter	Traditional screening for COVID-19 typically includes survey questions about symptoms and travel history, as well as temperature measurements. Here, we explore whether personal sensor data collected over time may help identify subtle changes indicating an infection, such as in patients with COVID-19. We have developed a smartphone app that collects smartwatch and activity tracker data, as well as self-reported symptoms and diagnostic testing results, from individuals in the United States, and have assessed whether symptom and sensor data can differentiate COVID-19 positive versus negative cases in symptomatic individuals. We enrolled 30,529 participants between 25 March and 7 June 2020, of whom 3,811 reported symptoms. Of these symptomatic individuals, 54 reported testing positive and 279 negative for COVID-19. We found that a combination of symptom and sensor data resulted in an area under the curve (AUC) of 0.80 (interquartile range (IQR): 0.73–0.86) for discriminating between symptomatic individuals who were positive or negative for COVID-19, a performance that is significantly better ($P < 0.01$) than a model1 that considers symptoms alone (AUC = 0.71; IQR: 0.63–0.79). Such continuous, passively captured data may be complementary to virus testing, which is generally a one-off or infrequent sampling assay.
These dogs are trained to sniff out the coronavirus. Most have a 100% success rate https://theconversation.com/these-dogs-are-trained-to-sniff-out-the-		Researchers running Helsinki pilot scheme say dogs can identify virus in seconds. Four Covid-19 sniffer dogs have begun work at Helsinki airport in a state-funded pilot scheme that Finnish researchers hope will provide a cheap, fast and effective alternative method of testing people for the virus.

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coronavirus-most-have-a-100-success-rate-143756 'Close to 100% accuracy': Helsinki airport uses sniffer dogs to detect Covid https://www.theguardian.com/world/2020/sep/24/close-to-100-accuracy-airport-enlists-sniffer-dogs-to-test-for-covid-19		