[FRANKD]

WHITE PAPER

COVID-19 & testing

a basic primer

August 2020

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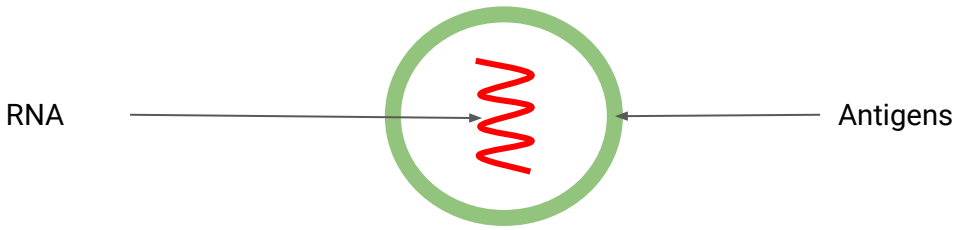
What is COVID-19?

SARS-CoV-2 is the name of this new virus, which causes the disease **COVID-19.** This virus contains genetic material (single stranded RNA, which is similar to double-stranded DNA that humans have). This is surrounded by a coat of proteins, called antigens. This virus belongs to a family of viruses called the **coronaviruses.**



Viruses are smaller than bacteria. Unlike bacteria, which can also cause disease but can reproduce on their own, viruses require host cells in order to reproduce.

A **vaccine** works by training the body's immune system to recognise and attack a virus when it encounters it.

There is currently no vaccine for COVID-19, although more than a hundred projects around the world are now looking for a vaccine.

https://www.healthline.com/health-news/heres-exactly-where-were-at-with-vaccines-and-treatments-for-covid-19#Vaccines

Vaccines normally take years or even decades to develop and successfully test for safety and efficacy. Even with the global effort to find a vaccine for COVID-19, the best estimates suggest it will take at least 6-18 months before one can be found, if one can indeed be found - this is by no means guaranteed.

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Typical Infection Cycle

Animals (probably **bats**) are believed to be the original source of the virus. However, the virus is now **spreading from person to person** (i.e. human-to-human transmission).

It is estimated that, on average, **one COVID-19 infected person will infect between 2 and 3 other people** i.e. the **R0 ("R nought")** factor is between 2 and 3; for comparison, the R0 of the seasonal flu virus is 1.3, and the R0 of the measles virus is between 12 and 18.

The virus seems to be **transmitted mainly via small respiratory droplets** through sneezing, coughing, or even breathing out or talking when people interact with each other.

These droplets can then be inhaled, or they can land on surfaces that others may come into contact with, who can then get infected when they touch their nose, mouth or eyes.

The **incubation period for COVID-19** (i.e. the time between exposure to the virus and onset of symptoms) is estimated to be **between 1 and 14 days.** The average incubation period between getting the virus and getting ill seems to be 4-5 days.

The **infectious period** most likely begins **1 to 2 days *before* symptoms appear** (if indeed they do have symptoms: 20-80% of people may be infected without symptoms - also known as **asymptomatic**). This is likely to **limit the effectiveness of screening people for symptoms such as fever, or temperature screens with temperature guns.**

The **infectious period is estimated to last for 7-12 days** in moderate cases and up to two weeks on average in severe cases.

Risk factors for severe infection include: being above 70 years of age; male gender; underlying health conditions (e.g. hypertension, obesity, diabetes, cardiovascular disease, chronic respiratory or kidney disease and cancer).

https://www.ecdc.europa.eu/en/covid-19/questions-answers

Given that the amount of virus in a person (and therefore in a sample from that person) will change throughout the course of their infection, there is concern that testing a person too early in their course of infection may result in a negative test result, because their viral load has not yet risen to a detectable level, rather than because they do not have the virus at all. **Scientists are increasingly recommending that repeated testing over a period of days is carried out to catch these very early infections.** This is particularly important to minimise the risk of spreading infection by airline passengers crossing international borders.

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Symptoms of COVID-19

COVID-19 symptoms may include the following: (However, many infected people may not develop any symptoms - see more on this later)

● **Fever** - the most common symptom BUT fever is not universal when patients first present with symptoms - see more on this later

● **Fatigue**

● **Dry cough**

● **Loss of appetite**

● **Myalgia** (muscle aches)

● **Difficulty breathing**

● **Sputum production**

● Abnormality of the sense of **smell** (anosmia) or **taste** (dysgeusia)

● **Nausea and diarrhoea**

● **Skin rashes**

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Infection and transmission of COVID-19 without symptoms

"**Asymptomatic infections have been well documented**" in COVID-19;

https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-epidemiology-virology-clinical-features-diagnosis-and-prevention

Between **20-80% of COVID-19 cases are thought to be asymptomatic;**

https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-epidemiology-virology-clinical-features-diagnosis-and-prevention

Presymptomatic or asymptomatic people who will not have symptoms such a fever will still be able to transmit infection. It is not yet known to what extent these types of infected people will transmit infection.

"It appears that SARS-CoV-2 can be transmitted prior to the development of symptoms and throughout the course of illness"- **people may indeed be most infectious just BEFORE they develop symptoms like fever** - a Chinese study "**suggested infectiousness started 2.3 days prior to symptom onset, peaked 0.7 days before symptom onset" - i.e. a person may actually be *most* infectious just *before* they have symptoms such as a fever - this limits the effectiveness of using temperature guns to screen for people with a temperature, or by using self-reported symptom questionnaires.**

https://www.ncbi.nlm.nih.gov/pubmed?term=32296168

Evidence has recently strengthened that **people with COVID-19 who are mildly ill and are recovering** have a low but real **possibility of infectiousness between 7 and 9 days after illness onset** - this has resulted in the **UK government increasing the self-isolation period from 7 to 10 days** for those in the community who have symptoms or a positive test result.
https://www.gov.uk/government/news/statement-from-the-uk-chief-medical-officers-on-extension-of-self-isolation-period-30-july-2020

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Measures that can help prevent the spread of COVID-19

Hygiene measures

A study has shown that hand washing ten times a day cuts the spread of SARS coronavirus by more than 50% https://www.bmj.com/content/336/7635/77. It is also important to clean and disinfect frequently touched objects and surfaces.

Physical distancing (e.g. >2 meters)

This reduces transmission of the virus between people in droplets as we speak, sneeze, cough or even breathe out. Common guidance suggests it is advisable to reduce exposure time with (potentially infected) people (<15 mins).

Although **lockdown measures** are effective in slowing transmission of the virus, they have **severe associated social, health and economic harms - there is an ongoing debate about the balance of the benefits of lockdown versus its harms both in the short and longer term.**

Regular screening

This may be with self-reported symptom questionnaires, temperature screening or, in the best case, testing for COVID-19 itself - **weekly screening of healthcare workers and other at-risk groups using PCR** (a type of virus test - see later for more details) or point-of-care tests for infection irrespective of symptoms is estimated to **reduce their contribution to transmission by 25-33%**, on top of reductions achieved by self-isolation following symptoms.
https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/covid-19/report-16-testing/

Contact tracing

This enables the interruption of further onward transmission. Contact tracing has been a key part of the response in several Asian countries that have successfully reduced case numbers. However, contract tracing alone will still rely on contacts self-isolating, which may prove unreliable. **Manual contact tracing is labour-intensive, and technologically automated contact tracing (e.g. using mobile phone apps) has significant technical limitations, and deep social risks,** such as transparency, accountability, proportionality, civil liberties, data sovereignty.

https://www.ecdc.europa.eu/sites/default/files/documents/COVID-19-Contract-tracing-scale-up.pdf

https://www.mobihealthnews.com/news/experts-warn-technical-limitations-contact-tracing-coronavirus

https://www.adalovelaceinstitute.org/our-work/covid-19/provisos-for-a-contact-tracing-app-4-may-2020/

Masks

These help with ‘source control’ i.e. preventing potentially infected people from spreading their infection to others - well-fitted surgical face-masks can help to significantly reduce the spread of infected droplets that people expel.

https://www.nature.com/articles/s41591-020-0843-2

Well-fitted N95 masks will also offer some protection to the wearer, but those with valves may allow potentially infected air to escape from the wearer to infect others.

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Temperature checks as a sole means of screening for infection

Temperature checks (e.g. by using temperature guns to screen people) as the sole means of controlling spread are unlikely to work.

There are various reasons for this:

- **Presymptomatic or asymptomatic people who may not have a temperature will still be able to transmit infection.**
- **Asymptomatic infections have been well documented** and between **20-80% of COVID-19 cases are asymptomatic.**

  https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-epidemiology-virology-clinical-features-diagnosis-and-prevention

- **Patients may indeed be most infectious just BEFORE they develop symptoms such as a fever.**
- "**Fever is not a universal finding on presentation**." - different studies suggest different numbers of SYMPTOMATIC people may lack the symptom of fever - **it is likely that most may have a fever at SOME POINT (but not necessarily at the beginning) of their illness.** A study in New York (https://www.ncbi.nlm.nih.gov/pubmed?term=32320003) showed that of hospitalised patients, **only 31% had a temperature >38°C *at presentation*** (i.e. when they first appeared to health care setting). Another study from Wuhan itself (https://www.ncbi.nlm.nih.gov/pubmed?term=32109013) showed that **only 44% of patients had a temperature >37.5°C on admission to hospital**.
- **This article also says temperature checks alone will not work, for similar reasons:** https://www.businessinsider.com/temperature-checks-flawed-coronavirus-cases-asymptomatic-no-fever-2020-5?r=US&IR=T
- All of the asymptomatic infected patients (20-80% of infection cases) by definition won't have any fever (i.e. the symptom of a raised temperature).
- There are many other **NON-COVID causes**, both pathological (e.g. bacterial and other viral infections such as the flu) and physiological (e.g. recent exercise), **that can raise the body's temperature.** A temperature screen will not be able to distinguish these from a raised temperature due to COVID-19.
- **Temperature measurement devices can vary significantly in their reliability.**
- **Infected people can take temperature-lowering medication (e.g. paracetamol/acetaminophen),** which may make a temperature reading appear normal, and thus falsely reassure authorities using temperature screening alone that they are not infected when they are. Likewise, a person who actually has a raised temperature but who has **just come inside from a cold external environment** may be incorrectly measured as having a normal temperature e.g. from a forehead temperature ‘gun’ (i.e. a non-contact infrared thermometer).
- **"Taken on its own, experts say absence of fever isn’t a reliable screening tool for COVID-19";** https://www.healthline.com/health-news/temperature-checks-not-effective-preventive-measure-against-covid-19#Does-it-help-stop-spread-of-COVID-19 (this article quotes an expert saying that 37.8°C is generally used as the cutoff for a true fever with regard to COVID-19 screening)

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Immunology - a very brief guide

When a person is infected with a virus, their body mounts an immune response, and produces particles called antibodies (also called "Ig" – pronounced "eye-gee"), which circulate in the blood and recognize a specific virus by the antigen on the virus coat, and then kill it.

The body takes some time to mount this immune response and produce various types of slightly different antibodies to a new virus that it has not seen before.

The first antibody that is produced by the body is called IgM – It is thought that this is produced in coronavirus infection after about 5-10 days from the start of symptoms. It is not yet known how long IgM lasts in the body/blood, but it usually declines once the next antibody (IgG) starts to be produced. IgM may slowly decline in the blood for several days, weeks or months – nobody yet knows.

The next antibody to be produced is called IgG. It is thought that IgG is produced in coronavirus infection after about 10-14 days from the start of symptoms. IgG may then remain circulating in your blood so that if the virus tries to re-infect you again in the future, the circulating IgG can immediately kill it (i.e. you are immune). However, again this is not yet known to be the case in COVID-19.

These tests that look for antibodies are also called serological tests, because they look for antibodies in blood samples, and blood is also called 'serum', hence 'serological'.

How to test for infection by the virus (present infection or past infection)

There are two types of tests that can each look for virus itself which is currently present in a person (e.g. from a throat swab):

- **ANTIGEN** tests: Antigen tests detect the presence of protein structures that are unique to the virus (e.g. spike proteins). Antigen tests are in general relatively less expensive and quicker to do, but are not as sensitive/accurate as molecular tests, especially during the early stages of infection. They may require also a special analyser to process a result.
- **Nucleic Acid Amplification Tests (NAATs), such as the RT-PCR** test and **RT-LAMP** (also called Molecular tests): These looks for the viral genetic material inside the virus, called RNA. They require a special machine to process a result. In the case of RT-PCR tests, this is usually in a laboratory and takes longer to process, requiring additional purification steps and equipment.

There is a third type of test which looks for **ANTIBODIES** that the body produces in response to a virus, rather than looking for the virus itself. These tests may indicate very recent or more remote previous infection.

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Does having IgG circulating in your blood mean you are immune to future re-infection from SARS-CoV-2?

Nobody knows this yet – only time will tell. It is possible that being infected does not offer any lasting immunity from re-infection.

There are several pieces of evidence that have been cited as support for the idea that an infected person will develop IgG antibodies, and will then become immune from reinfection for some period of time. These include:

- Low rates of re-infection in corona cases
- How immunity to other coronaviruses behaves – including the similar virus SARS-CoV (which was responsible for the SARS pandemic in 2003)
- Animal studies
- Some doubt cast on some of the studies that have shown rapid re-infection

However, there is also some evidence emerging that infection with SARS-CoV-2 may not mean a person is automatically immune from further reinfection:

A Chinese study from June 2020 (published in *Nature Medicine* https://www.nature.com/articles/s41591-020-0965-6) showed that antibodies faded quickly in both asymptomatic and symptomatic COVID-19 patient groups during recovery:

- >90% of both groups showed steep declines in levels of SARS-CoV-2 IgG antibodies within 2 - 3 months after onset of infection
- 40% of the asymptomatic group tested negative for IgG antibodies 8 weeks after they were released from isolation

These findings may mean that regular testing/retesting for the presence of the virus itself (over a long time period) is of even more critical importance (compared to testing for antibodies) in helping to control the spread of infection.

It is not yet known for sure if getting very sick from COVID-19 means you will make more antibodies than someone who is only mildly affected by the illness or has the virus without any symptoms.

Also, it is not yet known for sure if having a high level of antibodies in the blood (called the antibody titer) will offer you more immunity that if you have a low level of antibodies in the blood.

In addition to the antibody response, there has been some encouraging research that has shown that other parts of the immune system (called T-cells) may also be active in fighting infection with SARS-CoV-2 (e.g. https://www.biorxiv.org/content/10.1101/2020.06.29.174888v1.full)

However, T-cells are much harder to test for than antibodies, and may require several days of specialist laboratory testing to identify. Therefore, mass testing for this part of the immune response to infection may prove more difficult.

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Testing

Nucleic Acid Amplification Tests (NAATs)

There are several types of tests that all work by amplifying and detecting the genetic material inside the virus that may be contained in a tested sample - this genetic material is called nucleic acid - and so these tests are called Nucleic Acid Amplification Tests (NAATs).

NAATs are considered the gold standard reference test for diagnosing COVID-19.

NAATs include RT-PCR (Reverse Transcription Polymerase Chain Reaction) tests and RT-LAMP (Reverse Transcription Loop Mediated Isothermal Amplification) tests (such as the FRANKD test) - see below.

RT-PCR tests - how they work

Reverse Transcription Polymerase Chain Reaction (RT-PCR) is a technique for detecting genetic material (in this case, the genetic material of the SARS-CoV-2 virus, which causes the disease COVID-19).

The technique uses reverse transcription (RT) to convert the single-stranded viral RNA in to double-stranded DNA, through the use of enzymes, so it can be amplified.

This 'transcribed' viral DNA is then amplified hundreds of thousands of times in order to help make it detectable.

- Short fragments of DNA specific to the target sections of the viral DNA are added, along with fluorescent markers for those fragments, and the Polymerase Chain Reaction (PCR) cycles through hot and cool temperatures which induce chemical reactions that copy the viral DNA with every temperature cycle.
- Each cycle doubles the previous amount of viral DNA. So after about 35 cycles, a single strand of viral DNA may produce around 35 billion new copies.
- If the virus (DNA) is present, once it is amplified sufficiently, the fluorescent markers are then detected by the machine.

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When these machines are running traditional RT-PCR tests, they take a number of hours to return results. **A major benefit of a RT-LAMP test such as the FRANKD test is that the testing process takes a maximum of 30 minutes to return results, significantly reducing the time taken to issue a result to the person tested.**

Tests that can be processed on interchangeable hardware/machines offer users the opportunity to save costs, ensure multiple vendor sourcing, and offer more flexible/bespoke testing strategies suited to their particular requirements.

These PCR machines which can be used outside of a laboratory still cost approximately $7k - $30K USD (depending on the capacity, manufacturer and whether it is proprietary to a particular test).

Isothermal amplification tests such as RT-LAMP (e.g. the FRANKD test) - how they work

Whereas RT-PCR tests use heating/cooling cycles to help amplify the amount of genetic material present in a sample, more modern **Isothermal amplification tests** work in a very similar way, but **use special enzymes** to allow DNA amplification without requiring these time-consuming heating/cooling cycles.

This makes Isothermal amplification tests **quicker and easier to do**, and furthermore they do not rely on the same reagents that classical PCR tests require, and which may be in short supply during this global pandemic.

The **FRANKD test is one such Isothermal amplification test**, and can be carried out on a portable analyser that can be located at any site that requires testing at point-of-care. There are several subtypes of Isothermal amplification tests, one of which is called a **RT-LAMP (Reverse Transcription Loop Mediated Isothermal Amplification) test.** The FRANKD test is an example of a **RT-LAMP test**.

Reliability of Molecular tests (RT-PCR & RT-LAMP)

RT-PCR and RT-LAMP are types of Molecular tests, which can be very sensitive, as tiny amounts of viral genetic material can be amplified and detected. **RT-PCR and RT-LAMP tests tend to have higher Sensitivity and Specificity measures than Antigen or Antibody tests** (see more on these test reliability measures and Antibody tests later).

Another way of detecting the virus is an **Antigen test**. Antigen tests detect the presence of protein structures that are unique to the virus (e.g. spike proteins).

Antigen tests are in general relatively less expensive and quicker to do, but are not as sensitive as molecular tests, especially during the early stages of infection.

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Both **RT-PCR/RT-LAMP and antigen testing will only test for the current presence of virus in a person's sample** (e.g. from a throat swab). They will not tell you if a person has previously been infected with the virus which they have now cleared.

If a **poor sample is taken**, or is taken from a site in a person's body where there is currently no virus (even though there may be virus elsewhere in the body) then the test will come back as a false negative. This may also happen if the sample if taken too early or too late in an infection of COVID-19. **The UK government has been advised that these factors of poor sampling may contribute to a false negative error rate of between 2% and 20%,** irrespective of the technology of the particular test or analyser equipment used. https://www.bbc.co.uk/news/health-52906909

One way to reduce this sampling error is likely to be through **more frequent testing**, which will be easier to facilitate with Isothermal amplification on-site testing.

Some tests (e.g. FRANKD) can also **work with a less invasive saliva sample** (rather than a swab of the back of the throat or deep in to the nasal passage i.e. a nasopharyngeal swab sample). This sampling mode is likely to make frequent testing **easier to do** and **more acceptable to patients**, and thus **improve the overall testing accuracy.** It may also pose a **reduced risk of infection to healthcare workers compared to nasopharyngeal swab sampling.**

Saliva samples have recently been shown to be a reliable tool for detecting COVID-19 (paper in press; this study even found some patients whose salivary samples proved positive while their respiratory swabs showed negative results on the same days).
https://reader.elsevier.com/reader/sd/pii/S0163445320302139?token=F06DA41011BA53E8D04C6A33B3CAD1A568B5BA0FBB20BF74D1D66BD98E8236DC334E0F88537197E7EBC754DA979B204F

The reliability of the RT-PCR and RT-LAMP test can be measured in several ways:

- How **specific** the added DNA fragments are for enabling only the amplification of the viral genetic material you are interested in (in this case, that of SARS-CoV-2 virus).
- Analytical sensitivity: **Limit of Detection** (LOD) - the minimum concentration of DNA which consistently gives a positive PCR result using a particular method.
    - Other measures exist such as Limit of Quantification (LOQ), which is the minimum concentration of DNA that can be measured and quantified with defined precision and accuracy.

FRANKD SARS-CoV-2 RT-LAMP test - initial results

Sensitivity - Limit of Detection (LOD): 1 x 10^{-6} ng RNA virus, which corresponds to about **10 copies of the virus** (after 30 mins analysis).

- Detection of about 1000 PFU after 18 minutes

Specificity: **100% specificity** - tested against high levels of four other non-COVID-19 viruses from the coronavirus family and multiple other pathogens (i.e. this test did not result in any false positives result when these other non-COVID-19 coronaviruses/pathogens were tested). This is especially important when there is a low prevalence of a disease, and many people are being tested (as will be the case with COVID-19 in the coming months) - it is important not to have any false positives. For example, if a test had a specificity of 99%, and 500,000 people were tested daily, then there will be 5,000 false positives each day from that test, which may unnecessarily instigate new lockdowns etc.

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Clinical validation: An independent clinical trial (by DiMedical Diagnostic Laboratory) compared the gold-standard reference RT-PCR test (as per World Health Organisation (WHO) guidelines) to the FRANKD RT-LAMP test (using nasopharyngeal swab samples in both groups) in 120 clinical samples (60 positive for COVID-19, and 60 negative, as per RT-PCR) and found:

- **Sensitivity of 97%**
- **The FRANKD RT-LAMP method required significantly less time to analyse than the RT-PCR method recommended by WHO**
- A further independent clinical study starting in June will be carried out with a higher volume of sample data, comparing the RT-PCR reference test (using a nasopharyngeal sample) to the **FRANKD test (using a less invasive mouth saliva sample)** to verify this reliability

Reliability of antigen tests

Antigen tests can be useful as rapid screening tests, but they are less sensitive than molecular tests such as RT-PCR and RT-LAMP (for example, antigen tests have a sensitivity of only 80-85% vs. 97% for FRANKD RT-LAMP). **It is for this reason that the US FDA regulator recommends that antigen tests may still need to be confirmed by the more accurate molecular tests.**

Reliability of antibody tests

As mentioned, all medical tests have some inherent inaccuracy. In the case of antibody tests, scientists try to measure the reliability of any new test using two main measures:

- **Sensitivity** – this represents the probability of the test identifying patients who do in reality have the antibody ('reality' being defined by the established reference test for antibodies). In other words, the true positive rate.
- **Specificity** – this represents the probability of the test diagnosing the presence of the COVID-19 antibody specifically, without giving a false-positive result in a patient who in reality has, say, antibodies to a *different* virus. In other words, the true negative rate.

In order to know if a person really has the antibody, one needs to use an established reference test to compare a new antibody test, such as a 'fingerprick' antibody test. A reference antibody test might be an ELISA laboratory antibody test. ELISA stands for Enzyme-Linked Immunosorbent Assay. ELISA tests are a subset of a group of tests called EIA tests (Enzyme ImmunoAssay).

Another way to compare the reliability of a new antibody test is to compare it to patients who have tested positive for the viral RNA particles themselves (as tested for by the RT-PCR test). Sensitivity and Specificity are very useful measurements of how reliable a new test is compared to the established reference test.

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All of these measures of test reliability are calculated in formulas using measured values for a new test of True positives, False Positives, True Negatives and False Negatives.

There are other measures of the reliability of a test, such as Positive Percent Agreement, Negative Percent Agreement and Accuracy:

- **Positive and Negative Percent Agreement**: these measures are used when comparing agreement of a new test to a non-reference test for that measurement (e.g. comparing an antibody test to a test for viral RNA particles such as the RT-PCR test).
- **Accuracy**: In addition to sensitivity and specificity, the accuracy is also determined by how common the condition is in the selected population. A diagnosis for rare conditions in the population of interest may result in high sensitivity and specificity, but low accuracy. Accuracy needs to be interpreted cautiously.

Setting in which the test is carried out

No antibody, antigen, or molecular tests have so far been approved (either FDA EUA or CE mark) for home sample collection combined with home result processing.

Samples collected and processed at home may be less reliably collected and processed than those carried out by trained personnel.

There is also debate about whether serological (antibody) tests that use fingerprick (capillary) blood samples are as reliable as those that use blood taken from a vein (venous blood samples). All of the regulatory approvals for serological (antibody) tests to date have required that the blood sample be taken from a vein (via a needle) rather than be from a fingerprick blood sample.

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Testing machines for Molecular tests

LABORATORY-BASED machines:

These are testing machines (e.g. for RT-PCR) which are based in a laboratory, and require a high level of technical expertise to operate. These machines may be able to handle high volumes of tests. However, their downside is that they need to be operated in an expensive and often distant laboratory - one disadvantage of this is that the transport time to the laboratory delays the availability of results, and can contribute to invalid test results.

Many locations in the world are too far away from a laboratory which has the required equipment and trained personnel, and so those locations may not have sufficient/any access to such machines.

NON-LABORATORY BASED machines:

These include:

- Cartridge based tests: These require a special cartridge reader, which may itself be expensive to acquire due its to proprietary nature and single vendor sourcing.
- Using RT-PCR machines outside of a laboratory setting with tests that are technically easier to run that traditional RT-PCR tests, such as RT-LAMP tests (e.g. FRANKD) - see below. Some RT-LAMP tests will only work on specific PCR machines (e.g. proprietary machines for those specific tests). **Thankfully, some RT-LAMP tests, such as the FRANKD test, will work on a wide range of commercially available PCR machines, which therefore improves availability and buyer pricing.**
- Self-contained tests, such as Lateral Flow Assays (e.g. fingerpick tests) for antibodies. Whilst these have the benefits of ease-of-use, their main drawback is concerns over their accuracy; the US Food and Drug Administration (FDA) has recently removed the approval of a number such tests.

Outside of laboratories, PCR machines are available which have capacity for different numbers of test samples to be processed simultaneously (e.g. 6, 12, 24, 48, or 72 samples run in the machine at once).

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Mortality rate from COVID-19 infection

Mortality rate - The percentage of people who die after being infected **is still not known,** because it is not yet known how many people have been infected with the virus in total (given that a proportion of infected people will only have mild symptoms or no symptoms at all, and so would not have been tested/diagnosed with COVID-19).

There is a **wide range** of estimates of the **risk of dying** from COVID-19 infection, which range from **1 in 1000 to as high as 1 in 30.**
https://www.newscientist.com/article/2239497-why-we-still-dont-know-what-the-death-rate-is-for-covid-19/

Risk factors (e.g. age, existing medical problems, obesity, male gender, etc.) will increase an individual's risk of dying from COVID-19.

A study from the United Kingdom (not yet peer-reviewed) has found that **one third of of COVID-19 patients admitted to hospital died**, and **over half of COVID-19 patients put on a mechanical ventilator died.**
https://www.medrxiv.org/content/10.1101/2020.04.23.20076042v1

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Longer term health effects for people infected with COVID-19

Although most people recover from the acute COVID-19 infection within a few weeks, there are growing concerns amongst doctors about the **longer-term health effects of having been infected with COVID-19**. These include:

- Longer-term **lung damage** and shortness of breath
- **Kidney damage**
- Problems with the heart and **heart failure**
- Longer term **neurological symptoms** such as loss of taste or tingling sensations
- **Cognitive problems**
- **Chronic fatigue**
- **Psychological effects**

https://www.thetimes.co.uk/article/coronavirus-is-our-generations-polio-says-doctor-who-saved-boris-johnson-w2tk8pth0
https://www.bbc.co.uk/news/uk-scotland-52506669
https://www.dailymail.co.uk/health/article-8303305/Will-Covid-19-survivors-face-lifetime-illness-like-battled-polio.html

Scientists are increasingly emphasising that the full socioeconomic and health burden of COVID-19 is not fully reflected in the headline mortality rate measures (such as excess death rates); **these headlines measures fail to account for the longer-term ill health that is now being reported by some patients following infection with COVID-19.**

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