## Everything Is Worth Knowing about SARS-CoV-2 Rapid Tests

## We would like to give up-to-date information to our visitors. From time to time, there is more and more new scientific information on COVID-19 and its detection. To make this available we regularly update this page.

## Can it be detected if someone has been infected with the novel coronavirus?

**Yes, there are several methods for that. The three most frequently used are the following:**

* From several different types of human cells, the genetic matter (RNA) of the virus can be detected. This method is called PCR test (Polymerase Chain Reaction test). Obviously, it is impossible to spot the genetic matter of one single virus, but it is possible to detect multiple copies of it – the chain reaction is performed for producing the necessary amount of genetic matter.
* Certain proteins present especially in the SARS-CoV-2 virus are recognized by the human immune system (and triggers the immune response). These proteins are called antigens; the antigen tests can detect one of them.
* It is possible to detect the antibodies produced by the human body to the novel coronavirus. This method is called IgG/IgM, serology, serological, antibody or immunochromatography test.

The name “rapid test” usually refers to either of the latter two methods, because these tests can be performed quickly, in 15–30 minutes. (Older articles, on the other hand used the expression “rapid test” as a synonym of antibody test. The antigen tests have become wide-spread in the last couple of months.)

What is the theory of rapid tests?

**The human immune system is responsible for make a difference between the body’s “own” substances and cells and the “intruders”, such as bacteria or viruses. The job of the immune system is to fight of all these “intruders”.**

When the body meets a pathogen agent, the immune system notices that there is some trouble, by classifying certain substances as “intruders”. In simple terms, these are called antigens. These trigger the immune response, during which process the body starts producing antibodies. These antibodies bind to the antigens to form immunocomplexes (antigen-antibody complexes), which is one of the most important steps of eliminating the pathogen.

Thus, the **antigen test detects an antigen** (which is a protein of SARS-CoV-2) recognized by the immune system, too. The **antibody test detects certain antibodies** produced by the human body specifically against the SARS-CoV-2 virus.

## Who can perform a rapid test?

**In Hungary, only qualified and licensed medical staff (doctors, nurses etc). Private persons are not allowed to use a rapid test kit.** The rules may be different in other countries, therefore, we recommend you consult the local regulation.

The regulation applied to in vitro diagnostic tests for non-professional use is different to the same products intended for professional use. More on the legal background [**can be found here**](https://covid-19.hbs.hu/en/miert-nincsenek-a-piacon-otthoni-hasznalatra-is-alkalmas-covid-19-tesztek).

Moreover, there are other reasons that make non-professional use strongly not recommended:

* The regulation may be different from country to country, but usually only licensed institutions and/or persons are allowed to perform immunological assays (even if the testing takes place on-the-spot, for example in a factory). The efficient and safe use of these tests require proper specimen collecting environment, medical skills and knowledge. Improper specimen collection may lead to false test results!
* Epidemic health regulations must be obeyed by those who are using the tests.
* The materials, tools and specimens used during the testing count as hazardous waste.

## Why are there pages saying rapid tests are useless?

As always, “hot” topics make certain people posting content for increasing the panic, belittling the danger, spreading fake news, part-truth and statements taken out from their original context. It is the same for COVID-19. Unfortunately, it has not been without example that rapid tests have been used in a wrong way or the quality of the tests have been below standard.

We think it is worth clearing certain things that are often misunderstood, misinterpreted or misrepresented.

* **Rapid tests generate a false sense of security since they give negative result for infected people, too.**

As it was explained above, a negative result does not mean essentially that someone is not infected. That is why it is recommended to repeat the test later if the risk of being infected is high.

Antigen tests are the most reliable on the first week after the onset day (when the symptoms first appeared), whereas antibody tests effective from the second week after the onset day. Therefore, it is worth repeating the test or confirming the test result with the other rapid test or a PCR test even in case of a negative result if the risk of a persisting infection is considerable! It must not be forgotten that all the necessary precautions are to be obeyed regardless of the result of the test. Moreover, if the symptoms make it necessary, proper medical attention is the most important thing to do.

* **Tests are recommended only if someone has influenza-like symptoms.**

On the contrary. Check the corresponding sections of the tests about the recommendations.

* **Antibody tests can only detect the post-infection state.**

Wrong. IgM starts being detectable on the first week after the onset day. IgG indeed appears later in the body but it is usually present in the second half of the infection – and remains detectable for a long time. This alone makes those people identifiable who have already fought off the virus, which is in itself a valuable piece of information regarding the ability for work.

* **Antigen tests are so unreliable that it is not worth applying them.**

Indeed, these tests were started to apply for detecting COVID-19 later than the others, and the first products were not too reliable. But times have changed. Now there are antigen tests on the market almost as good as PCR tests. It is important to know, on the other hand, that antigen tests can used in the early-to-mid phase of the infection effectively; later they rarely detect the virus.

* **Rapid tests are suitable neither for monitoring nor for emergency cases.**

One of the most important advantages of antigen tests that they can be performed at point-of-care sites quickly and cost-effectively when the symptoms have already shown up or the risk of being infected is high. They are actually the best way to detect COVID-19 when the result is needed urgently and there is no time for a PCR test. For the same reason, it is worth considering using them if a lot of people needs to be tested in short time.

Regarding the antibody tests, they indeed cannot detect COVID-19 in the very early phase of the infection, because at that time there are very few antibodies present (if any). On the other hand, they can be done in large quantities quickly, they are capable of screening groups whose members are in regular contact with each other. (E.g. employees of a company or big families.) They are to identify whether the virus is already present among them.

Applying the antigen and the antibody tests together **it is possible to detect COVID-19 both in the early and the late phase of the infection**. Isolating those who are affected can considerably slow down the spread of SARS-CoV-2.

* **Rapid tests are useless Chinese tools, there is neither evidence for their efficacy nor approval for their use. That is why plenty of countries have stopped using them.**

These concerns are, unfortunately, real in certain cases – especially regarding a couple of products available at online shops. Sometimes there are indeed no data available about the manufacturer, the distributor or about any clinical trials performed on them.

In fact, only products with proper documentation, certificates and data about their efficacy can be marketed and sold in the European Union, which is independent of the manufacturing country.

The rapid tests imported by our company have the proper certificates and documentation, their registration numbers are shown on the product pages.

## Are PCR tests better than rapid tests?

From the aspect that PCR tests detect directly the virus (through its RNA), they are indeed better than antibody tests, because in the early phase of the infection there may not be enough antibodies present for detection.

Since PCR tests are usually more sensitive than antigen tests, they are indeed better.

**However, there are several reasons why PCR tests cannot replace rapid tests in all cases**.

* For performing a PCR test an instrument worth ten thousands of Euros is needed. The test itself and the other ingredients (used for e.g. isolating the genetic material of the virus) are expensive, too.
* Partly because of these financial reasons, partly because of the environment, instruments and licenses essential for performing a PCR test, much fewer institutions are able to perform them.
* In a given amount of time, much less PCR tests can be performed than rapid tests. The preparations needed for an antibody test last for a couple of minutes and the result can be obtained in 15 minutes. Performing an antigen test takes maximum 30 minutes, including the specimen collection and preparation. In case of a PCR test, both the preparations and the reactions take a lot of time – hours –, and often times people have to wait long either for having tested or for the results, or both.
* Performing an antibody test is very easy for a professional. Because of the relatively complicated specimen collection an antigen test is a bit trickier, but still, it can be performed anywhere, too. For preparing and running a PCR test, special skills are needed, and not many healthcare professionals have them. It cannot be done point-of-care: either the patient must travel to the testing point or the professionals have to travel to the patient for collecting the specimen.

According to some recent articles, the reliability of PCR test is questionable, too. Several researches have been done on these tests (for example: [**1**](https://asm.org/Articles/2020/April/False-Negatives-and-Reinfections-the-Challenges-of), [**2**](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7189409/)), but the most thorough summary was published by the John Hopkins University (Baltimore), which is one of the most prestigious institutions of the USA. [**Seven articles and 1330 PCR tests were reviewed by their researchers**](https://www.acpjournals.org/doi/10.7326/M20-1495), whose results were shocking.

It is known that the symptoms of COVID-19 usually appear 5 days after having been infected. During this time period, PCR tests were able to detect the virus **only in 0–33% of the cases**, depending on the day the test was actually taken on.

On the day of the onset of symptoms the performance of PCR tests was significantly better; **their sensitivity was 62%**. In the next 3 days it raised further, but **only to a sensitivity rate of 80%**. Afterwards – 9 days after having been infected, or 4 days after the onset – **the proportion of false negatives started to raise again**. Another 12 days later the **sensitivity of PCR tests dropped to 34%**.

Another summary which includes the opinion of 11 experts on the pandemic also emphasizes the high rate of false negatives of PCR tests: “They miss something like 30% of the infected people, and even more of those who are infected but not showing symptoms.”

Several conclusions can be drawn from these findings.

* **PCR tests are unable to detect the virus before the onset of symptoms** either; thus, it is impossible to tell whether someone who contacted with a confirmed case of COVID-19 actually caught the virus or not.
* It seems **there is a time interval the sensitivity of PCR tests the best is in**. It could be 1–7 days after the onset of symptoms – similar to antigen tests.
* Neither negative rapid test **nor negative PCR test results are capable of confirming the absence of the virus** if they are used as the only tool of diagnosing. Unfortunately,  [**it has elready been reported**](https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30322-4/fulltext), that two new infection clusters appeared because of a person who had been examined by PCR test twice – but both of the results had been negative!
* **The more time elapsed since the onset of symptoms, the less reliable the PCR tests are.**
* Although the reliability of rapid tests is often checked by performing PCR tests,**this appears to be a questionable method**.

According to the researchers of John Hopkins University, “Because antibodies appear later in the course of infection, a combination of antibody testing and RT-PCR might be the most useful for patients more remote from symptoms or exposure.”

The two methods seem to complement each other. In the early phase of the disease, RT-PCR tests are more reliable. About 2 weeks after the onset of symptoms it is worth using both tests. In the late phase of the infection, serological rapid tests appear to be more useful. However, whenever it is possible, as long as the symptoms are present, **it seems to be the best to apply both tests** so that COVID-19 could be diagnosed with the highest reliability. If someone is in the early phase of the infection, or it is suspected that someone is infected, an antigen test can replace the PCR test if getting the result quickly is essential. Antigen tests can replace PCR tests, too, when a lot of tests have to be performed and either PCR testing cannot be afforded or the capacity of the suitable laboratories are insufficient.

## How can the results of an antibody test and a PCR test be compared?

| **Test results** | | | **Most possible clinical explanation** |
| --- | --- | --- | --- |
| **PCR** | **IgM** | **IgG** |  |
| **+** | **-** | **-** | Patient may be in the window period of infection. (When the rapid tests cannot detect any antibodies.) |
| **+** | **+** | **-** | Patient may be in the early-to-mid stage of infection. |
| **+** | **+** | **+** | Patient may be in the mid-phase of infection. |
| **+** | **-** | **+** | Patient may be in the mid-to-late of infection (or he/she has been re-infected). |
| **-** | **+** | **-** | Patient may be in the early-to-mid stage of infection (and PCR result may be false negative) or the antibody result is false positive. |
| **-** | **-** | **+** | Patient may have had a past infection, and has recovered. |
| **-** | **+** | **+** | Patient may be in the mid-to-late stage of an infection, or PCR result might be false negative. |

## How can the results of an antigen test and a PCR test be compared?

Since both tests detect the virus itself, it is easier to interpret the results.

| **Test results** | | | **Most possible clinical explanation** |
| --- | --- | --- | --- |
| **PCR** | **Ag** |  |  |
| **+** | **-** |  | The patient is infected and the antigen test result must be false negative. |
| **+** | **+** |  | The patient is infected (the two results confirm each other). |
| - | **+** |  | The patient is infected, the PCR result must be false negative. |
| - | **-** |  | Most likely, the patient is not yet infected or not infected anymore. However, it is possible that the patient is in the late phase of the infection and neither tests can detect the virus. |

## It is said on the Internet that more often than not, positive results of a rapid test belong to people who are not infected at all!

It is true, in itself. However, for explaining this phenomenon a couple of concepts need to be explained. (In this section, we ignore the fact that rapid tests detect two kind of antibodies, for better understanding.)

The reliability of a test can be described with two different values. *Sensitivity* shows with what percentage a test can detect the event we search for (in our case, the antibody produced to SARS-CoV-2). *Specificity* shows what the chance is that the ground of a positive result is the event we search for (the antibody is actually present in the body and it is being produced because of the virus; again, in percentage form).

We need another concept, too. *Prevalence* gives us how many people have been infected in a certain area (e.g. a city or a country).

In the following example, imagine that a test works with 90% specificity and sensitivity, and the prevalence is 2%.

Using these data, if we examine a random sample of 1,000 people, there will be 20 infected persons, on average. 18 persons will be detected by the rapid test (2 of them will not – sensitivity is 90% - these 2 results are called false negatives). There are, on the other hand, 980 people who are not infected. The test will confirm the lack of the infection in 882 cases – but will give in 98 cases a positive result for healthy people, too (specificity is 90% – when the result shows infection by mistake, it is called false positive). Thus, the chance that a positive result belongs to an infected person is the following: 18(18+98)×100%, which is merely 15.52%. **This value is called positive predictive value**, counted by dividing the true positive cases with the sum of the true and false positive cases (multiplied by 100%).

The test will give a negative result for the 90% of the non-infected people, which is 882, plus for 2 of the infected ones. The chance that a negative value means the actual lack of infection is called **negative predictive value**. In our example, it is 884/(884+2)×100% - 99.77% (the true negatives divided by the sum of the true and false negatives, multiplied by 100%).

At first sight, this appears to be devastatingly bad: the chance of getting a false positive – the test shows the presence of the infection when there is no infection at all – is 84.48%! However, **this happens because of statistical reasons and has nothing to do with the particular rapid test. Whenever the prevalence is low, sensitivity and specificity have very little impact on the predictive values** – the 10% “specificity error” is paired with a huge amount of data (after all, most people are not infected), whereas the 90% sensitivity belongs to very few (the infected minority).

Without elaborating the deduction, it is worth looking at the following numbers, as well:

* If both specificity and sensitivity is raised to 95% and the prevalence is unchanged, the positive predictive value is still only 27.94%. The negative predictive value is 99.89%.
* If specificity and sensitivity remain 90% and we raise the prevalence to 4%, the positive predictive value is 27.27%, the negative predictive value is 99.53%.
* With specificity and sensitivity of 95% each, at 4% prevalence, these predictive values are 44.19% and 99.78%, respectively.
* If we raise the prevalence to 10%, with specificity and sensitivity of 90% each we get 50.00% for the positive predictive value and 98.78% for the negative predictive value. In case of specificity and sensitivity of 95% each, these values are 67.86% and 99.42%, respectively.

What we can see is the positive predictive value is affected by the prevalence at least as much as by the specificity and sensitivity of a test – in contrast, the negative predictive value changes very little as long as the prevalence is low. (The positive predictive value changes almost as much if we raise the prevalence to 4% as if we raise sensitivity and specificity to 95%!)

This is something that can be experienced regardless of COVID-19. **Whichever serological test we examine, the positive predictive value will be low if the prevalence is low, too.**(Actually, the same applies for any test. However, PCR and antigen tests rarely give false positive results, so their positive predictive value is much higher, especially if we consider the reasons described below.)

**Still, this does not mean that rapid tests are useless!**

Shortly said, there are three factors that are not taken into consideration at all in the deduction above.

**1. In case of an epidemic and/or a disease which causes severe symptoms, the primary objective is to detect those who are affected.** Even if there are several healthy people who get positive results. Regarding COVID-19, it would be a bigger risk not to find the infected (whose condition can become critical any time, and who can spread the virus, too) than to have a number of people examined thoroughly unnecessarily. Moreover, most SARS-CoV-2 rapid tests detect **two types of antibodies** – IgM and IgG –, which alone lowers the risk of remaining undetected. (Even if these antibodies are being produced in a different time interval.)

**2. Even if the positive predictive value of the rapid tests is low, using them narrows the amount of people who need to be examined further.** The method is cheap and quick, it is easy to test a lot of people with these tests. Therefore, only those are to be examined thoroughly who **may be infected**. In this way, fewer PCR test need to be made – these are more reliable, but, unfortunately, slower, more expensive and complicated, too. It must be pointed out that the safest way to diagnose those who are suspected to be infected is medical examination and history. If it is known that the subject has been in contact with infected people recently and he or she shows the typical symptoms of COVID-19, the chance of being infected is much higher than in case of a “mere” positive test result. Obviously, it would be the most efficient if every single person were examined thoroughly – but the capacity of the healthcare system is insufficient for this. Not only in Hungary, but also everywhere in the world.

**3. In case of an epidemic, prevalence is mostly theoretical.** Again, considering a prevalence of 2%, we can say the following: choosing 100 persons randomly we will find 2 infected on average. However, if we want to know **how many infected are there in an institution of 100 people** (e.g. a nursing home), **we are definitely not choosing that 100 people randomly!** If the virus has already appeared in that place, most likely there will be more than 2 infected persons – if not, prevalence will be exactly 0%. If we apply rapid testing to all these 100 people, **the sheer amount of positive results will give us information on the presence or the absence of the virus** – even if there are false positives and false negatives, too. That said, if 25% of the test results are positive, it is worth monitoring and confirming the infection with other methods too, for all the people. On the other hand, if there are only 1–2 positives, that might be because of false results; especially if no one shows the typical symptoms of COVID-19 currently, or in the near future.

Finally, we should not forget. **There is no test which is 100% reliable.** Thus, it is impossible to detect all the infected, nor to detect only the infected. The risk must be lowered to an acceptable rate, though, and that is what rapid tests are for.