COVID-19 Diagnostic Testing Chart

The COVID-19 pandemic has globally created disease and suffering for the world and the urgent need for diagnostic testing of patients and populations. In response a multitude of COVID-19 tests are available to use from many different manufacturers and organizations. The majority of available tests use a gold standard method to identify neucleic acids of the COVID-19 virus and some use protein antigens from the virus. Both types of testing (molecular and antigen) are summarized in the table below. Variations in patient respiratory sample collection methods also exist, with specifics included in a second table.

The basis for the molecular tests is to use regions of interest on the outer capsule of the COVID-19 virus to develop the probes used in molecular testing. The available tests generally target more than one of the regions of interest which improves the test ability to sustain activity if the virus mutates. The available tests differ as to which regions and how many of the regions are utilized. Some genes targeted within the regions of interest have proven more sensitive than others, thus the variability in sensitivity data among the tests (in vitro).

A link to tests that have received an Emergency Use Authorization (EUA) from the United States Food and Drug Administration (FDA) may be found at here.

A link to the authorized products from Health Canada may be found here.

The summary of the charts and introduction material is to provide pharmacists a quick understanding of the tests available to aid them in care and education of their patients within their practice.

The information contained in this COVID-19 Testing Chart is emerging and rapidly evolving because of ongoing research and is subject to the professional judgment and interpretation of the practitioner. ASHP provides this COVID-19 Testing Chart to help practitioners better understand current approaches related to COVID-19 testing. ASHP has made reasonable efforts to ensure the accuracy and appropriateness of the information presented. However, any reader of this information is advised that ASHP is not responsible for the continued currency of the information, for any errors or omissions, and/or for any consequences arising from the use of the information in the COVID-19 Testing Chart. Any reader of this document is cautioned that ASHP makes no representation, guarantee, or warranty, express or implied, as to the accuracy and appropriateness of the information contained in this COVID-19 Testing Chart and will bear no responsibility or liability for the results or consequences of its use. To the extent this COVID-19 Testing Chart is translated into languages other than English, any person or entity that relies on the translated content does so solely at their own risk. ASHP shall not be liable for any losses caused by reliance on the accuracy or reliability of translated information.

Types of COVID-19 Diagnostic Tests

COVID-19 Test Type	Molecular Testing—Major Examples			Antigen Testing
	RT-PCR	LAMP	CRISPR	
Term Definition	Reverse transcriptase polymerase chain reaction.	Loop-mediated isothermal amplification (LAMP).	Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR).	Rapid test for viral proteins or antigens of COVID-19.
What is the test identifying?	SARS- CoV-2 Viral RNA Presence [1]	SARS-CoV-2 Viral RNA Presence [1]	SARS-CoV-2 Viral RNA Presence [1]	Presence of the nucleocapsid protein antigen[5]
When should the test be used? Detectable COVID-19 virus begins approximately 3 to 7 days after exposure and peaks with symptom onset. [8,9]	Diagnosis of COVID-19 during the acute phase of infection Asymptomatic patients with COVID exposure Symptomatic patients[1]	For quicker diagnosis of COVID-19 during the acute phase of infection Asymptomatic patients with COVID exposure Symptomatic patients [1]	For quick diagnosis of COVID-19 during the acute phase of infection Asymptomatic patients with COVID exposure Symptomatic patients [1]	For quick diagnosis of COVID-19 during the acute phase of infection Asymptomatic patients with COVID exposure Symptomatic patients [1]
Where is the test conducted?	Medical laboratory [5]	Medical laboratory, Pharmacy, MD office, COVID-19 testing sites using point of care testing [5]	Medical laboratory, Pharmacy, MD office, COVID-19 testing sites using point of care testing [5]	Medical Laboratory, Pharmacy, MD office, COVID-19 testing sites using point of care testing [5]
How is the test sample obtained from the patient?	Various upper respiratory specimens (nasopharyngeal swab, oropharyngeal swab, anterior nasal swab, nasal mid-turbinate swab, saliva) [1,5]	Various upper respiratory specimens (nasopharyngeal, oropharyngeal swab, anterior nasal swab, saliva) [1,3]	Nasopharyngeal or oropharyngeal [5]	Nasopharyngeal or oropharyngeal [5]
Who can obtain the test sample?	All tests can be performed by a healthcare provider or trained operators Nasal mid-turbinate swab can also be performed by a supervised patient Anterior nasal swab and saliva collection can also be performed by a supervised or unsupervised patient [5]	All tests can be performed by a healthcare provider or trained operators Nasal mid-turbinate swab can also be performed by a supervised patient Anterior nasal swab and saliva collection can also be performed by a supervised or unsupervised patient [5]	Tests can be performed by a healthcare provider or trained operators.[5]	Tests can be performed by a healthcare provider or trained operators[5]

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	RT-PCR	LAMP	CRISPR	
How is the test performed by the laboratory?	The test uses nucleic acid amplification technology (NAAT) based on polymerase chain reaction where the RNA is extracted from the sample and transcribed into complementary DNA. Then, the primers will bind to the DNA which will allow for the DNA polymerase to copy it. The DNA polymerase will then degrade the bound probe, which will give off a fluorescence signal. The more copies of the virus DNA are made, there will be a greater fluorescence signal. Once the fluorescence signal reaches a certain threshold, then the test is positive for COVID-19.[1]	The LAMP tests use the same process as the RT-PCR except that it bypasses the thermal cycling process as it can provide amplification of the nucleic acids at constant temperatures. The amplified DNA can be detected by changes in turbidity, addition of intercalating dyes, or by a pH-sensitive dye. [3]	CRISPR is a biotechnological tool used for gene editing. It has the ability to detect certain DNA sequences such as those that exist in the SARS-CoV-2 virus.[1]	Using antibody-antigen recognition, rapid antigenic tests detect the presence of viral proteins. Antigenic strips are coated with antibodies that bind to a viral protein. The viral proteins in the blood sample bind to the antibodies forming a colored indicator on the strip. This change of color is normally induced by using the plasmonic properties of colloidal gold-based immunochromatographic assay, which helps provide sensitivity without losing the simplicity of lateral flow assays.[1]
How long does it take to run the test?	2 - 6 hours (average about 3 hours) depending on the manufacture Average of > 48 hours turnaround time [1]	5 - 13 minutes [1]	30 minutes [1]	15 minutes[5]
What does a positive test mean?	Definitive for active COVID-19. Positive results means that the fluorescence threshold is reached due to high number of DNA copies made. [1]	Definitive for active COVID-19. A positive result means that there is large amount of DNA seen. [1,3]	Definitive for active COVID-19. Positive results mean there is a detection of at least two SARS-CoV-2 viral gene targets.[1]	Positive results indicate the presence of viral antigens, but clinical correlation with patient history and other diagnostic information is necessary to determine infection status. [7]
What does a negative test mean?	Does not rule out COVID -19 due to chance of false negatives. [1]	Does not rule out COVID -19 due to chance of false negatives.[1,3]	Does not rule out COVID -19 due to chance of false negatives.[1]	Does not rule out COVID-19 due to chance of false negatives. [5]
Are there false positive results?	Yes. It is very unlikely for a false positive to occur; however, there is a slight chance due to contaminated specimens or inappropriate protocol implementation. Additionally, the patient may recover from COVID-19 and have small viral RNA particles	Yes. It is very unlikely for a false positive to occur; however, there is a slight chance due to contaminated specimens or inappropriate protocol implementation. Additionally, the patient may recover from COVID-19 and have small viral RNA particles	Yes, it is possible if specimen is contaminated or the protocol is not followed appropriately. [1]	Yes, it is possible if specimen is contaminated or the protocol is not followed appropriately. [1]

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COVID-19 Test Type	Molecular Testing—major examples			Antigen Testing
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Are there false negative results?	Yes. A false negative can occur due to inadequate levels of the virus, poor sample collection and preparation, and laboratory errors. [2]	Yes. A false negative can occur due to inadequate levels of the virus, poor sample collection and preparation, and laboratory errors. False negatives may also occur if an amplification inhibitor is present. [3]	Yes. Failure to detect the virus in infected patients (false negatives) can be due to low sensitivity or other issues, such as laboratories working under pressure, or poor sample collection and preparation.[1]	Yes. These false negatives are due to lower sensitivity compared to molecular diagnostic tests.[5]
Does the test need to be repeated?	This test should be repeated in a patient with a negative test and high clinical suspicion of COVID-19 as this test will not detect if the patient is at an early infection stage and the patient could still have symptoms in the futures. The test should not repeated after a positive COVID-19 test as the test will still be positive after the resolution of symptoms due to the detection of small viral	This test should be repeated in a patient with a negative test and high clinical suspicion of COVID-19 with a RT-PCR test. The test should not be repeated after a positive COVID-19 test as the test will still be positive after the resolution of symptoms due to the detection of small viral RNA particles. [1,3]	This test should be repeated in a patient with a negative test and high clinical suspicion of COVID-19 as this test will not detect if the patient is at an early infection stage and the patient could still have symptoms in the futures. The test should not repeated after a positive COVID-19 test as the test will still be positive after the resolution of symptoms due to the detection of small viral	The test should be repeated If both the Positive and Negative Controls fail during the testing process.[7] Additionally, a negative antigen test may require confirmatory testing with a molecular based diagnostic test prior to making treatment or prevention decisions.[5]
Key points to inform patients regarding the test	The RT-PCR test is the gold standard test for patients with current COVID-19. RT-PCR will only detect patients that are currently infected with COVID-19. This test does not show if the patient has had COVID-19 in the past or has current immunity to COVID -19. This test might cause a patient to get a false negative result if the patient is tested at an early infection state.	The LAMP test can be used as a point-of-care test due to quick test results and decreased equipment costs. However, the patient needs to know that point of care testing has more variable sensitivity than the RT-PCR testing and therefore a higher risk of false positives and false negatives. [1,3,9]	CRISPR based diagnosis represents a prime example where mixed technologies can lead, combining high specificity with efficient and -cost biosensors. They can also be run several time to decrease the chances of false negatives. [1,2]	The antigen tests may provider faster results but they also have lower sensitivity and specificity than molecular testing and therefore are plagued with more false negatives. [1,9]

Diagnostic Test Specimen Collection Methods

Specimen collection method [4,10,12]: Nasopharyngeal swab

Description of Collection Method	Who May Collect the Specimen	PPE Required
1. Have patient remove their mask 2. Blow nose into a tissue 3. Remove swab from packaging 4. Tilt the patient head back slightly 5. Ask patient to close eyes to lessen mild discomfort 6. Gently insert swab along nasal septum and parallel to the palate (not upwards) to nasopharynx until resistance it felt 7. Gently rub and roll swab and leave the swab in place for several seconds 8. Then, slowly remove the swab while rotating the swab several times 9. Ask patient to reapply their mask 10. Open the collection tube and inset the swab into the tube 11. Break the swab at the groove and discard the remaining swab 12. Close the labeled collection tube and wipe with surface-disinfectant wipe and place in a biohazard bad. [4,10]	Healthcare provider	• Protective gown • Nonsterile gloves • Protective mask with a rating of N95 or high • Face shield or goggles

Specimen collection method [3,5,10]: Oropharyngeal swab

Description of Collection Method	Who May Collect the Specimen	PPE Required
1. Have patient remove mask 2. Remove swab from packaging 3. Swab the posterior pharynx, tonsils, or other inflamed areas. Avoid touching the tongue, cheeks, and teeth with the swab 4. Ask patient to reapply their mask 5. Open the collection tube and insert the swab into the tube 6. Break the swab at the groove and discard the remaining swab 7. Close the labeled collection tube and wipe with surface-disinfectant wipe and place in a biohazard bag.	Healthcare provider	• Protective gown • Nonsterile gloves • Protective mask with a rating of N95 or high • Face shield or goggles

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Specimen collection method [3,5,10]: Nasal mid-turbinate swab

Description of Collection Method	Who May Collect the Specimen	PPE Required
1. Ask patient to remove mask 2. Remove swab from packaging 3. Tilt head back 70 degrees 4. Direct mid-turbinate swab straight back along nostril floor until stopper hits the nostril. 5. Rotate the swab several times (10 – 15 seconds), then slowly remove from the nostril 6. Repeat in the other nostril using same swab 7. Ask patient to reapply their mask 8. Open the collection tube and insert the swab into the tube 9. Close the labeled collection tube and wipe with surface-disinfectant wipe and place in a biohazard bag. [3]	Healthcare provider or supervised patient	If the pharmacist is collecting the specimen then: • Protective gown • Nonsterile gloves • Protective mask with a rating of N95 or high • Face shield or goggles If the patient is obtaining the sample and the pharmacist is collecting the specimen then: • 6 ft distance from the patient • Gloves and mask

Specimen collection method [3,5,10]: Anterior Nasal Swab

Description of Collection Method	Who May Collect the Specimen	PPE Required
1. Ask patient to remove mask 2. Remove direct nasal swab from packaging 3. Carefully insert the swab into the nostril exhibiting the most visible drainage or the nostril that is most congested if drainage is not visible. 4. Using gentle rotation, push the swab until resistance is met at the level of the turbinates (less than one inch into the nostril) 5. Rotate the swab several times against the nasal wall and leave in place 10 to 15 seconds then slowly remove from the nostril 6. Using the same swab, repeat the sample collection in the other nostril 7. Ask patient to reapply their mask 8. Open the collection tube and insert the swab into the tube. Immediately run the POCT test.	Healthcare provider, supervised patient, or unsupervised patient	If the pharmacist is collecting the specimen then: • Protective gown • Nonsterile gloves • Protective mask with a rating of N95 or high • Face shield or goggles If the patient is obtaining the sample and the pharmacist is collecting the specimen then: • 6 ft distance from the patient • Gloves and mask

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Specimen collection method [6,10,11]: Saliva sample

Description of Collection Method	Who May Collect the Specimen	PPE Required
1. Prior to test, ask the patient to avoid water for 10 minutes prior to the test and to avoid food, other liquids, or brushing of teeth for 30 minutes prior to the test. 2. Ask patient to remove mask if applicable 3. Hand specimen cup to patient 4. Ask the patient to allow the saliva to pool in their mouth for a few seconds without swallowing and then lean forward and let it drip (do not spit or cough) into the specimen cup repeatedly until roughly one third of the cup is full or up to 2 mls with liquid (excluding bubbles) 5. Ask patient to securely close liquid before handing back to healthcare worker 6. Ask patient to reapply their mask 7. Wipe the specimen container with surface-disinfectant wipe and place in a biohazard bag.	Healthcare provider, supervised patient, or unsupervised patient	If the pharmacist is collecting the specimen then: • Protective gown • Nonsterile gloves • Protective mask with a rating of N95 or high • Face shield or goggles If the patient is obtaining the sample and the pharmacist is collecting the specimen then: • 6 ft distance from the patient • Gloves and mask

References:

1. Santiago I. Trends and Innovations in Biosensors for COVID-19 Mass Testing [published online ahead of print, 2020 May 4]. Chembiochem. 2020;10.1002/cbic.202000250. doi:10.1002/cbic.202000250
2. Ward S, Lindsley A, Courter J, Assa'ad A. Clinical testing for COVID-19. J Allergy Clin Immunol. 2020;146(1):23-34. doi:10.1016/j.jaci.2020.05.012
3. ID Now COVID-19 [package insert]. Scarborough, ME: Abbott Diagnostic Scarborough, Inc; 2020.
4. Marty FM, Chen K, Verrill KA. How to Obtain a Nasopharyngeal Swab Specimen. N Engl J Med. 2020;382(22):e76. doi:10.1056/NEJMvcm2010260
5. Goode JVR, Page A, Burns A, Bernard S, Wheawill S, Gatewood SBS, The Pharmacist's Role in SARS-CoV-2 Diagnostic Testing, Journal of the American Pharmacists Association (2020), doi: https://doi.org/10.1016/j.japh.2020.08.017.
6. Wyllie, A., et al., 2020. Saliva Is More Sensitive For SARS-Cov-2 Detection In COVID-19 Patients Than Nasopharyngeal Swabs. [online] medRxiv. Available at: <https://doi.org/10.1101/2020.04.16.20067835> [Accessed 24 August 2020].
7. Sofia SARS Antigen [package insert]. Quidel Corporation; 2020.
8. Sethuraman N, Jeremiah SS, Royo A. interpreting Diagnositc Tests for SARS-CoV-2. J of Am Med Assoc. 2020;323:2249-51.
9. Chau CH, Strope JD, Figg WD. COVID-19 Clinical Diagnostics and Testing Technology Pharmacotherapy. 2020;40:857-868.
10. Centers for Disease Control and prevention. Interim Guidelines for Collecting, Handling, and Testing clinical Specimens for COVID-19. https://www.cdc.gov/coronavirus/2019-ncov/lab/guidelines-clinical-specimens.html#:~:text=Using%20a%20flocked%20or%20spun%20polyester%20swab%2C%20insert%20the%20swab,both%20nostrils%20with%20same%20swab. (Accessed August 31, 2020)
11. DeMarco C. Do COVID-19 saliva tests work? MD Anderson Cancer Center. https://www.mdanderson.org/cancerwise/do-covid-19-coronavirus-saliva-tests-work.h00-159384312.html. Published August 24, 2020. Accessed September 2, 2020.

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