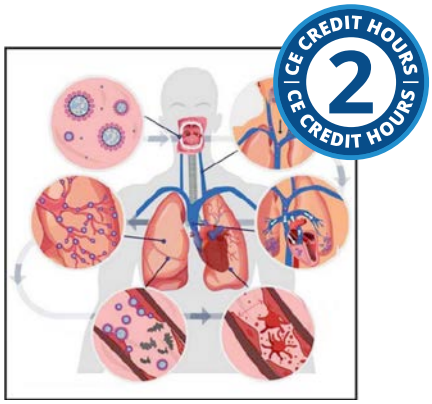
What You Need to Know About the Coronavirus (COVID-19) Pandemic



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Conflict of Interest Disclosure Statement

- Ms. Goldie reports no conflicts of interest associated with this course. She has no relevant financial relationships to disclose.

Introduction – Coronavirus Pandemic

This course will review characteristics of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)—the causative virus for COVID-19, the immunologic and genetic influences on COVID-19 disease severity, the implications of the COVID-19-induced cytokine storm, and the pathophysiological mechanisms associated with viral infection. It will further help dental healthcare professionals assess systemic risk factors that may influence COVID-19 severity and will summarize currently available and developing potential treatments and vaccines, including the concept of herd immunity. Finally, this course will explore the published scientific data identifying a potential connection between COVID-19 and periodontal diseases and the underlying mechanisms that are in-common to both diseases.

Course Contents

Overview

The ongoing coronavirus disease pandemic was first identified in late 2019 and its ongoing impact on nearly all aspects of our lives, including the delivery of dental care. One of the perplexing aspects of the current pandemic has been the heterogeneity of COVID-19 disease presentation and the influences of host factors and comorbidities on COVID-19 disease presentation. The current course will review characteristics of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)—the causative virus for COVID-19, the immunologic and genetic influences on COVID-19 disease severity, the implications of the COVID-19-induced cytokine storm, and the pathophysiological mechanisms associated with viral infection. This course will further help dental healthcare professionals critically assess systemic risk factors that may influence COVID-19 severity and will summarize currently available and developing potential treatments and vaccines, including the concept of herd immunity. Finally, this course will explore the published scientific data identifying a potential connection between COVID-19 and periodontal diseases and the underlying mechanisms that are in-common to both diseases—the roles of pro-inflammatory cytokines in their pathophysiology and leverage that knowledge to promote the importance of the establishment and maintenance of oral health and hygiene in the COVID-19 era.

Learning Objectives

Upon completion of this course, the dental professional should be able to:

- Understand the cytokine storm associated with severe COVID-19 disease presentation.
- Summarize the current knowledge regarding treatments and potential vaccines.
- Analyze the concept of herd immunity and its implications in the global pandemic environment.
- Recognize the evidence supporting a link between COVID-19 and periodontal diseases.
- Formulate a self-care oral health program for susceptible individuals.

Introduction

The new coronavirus epidemic is thought to have begun in Wuhan, China, in late December 2019, and there were 152,977,490 cases globally, according to John Hopkins University as of this writing.[1] COVID-19 was recognized as a pandemic by the World Health Organization (WHO) in March 2020. In the time since the identification of the COVID-19 pandemic, the heterogeneity of COVID-19 disease presentation and the influences of host factors have proved baffling to many in the medical community and have focused attention on comorbidities that may influence COVID-19 presentation.

Why do oral health care professionals need to understand this virus so completely? One reason is that a first-ever study shows the oral cavity is a robust site for infection and for sources of transmission of COVID-19.[2] As well, the influences of pro-inflammatory oral conditions on COVID-19 disease severity are of importance. A research team found that the coronavirus has an affinity for binding to cell-membrane receptors that are highly expressed in salivary gland tissues.[2] This allows the virus to replicate, and in some cases, may allow

for prolonged disease when infected saliva is swallowed into the gastrointestinal tract or aspirated to the lungs where it can lead to pneumonia. Based on angiotensin converting enzyme 2 (ACE2) expression and evaluation of cadaver tissue, the most likely sites of infection in the mouth are the salivary glands, tongue, and tonsils. The amount of virus in a patient's saliva was positively correlated with taste and smell changes.[2] Additionally, other research has demonstrated that SARS-CoV-2, the causative pathogen for of coronavirus disease 2019 (COVID-19), suppresses the expression and function of ACE2 and induces the expression of interferon-stimulated genes at the initial phase of infection.[2] SARS-CoV-2 uses the ACE2 receptor to facilitate viral entry into target cells, including oral mucosal epithelium.[3]

While much of COVID-19 research has centered on the upper respiratory tract, including the nasopharynx, nose and lungs, the Huang study is the first to identify the mouth as a primary site for coronavirus infection and highlights the significance of wearing a face covering and physical distancing to reduce viral transmission.[2] There were other studies identifying high ACE2 expression in salivary glands and discussing high affinity for SARS-COV virus in the SARS pandemic.[4-6] Collaborative efforts led by the Human Cell Atlas (HCA) utilized single cell RNA sequencing (scRNAseq) datasets from across the body to examine cell-specific SARS-CoV-2 tropism, leading to the COVID-19 Cell Atlas.[7] Tropism is defined as a growth response in a organism that lacks the ability to move, caused by an external stimulus.[8]

Recent evidence suggests a relevant role of the oral cavity in the transmission and pathogenicity of SARS-CoV-2. We now know that SARS-CoV-2 can infect and replicate in the oral mucosa or glands.[9-11] This is critical because if the glands or mucosa are sites of early infection, they may play an important and underappreciated role in transmitting virus intramucosally to the lungs or gastrointestinal tract.[2] Alternatively, saliva may also play a role in transmitting the virus extraorally from asymptomatic, pre-symptomatic, or symptomatic individuals.

The human oral cavity is a diverse collection of tissue niches with potentially unique vulnerabilities to viral infection.[2] These sites include oral mucosae (hard palate, buccal mucosa, dorsal and ventral tongue) as well as the terminally differentiated secretory epithelia of the minor saliva glands (distributed in the buccal and labial mucosa, hard and soft palate, ventral, and dorsal tongue) and major saliva glands (parotid, submandibular, and sublingual). Nearby are diverse oropharyngeal niches (palatine and lingual tonsils, soft palate). Saliva, a mixture of fluids, electrolytes, proteins, and cells (immune and sloughed mucosal epithelial cells) is made primarily by the saliva glands and empties into the oral cavity where it mixes with other fluids (crevicular fluid) and cells.

Pandemic Features

According to the World Health Organization (WHO), a pandemic is defined as the "worldwide spread of a new disease."[12] When a new disease initially appears, most individuals lack the natural immunity to defend against it. This can cause a sudden, sometimes rapid, spread of the disease between people, across communities, and around the world. Without a natural immunity to fight off an illness, many people can become ill as it spreads. This is the case with Coronavirus Disease 2019 (COVID-19) pandemic.

Pandemics are not automatically defined by their growth rate but rather by the spread of the disease. Understanding the *growth rate* of a pandemic can still help health officials prepare for an outbreak. The WHO is responsible for announcing the emergence of a new pandemic based on how the spread of the disease fits into the Pandemic Influenza Preparedness and Response.[13]

- **Phase 1**. Viruses circulating among animal populations have not been shown to transmit to human beings. They are not considered a threat and there's little risk of a pandemic.
- **Phase 2.** A new animal virus circulating among animal populations has been shown to transmit to human beings. This new virus is considered a threat and signals the potential risk of a pandemic.
- **Phase 3.** The animal virus has caused

disease in a small cluster of human beings through animal to human transmission. However, human to human transmission is too low to cause community outbreaks. This means that the virus places humans at risk but is unlikely to cause a pandemic.

- **Phase 4.** There has been human-to-human transmission of the new virus in considerable enough numbers to lead to community outbreaks. This kind of transmission among humans signals a high risk of a pandemic developing.
- **Phase 5.** There has been transmission of the new virus in at least two countries within the WHO Region Trusted Source. Even though only two countries have been affected by the new virus at this point, a global pandemic is inevitable.
- **Phase 6.** There has been transmission of the new virus in at least one additional country within the WHO region. This is known as the **pandemic phase** and signals that a global pandemic is currently occurring.

Many disease outbreaks follow a growth or spread pattern defined as *exponential growth*. This means they spread at a rapid rate over a specific period of days, weeks, or months.[14] Past pandemics include (but are not limited to): 1) the 1918 flu pandemic (H1N1 virus) from 1918-1920, which took the lives of anywhere from 50 to 100 million people around the world,[15] 2) the 1957 flu pandemic (H2N2 virus), which occurred from 1957–1958 and took the lives of roughly 1.1 million people worldwide,[16] and 3) and the 2002 SARS pandemic, which was associated with another coronavirus—SARS-CoV.17 The 2002 SARS coronavirus outbreak was a viral pneumonia epidemic that took the lives of over 770 people worldwide.[17]

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and Modes of Transmission

SARS-CoV-2 is a zoonotic human coronavirus (CoV) closely related to those coronaviruses that previously caused severe acute respiratory syndrome (SARS-CoV) and Middle East respiratory syndrome (MERS-CoV).[18] Coronaviruses have a lipoprotein envelope with spinous processes that resemble a crown (corona).[19] Coronaviruses that circulate among humans are usually benign and cause about a quarter of "common cold" illnesses.[20] Today and starting in 2019, a severe infection associated with a coronavirus, COVID-19, has emerged. This is a new, or novel, illness caused by a previously unknown coronavirus, SARS-CoV-2. It is postulated that SARS-CoV-2 emerged into the human population through an initial zoonotic virus that was infecting bats, which are a natural animal reservoir. This virus may have mutated and ultimately started causing disease in humans. Due to the novel nature of the SARS-CoV-2 virus, the long incubation period and worldwide spread, and the rapid development of treatments and vaccinations, the overall infection rate, mortality rate, and other statistics are, as of yet, unknown.

Modes of transmission for SARS-CoV-2 include contact, droplet, airborne, fomite, fecal-oral, bloodborne, mother-to-child, and animal-to-human transmission.[21] Infection with SARS-CoV-2 primarily causes respiratory illness ranging from mild disease to severe disease and death, and some people infected with the virus never develop symptoms.[21]

Immunology

The virus that causes coronavirus disease 2019 (COVID-19) attaches to specific molecules on the host cell surface, opening accesses into the cell interior.[22] Viral entry into host cells can cause an overwhelming immune response in some patients. Much of this immune response is focused within the lungs, which explains why many patients hospitalized with COVID-19 have severe respiratory symptoms. In addition to respiratory symptoms, there is also blood vessel inflammation, neurological symptoms, including dizziness, headache, nausea, and loss of concentration.[22] These symptoms indicate that SARS-CoV-2 affects cells of the central nervous system. A recent study reveals that the spike proteins that are on the surface of SARS-CoV-2 promote inflammatory responses on the endothelial cells that form the blood-brain barrier.[22] It is also known that SARS-CoV-2 infects host cells by using its spike proteins to bind to the ACE2 receptors on the host cell surface.[22]

In efforts to create a transparent interpretation of SARS-CoV-2 protective immunity, antibody analysis has been paralleled by T-cell studies

among patients with asymptomatic, mild, and severe COVID-19.[23] Defining CD4 and CD8 effector functions in protection is important, considering that antibody responses to natural infection appear short-lived and T-cell memory is potentially more durable. To fully understand population-level immunity, screening for both antibody and T-cell immunity using standardized testing methods may would be beneficial.[23]

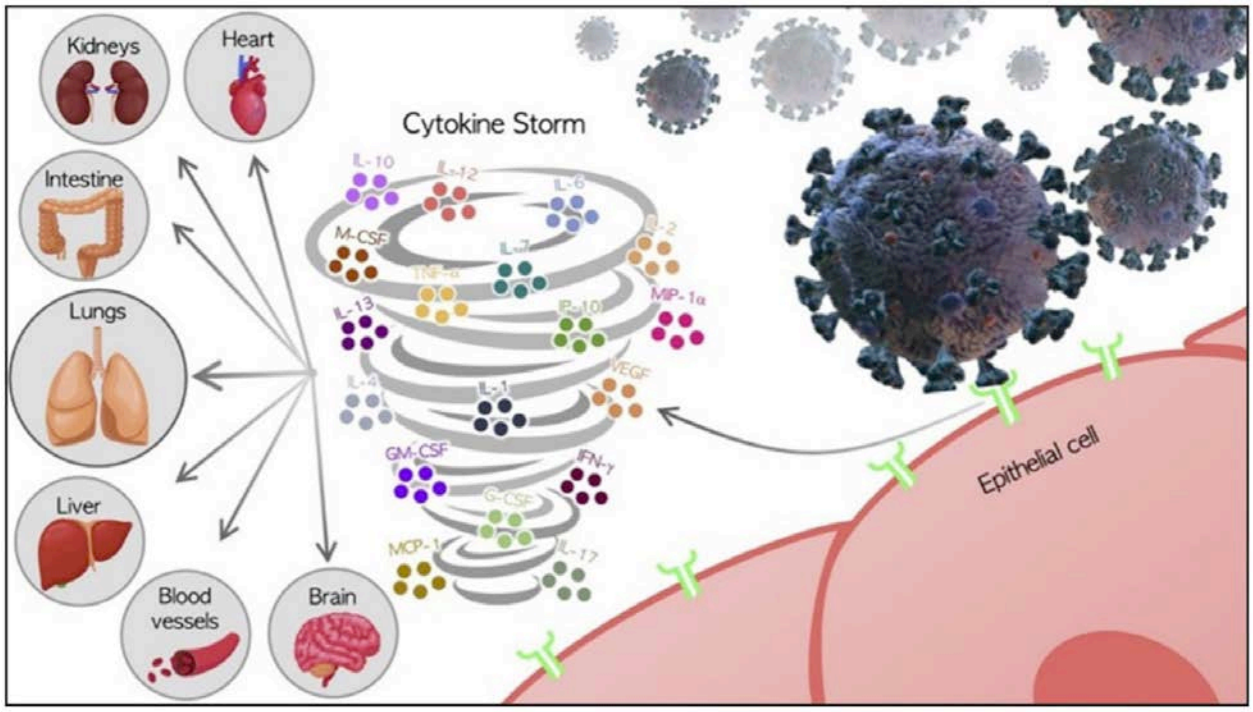
To appreciate the ongoing propagation of the virus, to identify those who are and were infected, and to follow the immune response longitudinally, reliable and rigorous analyses for SARS-CoV-2 detection and immunological monitoring are needed. SARS-CoV-2 antibodies are detectable up to seven months post symptomatic COVID-19 onset, and a recent study shows that 90% of subjects have detectable antibodies 40 days up to 7 months post contracting COVID-19.[24] The study then evaluated the function of these antibodies, namely, their neutralizing activity against the virus SARS-CoV-2. The study emphasizes a continued level of circulating neutralizing antibodies in most people with confirmed SARS-CoV-2.[24]

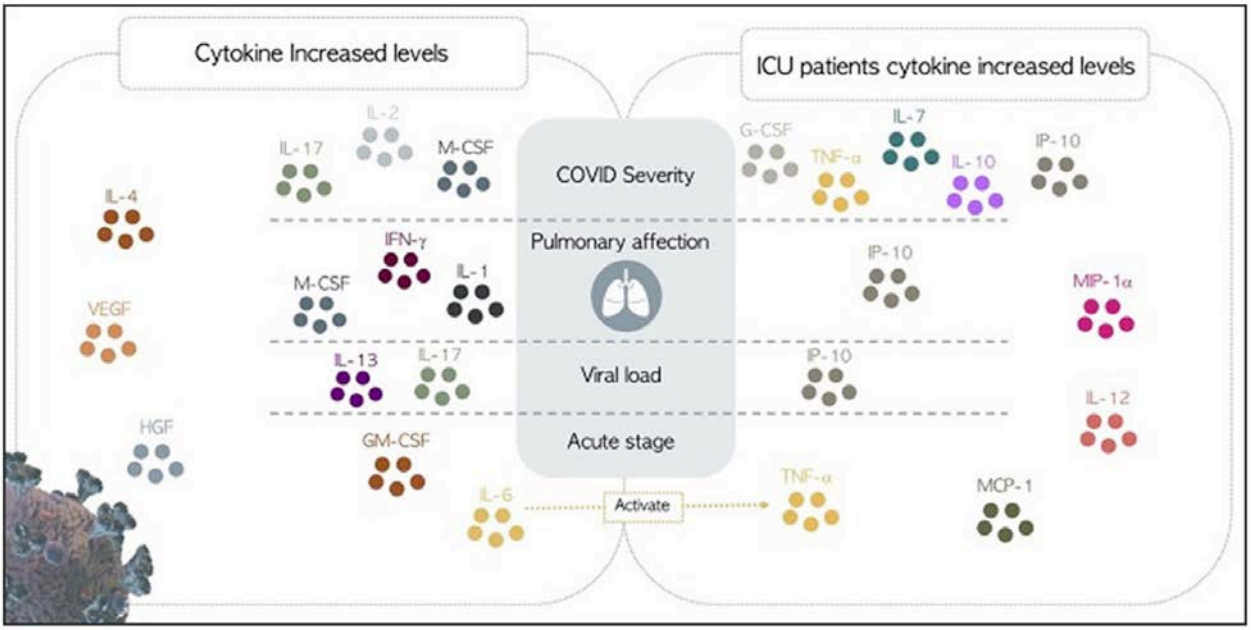
The clinical symptoms of individuals affected by the virus are diverse, ranging from mild upper respiratory symptoms to severe pneumonitis, and in some acute respiratory distress syndrome (ARDS) or death.[25] Early symptoms may include cough, shortness of breath, or at least one of the following: fever of 100.4 degrees Fahrenheit or higher; chills, shaking, muscle pain, headache, sore throat, or loss of taste/smell.[91] To best understand these symptoms, it is important to evaluate how the SARS-CoV-2 virus interacts with the innate and adaptive host immune response. The body's first line of defense, the innate immune response, including complement and the cellular immune response, is initiated after an infection is detected, with the intent to destroy viral particles and any cells damaged by virus. Further, the second line of defense, the adaptive immune response, is initiated days later if any virus remains. The adaptive immune response leverages exposure to viral materials to develop antibodies and other mechanisms through T-cell and B-cell mechanisms. It has been shown that an interaction between the body's two main lines of defense may be causing the immune system to go into overdrive in some patients.

Cytokines have been found that play a crucial role in the development of these clinical features and are also at the core of the development of inflammation. Systemic immune hyperactivation due to SARS-CoV-2 infection causes a cytokine storm, which is especially noteworthy in severely ill patients with COVID-19.[25] When SARS-CoV-2 infects the body, the inflammatory response performs an antiviral role, but a strong cytokine storm caused by an overactive host immune response can be very damaging to the patients. A cytokine storm, also called hypercytokinemia, is a physiological reaction in humans and other animals in which the innate immune system causes an uncontrolled and excessive release of pro-inflammatory signaling molecules called cytokines.[26] Suppressing the cytokine storm is one way to treat critically ill COVID-19 patients. The cytokine storm is a potentially fatal inflammatory syndrome that is caused by elevated levels of circulating cytokines and immune cell hyperactivation that can be triggered by various therapies, pathogens, cancers, and autoimmune conditions.[27]

Many people believe that microbes, such as bacteria, viruses, and fungi, that enter the body to initiate disease should be feared most during an outbreak of an illness such as influenza, but the contribution of the host immune system is potentially more lethal.

This is analogous to the pathophysiology of periodontitis, wherein bacteria initiate disease, but the disease progression is mitigated by the host immune-inflammatory response.[29] When the body identifies foreign microorganisms signaling an infection, it might respond by over-protecting the site of infection. It may quickly react, and numerous antibodies quickly migrate to the infection site and upregulate host pro-inflammatory reaction and cytokine formation. Typically, cytokines are a component of the immune response to infection, to protect our bodies, but their sudden release in large quantities can cause multisystem organ failure and death.[27] Cytokine





COVID-19 Cytokine Storm Response.[28]

storms can be caused by several infectious and non-infectious etiologies, but are especially prevalent in viral respiratory infections such as H5N1 influenza, SARS-CoV-1, and SARS-CoV-2.

The prevalence and tenacity of antibodies following a peak SARS-CoV-2 infection provides understanding of its dissemination in the community, the likelihood of reinfection, and potential for some level of population immunity. One of the questions about COVID-19 is whether people who are infected with the virus are immune from reinfection, and if so, for how long. Researchers studied the production of antibodies from a sample of nearly 6,000 people and found immunity persists for at least several months after being infected with SARS-CoV-2.[30] The study found that high-quality antibodies were being produced five to seven months after SARS-CoV-2 infection. The research provided the ability to accurately test for antibodies against COVID-19, as well as presented the knowledge that lasting immunity is a reality.[30]

Alternatively, the conclusions of other studies show that antibodies created against SARS-CoV-2 after natural infection are not long-lasting. One investigation found that up to 40% of individuals with previous COVID-19 infection lacked convalescent antibodies[25] and another study measured antibody levels in a group of 37 COVID-19 patients three to four weeks after initial infection, then two months thereafter. Nearly 20% tested negative for antibodies completely, indicating either total disappearance or undetectable antibody levels.[31] Further, it is not known what level of protection to the virus, if any, is provided by post-infection antibodies. Therefore, it is challenging to state with confidence whether this potential rapid dissipation of the antibody response after initial COVID-19 infection leaves the body vulnerable to reinfection.

Some reports have postulated that the T-cell response against coronavirus infections, including those caused by SARS-CoV-2, endures longer than the antibody response.[32] T-cells are a form of white blood cells that, like antibodies, are vital to our ability to prevent future confrontations with a harmful virus.[33] In the case of seasonal coronaviruses associated with the common cold, T-cell memory to a pathogen has little to no effect in preventing re-infection, which can occur once or more times per year.

Understanding the roles of different subsets of T-cells in protection or pathogenesis is crucial for preventing and treating COVID-19. Like B-cells, which produce antibodies, T-cells are key players in the immune response to viral infections. CD4+ T-cells help B-cells to produce antibodies and help CD8+ T-cells to kill virus-infected cells. Evolving studies imply that all or most people with COVID-19 develop a strong and broad T-cell response, both CD4 and CD8, and some have a memory phenotype, which signifies the potential for longer-term immunity.[32,33]

It has been indicated that the influenza vaccination might reduce the risk of COVID-19.[34] Patients who have received an influenza vaccine were found to have 24% lower odds of testing positive for coronavirus disease 2019 (COVID-19).[34] Those who were vaccinated against influenza and tested positive for COVID-19 were more likely to have better clinical outcomes than those who were not vaccinated.[34] While the cause of this association is unknown and could reflect the healthcare and infectious-disease attitudes of those individuals who received the influenza vaccination, influenza vaccination was associated with decreased positive COVID-19 testing and improved clinical outcomes and should be promoted to potentially reduce the burden of COVID-19.[34]

It might seem implausible that a vaccine designed to protect against one infection could protect against others as well. But a growing body of research suggests that this can occur through a process called "trained innate immunity."[35] Vaccines are known to work by stimulating the adaptive immune system, causing the body to make antibodies that can recognize and attack a specific pathogen if it is encountered again.[36] However, recent studies suggest that some vaccines also train the body's faster-acting and less specific innate immune system, improving its ability to fight off many kinds of infections. Vaccines appear to achieve this act by reprogramming stem cells that give rise to cells involved in this early innate immune response.[37]

Risk Factors

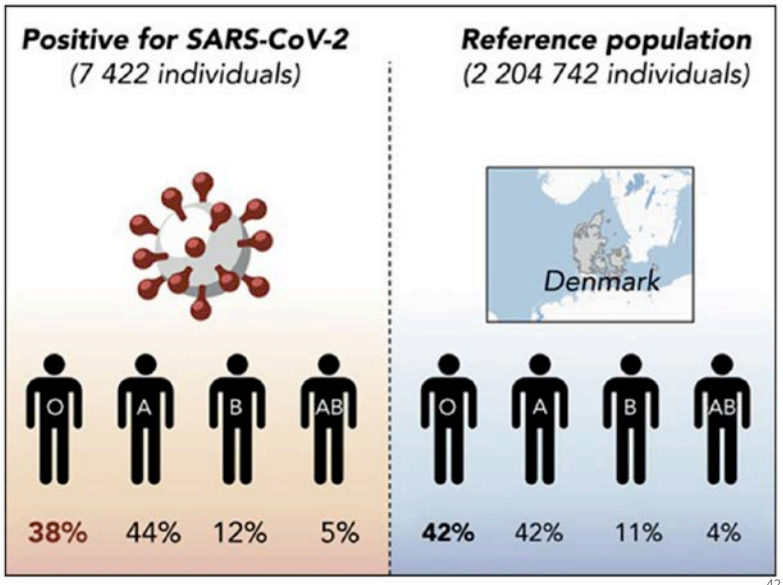
Anyone can contract COVID-19, but there are those that are more susceptible to developing increased symptom severity. This may be associated with co-morbid conditions and risk factors. Potential risk factors include age; race/ethnicity; sex or gender; some medical conditions; use of certain medications; poverty and crowding; certain occupations, and pregnancy.[38] Others that may need to take special precautions are those that have risky individual situations, such at-risk racial and minority groups and those with disabilities.[38] Also, those that live in care facilities/ group homes, or the homeless.[39] The risk of developing serious symptoms increases with age, especially those 85 years of age or and older.[39] In the U.S., about 80% of deaths from COVID-19 have been in people age 65 and older, and the risks increase for older individuals with underlying health conditions.[39] Existing lung issues, heart disease, diabetes, obesity, cancer, certain blood disorders, weakened immune systems, chronic kidney or liver disease place people at higher risk.[39] There is a COVID-19 Event Risk Assessment Planning Tool, which is a collaborative project led by Prof. Joshua Weitz and Prof. Clio Andris at the Georgia Institute of Technology, along with researchers at the Applied Bioinformatics Laboratory and Stanford University, and powered by RStudio. Description of the method and analyses available at Nature Human Behaviour.[40]

There has been some discussion that blood type may be a risk/protective factor regarding COVID-19. One researcher stated that a higher proportion of COVID-19 patients with blood group A or AB required mechanical ventilation and had a longer ICU stay compared with patients with blood group O or B. Blood types A and AB were also more apt to need a type of dialysis that helps the kidneys filter blood without too much pressure on the heart.[41] In this study, blood group O was associated with a decreased risk for contracting SARS-CoV-2 infection.

There are important caveats to consider from this research. There is no indication that any blood type is either totally protective or increases the risk of a patient to severe outcomes of COVID-19. The reason there is a concern regarding this issue is due to the biologic mechanism that might explain this interaction. Different blood types in patients are genetically inherited and have been linked to predisposing patients to cardiovascular diseases, cancers, and even susceptibility of COVID-19. Studies have shown a relationship between blood types and increased severity of infection from COVID-19 including increased risk of thrombosis.[43]

Genetics

One study postulates that the major genetic risk factor for severe COVID-19 is inherited



Data sharing requests should be sent to Torben Barington (torben.barington@rsyd.dk).[42]

from Neanderthals.[44] Researchers found that at least one copy of a Neanderthal-inherited haplotype on chromosome 3, known as the "risk haplotype," occurs in about 50 percent of people in South Asia, compared to only 16 percent of Europeans. This risk haplotype significantly increases the likelihood of severe symptoms and hospitalization from COVID-19.[44] A haplotype is a set of DNA variations that tend to be inherited together.[45] Another study stresses that genetic risk factors can make individuals susceptible to severe COVID-19, and with that understanding these mechanisms underlying COVID-19 can potentially pave the way to novel treatments for the disease.[46]

A comorbidity is the presence of one or more additional conditions often co-occurring with a primary condition.[47] These conditions may increase risk of acquiring certain diseases or becoming more seriously ill from a disease, such as COVID-19. Some conditions which may make an individual more susceptible to becoming extremely ill with COVID-19, and possibly requiring hospitalization and more advanced medical treatment include: cancer, chronic lung or kidney disease, dementia, diabetes, Down syndrome, heart conditions, HIV infection, immunocompromised state, liver disease, obesity, pregnancy, cerebrovascular disease, and smoking or other substance use disorders (Table 1).[47]

Table 1.

Comorbid Condition	Case Fatality Rate, %
Hypertension	6.0
Diabetes	7.3
Cardiovascular disease	10.5
Chronic respiratory disease	6.3
Cancer (any)	5.6
None	0.9

Treatments

Hundreds of treatments are being developed and tested to prevent or treat COVID-19. Many of these therapies that have received emergency use authorization (EUA) from the US Food and Drug Administration (FDA) and there are those that are nearing approval. Remdesivir was approved by the FDA to treat COVID-19 patients who are at least 12 years old and require hospitalization, but the WHO later recommended against its use.[48] It was initially recommended that remesivir only be administered in a hospital or in a healthcare setting capable of providing acute care comparable to inpatient hospital care. The WHO issued "A conditional recommendation against the use of remdesivir in hospitalized patients on November 20, 2020, regardless of disease severity, as they stated that there is currently no evidence that remdesivir improves survival and other outcomes in these patients.[47] The WHO states that, "a conditional recommendation is issued when the evidence around the benefits and risks of an intervention are less certain. In this case, there is a conditional recommendation against the use of remdesivir. This means that there isn't enough evidence to support its use."[49]

The FDA issued an EUA for the Regeneron company's product, REGEN-COV™ (casirivimab with imdevimab), an experimental medicine, to treat COVID-19 in high-risk patients with mild to moderate disease, on November 21, 2020.[50] The Regeneron treatment is a monoclonal antibody therapy to be used on COVID-19 patients, including children and at-risk elderly, to help them avoid hospitalization. On November 23, 2020, the US Department of Health and Human Services also approved casirivimab and imdevimab antibody therapy for administration.[51] Monoclonal antibodies are laboratory-made proteins that imitate the immune system's capability to protect against toxic pathogens such as viruses. Casirivimab and imdevimab are monoclonal antibodies that are explicitly targeted against the spike protein of SARS-CoV-2, intended to block the virus' attachment and entry into human cells.[51]

Dexamethasone is a common corticosteroid medication that has been used for many years to treat various health conditions,

such as autoimmune conditions and allergic reactions. RECOVERY, a randomized clinical trial in the UK, is an ongoing investigation of many medications, including dexamethasone, to see if any are effective against COVID-19.[52] They concluded that, in patients hospitalized with COVID-19, the use of dexamethasone resulted in lower 28-day mortality among those who were receiving either invasive mechanical ventilation or oxygen alone at randomization.[52] Increased survival rates were not seen in individuals with less severe disease who were not receiving respiratory support.[52] The medication was most helpful for patients who were on a ventilator or needed supplemental oxygen in an inpatient setting. There was no statistically significant benefit that was determined for those with less severe symptoms.

The National Institutes of Health (NIH) has published *The Coronavirus Disease 2019 (COVID-19) Treatment Guidelines* in an electronic format that can be updated when needed with the rapid pace and growing volume of information regarding the treatment of COVID-19.[53] On November 19, 2020, the FDA issued an EUA for the use of baricitinib in combination with remdesivir in hospitalized adults and children aged ≥2 years with COVID-19 who require supplemental oxygen, invasive mechanical ventilation, or extracorporeal membrane oxygenation.[54]

On December 17, 2020, it was announced that investigational COVID-19 therapeutics are to be evaluated in large clinical NIH trials enrolling people hospitalized with COVID-19. The two randomized, controlled Phase 3 clinical trials have begun evaluating investigational monoclonal antibodies for their safety and efficacy in treating people hospitalized with moderate COVID-19.[55] Researchers are also testing older medications that are typically used to treat other conditions, to see if they are also effective for COVID-19. Many people infected with COVID-19 will have mild symptoms and can recover at home. The CDC recommends basic measures such as rest, hydration, and over-the-counter medicines such as acetaminophen. Patients with more serious symptoms such as trouble breathing, chest pain, or bluish lips or face should seek emergency medical care.

Testing

Three kinds of tests are currently available in the US to determine COVID-19 infection: polymerase chain reaction (PCR), antigen, and antibody. A PCR test reveals if one has a current infection and detects disease by looking for traces of the virus' genetic material on a sample most often collected via a nasal/nasopharyngeal swab. A PCR test is considered the "gold standard" to detect active infection. Antigen tests (sometimes referred to as rapid diagnostic tests) detect specific proteins on the surface of the coronavirus. Positive antigen test results are highly specific, meaning that if you test positive you are highly likely to be infected. However, these tests have lower specificity, meaning that there is a higher chance of false negatives with antigen tests compared to PCR tests. An antibody (serology/blood) test detects the presence of COVID-19 antibodies and might indicate past and/or ongoing infection. The FDA has so far granted emergency-use authorization to more than 200 different tests meant to detect a current or past infection from SARS-CoV-2, the virus that causes COVID-19.[56]

It is important to note that antibody testing measures the proteins your body produces to protect against a specific disease-causing microorganism rather than live virus and has been used for epidemiologic surveillance throughout the pandemic to detect infections that may have been asymptomatic or mildly symptomatic. This is especially useful in detecting asymptomatic carriers, or "silent spreaders," who do not get tested because they have no symptoms and do not feel ill but may spread up to 80% of infections.[57]

Another testing modality may also be on the horizon, using a smartphone for more rapid results. It involves swabbing the nose, placing the sample into a devise, and getting a readout in 15-30 minutes. It uses CRISPR diagnostics and can enhance gold-standard PCR-based testing if researchers can make it rapid, portable, and accurate. Current testing for COVID-19 using PCR requires DNA.[58] The

Ellume's COVID-19 home test offers a complete at-home sampling and testing solution. The single-use, Bluetooth-enabled test cartridge and self-collection swab are designed for consumer use in conjunction with a smartphone.[59]
Image source: Ellume USA LLC, Valencia, California.

coronavirus is an RNA virus. Using PCR, the viral RNA must be converted to DNA, and there must be enough DNA present to be able to perform a reliable test. This 2-step process requires a reaction called amplification, which makes the required amount of DNA to test. It is a time-consuming, cumbersome procedure and requires specific laboratory reagents that can be expensive and difficult to procure.[58] CRISPR-Cas13a can quantitatively detect SARS-CoV-2 RNA without pre-amplification. A mobile phone-based device can allow for portable, private, and sensitive readout of the assay.[58]

Finally, on December 15, 2020, a NIH-funded home test receieved FDA authorization.[59] The test does not require a presciption. The test is completed using a nasal swab, and the sample is inserted into a single-use cartridge that returns results in 15 minutes. The at-home test analyzer connects to the user's smartphone through Bluetooth and pairs with a downloadable app that provides step-by-step instructions and displays results. The cost ranges from approximately $100-150.

Vaccines

The NIH has emphasized equity in vaccine distribution and states that "In response to the coronavirus disease 2019 (COVID-19) pandemic and the societal disruption it has brought, national governments and the international community have invested billions of dollars and immense amounts of human resources to develop a safe and effective vaccine in an unprecedented time frame. Vaccination against this novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), offers the possibility of significantly reducing severe morbidity and mortality and transmission when deployed alongside other public health strategies and improved therapies."[60] As of March 10, 2021, 75 different vaccines are in clinical trials on humans, and at least 78 in preclinical trials on animals, according to an interactive coronavirus vaccine tracker published by the New York Times.[61] Twenty-one vaccines have reached the final stages of testing. As of March 10, 2021, three vaccines have been granted an EUA by the FDA in the United States.[61]

The COVID-19 vaccines that have been developed may be vastly different than traditional vaccines, as several different vaccine technologies were used in the development of current vaccines and vaccine candidates in ongoing clinical trials. Prior to the current pandemic, researchers were developing a vaccine against the coronaviruses that caused the diseases SARS and MERS, so there is some proven knowledge about the structure and function of coronaviruses. This accelerated development during early 2020 using various technology platforms for a COVID-19 vaccine. In December 2020, the first vaccine to receive EUA in the US was a messenger RNA (mRNA) vaccine developed by Pfizer (Pfizer-BioNTech COVID-19 vaccine).[62] An internal assessment published by the FDA determined the vaccine was extremely effective with no known significant risks, although there is some question about whether the vaccine could trigger an allergic reaction in some people.[62] No vaccines have received full approval by the FDA, but three have been authorized for emergency use by FDA under an EUA to prevent Coronavirus Disease 2019 (COVID-19).[63]

Currently, three vaccines have received EUA are authorized and are recommended to prevent

symptomatic COVID-19 and severe COVID-19 symptoms in the USA:

- Pfizer-BioNTech COVID-19 Vaccine, (mRNA)
- Moderna COVID-19 Vaccine, (mRNA)
- Johnson & Johnson Janssen COVID-19 Vaccine (Adenovirus viral vector).

As of April 2021, large-scale (Phase 3 or Phase 4) clinical trials are in progress or awaiting initiation planned for five COVID-19 vaccines in the United States: AstraZeneca's COVID-19 vaccine; Janssen's COVID-19 vaccine; Moderna's COVID-19 vaccine; Novavax's COVID-19 vaccine; and Pfizer's COVID-19 vaccine.[61] Since vaccine distribution began in the U.S. on Dec. 14, more than 120 million doses have been administered, reaching 36% of the total U.S. population, according to federal data collected by the Centers for Disease Control and Prevention.[61] The CDC has released "Interim Public Health Recommendations for Fully Vaccinated People," which will be updated and expanded based on the level of community spread of SARS-CoV-2, the proportion of the population that is fully vaccinated, and the rapidly evolving science on COVID-19 vaccines.[64] These guidelines include the guidance that individuals that have been fully vaccinated may: "visit with other fully vaccinated people indoors without wearing masks or physical distancing; visit with unvaccinated people from a single household who are at low risk for severe COVID-19 disease indoors without wearing masks or physical distancing; and refrain from quarantine and testing following a known exposure if asymptomatic."[64]

Below is a chart comparing vaccines developed by Monica Gandhi, MD, MPH, professor of Medicine and Associate Division Chief (Clinical Operations/ Education) of the Division of HIV, Infectious Diseases, and Global Medicine at University of California, San Francisco (UCSF)/ San Francisco General Hospital.[65,66]

How Vaccines Work

Vaccines stimulate our immune systems to recognize foreign invaders and attack them. White blood cells (macrophages, B-lymphocytes, T-lymphocytes) help to fight the possible infection. As antigens are engulfed and presented by macrophages

Company	Platform	Doses	Non-clinical results	Number of people who got vaccine	Protection from hospitalizations /death	Protection from severe disease (may not be hospital)	Efficacy against milder disease
moderna	mRNA-1273 mRNA in lipid nanoparticle	2	Neutralizing Abs; Strong Th1 response; protection from challenge	~15,000	100%	100% (30 cases in placebo arm; 0 in vaccine)	94.1%
Pfizer	BNT162b2 mRNA in lipid nanoparticle	2	Neutralizing Abs; Strong Th1 and Th2 response; protection from challenge	~18,600	100%	100% (9 cases in placebo arm; 0 in vaccine)	95%
AstraZeneca	AZD 1222 Non-replicating Chimp Adenovirus-DNA	2	Neutralizing Abs; Strong Th1 and Th2 response; protection from challenge	~5800	100%	100% (10 in placebo; 0 in vaccine)	90% half-full-dose; 70% overall
Johnson & Johnson	JNJ-78436725 Non-replicating human adenovirus/DNA	1	Neutralizing Abs; Strong Th1 and Th2 response; protection from challenge	~22,000	100%	85% (across South Africa, U.S., Latin America	72% US; 66% Latin America; 57% S. Africa
NOVAVAX	NVX-CoV2373 Spike protein/RBD + Matrix M adjuvant	2	Neutralizing Abs; protection from challenge	~9700	100%		89.3% UK; 60% S. Africa
Sputnik V	Ad26 and Ad5 adenovirus/DNA	2	Neutralizing Abs; Strong Th1 and Th2	~11360	100%	100% (20 cases placebo; 0 in	91.4%

This is a summary of Phase 3 published findings by Monica Gandhi, MD, MPH, professor of Medicine and Associate Division Chief (Clinical Operations/ Education) of the Division of HIV, Infectious Diseases, and Global Medicine at University of California, San Francisco (UCSF)/ San Francisco General Hospital. Abbreviations: Neutralizing Abs - Serum Neutralizing Antibody Titers. Th1 and Th2 – Helper T-cells.

to antigen presenting cells, this leads to antibody production by the B-lymphocytes. In this instance, both the antigen and the subsequently produced antibody are major players in an individual's defense. Vaccines harness this natural function and work by creating a "memory" so that if infected by the same organism, it is recognized as foreign and destroyed.

There are three main types of COVID-19 vaccines that are undergoing large-scale (Phase 3) clinical trials in the United States and globally. Further, most COVID-19 vaccines require more than one vaccination injection and effective dosages and transportation variables may change.

mRNA vaccines are being utilized for public health applications for the first time against COVID-19. They contain messenger RNA (mRNA) from the coronavirus (that causes COVID-19) that gives our cells instructions for how to make a harmless protein that is unique to the virus and is highly conserved amongst coronaviruses. This messenger RNA does not enter the host cell nucleus but is transported to the endoplasmic reticulum (ER), the protein creation factory of the cell.[67] After host cells make copies of the protein, they destroy the mRNA from the vaccine. Our bodies recognize that the protein is non-self and build T-lymphocytes and B-lymphocytes that will remember how to fight the virus that causes COVID-19 if we are infected in the future.[67] Examples of mRNA vaccines are the Moderna and Pfizer vaccines.

Protein subunit vaccines include harmless pieces (proteins) of the virus that cause COVID-19 instead of the entire virus, which could cause disease. A protein subunit vaccine from the company Novavax (Gaithersburg, MD) is currently under investigation in the United States.

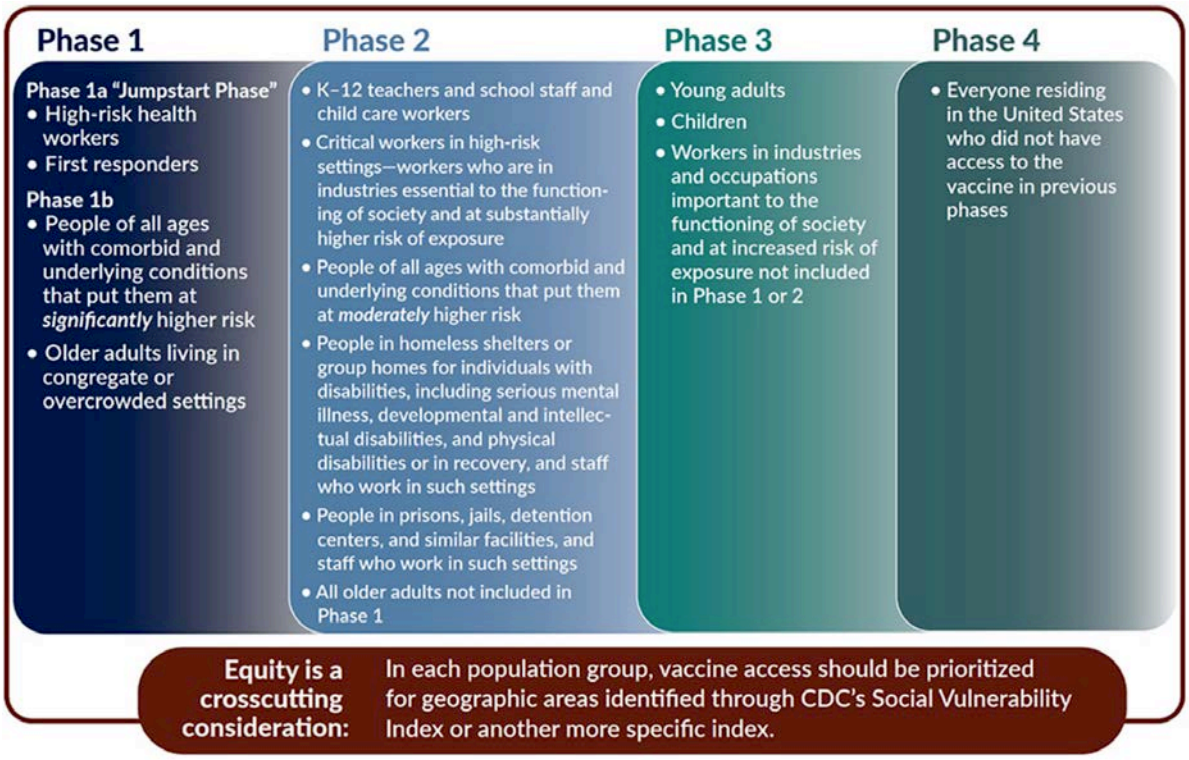
Vector vaccines use a weakened version of a different virus than the one that causes COVID-19 and its framework for replication (e.g. the virus that can cause the common cold), which has genetic material from the virus that causes COVID-19 inserted in it (this is called a viral vector).[67] Once the viral vector is inside our cells, the genetic material gives cells instructions to make a protein that is unique to the virus that causes COVID-19. These vaccines prompt the body to build T-lymphocytes and B-lymphocytes that will recall how to combat that virus if one is infected in the future. Both the Johnson & Johnson vaccine and the AstraZeneca vaccine are vector vaccines.

As of April 2021, large-scale (Phase 3 and Phase 4) clinical trials are in progress or being planned for five COVID-19 vaccines in the United States: AstraZeneca's COVID-19 vaccine; Janssen's COVID-19 vaccine; Moderna's COVID-19 vaccine; Novavax's COVID-19 vaccine; and Pfizer's COVID-19 vaccine.[68]

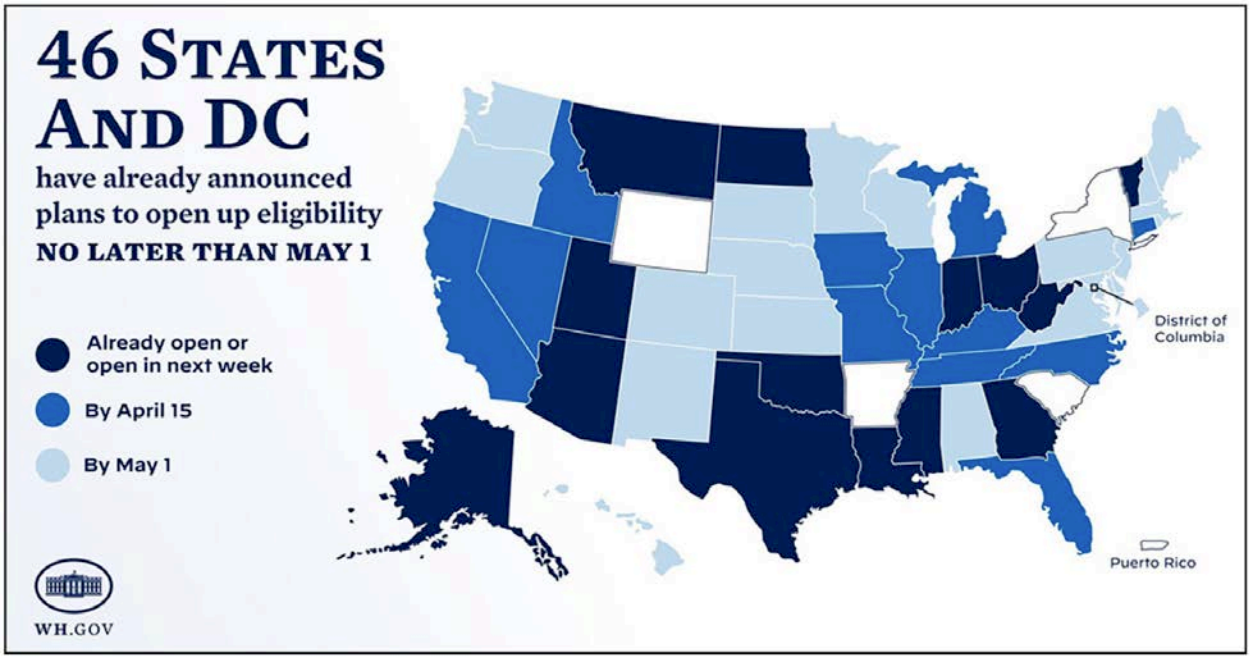
Vaccine Allocation

The rate by which dentists, dental hygienists, dental assistants, and other office staff are receiving their COVID-19 vaccinations varies widely across the state, depending on state-, county-, and local-level distribution. President Biden directed all states to open vaccine eligibility up to all adults by May 1, 2021.[70]

To address the states' shortage of health care providers eligible to administer COVID-19 vaccines, the Department of Consumer Affairs approved a public health emergency waiver that will allow dentists and pharmacy technicians to administer COVID-19 vaccines to people age 16 and over.[71] A number of states allow or are considering allowing dentists and other professionals to administer the vaccine.[72] As of March 11, 2021, the U.S. Department of Health and Human Services is amending an emergency declaration under the Public Readiness and Emergency Preparedness Act to authorize additional providers, including dentists and dental students, to vaccinate patients for COVID-19 nationwide.[72] As of March 13, 2021, at least 28 states have already engaged dentists to administer the COVID-19 vaccines during the COVID-19 public health emergency. The federal declaration allows licensed dentists throughout the country to vaccinate the public against COVID-19, regardless of state laws that prevent dentists from doing so.[72] The expanded list of providers does not include dental hygienists, in spite of efforts by the American Dental Hygienists' Association (ADHA). As of March 12, 2021, fourteen states have authorized dental hygienists to administer the COVID-19



COVID-19 Vaccine Allocation Phases within the Framework.[69]



White House COVID-19 Response Team on Twitter: "The President directed all states to open vaccine eligibility up to all adults by May 1. 14 states have already opened eligibility — or will in the next week — and 12 others will by April 15. So, by mid-April, about half the states will have opened eligibility to all adults."[70]

vaccine including: California, Connecticut, Idaho, Kentucky, Maryland, Massachusetts, Nevada, New Jersey, New York, Ohio, Rhode Island, South Carolina, Utah and Washington.[73]

The priority for dental healthcare providers in vaccination is important as it acknowledges the essential role that dental healthcare providers play in maintaining public health. Further, dental healthcare providers have known skill sets that allow them to deliver injections safely. Twenty-six healthcare organizations from a COVID-19 Dental Coordination Group wrote to ADM Brett P. Giroir, M.D., Assistant Secretary for Health, U.S. Department of Health and Human Services, to recommend that, under the PREP Act, they expand authorization for dental professionals to order and administer COVID-19 vaccines.[74] These organizations believe it will increase and/or improve access to safe and effective COVID-19 vaccine delivery. While the steps taken by the U.S. Department of Health and Human Services (HHS) to ensure vaccines can be delivered widely, safely, and effectively by 2021 are appreciated, it is believed that including the more than 340,000 U.S. dental healthcare professionals in the list of eligible providers permitted to administer the COVID-19 vaccine enhances the nation's ability to respond effectively to the present crisis and potential future crises as well.[74]

Vaccines and Variants

The emergence of variants has raised concerns that the virus (SARS-CoV-2) could mutate and evade immunity induced by currently available vaccines.[75] Viruses constantly mutate and change over time. Variants of the coronavirus that were first detected in the U.K., Brazil and South Africa have spread to dozens of countries, and scientists are working to determine what makes them behave differently from earlier versions. Several variants likely have evolved more efficient ways of binding to and entering cells, a critical step in being able to reproduce and spread throughout the body.[75] Many vaccines target the spike protein as a target for the development of antibodies as it is highly conserved.[76] These spike proteins line the virus's surface and play a critical role in docking with and attaching to human cells. Variant changes to the spike protein could result in reduced efficacy of currently deployed vaccines.

The variant known as B.1.1.7 was originally identified in the United Kingdom in the fall of 2020.[77] Another variant, called B.1.351, was identified in South Africa in October 2020. A third variant called P.1 is thought to have emerged in Brazil, after it was detected in travelers who arrived from the country at an airport in Japan in January of 2021.[77]

Observations from a study published April 2021 indicate a potential risk of illness after successful vaccination and subsequent infection with variant virus, and support is provided for continued efforts to prevent and diagnose infection and to characterize variants in vaccinated persons.[78] Researchers from Pfizer/BioNTech and the University of Texas ran laboratory tests using blood samples from people who received the vaccine and engineered versions of the virus with various mutations in its surface spike protein that resembled those found in several variants.[79] The researchers claim that the Pfizer/BioNTech COVID-19 vaccine is also effective against the more infectious P.1 Brazilian variant. However, it was a small laboratory study and it may not translate to clinical efficacy.[79]

Vaccine Passports

On March 17, 2021 the European Union proposed a vaccine passport plan to simplify summer travel. It is suggested that the passports be digital or paper documents, so travelers can prove that they have been vaccinated, that they recovered from the virus, or recently tested negative for it. In many cases, this could free travelers from quarantine and testing obligations. It may be similar to passes currently in use in Israel, where QR codes allow fully vaccinated people access to gyms or restaurants. This plan, however, is not without controversy.

The World Health Organization (WHO) stated that it is not encouraging the use of "vaccine passports" for both "ethical and scientific" concerns.[80] At the present time, it is WHO's position that national authorities and conveyance operators should not introduce requirements of proof of COVID-19 vaccination for international travel as a condition for departure or entry, given that there are still critical unknowns regarding the efficacy

of vaccination in reducing transmission. In addition, considering that there is limited availability of vaccines, preferential vaccination of travelers could result in inadequate supplies of vaccines for priority populations considered at high risk of severe COVID-19 disease. WHO also recommends that people who are vaccinated should not be exempt from complying with other travel risk-reduction measures, such as masking and social distancing.[80] In an updated statement, WHO believes that there is currently insufficient evidence about the effectiveness of antibody-mediated immunity to guarantee the accuracy of an "immunity passport" or "risk-free certificate."[81] The use of vaccine passports may increase the risks of continued transmission. As new evidence becomes available, WHO will update this scientific brief.[81] Extensive delivery of vaccinations will most likely help to limit SARS-CoV-2 transmission. Until vaccines become widely available and herd immunity prevails, control measures, such as wearing masks, social distancing, and frequent handwashing may continue to be necessary to reduce transmission.

Herd Immunity

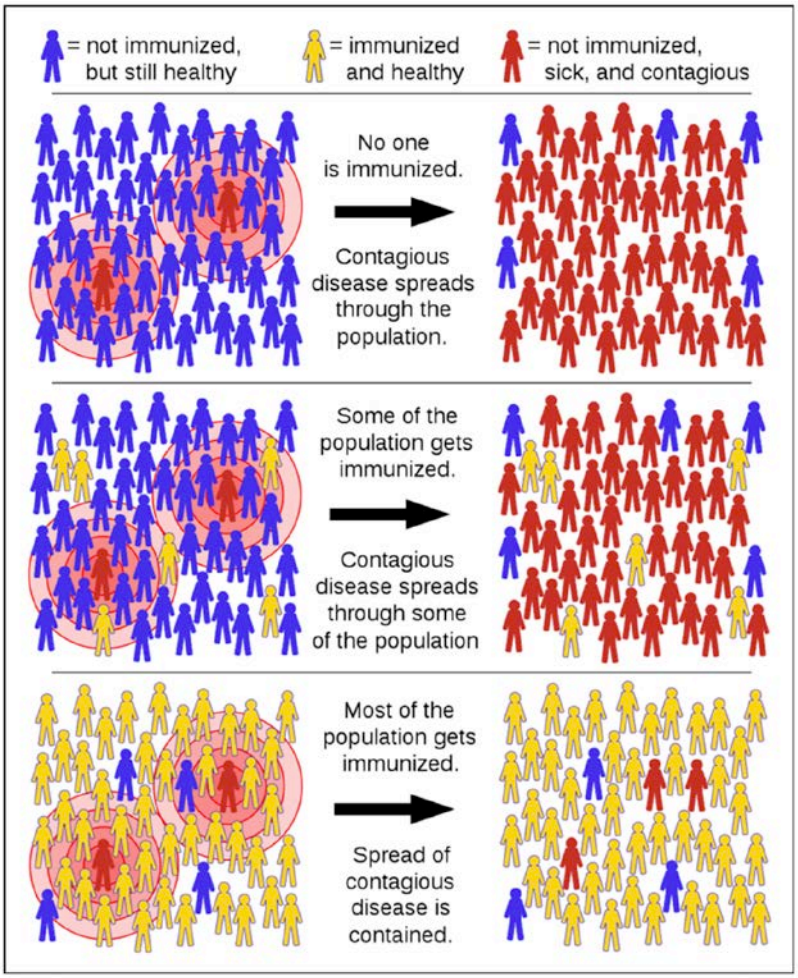
Herd immunity represents the concept of protection of the population from infection which is achieved by the presence of immune individuals.[82] Herd immunity is the resistance to the spread of a contagious disease within a population that results if a sufficiently high proportion of individuals are immune to the disease, either through vaccination or contracting the disease, called natural infection.[82] Once herd immunity is achieved, the spread of disease from person to person becomes unlikely. As a result, the whole community becomes protected, not just those who are immune. For a disease to spread, a sufficiently high percentage of the population must be capable of getting a disease to ensure that infectious individuals are likely to come into contact with susceptible individuals. This is called a *threshold proportion*. If the proportion of the population that is immune to the disease is greater than this threshold, the spread of the disease will decline. In the aforementioned case, the herd immunity threshold would be reached.[83]

The percentage of a community that needs to be immune to a disease to achieve herd immunity varies from disease to disease. The more contagious a disease is, the greater the proportion of the population that needs to be immune to the disease to stop its spread. For measles, the threshold is 94%, for COVID-19, while it is unknown, it is believed to be slightly lower. Dr. Anthony Fauci, the director of the National Institute of Allergy and Infectious Diseases (NIAID) since 1984 estimated the overall herd immunity threshold, "I would say 50% would have to get vaccinated before you start to see an impact," Fauci said. "But I would say 75 to 85% would have to get vaccinated if you want to have that blanket of herd immunity."[84]

Herd immunity is impacted by the basic reproduction number (R_0). The R_0, pronounced "R-naught," is also called the basic reproduction ratio/rate or the basic reproductive rate. R_0 is an epidemiologic metric used to describe the contagiousness or transmissibility of infectious agents.[85] In a susceptible, unvaccinated population, each measles carrier will infect an estimated 12 to 18 other people. In the language of epidemiology, the R_0 of measles is 12 to 18.86 While there is still some discussion about the R_0 of the COVID-19 coronavirus, without interventions is generally estimated to be between 2.2 and 2.7. If the R_0 falls below 1, that means the outbreak is subsiding as fewer people are infected. If it remains above 1, the outbreak is ongoing with increasing numbers of individuals becoming infected. The goal of social distancing practices and vaccinations are to curb the epidemic by driving the R_0 of the coronavirus below 1.

The Oral-Systemic Link: COVID-19 and Oral Health

We know there is a link between the mouth and the rest of the body. The same cytokines active in COVID-19, such as TNFα, IL-1β, IL-6, and IL-8, to name a few, are also involved with the inflammatory process and development of periodontitis. Periodontitis has long been recognized as having its pathophysiology established in a cytokine response.[87] The connection between COVID-19 and periodontal disease through their cytokine connection is



NIAID: The top box shows an outbreak in a community in which a few people are infected (shown in red) and the rest are healthy but unimmunized (shown in blue); the illness spreads freely through the population. The middle box shows a population where a small number have been immunized (shown in yellow); those not immunized become infected while those immunized do not. In the bottom box, a large proportion of the population have been immunized; this prevents the illness from spreading significantly, including to unimmunized people. In the first two examples, most healthy unimmunized people become infected, whereas in the bottom example only one fourth of the healthy unimmunized people become infected.

Image Source: Wikimedia Commons. *File:Herd immunity.svg*

an additional rationale for recommending maintenance of oral hygiene and continued provision of dental in the COVID era. Patients with periodontitis had a higher risk of ICU admission, need for assisted ventilation and death of COVID-19 patients, and with increased blood levels of biomarkers linked to worse disease outcomes, according to a new study. This may be explained by the fact that COVID-19 is associated with an exacerbated inflammatory response that can result in fatal outcomes, and systemic inflammation is also a main characteristic of periodontitis.[88]

A new study theorizes that the mouth and nose are key entry points for SARS-CoV-2 into the bloodstream, not the airway, and that at-home selfcare measures such as toothbrushing and interdental cleaning could reduce the risk of developing severe lung disease as a

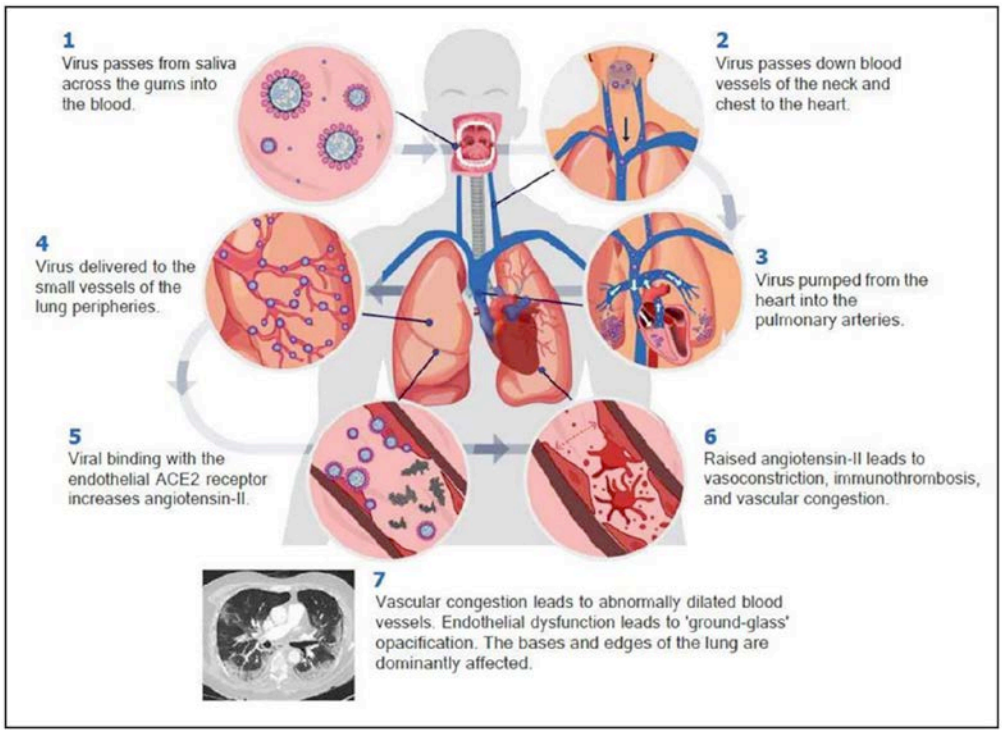


Figure 1. The COVID-19 Pathway: A Hypothetical Model for the Oral-vascular-pulmonary Route of Infection.[89]

result of coronavirus.[89] The hypothesis of the authors was based on a number of findings. Computerized tomography (CT) scans of COVID-19 patients have shown COVID-19 lung disease is not a pneumonia in the conventional sense, but it is similar to inflammation of the pulmonary vessels at the base of the lungs. They also stated that there is a viral reservoir in the oral cavity and saliva, and that there could be a possibility for translocation of the virus from saliva to the gingival sulcus/periodontal pocket. The authors further hypothesize that the route taken by the virus from saliva in the mouth, via the gingival tissues, into the blood vessels of the neck, and chest, through the heart, and to the lung blood vessels, is a possibility.[89]

We also know that dental procedures were initially thought to pose a high risk of viral transmission because the instruments and handpieces that are used often produce aerosols, which could potentially contain high numbers of SARS-CoV-2 virions, copies of the virus causing COVID-19. In a recent study, researchers stated that by understanding how to reduce the amount of aerosol generated in the first place, their suggestions could help dentists' practice more and help patients get the treatment they need.[90]

There are numerous resources available for Oral Health Professionals:

- *Summary of CDC COVID-19 Guidance for Dental Services*
- *Guidance for Dental Settings*
- *Aerosols in the Dental Office: Best Practices for Patient and Practitioner Safety (CE619)*
- *Getting Ahead of the Next Stage of the COVID-19 Crisis (CE624)*
- *Interim Dental Infection Prevention and Control Guidance for the COVID-19 Response – A New Paradigm (CE647)*
- *COVID-19 Resource Center for Dental Hygienists*
- *ADA Coronavirus (COVID-19) Center for Dentists*

Summary

In summary, the landscape of COVID-19 is constantly changing. Stay up-to-date, practice social distancing, wear a mask, wash your hands, and protect patients. Get vaccinated!

Course Test Preview

To receive Continuing Education credit for this course, you must complete the online test. Please go to: *www.dentalcare.com/en-us/professional-education/ce-courses/ce652/test*

1. How are pandemics *primarily* defined?

A. Growth rate.
B. The spread of the disease.
C. Animal to human transmission.
D. The type of organism responsible for the infection.

2. SARS-CoV-2 is a zoonotic human coronavirus closely related to all the following EXCEPT:

A. Middle East respiratory syndrome (MERS)
B. Ebola
C. Severe acute respiratory syndrome (SARS)
D. Coronaviruses that cause up to 25% of the common cold

3. The following are true of the virus that causes coronavirus disease 2019 (COVID-19) EXCEPT:

A. The virus attaches to specific molecules on the host cell surface.
B. Viral entry into host cells causes a massive immune response.
C. SARS-CoV-2 promotes inflammatory responses on the endothelial cells that form the blood-brain barrier.
D. The virus only affects the outside surface of the host cells.

4. To fully understand population-level immunity, it is important to screen for _____.

A. Antibody immunity
B. T cell immunity
C. Angiotensin converting enzyme 2 (ACE2)
D. Antibody and T cell immunity

5. The cytokine storm can best be described as _____.

A. an interaction between the body's two main lines of defense may be causing the immune system to go into overdrive in some patients
B. the adaptive immune response
C. the innate immune response
D. T cells

6. What is potentially more lethal to the human body?

A. Bacteria
B. Viruses
C. The host immuno-inflammatory response
D. Fungi

7. Which if the following concerning vaccines is NOT true?

A. A vaccine which is designed to protect against one infection could protect against other infections.
B. Vaccines cause the body to make antibodies.
C. Vaccines work by reprogramming stem cells that give rise to cells involved in a late innate immune response.
D. Vaccines train the body's fast-acting and less specific innate immune system, improving its ability to fight off many kinds of infections.

8. All of the following are true about herd immunity EXCEPT:

A. Represents the concept of protection of the population from infection which is achieved by the presence of immune individuals.
B. Can be achieved only by receiving a vaccination.
C. Herd immunity connotes that the whole community becomes protected, not just those who are immune.
D. The herd immunity threshold implies that the proportion of the population that is immune to the disease is greater than this threshold, and the spread of the disease will decline.

9. The connection between COVID-19 and oral health is likely associated by _____.

A. cytokines TNFα, IL-1β, IL-6, and IL-8
B. A*. actinomycetemcomitans, P. gingivalis, P. intermedia, B. forsythus, C. rectus, E. nodatum, P. micros, S. intermedius* and *Treponema sp.*
C. aerosols
D. fungi

10. Three types of tests are available for COVID-19. Which of the following is NOT recommended for disease identification?

A. Polymerase chain reaction (PCR)
B. Antigen test
C. Antibody test
D. Pooled sample screening tests

11. mRNA vaccines for the coronavirus _____.

A. use a common vaccine technology
B. contain an attenuated form of the virus
C. contain a live form of the virus
D. contain material that provides cells instructions for how to make a protein that is unique to the virus

12. Which of the following statements is NOT true?

A. All states allow dentists and dental hygienists to administer the vaccine.
B. The U.S. Department of Health and Human Services is amending an emergency declaration under the Public Readiness and Emergency Preparedness Act to authorize additional providers to vaccinate patients for COVID-19 nationwide.
C. The federal declaration allows licensed dentists throughout the country to vaccinate the public against COVID-19, regardless of state laws that prevent dentists from doing so.
D. The expanded list of providers does not include dental hygienists.

13. The following are true EXCEPT:

A. Viruses constantly mutate and change over time.
B. The emergence of variants has raised concerns.
C. The Pfizer/BioNTech COVID-19 vaccine is very effective against the more infectious Brazilian strain.
D. Several variants likely have evolved more efficient ways of binding to and entering cells.

14. A vaccine passport:

A. Is necessary so travelers can prove that they have been vaccinated.
B. The World Health Organization (WHO) is in favor of a vaccine passport.
C. The WHO does not recommend vaccine passports as it is currently unknown if vaccinations can reduce disease transmission.
D. A and B
E. A and C

15. Which of the following is NOT true about vaccines?

A. White blood cells (macrophages, B-lymphocytes, T-lymphocytes) help to fight the possible infection but have no role in vaccines.
B. The antigens are produced by macrophages.
C. B-lymphocytes produce the antibodies.
D. Vaccines work by creating cellular "memory" of a virus or viral components.

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Additional Resources

- *CDC. Guidance for Dental Settings: Interim Infection Prevention and Control Guidance for Dental Settings During the Coronavirus Disease 2019 (COVID-19) Pandemic.* Accessed May 19, 2021.
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About the Author

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Maria graduated from the University of Pennsylvania, School of Dental Hygiene & is the recipient of the 1999 University of Pennsylvania Dental Hygiene Alumni Achievement Award. She is also a 2003 winner of the Pfizer/ADHA Award for Excellence in Dental Hygiene and the 2011 Alfred C. Fones Award. She was awarded the first ever "2016 Distinction in Service Award" from the International Federation of Dental Hygienists in June, 2016 Presidential Citation in 2018 from ADHA. She earned her BA in Health Services Administration from Saint Mary's College and a MS in Health Science from San Francisco State University. Maria is a graduate of the 2004-2006 fellowship of the California Health Care Foundation's (CHCF) Health Care Leadership Program, administered by the Center for Health Professions at the University of California, San Francisco, a two-year program. She is the owner of Seminars for Women's Health and Sex Based Medicine, whose goal is to educate professionals about the differences in health and disease between men and women, communication styles, and the link between oral and general health.

As a noted researcher, author, and speaker, Maria has presented seminars nationally and internationally on topics such as Women's Health and Wellness, Cancers and Oral Care for the Cancer Patient, Oral Cancer, Enamel Therapy, and Immunology and Periodontal Disease. Maria was a member of the National Advisory Committee for the Robert Wood Johnson Foundation's Smoking Cessation Leadership Center. She conducted research with the late Dr. Margaret Walsh on smokeless tobacco at the University of California, San Francisco.

Maria is co-editor of the textbook: Dental Hygiene – Applications to Clinical Practice. Maria is co-founder of the International Dental Hygiene Educator's Forum (IDHEF), the fifth meeting to be held in Australia in 2019. Maria served as the 1997-98 President of the American Dental Hygienists' Association (ADHA), served on an advisory panel to develop "The Future of Dental Hygiene Report", and was the President of the International Federation of Dental Hygienists (IFDH) 2010-2013.

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