



Investigating SARS-CoV-2 and the Vaccine's Global Impact on Cardiac Complications

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Abstract

The COVID-19 pandemic, initiated by SARS-CoV-2 in early 2020, has profoundly impacted global health, particularly cardiovascular disease (CVD). This research paper examines the link between COVID-19 and CVD, highlighting the increase in CVD rates due to the inflammatory response triggered by the virus. Inflammation affects the heart's lining, muscle, and surrounding tissue, potentially leading to atherosclerosis, where plaque buildup can cause blood clots, heart attacks, and strokes (Heart Disease and Stroke). During SARS-CoV-2 infection, the immune system's pro-inflammatory cytokines exacerbate inflammation, impacting heart function and promoting heart disease. Furthermore, an analysis of data from the Centers for Disease Control and Prevention website CDC Wonder revealed that CVD rates post-COVID-19 increased in 2019-2021. While Oxford-AstraZeneca's vaccine, Vaxzevria, can trigger blood clotting, other studies show that various vaccinations, such as Johnson-Johnson, Pfizer, and Moderna, can reduce cardiovascular complications by decreasing inflammation and infection rates (Paknahad et al. 173).

Keywords

- 1) *Cardiovascular disease (CVD)* - Affects the heart and blood vessels. CVD can come in various forms and can often lead to heart attacks or heart palpitations.
- 2) *Severe acute respiratory syndrome-related coronavirus 2 (SARS-CoV-2)* - This highly contagious virus causes COVID-19. It can easily be spread through sneezes, coughing droplets, and speaking. A person can also inhale aerosol particles to become exposed.
- 3) *Heart Inflammation* - This is the body's reaction to an injury or infection in the heart. It can directly affect the lining of the heart or valves, the heart muscle, or the tissue surrounding the heart, creating irritation within the heart muscle and wall. Viruses, parasites, bacteria, fungi, injuries, or autoimmune diseases can cause it.
- 4) *Pro-inflammatory cytokines* - Signal polypeptides (proteins) that help maintain the inflammation.
- 5) *Oxygenation* - Inhaling and delivering oxygen to body tissues via the bloodstream. Adequate oxygenation is crucial for maintaining the heart's and other organs' health and function.
- 6) *Arrhythmia* - An irregular heartbeat is an abnormal heart rate or rhythm.

7) *Pericarditis* - The swelling and irritation of the thin, saclike tissue surrounding the heart. It also causes inflammation of the heart's outer lining.

8) *Myocarditis* - Viral infections are the primary cause of myocarditis (Inflammation of these cells). Heart attacks, due to a lack of blood flow, are a more common cause of myocardial cell death.

9) *The Fibrin web* - This is a network of fibrin strands that forms blood clots. Fibrin, a non-globular protein, is compact, spherical, and water-soluble.

10) *Post-acute care (PAC)* - Refers to medical services that help patients recover from an acute illness, injury, or surgery. In COVID-19, PAC is crucial for managing the virus's long-term health effects, including its impact on cardiovascular health.

11) The angiotensin-converting enzyme 2 (ACE2) receptor - A gateway for the virus to enter the body system.

Research Objective

The primary objective of this research is to highlight the detrimental effects of COVID-19 on heart health. This research is of utmost importance as it is crucial to be aware of the public health complications and potential solutions that would ultimately reduce the chances of developing CVD later in life. The significance of this study is paramount in understanding and addressing the impact of COVID-19 on cardiovascular health, ensuring that we are well-informed about this topic in general.

Introduction

SARS-CoV-2, or severe acute respiratory syndrome coronavirus 2, is an infectious disease that causes COVID-19. It can be spread through small liquid particles from an infected person's mouth or nose when coughing, sneezing, speaking, or breathing. These tiny particles from the mouth can range from large respiratory droplets to smaller aerosols. Symptoms of this virus include shortness of breath, wheezing, intense coughing, anosmia, severe pain throughout the body, digestive problems such as upset stomach and nausea, diarrhea, congestion, running nose, sore throat, fever or chills, painful headaches, and increased risk of developing cardiovascular disease (COVID-19 Symptoms).

By May 2020, SARS-CoV-2 resulted in 5,817,385 cases and 362,705 deaths worldwide. ("Coronavirus Disease 2019 Case Surveillance — United States). SARS-CoV-2 and cardiovascular disease were two of the leading causes of death from years in between 2020 and 2021. These diseases have caused a significant number of heart complications for the past three years. Conversely, years after recovering from SARS-CoV-2, individuals are more prone to certain heart complications such as abnormal heart rhythms, heart muscle inflammation, coronary artery disease, blood clots, strokes, and heart failure, among others. Studies have shown that individuals who have gotten COVID-19 can experience myocardial injury. They estimate these percentages to range from 7% to 40% (Heart Problems After Covid). In 2020, cardiovascular disease was the ultimate leading cause of death worldwide, affecting

approximately 523 million people globally, and roughly 19 million deaths were attributable to CVD (Coronado 1). Cardiovascular disease involves various heart disorders that affect the heart and its blood vessels ("cardiovascular diseases World Health Organization). Consequential risk factors of SARS-CoV-2 infection include severe heart complications and potentially high blood pressure.

SARS-CoV-2 enters the human cells by binding to the angiotensin-converting enzyme 2 (ACE2) receptor. This receptor can be found in various tissues, including cardiac muscle and the respiratory tract. Once inside the cells, SARS-CoV-2's RNA replicates, causing cell damage and prompting an immediate immune response. The innate immune system recognizes the viral infection and releases pro-inflammatory cytokines, which triggers heart inflammation and can lead to myocarditis and pericarditis within the inner and outer layers of the heart.

Types of heart disease

Coronary artery disease (CAD) and ischemic heart disease - Are common heart conditions caused by plaque buildup within the arteries that supply blood to the heart. This buildup is called atherosclerosis and narrows the arteries over time. Coronary heart disease can range from having no symptoms to severe chest pain or even a heart attack or stroke, which requires immediate attention. CAD is the primary cause of death in the United States.

Non-ischemic heart disease - Refers to heart conditions not caused by reduced blood flow due to blockage within the coronary arteries; these conditions arise from other factors affecting the heart muscle, structure, or electrical system.

Myopericarditis - This is a combination of both myocarditis and pericarditis.

Ischemic stroke - Occurs when blood flow to the brain is blocked or reduced by a blood clot or plaque.

Venous thromboembolism - This occurs when a blood clot forms within the vein.

Cerebrovascular disease - A disease of the blood vessels that affects the blood flow in vessels in the brain; this causes a reduction of blood flow within the brain, also known as Ischemia, bleeding, or hemorrhage.

Peripheral arterial disease - A common condition in which narrowed arteries reduce blood flow to the arms or legs. Usually, this is a sign of a buildup of fatty deposits within the arteries (atherosclerosis).

Symptoms of developing heart complications post-COVID-19 infection include consistent chest pain and discomfort, including a dull ache, a crushing or burning feeling, and a burning sensation within the heart. Heart palpitations are the feeling of having a fast-beating, fluttering, or pounding heart, usually occurring within the chest, throat, and neck. Furthermore, fast-occurring heart rates are also known as tachycardia. Symptoms include dizziness or lightheadedness, severe headaches, nausea, and faintness.

Reports/methodology

Table 1 CDC Wonder Data: Heart diseases were the leading cause of death during the infectious COVID-19.

Cardiovascular disease accounted for 2,706,931 deaths globally in 2020 and 2021. Additionally, COVID-19 was the leading cause of death worldwide, with a total of 767,724 deaths during 2020 - 2021.

Rank	Leading Cause of Death	Number of Deaths	Year
1	Disease of Heart	2,706,931	2020-2021
2	Malignant Neoplasms	2,406,438	2020-2021
3	COVID-19	767,724	2020-2021

Table 2 CDC Wonder Data: Cardiovascular rates have significantly increased post-COVID-19.

Between 2018 and 2019, the number of cardiovascular deaths increased by 15,633, but the crude rate per 100,000 (average deaths within a population per 100,000 individuals) did not change significantly from 2018 to 2019. However, between 2020 and 2021, the number of deaths increased by 80,502, which is more than five times the increase in CVD-related observed from 2018 to 2019.

Year	Number of Deaths	Crude Rate per 100,000
2018	2,839,205	867.8
2019	2,854,838	869.7
2020	3,383,729	1027.0
2021	3,464,231	1,043.8

Further research analyzed roughly 11,100 patients who had COVID-19 between May 2020 and May 2021 across 13 countries. This significant research shows higher rates of cardiovascular complications in men hospitalized with COVID-19 than in women. The cardiology team

observed that for every 100 women, 13 received a diagnosis of CVD during their recovery, whereas for every 100 men, 17 received a diagnosis. These findings indicate a 23.5% lower chance of heart complications in women than in men (Higher rates of heart complications in men hospitalized with COVID-19 not explained by pre-existing cardiovascular conditions). COVID-19 infection is indeed associated with an increase in the incidence and burden of long-term CVD, including ischemic and non-ischemic heart disease, myopericarditis, ischemic stroke, and venous thromboembolism. In the general population, without COVID-19, cardiovascular disease is still known to have higher risks in men rather than women. Some studies have suggested that men may have a slightly higher risk of severe cardiovascular outcomes than women with COVID-19. Regardless, COVID-19 has contributed to 15 million new cases of heart disease worldwide in 2022. The body's immune system causes inflammation in response to an infection or other severe triggers. For example, the COVID-19 virus can directly infect the heart muscle, causing inflammation within the heart and other cardiac complications. Regular checkups with a cardiac specialist are very crucial to ensure safety.

Moreover, vaccines such as Moderna, Pfizer, Johnson & Johnson, and AstraZeneca have protected us from COVID-19 and cardiovascular disease. However, studies have shown that Vaxzevria may lead to myocarditis, blood clots, heart attacks, inflammation within the heart, and other heart complications. Side effects of acute heart inflammation include chest pain, shortness of breath, heart pounding (palpitations), fainting, and flu-like symptoms, such as fever, fatigue, cough, nausea, vomiting, abdominal pain, and abnormal heart rhythms, called arrhythmias. Research has revealed that Vaxzevria, manufactured and developed by the pharmaceutical company Oxford-AstraZeneca, can cause rare side effects such as Thrombosis with Thrombocytopenia Syndrome (TTS), which occurs when blood clots block the blood vessels. (AstraZeneca Admits Its Covid Vaccine Can Cause Rare Side Effects in Court Documents for First Time. Pharmaceutical Giant Being Sued in Class Action over Claims Its Vaccine Caused Death and Serious Injury in Dozens of Cases). Symptoms of TTS include severe or persistent headaches, blurred vision, shortness of breath, chest pain, leg swelling, abdominal pain, consistent bruising, or tiny blood spots beneath the skin. Plaque forms within the blood vessels, obstructing the blood flow to the rest of the body. Cardiac death can occur within twelve weeks post-vaccination for individuals ages twelve to twenty-nine in England (Risk of Death Following COVID-19 Vaccination or Positive SARS-CoV-2 Test in Young People, England). Following the Vaxzevria vaccination, an individual's chances of experiencing myocarditis and pericarditis have significantly increased. Conversely, many vaccines, such as Pfizer, Moderna, and Johnson-Johnson, can ultimately reduce the number of cardiovascular disease cases. The COVID-19 vaccines, Pfizer, Moderna, and Johnson & Johnson, can profoundly reduce the likelihood of getting diagnosed with certain heart complications, such as myocarditis and blood clotting, which reduces the chances of experiencing a heart attack.

Heart Complication Treatments

Due to the number of deaths increasing significantly, there are various kinds of treatment available.

- 1) *Anticoagulants* - Helps reduce the risk of blood clot formation and artery blockade.



2) *Antiplatelets* - Medicine that stops blood cells (platelets) from sticking together and forming a blood clot. One example of an antiplatelet is aspirin.

3) *Antiarrhythmics* - This medication prevents and treats abnormal heart rate and rhythm (What Are Antiarrhythmics?)

4) *Lipid-lowering medications* - These are medications that help control cholesterol and triglyceride levels. Ezetimibe is an example of a lipid-lowering medication that inhibits cholesterol absorption within the intestine. Soluble fiber can reduce cholesterol absorption from foods and the production of cholesterol within the body (Top 5 Lifestyle Changes to Improve Your Cholesterol)

5) *Vasodilators* - Allows blood to flow more quickly through the arteries. ACE inhibitors are an example of a vasodilator used to treat high blood pressure and heart failure.

6) *Corticosteroids* - A type of anti-inflammatory drug that treats pericarditis.

7) *Beta Blockers* - Can help improve arrhythmias and remodel the heart muscle.

Illness Preventions

1). *Avoiding close contact* - Avoid people with flu symptoms or other respiratory viruses. If exposed to certain illnesses, avoid encounters with other individuals and quarantine.

2). *Wash hands daily* - Consistent hand washing can be one of the best ways to avoid getting sick and spreading illness.

3). *Getting recommended vaccines* - Staying up to date with vaccines for COVID-19 prevention, influenza, rubella, and other diseases that cause myocarditis.

Anti-Inflammatory Lifestyle Changes

Avoiding contributors that activate the body's inflammatory response can control inflammation. These lifestyle adjustments decrease built-in plaque, lower blood pressure, and reduce high blood sugar.

1) *Quit smoking* - Smoking damages blood vessels and promotes atherosclerosis. Quitting smoking can reduce heart complications by 50%.

2) *Maintaining a healthy weight* - Being overweight increases the risk for multiple diseases. Visceral fat produces cytokines that can trigger low-level inflammation and increase the risk of developing heart disease.

3) *Increase physical Activity* - Exercising at least 20 minutes can help reduce inflammation. Fast walking, jogging, bicycling, and yoga can vary and are incredibly effective.

4) *Eat a heart-healthy diet* - Processed and fast foods collectively increase inflammation. Whole foods can help. Consuming more fruits, vegetables, whole grains, beans, nuts, and fatty fish may help reduce inflammation.

Examinations/Tests

1) *Consistent blood tests* - Check for blood clots forming within the body and blood vessels. Certain heart complications began to develop after the mRNA COVID-19 vaccines, so regular checkups with a cardiac specialist are crucial to ensure safety.

2) *An electrocardiogram (ECG or EKG)* - Records the heart's electrical signals and can tell if the heart is beating too fast or too slow.

3) *Holter monitoring* - A portable ECG device is worn for a few days to record the heart's activity. It can detect irregular heartbeats and arrhythmia.

4) *Echocardiogram* - This noninvasive exam uses sound waves to create detailed images of the heart beating in motion. It shows how blood moves throughout the heart and heart valves. An echocardiogram can help determine if a valve is narrowed or leaking.

5) *Cardiac catheterization* - This procedure can show the blockage located in the heart.

6) *Heart (cardiac) CT scan* - An X-ray tube rotates around your body, capturing images of your heart and chest.

7) *Heart cardiac magnetic resonance imaging (MRI)* - Scans use a magnetic field and computer-generated radio waves to create detailed heart images.

Discussion

COVID-19 has been a massive concern for the past three years. The impact of COVID-19 has led to an increase in cardiovascular disease rates globally, with recent years showing a rise in cardiovascular disease-related deaths, according to CDC Wonder. COVID-19 was the third leading cause of death in 2020 and 2021. Subsequently, 15 million new cases of heart disease were reported worldwide in 2022 in patients who had COVID-19. (COVID-19 infections increase the risk of heart conditions up to a year later). COVID-19 infections increase the risk of heart conditions up to a year later, and cardiovascular care is an essential part of post-infection care. (COVID-19 Linked to Increased Risk of Cardiovascular Complications). COVID-19 may have contributed to the increase of CVD due to developed inflammation within the heart.

Additionally, various viruses, such as influenza and respiratory syncytial virus, also known as RSV, can contribute to increased rates of cardiovascular disease (RSV and Heart Health). Moreover, the vaccine Vaxzervria manufactured by AstraZeneca can harm cardiovascular health. Vaxzervria's effects range from myocarditis to pericarditis and produce blood clots, affecting blood flow through the heart's arteries.

Conversely, there are positive benefits to receiving COVID-19 vaccination, such as reducing the risk of developing CVD. Common cardiovascular complications of COVID-19 including blood clots, stroke, arrhythmias, and heart attacks - were substantially reduced within vaccinated patients (Cardiovascular Risks and COVID-19: New Research Confirms the Benefits of Vaccination). Various types of COVID-19 vaccines also reduce the chances of getting cardiovascular disease. A 2022 study of 231,037 people found that two COVID-19 vaccines reduced the risk of stroke and heart attack up to four months after a breakthrough infection (Cardiovascular risks and COVID-19). Additionally, factors such as age, predisposition, previous diseases, and preconditions may be beneficial in deciding what vaccine is better for each specific population within a particular region. When the blood vessels' endothelial lining is damaged, platelets, also known as thrombocytes, are drawn to the injury site. Platelets initiate the coagulation cascade, producing fibrin and forming a web that traps red blood cells, forming a blood clot. In rare cases, Vaxzevria has triggered blood clotting disorders, which involve an abnormal immune response causing platelets to form blood clots within the blood vessels. The blood clots formed by Vaxzevria are called vaccine-induced immune thrombotic thrombocytopenia (VITT). Reduced blood flow due to blood clotting can decrease oxygen supply to the heart, potentially leading to Ischemia or worsening conditions.

On the contrary, a subsequent study of 1.9 million people found that while two doses of the mRNA vaccine or one dose of the Johnson & Johnson vaccine protected against major cardiovascular events following COVID-19, even a single dose offered some benefit in reducing the risk of cardiovascular complications (Cardiovascular Risks and COVID-19: New Research Confirms the Benefits of Vaccination). Different types of vaccines can influence cardiovascular health in both beneficial and harmful ways. Many can reduce the chances of getting cardiovascular disease, and vaccines such as Vaxzevria can increase the chances of getting diagnosed with heart complications. Understanding this concept gives an in-depth standpoint on how heart complications can lead to infectious COVID-19 due to the respiratory system getting impacted due to artery damage. The lung damage caused by SARS-CoV-2 prevents oxygen from reaching the heart muscle, which in turn causes artery and tissue damage within the heart's structure.

Additionally, there are many novel therapies to prevent and treat patients with cardiovascular diseases. Therapies such as antiviral drugs, a new medicine specifically used to combat SARS-CoV-2 and ultimately lower the risk of getting diagnosed with heart complications, anti-inflammatory drugs, a therapy used to aim at reducing heart inflammation post-SARS-CoV-2, antithrombotic drugs (for those who have received Vaxzevria), to lower the chances of blood clotting and getting diagnosed with TTS, regenerative medicine, techniques such as stem cell therapy to repair heart damage caused by SARS-CoV-2. It is also essential to state the positive and adverse risk factors for receiving the COVID-19 vaccines and how this ultimately impacts cardiovascular health. As cardiovascular disease is the leading cause of death worldwide, it is crucial to understand how SARS-CoV-2 and Vaxzevria can increase the risk of developing cardiovascular diseases in the future.

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