

Review Article

Comprehensive Review of COVID-19: Symptoms, Diagnosis, and Management

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Introduction

The COVID-19 pandemic has a profound impact on the world. Since its emergence, the virus has spread rapidly, causing widespread illness and death [1]. It has also led to significant disruptions in daily life, economies, and healthcare systems. In terms of daily life, many countries have implemented lockdowns and social distancing measures to slow the spread of the virus. This has led to changes in how people work, socialize, and access essential services. For example, many businesses have shifted to remote work, and schools have had to adapt to on-line learning. Additionally, travel restrictions and quarantine measures have affected people's ability to move freely and visit loved ones [2]. Economically, the pandemic has caused major disruptions. Many businesses, especially those in the hospitality, tourism, and entertainment industries, have suffered due to lockdowns and reduced consumer spending [3]. Unemployment rates have risen in many countries, and governments have had to implement stimulus packages to support individuals

Abstract

COVID-19, caused by the novel coronavirus SARS-CoV-2, can lead to a wide range of symptoms, varying from mild to severe. Common symptoms include fever, cough, and shortness of breath. Other symptoms may include fatigue, muscle or body aches, headache, loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, and diarrhea. Some individuals may also experience more severe symptoms such as difficulty breathing, chest pain or pressure, confusion, inability to stay awake, and bluish lips or face, which require immediate medical attention. It's important to note that symptoms can appear 2-14 days after exposure to the virus, and some individuals may remain asymptomatic carriers. If you suspect you have COVID-19 or have been exposed to the virus, it's crucial to seek medical advice and follow public health guidelines to prevent the spread of the virus. COVID-19 diagnosis involves identifying the presence of the SARS-CoV-2 virus through various methods such as RT-PCR testing, antigen testing, antibody testing, and imaging techniques such as chest X-rays and CT scans. Early and accurate diagnosis is crucial for effective management and control of the disease. Rapid and widespread testing, along with proper isolation and contact tracing, are essential for containing the spread of the virus. COVID-19 management involves a multi-faceted approach, including vaccination, testing, contact tracing, and public health measures such as mask-wearing and social distancing. Treatment focuses on supportive care and, in some cases, antiviral medications. On-going research is crucial for developing effective strategies to control the spread of the virus and mitigate its impact on public health.

Keywords: COVID-19; SARS-CoV-2; COVID-19 symptoms; COVID-19 diagnosis; COVID-19 management; COVID-19 treatment

and businesses affected by the pandemic. Healthcare systems have also been significantly impacted. Hospitals and healthcare workers have been overwhelmed by the influx of COVID-19 patients, leading to shortages of medical supplies and personnel. Non-COVID-19 medical services have been disrupted, and many people have faced challenges in accessing routine healthcare. Real-time examples of the on-going impact of the pandemic include the emergence of new variants of the virus, such as the Delta and Omicron variants, which have led to surges in cases in various parts of the world. Additionally, vaccination campaigns continue to be a major focus, with efforts to increase vaccine distribution and access, as well as to address vaccine hesitancy in some communities [4]. Overall, the COVID-19 pandemic has far-reaching effects on the world, and its impact continues to be felt as efforts to control the virus and mitigate its consequences remain on-going.

The COVID-19 pandemic has a profound impact on public health worldwide. One of the most significant effects has been the strain on healthcare systems [5]. For example, during the peak of the pandemic, hospitals in many countries faced shortages of essential medical supplies such as Personal Protective Equipment (PPE), ventilators, and even basic items like masks and gloves. This scarcity not only endangered healthcare workers but also compromised the ability of hospitals to provide adequate care to patients. Furthermore, the surge in COVID-19 cases led to a shortage of hospital beds in many regions. This scarcity forced healthcare providers to make difficult decisions about which patients could receive treatment, potentially leading to delays in care for non-COVID-19-related conditions [6].

The pandemic has also exacerbated the existing shortage of healthcare workers. Many doctors, nurses, and other medical professionals have faced immense pressure and exhaustion due to the increased workload and the emotional toll of treating severely ill patients. Some healthcare workers have also fallen ill themselves, further straining the workforce. In terms of the virus's disproportionate impact on certain populations, the elderly and individuals with underlying health conditions have been particularly vulnerable to severe illness and death from COVID-19. For example, nursing homes and long-term care facilities have experienced devastating outbreaks, leading to a high number of fatalities among elderly residents. Marginalized communities with limited access to healthcare have also been disproportionately affected. These communities often face barriers to testing, treatment, and vaccination, leading to higher infection rates and poorer health outcomes. For instance, in some areas, language barriers, lack of transportation, and limited healthcare infrastructure have hindered marginalized individuals' ability to access critical healthcare services. Finally, the pandemic has strained healthcare systems, leading to shortages of medical supplies, hospital beds, and healthcare workers [7]. It has also disproportionately affected vulnerable populations, highlighting pre-existing health disparities and the need for targeted interventions to ensure equitable access to healthcare.

The COVID-19 pandemic has a profound impact on the global economy. Let's take a closer look at some of the effects:

Job Losses

The COVID-19 pandemic has had a profound impact on various industries, leading to significant job losses. Let's delve into some real-time examples to illustrate this.

The travel industry has been severely affected, with major airlines like American Airlines, Delta Air Lines, and United Airlines having to lay off thousands of employees due to reduced travel demand. For instance, American Airlines announced in 2020 that it would furlough or lay off 19,000 employees, while United Airlines warned of potential furloughs for 36,000 employees. These job losses were a direct result of the sharp decline in air travel as people cancelled or postponed their trips due to the pandemic. In the hospitality sector, hotels, resorts, and restaurants faced a similar plight. Many establishments had to reduce their workforce or shut down altogether due to decreased demand for travel and leisure activities [8]. For example, major hotel chains such as Marriott International and Hilton Worldwide Holdings had to implement layoffs and furloughs to cope with the impact of the pandemic on their business. The retail industry also experienced significant job losses as many non-essential stores were forced to close temporarily or operate with limited capacity. This led to layoffs and reduced

working hours for retail employees across the country. Companies like Gap, Inc. and Macy's announced widespread layoffs and store closures as a result of the economic challenges posed by the pandemic. These examples highlight the widespread impact of the pandemic on industries such as travel, hospitality, and retail, leading to substantial job losses and economic hardship for many individuals and families.

Business Closures

The COVID-19 pandemic has a significant impact on small businesses, especially those in the hospitality and entertainment industries [9]. For example, many small restaurants and cafes have struggled to stay afloat due to prolonged lockdowns and restrictions on indoor dining. The reduced customer traffic has led to a decline in revenue, making it difficult for these businesses to cover their operational costs. In real-time, we can see that some small restaurants have to close their doors permanently. For instance, a family-owned Italian restaurant in a local neighbourhood recently announced its closure after being in business for over 20 years. The owner cited the financial strain caused by the pandemic as the primary reason for the closure. Similarly, a small music venue that used to host live performances has also shut down due to the on-going challenges of operating at limited capacity and the uncertainty surrounding future events. These examples illustrate the real and devastating impact of the pandemic on small businesses in the restaurant, bar, and entertainment sectors [10]. The road to recovery for these businesses will likely be long and challenging, requiring support from both the government and the local community.

Financial Hardship

The pandemic has caused significant financial hardship for many individuals and families [11]. For example, hourly workers in the service industry, such as restaurant staff, have faced reduced hours or even job loss due to restrictions on indoor dining and other public health measures. This has led to struggles in paying for rent, mortgages, and other essential expenses. In real-time, we can see that despite some economic recovery, many people are still facing challenges. For instance, a family in a tourist-dependent area might have seen a drastic reduction in income due to decreased travel and tourism. This could make it difficult for them to keep up with their housing payments and other bills. Furthermore, individuals who work in the gig economy, such as rideshare drivers or freelance workers, have also experienced financial strain as demand for their services decreased during lockdowns and restrictions [12]. Overall, the pandemic's impact on employment and income has created widespread financial difficulties for many, particularly those in hourly wage jobs and heavily impacted industries.

The COVID-19 pandemic has profound economic impacts globally, leading governments to implement various measures to mitigate these effects, as shown in Table 1. Let's delve into some of these measures and their real-time examples.

Stimulus Packages

Many governments have rolled out stimulus packages to inject funds into their economies and support businesses and individuals [13]. For instance, the United States passed the American Rescue Plan Act, which included direct payments to individuals, extended unemployment benefits, and funding for small businesses to retain employees and cover operational costs.

Table 1: Various measures to mitigate COVID-19 effects.

Country	Stimulus Package	Unemployment Benefits	Support for Small Businesses
United States	American Rescue Plan Act: Direct payments to individuals, extended unemployment benefits, funding for small businesses	Extended unemployment benefits to support workers during the economic downturn	Funding for small businesses to retain employees and cover operational costs
United Kingdom	Furlough scheme: Initially covered 80% of employees' wages to prevent widespread job losses	Expanded unemployment benefits to provide financial support to those who have lost their jobs due to the pandemic	Various support including grants, loans, and tax relief to help small businesses cover operating costs during reduced revenue
Canada	Canada Emergency Business Account (CEBA): Interest-free loans to small businesses and non-profit organizations	-	Interest-free loans to help small businesses cover operating costs during a period of reduced revenue

Table 2: Key factors contributing to the impact of COVID-19, vulnerable groups affected, and the efforts to combat COVID-19.

Factors Contributing to COVID-19 Impact	Vulnerable Groups	Efforts to Combat COVID-19
Public health measures (lockdowns, mask mandates, social distancing)	Older adults	Vaccination campaigns
Healthcare system effectiveness	Individuals with underlying health conditions	Public health interventions (mask mandates, social distancing)
Vaccination rates	Communities with limited healthcare access	On-going research for new treatments and vaccines
Emergence of new variants	Essential workers	Coordinated efforts across healthcare, government, and research sectors

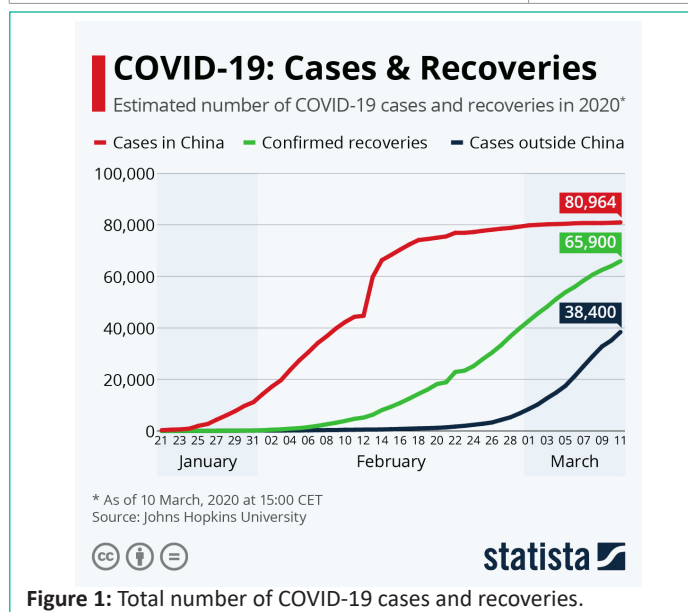


Figure 1: Total number of COVID-19 cases and recoveries.

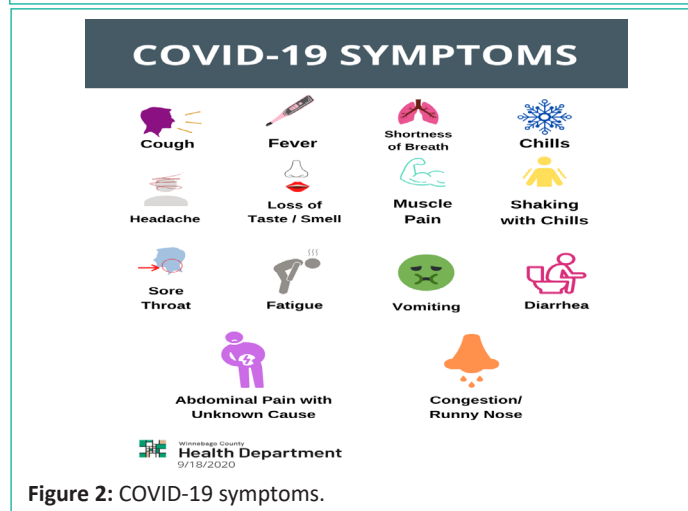


Figure 2: COVID-19 symptoms.

Unemployment Benefits

Governments have expanded or extended unemployment benefits to provide financial support to those who have lost their jobs due to the pandemic [14]. In the UK, the government introduced the furlough scheme, which initially covered 80% of employees' wages, helping to prevent widespread job losses and support workers during the economic downturn.

Support for Small Businesses

Various countries have offered support to small businesses through grants, loans, and tax relief [15]. For example, in Canada, the government introduced the Canada Emergency Business Account (CEBA), providing interest-free loans to small businesses and non-profit organizations to help cover operating costs during a period of reduced revenue.

Despite these measures, the road to economic recovery remains uncertain. The long-term effects of the pandemic on industries and the global economy are yet to be fully realized. Sectors such as travel and tourism, hospitality, and retail continue to face significant challenges, with recovery timelines dependent on factors such as vaccination rates, new variants of the virus, and global supply chain disruptions. In conclusion, while governments have taken significant steps to mitigate the economic impacts of the pandemic, the full extent of its effects on industries and the global economy will only become clear in the coming years as we navigate the path to recovery.

The COVID-19 pandemic has indeed led to widespread isolation due to the measures implemented to curb the spread of the virus. Lockdowns and social distancing have limited in-person social interactions, leading to feelings of loneliness and disconnection for many people. This has been particularly challenging for individuals who live alone or those who rely on social activities for their mental well-being. For example, consider individuals who used to regularly meet with friends for social activities, such as going to the gym, attending religious services, or participating in community events. With these activities restricted or cancelled, many have experienced a loss of social support and a decrease in opportunities for meaningful social engagement. Furthermore, the shift to remote work and online learning has blurred the boundaries between work, home, and personal life for many individuals. This constant blending of spaces can contribute to feelings of burnout, stress, and a sense of being constantly "on," which can take a toll on mental health.

In addition, the uncertainty and fear surrounding the pandemic, as well as the constant exposure to distressing news, have contributed to increased rates of anxiety and depression. The disruptions of routines, financial strain, and concerns about the health of loved ones have also added to the psychological burden experienced by many. It's important to note that these

Table 3: COVID-19 most frequently reported symptoms.

Symptom	Description
Fever	Elevated body temperature
Dry cough	Cough without mucus or phlegm
Fatigue	Extreme tiredness and lack of energy
Shortness of breath	Difficulty breathing or feeling breathless
Difficulty breathing	Struggle to take in an adequate amount of air

Table 4: Less common manifestations of COVID-19.

Manifestation	Description
Loss of taste or smell	Anosmia or ageusia
Sore throat	Pain or irritation in the throat
Congestion or runny nose	Blocked or runny nasal passages
Nausea or vomiting	Feeling of sickness or vomiting
Diarrhea	Frequent, loose, or watery stools
Muscle or body aches	Discomfort or pain in muscles or body
Headache	Pain or discomfort in the head
Chills	Feeling of cold with shivering or shaking

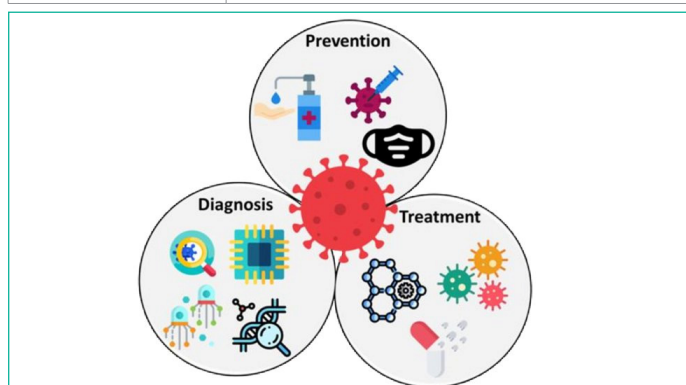


Figure 3: COVID-19 prevention, Diagnosis and treatment.

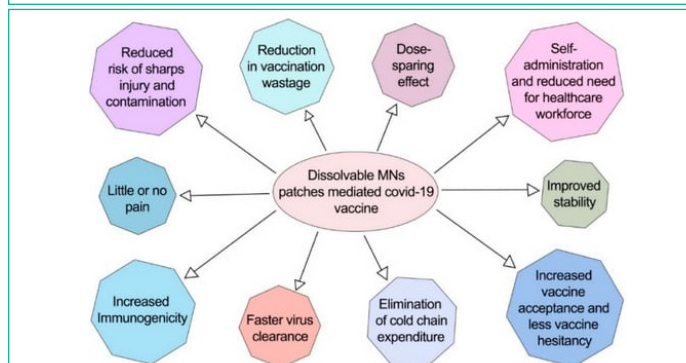


Figure 4: Vaccination and its role in preventing and managing the COVID-19 disease.

challenges have not affected everyone equally. Certain groups, such as frontline healthcare workers, individuals with pre-existing mental health conditions, and those facing economic hardship, have been particularly vulnerable to the mental health impacts of the pandemic. In response to these challenges, mental health professionals and organizations have been working to provide support through teletherapy, online support groups, and mental health hotlines. Employers and schools have also been encouraged to promote mental well-being by offering resources for stress management, flexible work arrangements, and mental health days.

As we continue to navigate the pandemic, it's crucial to prioritize mental health support and destigmatize seeking help for psychological distress. Building and maintaining social connections, engaging in self-care practices, and seeking professional help when needed are important steps in mitigating the mental health implications of prolonged isolation and uncertainty.

The COVID-19 pandemic has laid bare the deep-seated global inequalities that exist in our world. One of the most glaring examples of this is the unequal access to vaccines. Wealthier countries have been able to secure and distribute vaccines at a much faster rate than poorer nations, leaving the latter at a significant disadvantage in their efforts to protect their populations. This has not only led to disparities in vaccination rates between countries but has also perpetuated global health inequities. Furthermore, within countries, there have been disparities in access to healthcare and economic support. Marginalized communities, including racial and ethnic minorities, low-income individuals, and those in rural areas, have faced greater challenges in accessing healthcare services and financial assistance. For example, in some countries, marginalized communities have experienced higher rates of COVID-19 infection and mortality due to a lack of access to quality healthcare and preventive measures. The economic impact of the pandemic has also disproportionately affected vulnerable populations. Many low-wage workers, who are often essential to the functioning of society, have faced job losses, reduced hours, and economic instability. Meanwhile, wealthier individuals and corporations have been able to weather the economic storm more effectively. These disparities have widened existing social and economic divides, further entrenching inequality. The pandemic has underscored the urgent need for global cooperation and solidarity to address these systemic issues and ensure that all people, regardless of their background or location, have equal access to healthcare, vaccines, and economic support.

Governments and organizations worldwide have indeed implemented a range of measures to combat the spread of the virus. One of the most significant efforts has been the vaccination campaigns. Many countries have rolled out extensive vaccination drives, aiming to inoculate as much of their populations as possible. For example, the United States has administered millions of vaccine doses through various channels, including mass vaccination sites, pharmacies, and mobile clinics. Testing and contact tracing have also been crucial in controlling the spread of the virus [16]. Many countries have expanded their testing capacity, offering free or low-cost testing to the public. Contact tracing efforts have involved using technology, such as mobile apps, to identify and notify individuals who may have been exposed to the virus. For instance, in South Korea, an advanced contact tracing system has been instrumental in containing outbreaks.

Public health guidelines, including mask mandates and social distancing requirements, have been widely implemented. In the United Kingdom, for instance, mask mandates have been enforced in indoor public spaces, and social distancing measures have been in place in various settings to reduce the risk of transmission. These measures, along with others such as travel restrictions and quarantine protocols, have been essential in the global effort to control the spread of the virus and mitigate its impact on public health and the economy.

The COVID-19 pandemic has highlighted the interconnectedness of the global community and the necessity of international cooperation in addressing public health crises [17]. One of the most significant advancements has been the rapid development and distribution of vaccines. For example, the development of mRNA vaccines, such as those produced by Pfizer-BioNTech and Moderna, represents a ground-breaking achievement in vaccine technology. These vaccines have demonstrated high efficacy in preventing COVID-19 and have been distributed

Table 5: Symptoms and their severity in individuals infected with COVID-19.

Symptom	Severity Level	Commonality
Fever	Mild to Severe	Common
Cough	Mild to Severe	Common
Shortness of Breath	Mild to Severe	Less Common
Fatigue	Mild to Severe	Common
Muscle or Body Aches	Mild to Severe	Common
Loss of Taste or Smell	Mild to Severe	Less Common
Sore Throat	Mild	Common
Congestion or Runny Nose	Mild	Less Common
Nausea or Vomiting	Mild	Less Common
Diarrhea	Mild	Less Common

Table 6: Various mechanisms of COVID-19 and their impact.

Mechanism	Description
Transmission	COVID-19 is primarily transmitted through respiratory droplets when an infected person coughs, sneezes, or talks. It can also spread by touching surfaces contaminated with the virus.
Respiratory System	The virus enters the body through the respiratory tract and infects cells in the nose, throat, and lungs. This can lead to symptoms such as cough, shortness of breath, and pneumonia.
Other Organs	COVID-19 can also affect other organs, including the heart, kidneys, liver, and brain. It has been associated with various complications such as myocarditis, acute kidney injury, liver dysfunction, and neurological symptoms.
Immune Response	The body's immune system responds to the virus by triggering inflammation and releasing cytokines. In some cases, this immune response can become deregulated, leading to a cytokine storm and widespread tissue damage.
Long-Term Effects	Some individuals experience long-term effects of COVID-19, known as long COVID, which can involve persistent symptoms affecting multiple organ systems.

Table 7: Potential complications of COVID-19.

Complication	Description
Acute Respiratory Distress Syndrome (ARDS)	Severe lung condition that can lead to respiratory failure.
Thrombosis	Formation of blood clots, which can lead to serious health issues such as stroke or heart attack.
Long-term effects on organ systems	COVID-19 can have long-lasting effects on various organ systems, including the heart, lungs, and brain.

Table 8: Role of public health measures.

Public Health Measure	Role in Controlling COVID-19 Spread
Testing	Identifying and isolating infected individuals, preventing further spread
Contact Tracing	Identifying and notifying individuals who may have been exposed, containing outbreaks
Quarantine	Isolating individuals who have been exposed, preventing transmission
Vaccination Campaigns	Building immunity in the population, reducing transmission and severity of illness

globally, contributing to efforts to control the spread of the virus. Furthermore, the pandemic has accelerated the adoption of telemedicine, allowing patients to consult with healthcare providers remotely [18]. This has not only helped to reduce the risk of virus transmission but has also improved access to healthcare for individuals who may have difficulty traveling to in-person appointments. Remote work has also become more prevalent, with many companies implementing flexible work arrangements and embracing digital collaboration tools. This shift

has not only enabled businesses to continue operations during lockdowns but has also provided employees with greater flexibility and work-life balance.

In addition, the pandemic has driven innovation in other areas of daily life. For instance, contactless payment methods have become more widely used to minimize physical contact, and the use of delivery services for groceries and other essentials has surged, transforming the way people shop for necessities. Overall, the COVID-19 pandemic has catalysed advancements in vaccine development and distribution, as well as innovations in telemedicine, remote work, and various aspects of daily life, demonstrating the resilience and adaptability of the global community in the face of unprecedented challenges.

As the world continues to grapple with the on-going impact of the pandemic, it is clear that COVID-19 has fundamentally reshaped societies, economies, and healthcare systems, and its effects will continue to be felt for years to come.

Epidemiology

This section covers the global and regional spread of COVID-19, including the number of cases, mortality rates, and affected populations.

The global spread of COVID-19 has been a significant and complex phenomenon. The virus has affected different regions in diverse ways, and several factors have contributed to this variation. Population density has played a crucial role in the spread of the virus [19]. In densely populated areas, such as urban centres, the virus has had more opportunities to spread due to close proximity and increased interactions among people. This has led to higher rates of infection in such areas. Healthcare infrastructure has also been a determining factor in the impact of the virus. Regions with robust healthcare systems, including ample hospital capacity, medical supplies, and healthcare personnel, have been better equipped to handle the influx of COVID-19 cases. In contrast, areas with limited healthcare resources have struggled to provide adequate care to those affected, leading to higher mortality rates.

Government response has been another critical factor. Swift and coordinated government actions, such as implementing lockdowns, mass testing, contact tracing, and vaccination campaigns, have proven effective in controlling the spread of the virus in some regions. In contrast, delayed or inadequate government responses have allowed the virus to spread more rapidly, resulting in higher infection and mortality rates. Additionally, cultural and social factors have also influenced the spread of the virus. Practices such as large social gatherings, religious events, and communal living arrangements have contributed to the transmission of the virus in certain regions. The global spread of COVID-19 has highlighted the interconnectedness of the world and the importance of a coordinated, multifaceted response to such public health crises. It has also underscored the need for on-going research, preparedness, and collaboration among nations to effectively address and mitigate the impact of future pandemics.

Number of Cases and Mortality Rates

The variation in reported COVID-19 cases and mortality rates across different regions can be attributed to a multitude of factors [20]. These include differences in testing capacity, healthcare infrastructure, population density, government responses, public health measures, and demographic characteristics. Re-

gions with robust testing infrastructure and widespread access to healthcare services are more likely to report higher numbers of cases, as they are able to identify and confirm infections more effectively. Conversely, areas with limited testing capabilities may have artificially lower-case counts, leading to an underestimation of the true prevalence of the virus.

Mortality rates can also be influenced by factors such as the age distribution of the population, prevalence of underlying health conditions, quality of healthcare services, and the timing and effectiveness of public health interventions. Regions with older populations or higher rates of chronic illnesses may experience higher mortality rates compared to areas with younger, healthier populations. Furthermore, differences in government responses and public adherence to preventive measures, such as mask-wearing, social distancing, and vaccination campaigns, can significantly impact the spread of the virus and subsequent mortality rates [7]. It's important to note that the availability and distribution of vaccines and treatments also play a crucial role in mitigating the impact of the virus. Regions with successful vaccination campaigns and widespread access to effective treatments are likely to experience lower mortality rates and a more contained spread of the virus.

Overall, the variation in reported cases and mortality rates across different regions underscores the complex interplay of numerous factors in the global response to the COVID-19 pandemic. Understanding these dynamics is essential for developing targeted strategies to control the spread of the virus and minimize its impact on public health.

Affected Populations

The COVID-19 pandemic has highlighted the vulnerability of certain demographics, particularly the elderly and those with underlying health conditions [21]. These groups have been disproportionately affected by the virus, experiencing higher rates of severe illness and mortality. This has prompted discussions and actions aimed at protecting these vulnerable populations, such as prioritizing them for vaccination, implementing targeted public health measures, and providing additional support and resources to ensure their safety. It has also underscored the importance of addressing health disparities and ensuring equitable access to healthcare for all members of society.

The response to the pandemic has also varied greatly from region to region, with some countries implementing strict lockdowns, widespread testing, and vaccination campaigns, while others have faced challenges in controlling the spread of the virus due to limited resources or political factors. Overall, the global and regional spread of COVID-19 has a profound impact on public health, economies, and daily life, and continues to be a significant challenge as efforts to control and mitigate the virus's impact continue, as shown in Figure 1.

Table 2 summarizes the key factors contributing to the impact of COVID-19, the vulnerable groups affected, and the efforts to combat the spread of the virus.

Clinical Symptoms

COVID-19, which is caused by the novel coronavirus SARS-CoV-2, can lead to a variety of symptoms. The most frequently reported symptoms include fever, dry cough, and fatigue [22]. Some individuals may also experience respiratory symptoms like shortness of breath and difficulty breathing, especially in more severe cases, as shown in Table 3. It's important to note

that COVID-19 symptoms can vary widely from person to person, and some individuals may even be asymptomatic carriers, meaning they show no symptoms at all. This variability in symptoms has made it challenging to identify and contain the spread of the virus. If you have concerns about COVID-19, it's important to seek guidance from a healthcare professional or local health authorities.

While fever, cough, and shortness of breath are commonly known symptoms of COVID-19, as shown in Figure 2, there are several less common manifestations that individuals may experience. These include:

Loss of Taste or Smell

Anosmia refers to the partial or complete loss of the sense of smell, while ageusia is the partial or complete loss of the sense of taste. These symptoms can occur suddenly and are often reported by individuals who have contracted COVID-19. The loss of smell and taste is one of the hallmark symptoms of COVID-19 and can occur even in the absence of other symptoms [23]. This can have a significant impact on a person's quality of life, as it affects their ability to enjoy food and detect potential dangers through smell. The exact mechanisms behind these sensory losses in COVID-19 are still being studied, but it is thought to be related to the virus's impact on the olfactory and gustatory systems. If you or someone you know experiences sudden loss of smell or taste, especially in the context of the on-going pandemic, it's important to seek medical advice and consider getting tested for COVID-19.

Sore Throat

When a person contracts COVID-19, the virus can cause inflammation and irritation in the throat, leading to symptoms such as a sore or scratchy throat [24]. This occurs as the virus infects the cells in the respiratory tract, leading to an immune response that causes the throat to become inflamed. The body's natural defense mechanisms, such as increased mucus production and immune cell activity, can also contribute to the sensation of a sore or scratchy throat. It's important to note that while a sore throat can be a symptom of COVID-19, it can also be caused by other conditions, so it's essential to consider other symptoms and seek medical advice if there is concern about potential COVID-19 infection.

Congestion or Runny Nose

The symptoms commonly associated with the common cold, flu, and COVID-19 can overlap, making it challenging to differentiate between them based solely on symptoms [25]. Common symptoms shared by these illnesses include fever, cough, and fatigue. However, COVID-19 has been found to cause a broader range of symptoms, including loss of taste or smell, shortness of breath, and gastrointestinal issues such as diarrhea. It's important to note that the severity of symptoms can vary widely among individuals, and some people infected with COVID-19 may remain asymptomatic. Given the similarities in symptoms, testing is often necessary to confirm a diagnosis and determine the appropriate course of action. If you're experiencing any of these symptoms, especially if you've been in close contact with someone who has tested positive for COVID-19, it's important to seek medical advice and consider getting tested.

Nausea or Vomiting

Gastrointestinal symptoms such as nausea and vomiting have indeed been reported in some COVID-19 patients, espe-

cially during the initial stages of the illness [26]. This is because the virus that causes COVID-19, known as SARS-CoV-2, can affect the gastrointestinal system in addition to the respiratory system. The virus enters the body through the respiratory tract, but it has been found to also affect the cells lining the gastrointestinal tract, which can lead to symptoms such as nausea, vomiting, diarrhea, and abdominal pain. The presence of the virus in the gastrointestinal tract can cause inflammation and disrupt the normal functioning of the digestive system. It's important to note that gastrointestinal symptoms can occur in the absence of respiratory symptoms, and in some cases, they may even precede the typical respiratory symptoms of COVID-19. This is why it's crucial for healthcare providers to consider the possibility of COVID-19 in patients presenting with gastrointestinal symptoms, especially in areas with high rates of COVID-19 transmission. Additionally, the presence of gastrointestinal symptoms in COVID-19 patients has implications for infection control and prevention, as the virus can be present in the stool of infected individuals, potentially leading to fecal-oral transmission. Overall, the recognition of gastrointestinal symptoms in COVID-19 patients is important for early identification, appropriate management, and the implementation of infection control measures to limit the spread of the virus.

Diarrhea

Diarrhea as a symptom of COVID-19 is known as a gastrointestinal manifestation of the virus [27]. While COVID-19 is primarily associated with respiratory symptoms such as cough, fever, and shortness of breath, it can also affect the gastrointestinal system. The virus can cause inflammation in the digestive tract, leading to symptoms such as diarrhea, nausea, vomiting, and abdominal pain. The presence of gastrointestinal symptoms, including diarrhea, can occur in conjunction with respiratory symptoms or even on its own. This means that individuals with COVID-19 may experience diarrhea as the primary symptom without showing typical respiratory signs. It's important to note that the severity of gastrointestinal symptoms can vary widely among individuals, and some may experience mild discomfort while others may have more pronounced digestive issues. The exact mechanism by which COVID-19 affects the gastrointestinal system is still being studied, but it's believed that the virus can directly infect the cells lining the digestive tract.

Additionally, the body's immune response to the virus can contribute to gastrointestinal symptoms. It's crucial for individuals experiencing gastrointestinal symptoms, especially in the context of the on-going COVID-19 pandemic, to seek medical advice and testing if they suspect they may have been exposed to the virus. This can help in early detection, appropriate management, and the prevention of further transmission.

Muscle or Body Aches

Muscle pain, body aches, and general discomfort are common symptoms experienced by some individuals with COVID-19 [28]. These symptoms are often described as similar to those experienced with the flu. The reason for these symptoms lies in the body's immune response to the virus. When the immune system detects the presence of the virus, it releases various chemicals, such as cytokines, as part of the inflammatory response. These chemicals can lead to muscle pain and body aches. Additionally, the virus can directly infect muscle cells, leading to further discomfort. It's important to note that while these symptoms are common, they can vary widely in severity from person to person. If you or someone you know is experi-

encing these symptoms, it's important to seek medical advice and follow the guidance of healthcare professionals.

Headache

Headaches can indeed be a symptom of COVID-19 [29]. When a person contracts the virus, it can lead to a range of symptoms, and headaches are among them. These headaches can vary in intensity from mild to severe and may present as a persistent pressure or throbbing sensation in the head. The exact cause of these headaches in the context of COVID-19 is not fully understood, but it is believed to be related to the body's immune response to the virus and the associated inflammation. In some cases, COVID-19-related headaches may be accompanied by other symptoms such as fever, cough, fatigue, and loss of taste or smell. It's important to note that not everyone with COVID-19 will experience headaches, and the presence of headaches alone does not confirm a COVID-19 diagnosis. However, if you are experiencing headaches along with other symptoms or have been in close contact with someone who has tested positive for COVID-19, it's important to seek medical advice and consider getting tested for the virus. As with any potential COVID-19 symptoms, it's crucial to monitor your health closely, follow public health guidelines, and seek medical attention if you have concerns about your symptoms or possible exposure to the virus.

Chills

Chills, or feeling cold despite having a normal body temperature, can indeed be a less common symptom of COVID-19 [30]. When a person is infected with the virus, their immune system responds by releasing chemicals called cytokines. These cytokines can cause the body's temperature to rise, leading to fever and, in some cases, chills. Chills are the body's way of generating heat to combat an infection. They often occur as the body tries to raise its temperature to create an inhospitable environment for the virus. However, it's important to note that chills can also be caused by other illnesses or conditions, so they should not be used as the sole indicator of a COVID-19 infection. If you experience chills along with other symptoms such as fever, cough, or difficulty breathing, it's important to seek medical advice and get tested for COVID-19. Additionally, following public health guidelines, such as wearing masks, practicing good hand hygiene, and getting vaccinated, can help reduce the risk of contracting and spreading the virus. It's important to note that symptoms can vary widely from person to person, and some individuals may experience a combination of these less common manifestations along with more typical respiratory symptoms. If you or someone you know is experiencing any of these symptoms, especially in the context of potential COVID-19 exposure, it's important to seek medical advice and consider getting tested for the virus. Table 4 illustrates several less common manifestations and their descriptions.

The symptoms of COVID-19 can indeed vary greatly from person to person. While some individuals may experience mild symptoms or even remain asymptomatic, others may develop more severe symptoms that require medical attention. Common symptoms include fever, cough, shortness of breath, fatigue, muscle or body aches, loss of taste or smell, sore throat, congestion, nausea, or diarrhea. It's crucial to seek medical advice if you or someone you know is experiencing these symptoms, especially if they worsen or are accompanied by difficulty breathing. Following public health guidelines, such as wearing masks, practicing good hand hygiene, and maintaining physical

distance, is essential to prevent the spread of the virus and protect those around us. Table 5 illustrates the varying symptoms and their severity in individuals infected with COVID-19.

It's important to note that this is a general overview, and individuals may experience a wide range of symptoms with varying severity. If you or someone you know is experiencing these symptoms, seeking medical advice and following public health guidelines is crucial.

Pathophysiology

This section delves into the underlying mechanisms of COVID-19, including how the virus affects the respiratory system and other organs, as well as the body's immune response.

Transmission

COVID-19, short for "coronavirus disease 2019," is caused by the virus SARS-CoV-2. This virus primarily affects the respiratory system but can also impact other organs in the body. When SARS-CoV-2 enters the body, it attaches to cells in the respiratory tract using its spike protein. This spike protein binds to a specific receptor on the surface of human cells called Angiotensin-Converting Enzyme 2 (ACE2) [31]. This binding allows the virus to enter the cells and start replicating. Once inside the cells, the virus hijacks the cellular machinery to produce more copies of itself. This leads to the spread of the virus within the body, causing the characteristic symptoms of COVID-19, such as fever, cough, and difficulty breathing. In some cases, the immune system's response to the virus can lead to an overactive inflammatory response, causing damage to the lungs and other organs.

The ability of SARS-CoV-2 to affect multiple organ systems underscores the importance of understanding the virus's behaviour and developing effective strategies for prevention, treatment, and vaccination.

Respiratory System

The respiratory system is indeed a primary target for viruses, including the one responsible for COVID-19 [32]. When the virus enters the body, it primarily targets the cells lining the airways and lungs. These cells are essential for maintaining the health and function of the respiratory tract. When the virus infects these cells, it triggers an immune response, leading to inflammation and damage to the respiratory tract. As a result of this damage, individuals may experience symptoms such as cough, shortness of breath, and in severe cases, pneumonia. The virus can also affect the alveoli, which are tiny air sacs in the lungs where the exchange of oxygen and carbon dioxide takes place. When the alveoli are affected, it can lead to further respiratory distress, as the ability of the lungs to oxygenate the blood is compromised. This respiratory distress can be particularly severe in individuals with underlying health conditions or weakened immune systems. Understanding how the virus affects the respiratory system is crucial for developing effective treatments and interventions to mitigate its impact.

Other Organs

SARS-CoV-2, the virus responsible for COVID-19, primarily affects the respiratory system, but it can indeed have significant impacts on other organs in the body [33]. One of the most concerning effects is its potential to cause damage to the heart. This can manifest as myocarditis, an inflammation of the heart muscle, or other cardiac complications such as arrhythmias or even heart failure. The exact mechanisms through which the

virus affects the heart are still being studied, but it's thought that the virus can directly infect heart cells or trigger an inflammatory response that affects the heart. In addition to the heart, SARS-CoV-2 can also impact the kidneys. Some COVID-19 patients experience acute kidney injury, which can be a result of the body's inflammatory response to the virus or due to the virus directly affecting the kidneys. This can lead to complications such as electrolyte imbalances and impaired kidney function. The liver is another organ that can be affected by SARS-CoV-2. COVID-19 patients may experience liver damage, which can manifest as elevated liver enzymes or, in severe cases, as liver failure. Again, the exact mechanisms of liver involvement are still being investigated, but it's believed that the virus can directly infect liver cells or trigger an inflammatory response that affects the liver.

Furthermore, the central nervous system can be impacted by the virus, leading to a range of neurological symptoms. Some COVID-19 patients experience symptoms such as headache, dizziness, confusion, and loss of taste or smell. In more severe cases, the virus can lead to conditions such as encephalitis or stroke. Long-term neurological complications are also a concern for some COVID-19 survivors. It's important to note that while these extra-pulmonary effects of SARS-CoV-2 are concerning, not all COVID-19 patients will experience complications in these organs. However, the potential for multi-organ involvement underscores the importance of continued research into the long-term effects of COVID-19 and the development of strategies to mitigate these impacts.

Immune Response

The body's immune response to a virus is a complex and finely tuned process aimed at protecting the body from infection [34]. When a virus enters the body, the innate immune system, which is the body's first line of defense, recognizes the virus as foreign and initiates a response. This response often involves the release of signalling molecules called cytokines, which help to trigger inflammation and recruit immune cells to the site of infection. In some cases, however, the immune response can become deregulated. This can lead to an excessive and harmful release of cytokines, a phenomenon known as a cytokine storm. During a cytokine storm, the immune system goes into overdrive, releasing large amounts of cytokines that can cause widespread inflammation and damage to healthy tissues and organs. This can result in a range of symptoms, from fever and fatigue to organ failure and even death.

Cytokine storms are particularly associated with severe cases of viral infections, including certain strains of influenza and, more recently, with COVID-19. The exact reasons why some individuals experience cytokine storms while others do not are still not fully understood, but it is believed to involve a complex interplay of genetic, immunological, and environmental factors. Understanding and managing the immune response, including the potential for cytokine storms, is an important area of research in the treatment of viral diseases. Therapies aimed at modulating the immune response, such as the use of anti-inflammatory drugs or immunomodulators, are being investigated as potential treatments to prevent or mitigate the harmful effects of cytokine storms.

The adaptive immune system is a crucial component of the body's defense against viruses and other pathogens. It consists of specialized cells, including T cells and B cells, that work together to identify and eliminate foreign invaders. T cells are a

type of white blood cell that can directly attack and destroy cells infected with a virus. They recognize specific proteins, called antigens, on the surface of infected cells and initiate a targeted immune response to eliminate the threat. This process helps prevent the virus from spreading within the body. On the other hand, B cells are responsible for producing antibodies, which are proteins that can bind to and neutralize viruses. When a virus enters the body, B cells produce antibodies that specifically target the virus, marking it for destruction by other immune cells or directly neutralizing its ability to infect healthy cells.

Long-Term Effects

Despite the effectiveness of the adaptive immune system, viruses like SARS-CoV-2, which causes COVID-19, have evolved mechanisms to evade or suppress the immune response. This can lead to prolonged infection and potential long-term complications. For example, some viruses may mutate to avoid recognition by T cells or B cells, allowing them to continue replicating and causing persistent illness. In addition, certain viruses can directly interfere with the function of immune cells, weakening the body's ability to mount an effective defense. This evasion of the immune response can contribute to chronic infections and increase the risk of long-term health issues. Understanding the complex interplay between viruses and the adaptive immune system is crucial for developing effective treatments and vaccines to combat viral infections. On-going research aims to uncover new strategies to enhance the immune response and overcome viral evasion, ultimately improving outcomes for individuals affected by these infections.

Understanding the underlying mechanisms of COVID-19 is essential for developing effective treatments and vaccines. The virus primarily infects cells by binding to a specific receptor called ACE2, which is found on the surface of many cell types, particularly in the respiratory system [35]. Once inside the cell, the virus hijacks the cellular machinery to replicate itself, leading to the destruction of the infected cell and the release of more virus particles. This process triggers an immune response, leading to the release of inflammatory molecules and the recruitment of immune cells to the site of infection. In some cases, this immune response can become deregulated, leading to a condition known as cytokine storm, which can cause severe damage to the lungs and other organs.

Understanding these processes at a molecular and cellular level can help researchers identify potential targets for therapeutic intervention. For example, drugs that block the virus from entering cells or that modulate the immune response could be developed to treat COVID-19. Additionally, understanding the long-term health effects of the disease, such as long COVID, can help healthcare providers better manage and treat patients who continue to experience symptoms after the acute phase of the illness. By unravelling the underlying mechanisms of COVID-19, scientists and healthcare professionals can work towards developing more effective strategies to combat the disease and its long-term consequences. Table 6 shows the various mechanisms of COVID-19 and their impact.

Diagnosis

A review of the different diagnostic methods for COVID-19, including RT-PCR testing, antigen testing, antibody testing, and imaging techniques such as chest X-rays and CT scans. Here's an in-depth explanation of the different diagnostic methods for COVID-19:

RT-PCR Testing

RT-PCR testing, or Reverse Transcription Polymerase Chain Reaction testing, is indeed considered the gold standard for diagnosing COVID-19 [36]. This method detects the genetic material of the virus by amplifying specific segments of the viral RNA. Here's a more in-depth explanation:

Sample collection: A sample for RT-PCR testing is typically collected from the nasal swab, throat swab, or saliva. This sample contains genetic material from the patient, including any viral RNA if the patient is infected with COVID-19.

Reverse Transcription: In the first step of the RT-PCR process, the viral RNA is converted into complementary DNA (cDNA) through a process called reverse transcription. This step is necessary because the PCR process amplifies DNA, not RNA.

Amplification: The cDNA is then amplified using the Polymerase Chain Reaction (PCR). This process involves repeatedly heating and cooling the sample to allow DNA polymerase to replicate the cDNA, creating millions of copies of the viral genetic material if it is present in the sample.

Detection: The amplified DNA is then analyzed to determine if it contains genetic material specific to the COVID-19 virus. If the virus is present, the test will produce a positive result.

Accuracy: RT-PCR testing is highly accurate and can detect the virus in the early stages of infection, making it a valuable tool for diagnosing COVID-19.

Overall, RT-PCR testing plays a crucial role in identifying individuals infected with COVID-19, allowing for appropriate medical care and public health measures to be implemented.

Antigen Testing

Antigen tests work by detecting specific proteins, known as antigens, on the surface of the virus [37]. These tests are designed to provide rapid results, often within 15-30 minutes, making them valuable for quickly identifying potential cases of COVID-19. This rapid turnaround time is one of the key advantages of antigen tests compared to RT-PCR tests, which can take several hours to produce results. However, it's important to note that antigen tests are generally less sensitive than RT-PCR tests. This means that they may not detect the virus in individuals with low levels of the virus in their system, leading to false-negative results. As a result, antigen tests are most effective when used to test individuals who are likely to have high viral loads, such as those who are symptomatic or have been recently exposed to the virus. Finally, while antigen tests offer the advantage of speed, they may be less reliable in detecting the virus, especially in individuals with low viral loads. As with any diagnostic test, it's important to consider the limitations and use antigen tests in conjunction with other testing methods and clinical evaluation to ensure accurate results.

Antibody Testing

Antibody tests, also called serology tests, work by detecting the presence of antibodies that the immune system produces in response to a virus, such as the one causing COVID-19 [38]. These tests are valuable for identifying whether someone has been exposed to the virus in the past, as the body takes time to generate detectable levels of antibodies after an infection. It's crucial to understand that antibody tests are not typically used to diagnose active infections. This is because it can take days

to weeks for the body to produce enough antibodies to be detected by these tests, so they are not useful for early diagnosis of an on-going infection. Finally, antibody tests are helpful for understanding past exposure to the virus, but they are not suitable for diagnosing active infections. For diagnosing an active infection, other types of tests, such as molecular tests like PCR, are more appropriate.

Imaging Techniques (Chest X-rays and CT Scans)

Chest X-rays and CT scans are indeed valuable tools in assessing the severity of lung involvement in COVID-19 patients [39,40]. These imaging techniques can reveal characteristic patterns of lung abnormalities associated with the virus, such as ground-glass opacities and consolidations. Ground-glass opacities appear hazy on imaging and are often associated with inflammation and fluid accumulation in the lungs, while consolidations represent regions where air spaces in the lungs are filled with fluid, inflammatory cells, and tissue debris. While these imaging techniques can provide valuable information about the extent of lung damage, they are not typically used as standalone diagnostic tools for COVID-19. This is because the presence of these abnormalities is not specific to COVID-19 and can be seen in other respiratory conditions as well. Additionally, the availability of imaging resources and the need to limit radiation exposure in certain patient populations are important considerations. Instead, the diagnosis of COVID-19 is primarily based on clinical symptoms, laboratory tests (such as PCR testing for the virus), and epidemiological factors. However, in cases where there is clinical suspicion of COVID-19 and initial tests are inconclusive, imaging may be used to support the diagnosis and assess the severity of lung involvement. It's important to note that the use of imaging in COVID-19 diagnosis and management should be guided by established protocols and guidelines to ensure appropriate and effective use of these valuable tools.

Each of these diagnostic methods has its own strengths and limitations. RT-PCR testing is the most reliable for diagnosing active infections, while antigen testing offers rapid results. Antibody testing is useful for determining past exposure, and imaging techniques provide insights into the impact of the virus on the lungs. Healthcare providers often use a combination of these methods to obtain a comprehensive understanding of a patient's COVID-19 status.

Management and Treatment

This section covers the current approaches to managing COVID-19, including supportive care, antiviral medications, corticosteroids, and other therapies [41,42]. It may also discuss vaccination and its role in preventing and managing the disease.

Supportive Care

Supportive care is an essential aspect of medical treatment that focuses on alleviating symptoms and maintaining the proper functioning of vital organs in patients [43]. When a patient is experiencing respiratory distress, oxygen therapy can be administered to ensure they are receiving an adequate supply of oxygen. For patients who are dehydrated, intravenous fluids can be given to restore their fluid balance and prevent further complications.

Additionally, medications can be used to reduce fever and alleviate pain, helping to make the patient more comfortable and aiding in their recovery. Overall, supportive care plays a critical role in managing the immediate needs of patients and improv-

ing their overall well-being during illness or medical treatment.

Antiviral Medications

Antiviral medications like remdesivir are designed to directly target the SARS-CoV-2 virus, which is the virus responsible for COVID-19 [44]. They work by inhibiting the virus's ability to replicate and spread within the body. When someone is infected with SARS-CoV-2, the virus enters their cells and begins to make copies of itself, leading to the spread of the infection. Remdesivir, for example, interferes with the virus's replication process, essentially slowing down or stopping its ability to make more copies of itself. This can be particularly beneficial when used in the early stages of the illness, as it may help to reduce the overall viral load in the body and potentially lessen the severity and duration of the illness.

By targeting the virus directly, antiviral medications like remdesivir aim to help the body's immune system gain the upper hand in fighting off the infection. It's important to note that the effectiveness of these medications can depend on various factors, including the specific stage of the illness, the patient's overall health, and any potential interactions with other medications. As with any medical treatment, the use of antiviral medications should be carefully considered and monitored by healthcare professionals.

Corticosteroids

Corticosteroids, like dexamethasone, are a type of medication that can help reduce inflammation in the body [45,46]. In severe cases of COVID-19, the body's immune system can become overactive, leading to a condition known as a cytokine storm. This overactive immune response can cause significant damage to organs and tissues.

By dampening the immune response, corticosteroids can help prevent this cytokine storm from causing further harm. They work by suppressing the activity of the immune system, including the production of inflammatory molecules called cytokines. This can help reduce inflammation in the lungs and other organs, potentially improving outcomes for patients with severe COVID-19.

It's important to note that the use of corticosteroids in COVID-19 treatment is carefully considered and should be prescribed by healthcare professionals. While they can be beneficial in certain cases, they may not be appropriate for all patients, and their use should be guided by the latest medical guidelines and research.

Other Therapies

Monoclonal antibodies and convalescent plasma are two types of therapies used to provide passive immunity or neutralize the virus in patients. Monoclonal antibodies are laboratory-made proteins that mimic the immune system's ability to fight off harmful pathogens such as viruses [47]. They are designed to target specific parts of the virus and can be especially beneficial for individuals at high risk of developing severe disease. These antibodies can be administered to patients who have been recently exposed to the virus or who are at high risk of severe illness.

Convalescent plasma, on the other hand, is derived from the blood of individuals who have recovered from the virus [48]. This plasma contains antibodies that their immune systems produced to fight off the virus. When transfused into a patient who

is currently battling the virus, the antibodies in the convalescent plasma can help neutralize the virus and potentially reduce the severity of the illness. Both of these therapies aim to provide immediate immunity or neutralization of the virus in patients, particularly those who are at high risk of developing severe disease. They represent important tools in the fight against infectious diseases like COVID-19.

The management of COVID-19 has been a dynamic and evolving process. As new research and clinical trials yield insights into the most effective treatments, healthcare professionals and policymakers have been able to adapt their approaches to better address the virus. Vaccination has played a crucial role in this on-going battle against COVID-19. Vaccines have proven to be effective in reducing the severity of the illness and preventing hospitalizations and deaths. Furthermore, widespread vaccination has been a key component in controlling the spread of the virus within communities. In addition to vaccination, public health measures such as mask-wearing, social distancing, and good hand hygiene have remained essential tools in managing the spread of the virus, as shown in Figure 3. These measures help to reduce the risk of transmission and protect vulnerable individuals within the population. It's important for individuals to stay informed about the latest developments in COVID-19 management and to follow the guidance of public health authorities to help protect themselves and others. As our understanding of the virus continues to evolve, so too will our strategies for managing and mitigating its impact.

Vaccination and its Role in Preventing and Managing the Disease

Vaccination is a critical tool in the fight against diseases. When a person is vaccinated, a small, harmless part of a virus or bacteria, or a weakened form of the pathogen, is introduced into the body [49]. This exposure triggers the immune system to produce an immune response, including the production of antibodies and the activation of immune cells. By doing so, the immune system "learns" to recognize and remember the specific pathogen. If the vaccinated person is later exposed to the actual pathogen, their immune system can quickly recognize it and mount a defense, often preventing the person from getting sick or reducing the severity of the illness. This process of priming the immune system through vaccination is a powerful way to protect individuals and communities from the spread of infectious diseases. It not only helps to safeguard the health of the vaccinated individuals but also contributes to the broader goal of achieving herd immunity, where a sufficient proportion of the population is immune to a disease, making its spread less likely.

Vaccines are a crucial tool in the fight against infectious diseases. They work by stimulating the immune system to produce an immune response without causing the disease itself. This prepares the body to fight the actual disease if and when it encounters it in the future. The concept of community immunity, or herd immunity, is particularly important. When a significant portion of a community is vaccinated against a particular disease, it becomes more difficult for the disease to spread, as there are fewer susceptible individuals for it to infect. This indirectly protects those who cannot be vaccinated, such as individuals with weakened immune systems or certain medical conditions, who are at higher risk of severe illness or complications from these diseases. For example, in the case of smallpox, a highly contagious and deadly disease, a global vaccination campaign led to the successful eradication of the disease in 1980.

Similarly, widespread vaccination efforts have significantly reduced the incidence of polio, bringing many countries close to eradicating it altogether. By getting vaccinated, individuals not only protect themselves from potentially serious illnesses but also contribute to the overall health and safety of their communities, as shown in Figure 4. This collective effort is essential in preventing the resurgence of infectious diseases and safeguarding the most vulnerable members of society.

Vaccination is a crucial tool in managing diseases as it helps to reduce the severity of illnesses and their associated complications [50,51]. When a person is vaccinated against a particular disease, their immune system is primed to recognize and fight off the pathogen responsible for that disease. This means that if the person is later exposed to the disease-causing pathogen, their immune system can respond more effectively, potentially preventing the illness altogether or reducing its severity. For example, the flu vaccine is designed to protect against influenza viruses. By getting vaccinated against the flu, individuals can lower their risk of developing severe flu-related complications, such as pneumonia, and reduce the likelihood of hospitalization or even death due to flu-related complications. This is especially important for vulnerable populations, such as the elderly, young children, and individuals with certain underlying health conditions, who are at higher risk of experiencing severe flu-related outcomes.

Similarly, vaccines for diseases like measles, mumps, and rubella are essential for preventing serious health issues associated with these infections [52]. Measles, for instance, can lead to complications such as pneumonia, encephalitis, and even death in some cases. By ensuring high vaccination coverage against measles, the spread of the disease can be significantly reduced, protecting individuals and communities from its potentially devastating effects. In addition to protecting vaccinated individuals, widespread vaccination also contributes to community immunity, also known as herd immunity. When a large proportion of a population is vaccinated against a particular disease, it becomes more difficult for the disease to spread, providing indirect protection to those who cannot be vaccinated, such as individuals with certain medical conditions or weakened immune systems. Overall, vaccination plays a critical role in disease management by reducing the burden of illness, preventing complications, and safeguarding public health. It is an essential strategy for protecting individuals and communities from the harmful effects of infectious diseases.

Vaccination plays a crucial role in public health by reducing the burden on healthcare systems in several ways [53,54]. Firstly, it helps prevent the spread of infectious diseases, thereby lowering the number of people requiring medical attention for preventable illnesses. This, in turn, reduces the strain on healthcare facilities and personnel, allowing them to allocate their resources more effectively. Additionally, widespread vaccination can lead to a decrease in healthcare costs. By preventing illnesses that would otherwise require expensive treatments, hospitalizations, and medications, vaccination helps to save both individuals and healthcare systems significant amounts of money. This can make healthcare more affordable and accessible for everyone, as resources can be directed towards addressing other pressing health issues.

Moreover, vaccination contributes to improved productivity by preventing illness-related absences from work or school. When individuals are vaccinated against common infectious diseases, they are less likely to fall ill and miss days of work

or school. This not only benefits the individuals themselves but also the overall economy and educational systems, as productivity is maintained and disruptions are minimized. Finally, vaccination's impact on public health extends beyond individual protection. It helps alleviate the strain on healthcare systems, reduces healthcare costs, and promotes productivity by preventing the spread of infectious diseases. These collective benefits make vaccination a crucial component of public health strategies worldwide.

Vaccination is a crucial public health responsibility. When individuals choose to get vaccinated, they not only safeguard their own health but also play a part in creating a safer environment for those around them. This is particularly important for individuals who may be more vulnerable to severe illness, such as the elderly or those with underlying health conditions. Informed decision-making is key when it comes to vaccination. It's essential for individuals to seek out reliable information from reputable sources, such as healthcare professionals, public health organizations, and scientific research. By doing so, individuals can better understand the benefits and potential risks associated with vaccination and make choices that are well-informed and aligned with their personal health needs. Furthermore, open and honest communication with healthcare professionals can provide individuals with the guidance and support they need to make the best decisions for themselves and their communities. This collaborative approach helps ensure that individuals have access to accurate information and can address any concerns they may have about vaccination. Ultimately, by making informed decisions about vaccination, individuals can positively impact not only their own health but also the well-being of their communities, contributing to the collective effort to control and prevent the spread of infectious diseases.

Complications and Long-Term Effects

This section covers the potential complications of COVID-19, such as acute respiratory distress syndrome (ARDS), thrombosis, and long-term effects on various organ systems, as shown in Table 7.

Acute Respiratory Distress Syndrome

COVID-19, caused by the novel coronavirus SARS-CoV-2, can indeed lead to various complications, some of which can be severe and have long-lasting effects [55,56]. One of the most serious complications is Acute Respiratory Distress Syndrome (ARDS). ARDS is a life-threatening condition characterized by severe lung inflammation and fluid build-up, which leads to difficulty in breathing [57-59]. This condition can be very serious and often requires the use of mechanical ventilation to support the patient's breathing. When a person contracts COVID-19, the virus can cause significant inflammation in the lungs, leading to the accumulation of fluid in the air sacs. This makes it difficult for oxygen to pass from the lungs into the bloodstream, and for carbon dioxide to be removed from the body. As a result, the person may experience severe shortness of breath and low levels of oxygen in the blood.

In some cases, the body's immune response to the virus can be so intense that it causes further damage to the lungs, exacerbating the inflammation and fluid build-up. This can lead to ARDS, which is a serious and potentially life-threatening condition. Patients with ARDS often require intensive care and mechanical ventilation to support their breathing while their lungs recover. The treatment for ARDS may also involve medications

to reduce inflammation, oxygen therapy, and other supportive measures. It's important to note that while ARDS is a serious complication of COVID-19, not all patients with COVID-19 will develop this condition. However, it underscores the importance of taking preventive measures, such as vaccination, wearing masks, and practicing good hand hygiene, to reduce the risk of contracting the virus and developing severe complications.

Thrombosis

Thrombosis, or the formation of blood clots in blood vessels, is a significant concern in COVID-19 patients [60-62]. The virus has been linked to an elevated risk of blood clot formation, which can result in serious complications like pulmonary embolism (a clot in the lungs) or stroke. These conditions are particularly hazardous and often necessitate urgent medical attention. The exact mechanisms behind COVID-19-related thrombosis are not fully understood, but it's believed that the virus can trigger an inflammatory response in the body, leading to a hypercoagulable state where blood clots are more likely to form. Additionally, the virus may directly damage blood vessels, further contributing to clot formation.

Patients with COVID-19 who are at higher risk for thrombosis may receive anticoagulant medications to help prevent blood clots. It's crucial for healthcare providers to closely monitor these individuals for any signs of clotting and to promptly address any emerging issues to minimize the risk of severe complications. Given the potential severity of thrombotic complications in COVID-19, on-going research is focused on better understanding the underlying mechanisms and developing effective strategies for prevention and treatment.

Long-Term Effects on Various Organ Systems

Long COVID, also known as post-acute sequelae of SARS-CoV-2 infection (PASC), refers to the lingering symptoms experienced by some individuals even after they have recovered from the acute phase of COVID-19 [63-65]. These persistent symptoms can affect various organ systems in the body, leading to a range of health issues. One of the most commonly reported symptoms of long COVID is fatigue, which can be debilitating and significantly impact a person's quality of life. Additionally, individuals may experience on-going respiratory problems such as shortness of breath, which can make simple activities like walking or climbing stairs challenging.

Joint pain and chest pain are also frequently reported symptoms of long COVID [66,67]. These can be distressing and affect a person's mobility and overall well-being. The impact of long COVID is not limited to these symptoms, as it can also affect the cardiovascular system, leading to issues such as heart palpitations and decreased exercise tolerance. Furthermore, long COVID can have neurological effects, causing problems such as "brain fog," difficulty concentrating, and headaches. Some individuals may also experience mood changes and mental health challenges as a result of long COVID.

The musculoskeletal system can also be affected, leading to muscle weakness, joint stiffness, and overall reduced physical function. These symptoms can persist for an extended period of time, significantly impacting an individual's daily life and overall health. The exact mechanisms behind long COVID are still being studied, and researchers are working to understand why some individuals experience these prolonged symptoms. It is clear that long COVID is a complex condition that can affect multiple organ systems, and its management often requires a multi-

disciplinary approach involving healthcare professionals from various specialties [68,69]. As our understanding of long COVID continues to evolve, on-going research is crucial to develop effective treatments and support strategies for individuals living with this condition.

It's important to note that while these complications can occur, not everyone who contracts COVID-19 will experience them. However, understanding these potential complications is crucial for healthcare providers to effectively manage and treat individuals with COVID-19, as well as for on-going research into the long-term effects of the disease.

Public Health Interventions

This section may address the role of public health measures such as testing, contact tracing, quarantine, and vaccination campaigns in controlling the spread of COVID-19. Here's an in-depth explanation of each:

Testing

Testing for viruses, such as COVID-19, is crucial because it helps identify both symptomatic and asymptomatic individuals who are infected [70,71]. By finding these cases early, public health officials can take steps to isolate those who are infected, preventing the virus from spreading further. This early identification also allows for the implementation of other public health measures to control the spread of the virus, such as contact tracing and targeted quarantine efforts. Overall, testing plays a vital role in managing and controlling the spread of infectious diseases within a community.

Contact Tracing

Contact tracing is a crucial public health strategy used to control the spread of infectious diseases like COVID-19 [72-75]. When someone tests positive for the virus, public health officials work to identify and notify individuals who have been in close contact with the infected person during the time they may have been contagious. Close contacts are those who have been within a certain distance of the infected person for a prolonged period of time. Once these close contacts are identified, they are informed of their potential exposure and advised to quarantine themselves for a specific period of time, usually 10 to 14 days, depending on the local health guidelines. This helps prevent further transmission of the virus, as individuals who may have been exposed are kept away from others during the incubation period of the virus.

Contact tracing is a critical tool in controlling the spread of COVID-19, as it helps break the chain of transmission by quickly identifying and isolating potentially infected individuals. It also provides valuable data for public health officials to understand how the virus is spreading within communities and to implement targeted interventions to prevent further spread.

In addition to traditional contact tracing methods, technology such as mobile apps and digital tools have been used to enhance contact tracing efforts, allowing for more efficient and widespread notification of potential exposures. However, privacy concerns and data security are important considerations in the use of these technologies. Overall, contact tracing plays a vital role in controlling the spread of COVID-19 and other infectious diseases, and its effectiveness relies on the cooperation of individuals who may have been exposed and the support of public health authorities.

Quarantine

Quarantine measures are crucial in controlling the spread of the virus, especially in the case of COVID-19 [76-78]. When individuals have been exposed to the virus, they are asked to quarantine themselves for a specific period, typically 10-14 days, even if they do not have symptoms. This is because people can spread the virus to others before they show symptoms themselves. By quarantining, individuals reduce the risk of transmitting the virus to others in the community. This is particularly important in preventing further transmission, especially when dealing with a highly contagious virus like COVID-19. Quarantine helps to break the chain of transmission and protect the health of the broader population.

Vaccination Campaigns

Vaccination plays a crucial role in managing the spread of COVID-19. When individuals receive a COVID-19 vaccine, their immune systems are stimulated to produce antibodies that can recognize and fight the virus. This not only reduces the likelihood of severe illness and death in vaccinated individuals but also contributes to a phenomenon known as herd immunity. Herd immunity occurs when a large portion of a community becomes immune to a disease, making the spread of the disease from person to person less likely. As more people get vaccinated, the overall transmission of the virus decreases, protecting those who cannot be vaccinated, such as individuals with certain medical conditions or weakened immune systems. By reducing the transmission of the virus, vaccination helps to protect the entire population, including those who may be more vulnerable to severe illness. This is why widespread vaccination is considered a critical tool in controlling the impact of COVID-19 and ultimately bringing an end to the pandemic [79-81].

In combination, these public health measures work synergistically to control the spread of COVID-19. Testing and contact tracing identify cases and close contacts, while quarantine measures prevent further spread from those contacts. Vaccination campaigns help to build immunity in the population, reducing the overall transmission of the virus. It's important to note that the effectiveness of these measures is enhanced when they are implemented comprehensively and in a coordinated manner.

Conclusions and Future Directions

The findings from clinical practice can have significant implications for patient care. They may pave the way for the development of innovative treatment approaches, the improvement of current protocols, or the discovery of previously overlooked risk factors. This underscores the importance of on-going research and the translation of findings into practical applications to enhance healthcare outcomes. Key findings in public health play a crucial role in shaping policy decisions and resource allocation. By identifying populations at higher risk for certain conditions, public health officials can tailor interventions and campaigns to address specific needs. For example, if a key finding shows that a certain demographic is at higher risk for a particular disease, resources can be directed towards targeted interventions for that group. This approach can lead to more effective and efficient public health efforts. Additionally, key findings can also help in evaluating the impact of existing interventions and guide the development of new strategies to address emerging health challenges.

The implications of key findings in research are crucial for guiding future investigations and shaping the development of new hypotheses and theories. By highlighting areas that require further investigation and suggesting new research questions, these findings pave the way for advancing both clinical practice and public health initiatives. Robust research serves as the cornerstone for progress in these areas, ultimately leading to improved outcomes and a deeper understanding of various health-related phenomena.

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