

LONG-TERM EFFECTS OF COVID-19

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Abstract: The COVID-19 pandemic has been a defining global event, impacting nearly every aspect of life worldwide. This paper presents a review of the long-term effects of COVID-19, focusing on the impacts on people's physical and mental health. It synthesizes current knowledge from different studies, articles, analyses, and case reports to provide a comprehensive understanding of the prolonged physical, psychological and socioeconomic consequences of COVID-19. The virus has prolonged effects on various organ systems in human body especially in individuals who experienced severe cases or complications, as well as profound psychological impact. Efforts to address the physical and mental consequences of COVID-19 require a comprehensive approach involving healthcare professionals, mental health providers, policymakers, community organizations, and individuals themselves.

Keywords: COVID-19, pandemic, physical health, mental health, post-COVID conditions

Field: Medical sciences

1. INTRODUCTION

SARS-CoV-2 virus emerged in late 2019 in Wuhan, China, and rapidly spread all over the globe. It is classified as a novel coronavirus and is similar to previous coronaviruses like SARS-CoV and MERS-CoV.

COVID-19 mode of transmission (through respiratory droplets, aerosols, surface contact) and high transmissibility, with incubation period of typically 2-14 days, led to widespread outbreaks. Key factors contributing to the pandemic's spread were asymptomatic transmission, superspreader events, and global travel. Risk factors associated with increased transmission were crowded settings, close contact with infected individuals, poor ventilation, and prolonged exposure. Populations at higher risk of severe illness or complications from COVID-19 were mostly elderly, immunocompromised individuals, and individuals with comorbidities, which had increased susceptibility to transmission.

Understanding the clinical presentation and methods of diagnosing COVID-19 was crucial for timely identification, management, and control of the disease. The spectrum of COVID-19 illness, ranged from asymptomatic/mild cases to severe pneumonia and acute respiratory distress syndrome (ARDS). Most common symptoms of the illness were fever, cough, shortness of breath, fatigue, muscle aches and loss of taste/smell (anosmia/ageusia), while less common but notable manifestations were skin rashes, gastrointestinal symptoms (e.g., diarrhoea, nausea), neurological manifestations (e.g., headache, confusion), skin rashes, and multisystem inflammatory syndrome in children (MIS-C). Variability in symptoms and disease severity was present among different age groups and populations. Potential complications of COVID-19 were thromboembolic events, myocarditis, renal failure, and neurological sequelae.

Diagnostic methods included reverse transcription-polymerase chain reaction (RT-PCR) testing, antigen testing, and nucleic acid amplification tests (NAATs), as well as imaging studies (e.g., chest X-ray, CT scan) in diagnosing and monitoring COVID-19-related pulmonary complications, such as pneumonia and lung involvement. Strategies for prioritizing testing were based on risk factors, symptoms, and community transmission rates.

Various COVID-19 vaccines had been developed during the pandemics, including mRNA vaccines (e.g., Pfizer-BioNTech, Moderna), viral vector vaccines (e.g., AstraZeneca, Johnson & Johnson), protein subunit vaccines, and inactivated vaccines. Strategies for vaccine distribution prioritized the high-risk groups (e.g., healthcare workers, elderly, immunocompromised individuals). Vaccine distribution was followed by global vaccination campaigns to highlight vaccine efficacy. Therapeutic options for COVID-19, included antiviral medications (e.g., remdesivir), monoclonal antibodies (e.g., casirivimab/imdevimab, bamlanivimab/etesevimab), corticosteroids (e.g., dexamethasone), and immunomodulatory agents, and supportive care in severe cases, including oxygen therapy, mechanical ventilation, fluid management, anticoagulation, and monitoring for complications (e.g., cytokine release syndrome, thromboembolism).

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The role of non-pharmacological interventions in COVID-19 treatment, such as respiratory support (e.g., proning), physical therapy, nutritional support, and psychological support for patients and caregivers, was also highly significant.

2. PUBLIC HEALTH RESPONSE

Public health measures were implemented to mitigate the pandemic's impact, such as lockdowns, social distancing, mask mandates, travel restrictions, and quarantine/isolation protocols. Surveillance systems to track COVID-19 cases, test positivity rates, hospitalizations, and deaths, were established, as well as contact tracing and digital tools (e.g., mobile apps) in identifying and isolating infected individuals and their contacts. Protocols for quarantining individuals exposed to COVID-19 and isolating those who test positive, including guidelines for duration and monitoring of symptoms were implemented. Developed countries also implemented strategies for supporting individuals in quarantine or isolation, such as access to healthcare, mental health resources, and social services.

The importance of clear and timely communication from public health authorities to provide guidance on preventive measures (e.g., mask-wearing, hand hygiene, physical distancing), was continuously highlighted, and there were great efforts to combat misinformation and promote accurate information through media campaigns, public service announcements, and educational materials.

Travel restrictions, border closures, and quarantine requirements for international travellers to reduce importation of cases and prevent spread across regions, were implemented all over the world. There were significant efforts to ensure adequate supply and distribution of Personal Protective Equipment (e.g., masks, gloves, gowns) for healthcare workers, essential workers, and the public, as well as infection control measures in healthcare settings, workplaces, schools, and public spaces to minimize transmission risk.

Development, approval, and rollout of COVID-19 vaccines was an absolute priority, including prioritization of high-risk groups, vaccination clinics, and vaccine distribution strategies. Vaccination campaigns were implemented worldwide to have an impact on reducing severe illness, hospitalizations, and mortality rates.

The use of epidemiological data, modelling studies, and surveillance systems was essential to assess trends, forecast transmission dynamics, and inform decision-making on public health interventions. However, the ethical considerations related to data privacy, transparency, and equity in data-driven approaches, were often neglected.

The public health response during the COVID-19 pandemic has been multifaceted, involving a range of measures aimed at controlling the spread of the virus, protecting populations, and mitigating the impact on healthcare systems. However, the effectiveness of these measures in controlling viral spread and reducing healthcare system burden is questionable, because of the obvious rapid spread of the virus and great death rates.

3. LONG-TERM IMPACT OF COVID-19 ON PHYSICAL HEALTH

COVID-19 can have long-term effects on the respiratory system, particularly in individuals who experience severe cases or complications. Here are some of the potential long-term effects:

- Chronic respiratory symptoms- shortness of breath, coughing, and chest tightness, which can persist for weeks or even months after the initial infection, a condition often referred to as "long COVID" or post-COVID syndrome.
- Pulmonary fibrosis- severe cases of COVID-19 can lead to lung damage and scarring, which can impair lung function and lead to long-term breathing difficulties.
- Reduced lung function, leading to reduced lung capacity and impaired ability to breathe deeply. This reduced lung function can persist long after the acute phase of the illness has passed.
- Increased susceptibility to respiratory infections- damage to the respiratory system can weaken the lungs' ability to defend against infections, which increases the risk of developing respiratory infections in future.
- Respiratory muscle weakness-prolonged periods of bed rest or ventilation support during severe COVID-19 illness can lead to respiratory muscle weakness, that may persist after recovery and contribute to ongoing respiratory symptoms.
- Exacerbation of pre-existing respiratory conditions, such as asthma or chronic obstructive pulmonary disease (COPD)
- Psychological impact- the experience of severe respiratory symptoms during the illness,

especially if it required hospitalization or intensive care, can lead to psychological effects such as anxiety, depression, or post-traumatic stress disorder (PTSD). These psychological factors can further impact respiratory health and overall well-being.

It's important to note that the long-term effects of COVID-19 on the respiratory system can vary widely from person to person and may depend on factors such as the severity of the initial illness, pre-existing health conditions, age, and overall health status. Ongoing research is being conducted to better understand these effects and develop appropriate treatments and interventions for individuals experiencing long-term respiratory complications from COVID-19.

COVID-19 can lead to various cardiovascular complications, particularly in individuals with pre-existing heart conditions or those who experience severe illness. Here are some of the cardiovascular complications:

- Myocarditis- an inflammation of the heart muscle, a condition that can affect the heart's ability to pump blood effectively and may lead to symptoms such as chest pain, shortness of breath, and arrhythmias.
- Heart failure- occurs when the heart is unable to pump enough blood to meet the body's needs, resulting in symptoms such as fatigue, shortness of breath, swelling in the legs, and fluid retention.
- Arrhythmias, which can cause palpitations, dizziness, fainting, and in severe cases, cardiac arrest.
- Blood clots, including deep vein thrombosis (DVT) and pulmonary embolism (PE), which can obstruct blood flow to the heart, lungs, or other organs, leading to complications such as heart attack or stroke.
- Acute coronary syndromes, such as unstable angina or myocardial infarction (heart attack). This can occur due to a combination of factors including inflammation, plaque rupture, and increased demand on the heart during illness.
- Pericarditis and pericardial effusion- this can cause chest pain, especially when breathing deeply or lying down. In some cases, fluid may accumulate around the heart (pericardial effusion), further compromising heart function.
- Vascular dysfunction and impaired blood flow, which can contribute to complications such as high blood pressure, blood vessel damage, and organ dysfunction.
- Long-term cardiovascular effects, such as persistent heart damage, ongoing arrhythmias, or increased risk of cardiovascular events in the future.

It's important for healthcare providers to monitor and manage cardiovascular complications in individuals with COVID-19, especially those at higher risk due to pre-existing heart conditions or severe illness. Treatment may involve medications to support heart function, manage arrhythmias, prevent blood clots, and address underlying inflammation or infection. Rehabilitation programs may also be beneficial for individuals recovering from cardiovascular complications of the illness.

COVID-19 is known to have various neurological and cognitive impacts, ranging from mild symptoms to more severe complications:

- Neurological symptoms- headache, dizziness, confusion, and loss of taste or smell (anosmia or ageusia). These symptoms can occur even in mild cases of the illness and may persist after other symptoms resolve.
- Encephalopathy- severe cases of COVID-19 can lead to encephalopathy, a generalized brain dysfunction that can cause confusion, altered mental status, and cognitive impairment.
- Stroke, as a result from blood clots (ischemic stroke) or bleeding in the brain (haemorrhagic stroke).
- Guillain-Barré syndrome (GBS)- a rare but serious neurological disorder characterized by muscle weakness, numbness, and in severe cases, paralysis. GBS is thought to occur due to an autoimmune response triggered by the virus.
- Neuropsychiatric symptoms- anxiety, depression, post-traumatic stress disorder (PTSD), and cognitive changes. These symptoms may arise due to the stress of illness, social isolation, or direct effects of the virus on the brain.
- Long COVID neurological effects, such as brain fog, memory problems, difficulty concentrating, and mood changes.
- Neurological complications in children- multisystem inflammatory syndrome in children (MIS-C) which can affect the brain and other organs, causing symptoms such as fever, rash, abdominal pain, and neurological dysfunction.
- Neurodegenerative concerns- there is ongoing research into the potential long-term neurodegenerative effects of COVID-19, including its impact on conditions like Alzheimer's disease and

Parkinson's disease. Some studies suggest a possible link between COVID-19 and an increased risk of cognitive decline in older adults.

Managing the neurological and cognitive impacts of COVID-19 requires a multidisciplinary approach involving neurologists, psychiatrists, rehabilitation specialists, and other healthcare providers. Treatment may include supportive care, medications to manage symptoms, rehabilitation therapies, and mental health support for individuals experiencing neuropsychiatric symptoms. Long-term monitoring and research are needed to better understand the full spectrum of neurological consequences associated with COVID-19.

COVID-19 can also affect the renal, hepatic, and gastrointestinal systems. Here are some of the effects COVID-19 can have on these systems:

- Renal effects- acute kidney injury which is characterized by a sudden loss of kidney function, proteinuria and haematuria, renal thrombotic complications, such as renal infarction and renal vein thrombosis.

- Hepatic effects- elevated liver enzymes, such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) in the blood, hepatitis, and drug-induced liver injury caused by some medications used in the treatment of COVID-19, especially in individuals with pre-existing liver conditions.

- Gastrointestinal effects- nausea, vomiting, diarrhoea, intestinal inflammation, and gastrointestinal bleeding.

COVID-19 can induce various immunological changes and may be associated with the development or exacerbation of autoimmune conditions such as:

- Immune response to COVID-19- Innate Immune Response (upon infection with SARS-CoV-2, the innate immune system responds by activating various immune cells such as macrophages and dendritic cells, which release cytokines and chemokines to recruit and activate other immune cells), and Adaptive Immune Response (involves the activation of T cells which can help in eliminating virus-infected cells, and B cells which can produce antibodies that can neutralize the virus).

- Cytokine Storm and hyperinflammation, which involves the overproduction of pro-inflammatory cytokines such as interleukin-6 (IL-6), tumour necrosis factor-alpha (TNF- α), and interleukin-1 beta (IL-1 β), and can lead to tissue damage and contribute to the severity of respiratory and systemic symptoms.

- Autoimmunity- new-onset autoimmune conditions (cases of Guillain-Barré syndrome, autoimmune hepatitis, autoimmune thyroiditis), exacerbation of pre-existing autoimmune conditions (rheumatoid arthritis, systemic lupus erythematosus (SLE), multiple sclerosis and inflammatory bowel disease), molecular mimicry (a phenomenon where antigens from infectious agents resemble self-antigens, leading to immune responses against self-tissues).

- Immunosuppression and Autoimmunity- immunosuppressive treatments (corticosteroids and certain biologic agents) are sometimes used in the management of severe COVID-19. These treatments can modulate the immune response but may also increase the risk of opportunistic infections and potentially trigger or exacerbate autoimmune conditions in susceptible individuals.

Overall, COVID-19's impact on the immune system and its potential to influence autoimmune processes are areas of active research. Understanding these mechanisms is essential for optimizing COVID-19 management, identifying at-risk individuals, and developing targeted therapies for immunological complications and autoimmune reactions associated with the virus.

4. SOCIOECONOMIC AND PSYCHOSOCIAL IMPACT OF COVID-19

Socioeconomic and psychosocial impact of COVID-19 has been extensive and far-reaching. The pandemic has affected individuals, communities, and societies in terms of socioeconomic factors and mental well-being.

The economic impact of COVID-19 included job losses, business closures, supply chain disruptions, economic recession, and financial hardships experienced by individuals and families, which was especially critical for poor countries and vulnerable populations.

Pandemic caused disruptions to education systems, including school closures, transition to remote learning, digital divide challenges, and negatively impacted students' academic progress and social development. Also, it led to changes in the workforce landscape, such as remote work arrangements, telecommuting, flexible schedules, and adaptation of businesses to remote operations, which had deep implications on work-life balance, productivity, and job satisfaction.

The COVID-19 pandemic has had significant psychological and mental health consequences on individuals and communities worldwide. The uncertainty surrounding the pandemic, fear of contracting the virus, concerns about the health of oneself and loved ones, and changes in daily routines have contributed

to increased levels of anxiety and stress in many individuals. Frontline healthcare workers, essential workers, and individuals with pre-existing mental health conditions often experienced heightened anxiety and stress due to their roles, exposure risks, and the challenges of managing mental health during the pandemic.

The pandemic's impact on social interactions, economic stability, and daily life activities has contributed to higher rates of depression and mood disorders. Social isolation, loneliness, grief and loss, financial hardships, and disruptions to regular support systems can exacerbate feelings of sadness and hopelessness.

Individuals who have directly experienced or witnessed severe illness, death, or trauma related to COVID-19 may be at risk of developing post-traumatic stress disorder (PTSD). Healthcare workers and first responders, as well as individuals who have been hospitalized or lost loved ones due to COVID-19, are particularly vulnerable to PTSD symptoms such as intrusive memories, hyperarousal, and avoidance behaviours.

Stress, anxiety, and isolation associated with the pandemic, unfortunately have contributed to increased substance use and addiction issues in some individuals. Access to mental health and addiction services may have been limited during lockdowns or disrupted healthcare systems, exacerbating challenges for those struggling with substance use disorders.

The psychological impact of the pandemic, combined with social isolation, financial strain, and limited access to mental health support, has raised concerns about increased suicide risk and self-harm behaviours. Monitoring and addressing mental health needs, promoting access to crisis intervention services, and reducing stigma around seeking mental health support are critical in suicide prevention efforts.

Children and adolescents have faced unique psychological challenges during the pandemic, including disruptions to education, social isolation from peers, and uncertainty about the future. Mental health issues such as anxiety, depression, behavioural problems, and adjustment difficulties have been observed in this population, highlighting the importance of support and resources for youth mental health.

Understanding and addressing the long-term psychological effects of COVID-19 and its aftermath, including "long COVID" mental health symptoms, will be crucial. Building resilience, promoting coping strategies, providing accessible mental health services, and fostering social support networks are essential components of psychological recovery and well-being. Strategies for overcoming the psychological and mental health consequences of COVID-19, may include increased access to mental health services, destigmatization of mental health issues, public education and awareness campaigns, and promoting social connections and support systems.

5. GLOBAL COLLABORATION AND LESSONS LEARNED

Global collaboration and lessons learned from the COVID-19 pandemic are crucial for shaping future responses to health crises. Global collaboration in addressing the COVID-19 pandemic and the insights gained from the experience is highly important, as well as the role of international organizations (e.g., World Health Organization, WHO) in coordinating global response efforts, disseminating guidelines, and facilitating information sharing among countries. International collaboration in pandemic response efforts, scientific research, data sharing platforms, vaccine distribution through initiatives like COVAX, and established global health partnerships must also be highlighted.

Scientific research and innovation contributed to understanding COVID-19, developing diagnostics, treatments, and vaccines, and sharing scientific knowledge globally. Collaborative research networks, clinical trials, data repositories, and open-access publications have accelerated progress in pandemic response. Public health surveillance systems, early warning mechanisms, and rapid response teams in detecting outbreaks, monitoring transmission dynamics, and implementing control measures had very important role in pandemic preparedness, risk communication, and community engagement for effective public health response.

Digital health technologies (e.g., telemedicine, contact tracing apps, digital vaccination certificates) in pandemic response, surveillance, and healthcare delivery manifested great significance in remote care, data analytics, supply chain management, and public health communication.

The importance of cross-sectoral collaboration between government agencies, healthcare systems, academia, industry, non-profit organizations, and civil society in pandemic response, was evident. Key lessons learned from the COVID-19 pandemic include people and society strengths, weaknesses, gaps, and areas for improvement in pandemic preparedness, response capacity, and resilience.

6. CONCLUSIONS

The fight against COVID-19 is far from over, due to its proven long-term negative effects on multiple organ systems and mental health. Ongoing research on post-COVID conditions, multidisciplinary care approaches, and public health interventions to address the complex needs of individuals with post-COVID conditions, are extremely important. There is a constant necessity to raise awareness for social cohesion, community resilience, reduce stigma, promote mental health literacy, mental health integration in healthcare systems and provide education on coping strategies and self-care. Humanity must never forget the key lessons learned from the COVID-19 pandemic, including the importance of preparedness for future crisis, resilient healthcare systems, effective risk communication, and equitable access to healthcare.

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