Quality in Sport. eISSN 2450-3118.

Journal Home Page https://apcz.umk.pl/QS/index

ORZEŁ, Jakub, PELCZAR, Patrycja, SKOWRON, Aleksandra, and PRZYGODA, Aleksandra. Long-Term Sequaloe of COVID 19: A Review. Quality in Sport. 2026;55:71015. eISSN 2450-3118. https://doi.org/10.12775/QS.2026.55.71015

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 18.04.2026. Revised: 25.04.2026. Accepted: 3.05.2026. Published: 10.05.2026.

Long-Term Sequelae of COVID-19: A Review

Jakub Orzeł

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

jakuborzl11@gmail.com

https://orcid.org/0009-0006-7384-7415

Patrycja Pelczar
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland
patrycjap08082001@gmail.com
https://orcid.org/0009-0001-9532-6972

Aleksandra Skowron
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland
askowron1007@gmail.com
https://orcid.org/0009-0006-2164-0906

Aleksandra Przygoda
Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland
aleksandra.przygoda2001@gmail.com
https://orcid.org/0009-0001-1607-1124

ABSTRACT

Introduction. Long COVID (post-COVID-19 syndrome) is defined as a constellation of symptoms persisting or emerging at least three months after acute SARS-CoV-2 infection, lasting for a minimum of two months and not explained by an alternative diagnosis. It affects millions of patients worldwide regardless of the severity of primary infection, and its underlying pathophysiology remains incompletely understood.

Aim. The aim of this review is to summarize the current state of knowledge on Long COVID syndrome, with a particular focus on its clinical manifestations across multiple organ systems, underlying pathophysiological mechanisms, and long-term consequences in both adult and pediatric populations.

Methodology. A review of the literature was conducted through a systematic search of the PubMed database using the keywords: "Long COVID", "post-COVID syndrome", "post-acute sequelae of SARS-CoV-2", "PASC". Publications from 2020 to 2026 were included.

Materials and methods. A narrative review of the literature was conducted to summarize the current state of knowledge on the Long COVID syndrome. A systematic search of the PubMed database was performed using the following keywords: *"Long COVID"*, *"post-COVID syndrome"*, *"post-acute sequelae of SARS-CoV-2"*, *"PASC"*. Publications from January 2020 to January 2026 were considered.

Results. Long COVID affects multiple organ system. The most common symptoms are neurological, including fatigue, brain fog and memory impairment. Cardiovascular complications include POTS, myocarditis, arrhythmias and thromboembolic events. Pulmonary sequelae are common even after a mild course of the disease. Other documented complications include renal dysfunction, female fertility disorders and paediatric post-COVID syndrome. Immunological mechanisms appear to play a key role in the pathogenesis of the syndrome.

Conclusions. Long COVID is a multisystemic and complex condition requiring a holistic diagnostic and therapeutic approach. There are currently no reliable biomarkers or targeted therapies. It poses a serious public health problem, and further research is needed to improve treatment outcomes.

Keywords: long COVID, post-COVID syndrome, SARS-CoV-2, brain fog, post-acute infection syndrome

INTRODUCTION

The SARS-CoV-2 virus causes not only acute infection but also chronic symptoms collectively referred to as Long COVID [1].

Long COVID is a syndrome of symptoms that persists or appears 3 months after an acute SARS-CoV-2 infection and lasts for at least 2 months, and cannot be explained by any other diagnosis. It is estimated that it may affect millions of people and affects patients regardless of the severity of the primary infection [1,2]. It manifests through numerous symptoms that can affect any organ or system. These include general symptoms such as fatigue, muscle and joint pain, as well as neurological, neuropsychiatric, cardiopulmonary and gastrointestinal symptoms [4].

Due to the pathophysiology not yet being fully understood, we currently lack a reliable diagnostic test and treatment options [2,6]. Potential pathophysiological causes include, amongst others, coagulation disorders, damage to the vascular endothelium, or reactivation of latent herpes viruses such as EBV [2].

This review summarises the current state of knowledge regarding Long COVID with a particular focus on its clinical manifestations and long-term symptoms.

DISCUSSION

Neurological and neuropsychiatric manifestations of long COVID

COVID-19 may affect the central nervous system by causing inflammation of the nervous system, as well as by interacting with the nervous system's immune cells. Direct infection of the CNS is rare [3]. It is suspected that the nasal cavity and the first pair of cranial nerves—the olfactory nerves—are the route through which SARS-CoV-2 enters the brain [7]. Other mechanisms include, amongst others, an autoimmune reaction, microbiota dysbiosis, neurotransmission dysregulation, reactivation of latent viruses, and thromboembolic diseases, which may disrupt the blood-brain barrier and impair blood flow through the brain. In severe cases of COVID-19, failure of the lungs and other organs occurs, which can lead to hypoxaemia, a drop in blood pressure, and serious metabolic disturbances that may damage nerve cells [3,7]. Changes in brain metabolism have also been observed in patients with long COVID. These involve four areas: the bilateral rectal/orbital gyrus, including the olfactory gyrus. the right temporal lobe, including the amygdala and the hippocampus, extending to the right thalamus; the bilateral pons/medulla, the bilateral cerebellum [5].

The SARS-CoV-2 virus binds to the angiotensin-converting enzyme II receptor, which exacerbates the inflammatory cascade and increases the release of cytokines such as IL-1, IL-6, IL-2, IL-17 and TNF-α, which may directly damage the nervous system [6].

A meta-analysis of 18 studies including 10,530 patients revealed that the most prevalent neurological symptoms three months after COVID-19 onset were fatigue (37%), brain fog (32%), and memory impairment (28%), followed by attention disorders (22%), headache (15%), myalgia (17%), anosmia (12%), and dysgeusia (10%). Neuropsychiatric manifestations were also common, with sleep disturbances affecting nearly one-third of patients (31%), anxiety present in 23%, and depression in 17% [8].

Neurological symptoms of Long COVID resemble chronic fatigue syndrome (CFS). They share a similar clinical presentation and pathophysiological basis. Both conditions are characterized by chronic fatigue, post-exertional malaise, autonomic dysfunction, mitochondrial dysfunction, mast cell activation syndrome (MCAS) and orthostatic intolerance [7, 9].

Patients also experience symptoms affecting the peripheral nervous system. Chronic pain occurs in up to 30% of patients, often manifesting as chest pain. Another reported complication is Guillain-Barré syndrome, which involves sensorimotor demyelination and bilateral damage to the facial nerves. Other complications include ophthalmic disorders, occurring in 12% of patients, and, less commonly, hearing disorders [7].

Cardiovascular manifestations of Long COVID

The most common symptoms reported by patients include chest pain, shortness of breath, palpitations, fainting, and POTS (postural orthostatic tachycardia syndrome) [10].

The main mechanism by which SARS-CoV-2 affects the cardiovascular system is its interaction with the ACE2 receptor; downregulation of this receptor disrupts the renin-angiotensin-aldosterone system (RAAS). An overactive RAAS leads to vasoconstriction, a tendency towards thrombosis, myocardial fibrosis and endothelial dysfunction. Furthermore, the virus triggers a cytokine storm, which damages the endothelium, activates platelets and forms thrombi in the coronary vessels, disrupting microcirculation. Molecular mimicry leads to the formation of autoantibodies against cardiac antigens and cholinergic and adrenergic receptors, which damages the autonomic nervous system [11].

Meta-analyses have shown that patients >=4 weeks after a COVID-19 infection are at increased risk of new cardiovascular conditions compared to healthy individuals, such as stroke, cardiac arrhythmias, myocarditis, cardiomyopathy, coronary artery disease, hypertension, heart failure, thromboembolic events and cardiogenic shock [12].

Magnetic resonance imaging revealed signs of myocarditis in 60% of patients 71 days after the acute infection. Isolated pericarditis and effusion were less common. In one study, 9% of patients with cardiopulmonary symptoms had evidence of fluid in the pericardial sac after 7 months. One in five hospitalised patients shows signs of myocardial fibrosis after recovery. [13].

Long Covid in Pediatric Practice

When discussing the long-term effects of COVID-19 infection—commonly known as “long COVID”—we must not overlook pediatric patients. Although children and adolescents typically have fewer underlying medical conditions compared to the adult and elderly populations—in whom we much more frequently observe multimorbidity—they are also at risk of developing long-term complications following a COVID-19 infection. The medical literature was reviewed to gather information from available sources, clinical studies, and expert opinions. The pathophysiological mechanisms believed to be primarily responsible for the development of long COVID in the youngest patients include persistent viral infection, an abnormal immune response, permanent organ damage, and immune system dysfunction resulting from the temporary isolation of children at home during the pandemic. Clinical data on the potential pathophysiological mechanisms underlying the development of long COVID in the pediatric population indicate that they are quite similar to those observed in adult patients, with the exception of persistent internal organ damage, which does not appear to be a major cause in this age group [15,16].

Post-COVID-19 condition (PCC) in children and adolescents is defined by the WHO as a cluster of symptoms that appear within three months of recovering from acute COVID-19, last for at least two months, and limit the ability to perform daily activities. Post-acute sequelae of COVID-19 mainly occur following a mild acute COVID-19 infection, and in most cases last no longer than a few months.However, there have also been reports of cases in which long COVID persisted for more than a dozen months or even led to significant disability. The most common symptoms of PASC include chronic weakness and fatigue, poor exercise tolerance, and anxiety disorders. Other commonly reported symptoms include olfactory disturbances, including anosmia; chest pain; cognitive impairments and difficulty concentrating, often referred to as “brain fog”, chronic muscle and joint pain, chronic cough, diarrhea, nausea, dizziness and headaches, sleep disorders, nasal congestion and mood swings. Furthermore, it was shown that children infected with the SARS-CoV-2 virus were at greater risk of experiencing prolonged shortness of breath, loss of taste, and fever (the analysis was conducted in comparison with a control group). Chronic fatigue is considered the most commonly reported symptom in the pediatric population, regardless of the patient’s exact age. Cases of postural orthostatic tachycardia have also been reported in the context of PASC, characterized by an increase in heart rate of at least 30–40 beats per minute within 10 minutes of changing body position from lying down to standing.The cause of this phenomenon lies in abnormal blood flow in the body due to autonomic nervous system dysfunction. During the orthostatic test, cyanosis of the peripheral parts of the body often occurs, whereas this symptom is not observed in the supine position. A few cases meeting the criteria for encephalomyelitis have also been described [15,17].

It has been shown that COVID-19 vaccination reduces the risk of PASC depending on the virus variant that caused it. Studies and analyses have shown that older age, female gender, and pre-existing chronic conditions (unrelated to COVID-19 infection) increase the risk of developing long COVID-19 in the pediatric population. Differential diagnosis of post-acute sequelae of COVID-19 is very difficult, as there are no specific tests or laboratory markers, and the vast majority of symptoms are highly nonspecific and may occur in the course of many other conditions, both acute and chronic. Among hospitalized patients, the prevalence of post-acute sequelae of COVID-19 is slightly higher than among non-hospitalized patients; the difference is approximately a few percentage points. In the future, there will still be a need for "in-depth phenotyping" of children and young people (CYP) who experience persistent symptoms of long COVID [15,17,18].

The Effect of Long Covid-19 on Female Fertility

When describing the long-term effects of a COVID-19 infection, one cannot overlook the complications it causes in the female reproductive system and its impact on women's reproductive health. Long COVID-19 in the context of the reproductive system is defined as menstrual cycle disorders, impaired ovarian function, and impaired gonadal function, as well as an exacerbation of premenstrual syndrome symptoms and symptoms during menstruation, such as pain, general malaise, and increased fatigue. When discussing the impact of COVID-19 on reproductive health, it is important to note that the relationship between a past history of acute COVID-19 infection and reproductive health is often indirect; specifically, these complications stem from other conditions that are manifestations of long COVID-19, such as myalgic encephalomyelitis, chronic fatigue syndrome, and orthostatic tachycardia syndrome. Additionally, other chronic conditions unrelated to COVID-19 infection but coexisting in a given patient may also have an impact; these include endometriosis and connective tissue diseases. Among the women surveyed, symptoms such as an increased frequency of painful menstruation, amenorrhea, irregular menstrual cycles, dyspareunia (discomfort and pain during intercourse), vulvodynia, intermenstrual bleeding, and even an increased incidence of pelvic congestion syndrome. A higher number of obstetric complications, such as preeclampsia and preterm labor, were also noted; these, of course, not only affect the woman's health but also carry a higher risk of complications for the newborn [23,24,25]. Case reports indicate that COVID-19 infection may lead to long-term deterioration of ovarian health; we define this condition as partial or complete loss of ovarian function before the age of 40. Furthermore, studies have shown that the composition of follicular fluid can change even months after recovering from COVID-19, which may have a significant impact on the quality and function of oocytes and, consequently, on fertility [23].

A report on clinical trials conducted in 2022 showed that the prevalence of long COVID (8.5%) was higher among women than among men (5.2%). This may be due to the fact that women typically have a stronger innate immune response than men, which leads to more severe symptoms during acute viral illness and likely also contributes to long COVID-19 symptoms. Genetics also plays a role in the gender disparity regarding the prevalence of long COVID-19. This is because the X chromosome contains genes suspected of influencing innate immunity, such as the TLRT gene. Therefore, females, who have two X chromosomes, may exhibit a stronger autoimmune response to infection and be predisposed to more severe manifestations of Long COVID-19 compared to male patients. However, it is suspected that cultural differences also influence the aforementioned statistics, specifically the fact that women seek medical help much more often than men and report all their symptoms to their doctor, which also results in a higher rate of Long COVID-19 diagnoses. Analysis of clinical data has also shown that women are more susceptible to developing sexual dysfunction as a result of the many complications that make up the long COVID-19 syndrome. It is also worth mentioning the potential impact of stress associated with the disease on the hypothalamic-pituitary-gonadal axis, the dysregulation of which ultimately leads to reproductive system disorders. Given the complex interactions between tropic hormones, estrogens, cortisol, and immune system functions, it is evident that women are particularly susceptible to stress-induced disruptions in neuroendocrine pathways [24]. The impact of SARS-CoV-2 on the reproductive system can also be explained by various pathophysiological mechanisms, such as the co-expression of ACE2 and TMPRSS2, primarily in oocytes and, to a lesser extent, in granulosa cells [25].

The Effect of Long-COVID on Kidneys and Urinary Tract

Care for patients who have recovered from acute COVID-19 should include close monitoring of kidney function. It has been documented that the risk of developing kidney disease or impaired kidney function as a complication of acute coronavirus disease is relatively high even in mild cases of COVID-19 and in patients with mild to moderate symptoms. At this time, we do not yet know exactly how long COVID-19 affects kidney function. Future prospective clinical trials that include longer-term monitoring of kidney function in patients diagnosed with long COVID-19 are needed. Long COVID-19 primarily involves complications affecting the function of organs in the respiratory, nervous, and cardiovascular systems, as well as mental health. However, the kidneys must not be overlooked, as they are also affected by a history of coronavirus infection, particularly in patients with underlying medical conditions or other predisposing factors. A systematic review summarizing the prevalence and treatment outcomes of COVID-19 patients with chronic kidney disease (CKD) based on 348 studies showed that COVID-19 disproportionately affected individuals with CKD. Furthermore, COVID-19 affected patients on chronic dialysis more frequently than patients with chronic kidney disease who did not require dialysis. Patients who have undergone a kidney transplant also face a significantly higher risk of contracting COVID-19—and consequently of developing long COVID—than the average risk in the general population. Chronic kidney disease may increase the risk of COVID-19 both directly and indirectly—due to exposure associated with receiving medical care outside the home, specifically at clinics or hospitals—which would explain the even higher susceptibility to the disease among patients on chronic dialysis [20,21,22]. COVID-19-associated kidney injury is a fairly common complication and can present in a wide variety of ways, including proteinuria, hematuria, and acute kidney injury requiring renal replacement therapy (RRT). In recent years, large-scale observational studies have been conducted in the United States, Europe, and Brazil; analysis of their results has shown that the prevalence of COVID-19-associated AKI ranged from 28% to 34% among all hospitalized patients and 46–77% among patients hospitalized for COVID-19 in the intensive care unit [20]. The most common manifestation of renal complications in patients with severe COVID-19 is acute tubular injury characterized by loss of the brush border, non-isometric vacuolar degeneration, and even overt necrosis, and typical changes observed at the tissue level include features of glomerular inflammatory disease, which is a subtype of focal segmental glomerulosclerosis. This disease is characterized by glomerular collapse as well as podocyte hypertrophy and hyperplasia. The pathophysiological mechanisms most commonly underlying acute kidney injury caused by COVID-19 infection include activation of the complement cascade, inflammation with immune cell infiltration in the kidneys, which can be either acute or chronic, hypercoagulability with the formation of microvascular clots, vascular endothelial dysfunction secondary to its inflammation, pigmentary nephropathy, and mitochondrial dysfunction, SARS-CoV-2 infection of podocytes and proximal convoluted tubules involving angiotensin-converting enzyme 2 (ACE2) and transmembrane serine protease 2. Although serum creatinine levels gradually return to normal in many patients following acute kidney injury (AKI), the kidneys may nevertheless fail to regain full functional capacity. Studies have shown that despite creatinine levels returning to normal, many patients continued to exhibit inflammation and abnormalities such as renal fibrosis, abnormal expression of renal genes, and functional impairments resulting from ischemic kidney injury. [21,22].

Mental Health and Brain Fog in People with Long COVID

Brain fog is a term that frequently appears in descriptions of so-called post-COVID-19 sequelae—that is, a cluster of diverse symptoms that emerge several weeks or more after the initial acute coronavirus infection and typically persist for a relatively long time. What exactly is brain fog? It is not a technical medical term, nor is it a recognized medical condition, but the term is often used to describe a range of symptoms, including difficulty concentrating, a feeling of disorientation, slowed thinking, forgetfulness, and difficulty quickly recalling facts, a sense of being at a loss for words, and broadly defined mental fatigue [19,26,27]. Brain fog can be a symptom or complication of many conditions, but it is most commonly discussed in the context of long COVID. There are currently no studies that have fully analyzed all the symptoms that make up the picture of brain fog. This is a very important topic, as it can, in some cases, lead to impaired functioning or psychological distress. However, it is difficult to determine whether a patient's brain fog is a complication of an acute COVID-19 infection, a symptom of another disease, or the result of multiple conditions currently affecting the patient or experienced in the past [19].

It is suspected that neuroinflammatory processes and the impact of immune reactions occurring in the body on central nervous system tissues—particularly on microglia and astrocytes, which are often affected by inflammation and experience impaired function—play a role in the pathogenesis of this syndrome. It has been found that inflammatory cytokines play a significant role in impairing neurogenesis and hindering axonal growth. As many as 88% of all patients who have previously had COVID-19 experience cognitive impairments and memory problems to a greater or lesser extent, regardless of the age group studied. This statistic is based on symptoms reported by patients, such as difficulties with planning, decision-making, maintaining selective attention, procedural memory, word-finding difficulties, and impaired fluency and syntax in speech [27].

Studies have shown that certain factors contribute to brain fog caused by long COVID. Specifically, the studies found that women are more likely to develop this complication than men, and furthermore, people who had a milder acute COVID-19 infection are more likely to develop the complications that make up the brain fog syndrome. Research also points to a very important psychosocial aspect of brain fog: namely, people experiencing these symptoms often suffer from reduced occupational functioning, which makes it difficult for them to return to work in line with their skills and education, or even, in more severe cases, to resume daily activities. To date, several potentially promising treatments for brain fog have been explored, such as non-invasive brain stimulation, hyperbaric oxygen therapy, and various neuropsychiatric rehabilitation methods. However, this topic requires further investigation and additional clinical trials [26].

The impact of long COVID on the immune system

Infection with the SARS-CoV-2 virus can result in tissue damage and the release of antigens through a mechanism of direct self-antigen mimicry, as well as through the production of large amounts of interferon—a natural protein produced by the body's immune system in response to a threat, such as a viral infection in this case. Such mechanisms can lead to autoimmunity. The binding of autoantibodies to different sites on a protein can have varying effects on its function; for example, it can prevent the protein from binding to its target receptor. In this article, we will describe the effects of these processes using immune cells as an example. Binding of the Fc receptor on neutrophils or monocytes can result in a series of adverse reactions, such as the release of pro-inflammatory cytokines, which trigger an inflammatory process in tissues and contribute to their damage. Autoantibody-antigen immune complexes can induce the activation of the complement pathway, leading to the hydrolysis of C3 and cytotoxic processes. Furthermore, specific autoantibodies directed against phospholipids may also be activated. Their activation can induce the activation of endothelial cells, which, in turn, by damaging the vascular endothelium, may lead to the formation of vascular clots and increase susceptibility to cardiovascular diseases [28].

A clinical trial was conducted involving a relatively large group of 275 participants from various study groups, with the aim of elucidating the biological basis of the cluster of symptoms that constitute long COVID. Participants included healthcare workers, asymptomatic individuals from the control group, individuals from the control group in the recovery phase, individuals with persistent symptoms following acute infection (LC), and an external group of LC patients from an independent study. The authors used system-level immunomonitoring of cells, cytokines, antibodies, and physiological measurements in combination with machine learning analyses to identify biomarkers associated with LC. Such systemic approaches are particularly valuable in patient studies where individual parameters vary widely, but common patterns in measurements can indicate co-regulated cells and proteins, leading to new hypotheses that need to be tested mechanistically.Participants with LC reported significantly greater severity of symptoms, which led to the creation of the Long COVID Predisposition Score (LCPS) with diagnostic potential. Fatigue, brain fog, memory difficulties, and confusion were found to be the most common symptoms among individuals with LC [29].

Pulmonary manifestations of Long COVID

Pulmonary complications result from a cascade of immune dysregulations triggered during an acute infection. These primarily include complement system dysregulation, dysregulation of the innate immune response, and an influx of macrophages, which create an environment conducive to inflammation. Immature type 2 pneumocytes perpetuate this state, as their abnormal interaction with monocytes prevents the restoration of the physiological architecture of the lungs. Elevated levels of type I and III interferons are observed for up to eight months after infection, regardless of its severity. In addition, numerous antibodies and autoantibodies are produced against vascular and pulmonary antigens. All these mechanisms sustain tissue damage following the acute phase of the disease [30].

On average, 15% of patients with COVID-19 report persistent respiratory symptoms; this proportion is significantly higher in patients requiring hospitalisation. Shortness of breath occurs in 15 to 81% of patients between one and three months after infection, decreasing to 5–23% after one year. Impaired diffusion was detected in approximately 25% of patients both one month and six months after infection. Radiological changes are present in 13–27% of patients three to four months after a severe course of the disease. Honeycomb-like fibrosis affects 1% of people after twelve months [14].

The predominant symptom of long COVID is shortness of breath. It is the second most common symptom of long COVID, after chronic fatigue. Cough is reported by 2–42% of patients in the first three months following hospitalisation; its prevalence decreases after one year. Chest pain affects 20% of patients. Patients also exhibit reduced exercise tolerance, decreased carbon monoxide diffusion capacity, and, in those with a severe course of the disease, a restrictive ventilatory pattern with reduced total lung capacity is observed in the initial phase. In some patients, no parenchymal changes are observed, yet exercise limitations are present, likely due to pulmonary vascular dysfunction [14].

SUMMARY

Long COVID is one of the most challenging problems facing modern medicine. It is a multi-systemic condition caused by a variety of mechanisms. Neurological and neuropsychiatric symptoms are the most common. Fatigue, brain fog and problems with short-term memory occur in over a quarter of patients. Cardiovascular complications include POTS, myocarditis and thromboembolic events. The underlying mechanisms are complex and linked to RAA system dysfunction, vascular endothelial damage and the production of autoantibodies. Patients may experience impaired gas exchange in the lungs for over a year following infection. Kidney damage is particularly high in patients with pre-existing chronic kidney disease. Women's reproductive health may be affected by hormonal dysregulation and ovarian dysfunction, and pre-existing gynaecological conditions may worsen.

The paediatric form of Long COVID resembles the adult condition in many respects, but it is more difficult to diagnose. Mental health disorders such as depression, anxiety and reduced concentration impair patients' quality of life regardless of the severity of somatic symptoms.

Although knowledge about this condition is growing rapidly, there is a lack of diagnostic biomarkers and evidence-based targeted therapies. Caring for patients with Long COVID is challenging and requires a multidisciplinary approach.

DISCLOSURE

Author's Contribution Statement:

Conceptualization: Jakub Orzeł

Methodology: Jakub Orzeł, Aleksandra Skowron, Patrycja Pelczar, Aleksandra Przygoda

Resources: Jakub Orzeł, Aleksandra Skowron, Aleksandra Przygoda, Patrycja Pelczar

Writing-rough preparation: Jakub Orzeł, Aleksandra Skowron, Patrycja Pelczar, Aleksandra Przygoda

Writing-review and editing: Jakub Orzeł, Aleksandra Skowron, Patrycja Pelczar, Aleksandra Przygoda

Supervision: Jakub Orzeł

Funding: No external funding was received

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Not applicable

Data Availability Statement: Not applicable

All authors have read and agreed with the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Declaration of the use of generative AI and AI-assisted technologies in the writing process. In preparing this work, the authors used Claude for the purpose of checking grammar, punctuation and improving the readability of the article. After using this tool, the authors have reviewed and edited the content as needed and accept full responsibility for the substantive content of the publication.

References

1. Greenhalgh T, Sivan M, Perlowski A, Nikolich JŽ. Long COVID: a clinical update. *Lancet*. 2024;404(10453):707-724. https://doi.org/10.1016/S0140-6736(24)01136-X
2. Peluso MJ, Deeks SG. Mechanisms of long COVID and the path toward therapeutics. *Cell*. 2024;187(20):5500-5529. https://doi.org/10.1016/j.cell.2024.07.054
3. Monje M, Iwasaki A. The neurobiology of long COVID. *Neuron*. 2022;110(21):3484-3496. https://doi.org/10.1016/j.neuron.2022.10.006
4. Natarajan A, Shetty A, Delanerolle G, et al. A systematic review and meta-analysis of long COVID symptoms. *Syst Rev*. 2023;12(1):88. Published 2023 May 27. https://doi.org/10.1186/s13643-023-02250-0
5. Zawilska JB, Kuczyńska K. Psychiatric and neurological complications of long COVID. *J Psychiatr Res*. 2022;156:349-360. https://doi.org/10.1016/j.jpsychires.2022.10.045
6. Mueller MR, Ganesh R, Beckman TJ, Hurt RT. Long COVID: emerging pathophysiological mechanisms. *Minerva Med*. 2025;116(2):156-165. https://doi.org/10.23736/S0026-4806.25.09539-4
7. Cáceres E, Divani AA, Viñan-Garces AE, et al. Tackling persistent neurological symptoms in patients following acute COVID-19 infection: an update of the literature. *Expert Rev Neurother*. 2025;25(1):67-83. https://doi.org/10.1080/14737175.2024.2440543
8. Premraj L, Kannapadi NV, Briggs J, et al. Mid and long-term neurological and neuropsychiatric manifestations of post-COVID-19 syndrome: A meta-analysis. *J Neurol Sci*. 2022;434:120162. https://doi.org/10.1016/j.jns.2022.120162
9. Eckey M, Li P, Morrison B, Bergquist J, Davis RW, Xiao W. Patient-reported treatment outcomes in ME/CFS and long COVID. *Proc Natl Acad Sci U S A*. 2025;122(28):e2426874122. https://doi.org/10.1073/pnas.2426874122
10. Raman B, Bluemke DA, Lüscher TF, Neubauer S. Long COVID: post-acute sequelae of COVID-19 with a cardiovascular focus. *Eur Heart J*. 2022;43(11):1157-1172.

https://doi.org/10.1093/eurheartj/ehac031

11. Składanek JA, Leśkiewicz M, Gumiężna K, et al. Long COVID and its cardiovascular consequences: What is known?. *Adv Clin Exp Med*. 2024;33(3):299-308. https://doi.org/10.17219/acem/167482
12. Zhang T, Li Z, Mei Q, et al. Cardiovascular outcomes in long COVID-19: a systematic review and meta-analysis. *Front Cardiovasc Med*. 2025;12:1450470. Published 2025 Jan 29. https://doi.org/10.3389/fcvm.2025.1450470
13. Parhizgar P, Yazdankhah N, Rzepka AM, et al. Beyond Acute COVID-19: A Review of Long-term Cardiovascular Outcomes. *Can J Cardiol*. https://doi.org/10.1016/j.cjca.2023.01.031
14. Sommer N, Schmeck B. Pulmonale Manifestationen bei Long-COVID [Pulmonary manifestations in long COVID]. *Inn Med (Heidelb)*. 2022;63(8):819-829. https://doi.org/10.1007/s00108-022-01371-3
15. Toepfner N, Brinkmann F, Augustin S, Stojanov S, Behrends U. Long COVID in pediatrics-epidemiology, diagnosis, and management. *Eur J Pediatr*. 2024;183(4):1543-1553. https://doi.org/10.1007/s00431-023-05360-y
16. Coughtrey A, Pereira SMP, Ladhani S, Shafran R, Stephenson T. Long COVID in children and young people: then and now. *Curr Opin Infect Dis*. 2025;38(5):487-492. https://doi.org/10.1097/QCO.0000000000001136
17. Lopez-Leon S, Wegman-Ostrosky T, Ayuzo Del Valle NC, et al. Long-COVID in children and adolescents: a systematic review and meta-analyses. *Sci Rep*. 2022;12(1):9950. Published 2022 Jun https://doi.org/10.1038/s41598-022-13495-5
18. Stephenson T, Shafran R, Ladhani SN. Long COVID in children and adolescents. *Curr Opin Infect Dis*. 2022;35(5):461-467. https://doi.org/10.1097/QCO.0000000000000854
19. Van der Feltz-Cornelis C, Turk F, Sweetman J, et al. Prevalence of mental health conditions and brain fog in people with long COVID: A systematic review and meta-analysis. *Gen Hosp Psychiatry*. 2024;88:10-22. https://doi.org/10.1016/j.genhosppsych.2024.02.009
20. Schiffl H, Lang SM. Long-term interplay between COVID-19 and chronic kidney disease. *Int Urol Nephrol*. 2023;55(8):1977-1984. https://doi.org/10.1007/s11255-023-03528-x
21. Rai V. COVID-19 and Kidney: The Importance of Follow-Up and Long-Term Screening. *Life (Basel)*. 2023;13(11):2137. Published 2023 Oct 30. https://doi.org/10.3390/life13112137

22. Yende S, Parikh CR. Long COVID and kidney disease. *Nat Rev Nephrol*. 2021;17(12):792-793. https://doi.org/10.1038/s41581-021-00487-3
23. Pollack B, von Saltza E, McCorkell L, et al. Female reproductive health impacts of Long COVID and associated illnesses including ME/CFS, POTS, and connective tissue disorders: a literature review. *Front Rehabil Sci*. 2023;4:1122673. Published 2023 Apr 28. https://doi.org/10.3389/fresc.2023.1122673
24. Maham S, Yoon MS. Clinical Spectrum of Long COVID: Effects on Female Reproductive Health. *Viruses*. 2024;16(7):1142. Published 2024 Jul 16. https://doi.org/10.3390/v16071142
25. Bechmann N, Maccio U, Kotb R, et al. COVID-19 Infections in Gonads: Consequences on Fertility?. *Horm Metab Res*. 2022;54(8):549-555. https://doi.org/10.1055/a-1891-6621
26. Gorenshtein A, Liba T, Leibovitch L, Stern S, Stern Y. Intervention modalities for brain fog caused by long-COVID: systematic review of the literature. *Neurol Sci*. 2024;45(7):2951-2968. https://doi.org/10.1007/s10072-024-07566-w
27. Kavanagh E. Long Covid brain fog: a neuroinflammation phenomenon?. *Oxf Open Immunol*. 2022;3(1):iqac007. Published 2022 Sep 27. https://doi.org/10.1093/oxfimm/iqac007
28. Talwar S, Harker JA, Openshaw PJM, Thwaites RS. Autoimmunity in long COVID. *J Allergy Clin Immunol*. 2025;155(4):1082-1094. https://doi.org/10.1016/j.jaci.2025.02.005
29. Rodriguez L, Brodin P. Immune system perturbations in patients with long COVID. *Trends Mol Med*. 2024;30(3):200-201. https://doi.org/10.1016/j.molmed.2023.12.008
30. Borczuk AC. Pathogenesis of Pulmonary Long COVID-19. *Mod Pathol*. 2024;37(2):100378. https://doi.org/10.1016/j.modpat.2023.100378