

Pediatric Long COVID

Stefan Schwarz, Veith Hümmert*

Freie Universität Berlin, Kaiserswerther Str. 16-18, 14195 Berlin, Germany

*: All correspondence should be sent to: Dr. Veith Hümmert

Author's Contact: Mr. Stefan Schwarz, M.D. Candidate, E-mail: stefan.schwarz@gmail.com; Dr. Veith Hümmert, M.D., Ph.D., veithhummert@outlook.com

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The emergence of long COVID, a condition characterized by persistent symptoms lasting beyond the acute phase of COVID-19 infection, has raised concerns about its impact on pediatric populations. While initially thought to affect primarily adults, increasing reports suggest that children can also experience prolonged symptoms post-COVID-19. Understanding the unique aspects of pediatric long COVID, including its symptoms, diagnosis, and management, is crucial for healthcare providers and families navigating the long-term effects of the pandemic on children's health. This article provides an overview of pediatric long COVID, exploring its symptoms, diagnosis, impact, treatment options, prognosis, current research efforts, and recommendations for healthcare providers and families.

Keywords: Long COVID; Pediatric Population; Symptom Variation; Prognosis; Negative Impact

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Introduction

PEDIATRIC long COVID, also referred to as post-acute sequelae of SARS-CoV-2 infection (PASC) in children, is a term that denotes the extended symptoms that children experience following the recovery from acute COVID-19 (Toepfner et al., 2024). Although children typically experience milder cases of the virus, some may develop persistent symptoms, including fatigue, respiratory issues, cognitive difficulties, and neurological problems (Rao et al., 2024). The precise cause of pediatric long COVID is not yet fully comprehended; however, it is suspected to be associated with the body's immune response and inflammation induced by the initial infection (Ha et al., 2023). The diverse spectrum of symptoms and their fluctuating nature over time can make the diagnosis a difficult task

(Sansone et al., 2023). The provision of appropriate care for affected children is contingent upon the early recognition and management of the condition. This may necessitate a multidisciplinary approach that involves pediatricians, infectious disease specialists, neurologists, and mental health professionals. To enhance treatment strategies for these juvenile patients and gain a more comprehensive understanding of this phenomenon, it is crucial to conduct ongoing research.

Defining Long COVID in Children

One of the challenges in defining long COVID in children is the lack of a standardized set of symptoms. Children with long COVID may experience a range of symptoms, including fatigue, respiratory issues, cognitive difficulties, and gastrointestinal

problems (Harris, 2024; Morello et al., 2023). These symptoms can vary in severity and duration, making it difficult to accurately diagnose the condition. Additionally, some children may not exhibit the classic symptoms of COVID-19, such as fever or cough, making it even harder to identify cases of long COVID in this population (Sugiyama et al., 2024).

Despite these challenges, there have been efforts to define long COVID in children. The Centers for Disease Control and Prevention (CDC) has recognized that children can experience long-lasting symptoms after contracting COVID-19 and has provided guidance on how to identify and manage the condition (Post-COVID Conditions, 2024). The CDC has also established a surveillance system to track cases of long COVID in children, in order to better understand the scope of the problem and develop evidence-based interventions (Jones & Yeralan, 2022).

In addition to the CDC, other organizations and researchers have been working to define long COVID in children. Studies have shown that a significant number of children who have had COVID-19 continue to experience symptoms for weeks or even months after their initial diagnosis (Rao et al., 2024; Stephenson et al., 2021). These symptoms can have a significant impact on a child's quality of life, leading to missed school days, decreased physical activity, and emotional distress. By defining long COVID in children, healthcare providers can better identify and address these symptoms, ultimately improving outcomes for pediatric patients.

While a formal, universally accepted definition of Long COVID in children remains elusive, there is a consensus that it refers to the persistence of symptoms for at least three months after the initial SARS-CoV-2 infection, with these symptoms having a negative impact on a child's daily life and without alternative explanations (Morello et al., 2023). Symptoms may be new-onset following initial recovery from an acute COVID-19 episode or may persist from the initial illness, and they may also fluctuate or relapse over time.

Studies have indicated that long COVID can affect children in various ways, including respiratory, upper airway, cardiac, neurological, motor, and psychological issues (Sansone et al., 2023). In some cases, additional diagnoses may be uncovered during the workup, but this does not exclude the underlying diagnosis of post-COVID condition. Identification of populations disproportionately affected by long COVID, such as those with preexisting conditions or certain demographic factors, can help guide efforts to prioritize prevention and treatment (Perlis et al., 2022; Tartof et al., 2022). As the pathophysiological basis of long COVID in children remains largely unknown, further research is needed to better understand this emerging phenomenon and develop effective management strategies.

Epidemiology and Prevalence

Approximately 2.3% of children who tested positive for COVID-19 experienced symptoms for more than 12 weeks (Harris, 2024). Studies conducted in Europe estimated that approximately 10-14% of children who have COVID-19 infection may experience symptoms that last for a long time (Dumont et al., 2022; Pellegrino et al., 2022). These studies underscore the fact that the long COVID is not solely a concern for adults, but also for minors.

The severity of the initial COVID-19 infection, underlying health conditions, and genetic predisposition are all factors that may increase the risk of developing long COVID in children (Böhmwald et al., 2024). Furthermore, the presence of specific antibodies and inflammatory markers in the blood has been linked to an elevated risk of developing a long-term COVID case (Brackel et al., 2021). Healthcare providers can more effectively customize treatment and support for children who are at risk of developing long COVID. This can be achieved by identifying these risk factors.

Symptoms and Clinical Presentation in Children

Fatigue is one of the most prevalent symptoms of long COVID-19 in adolescents (Sun et al., 2024). Extreme exhaustion is frequently a symptom of long COVID in children, and it does not respond to sleep or rest. This fatigue can have a substantial effect on a child's capacity to engage in daily activities, including school, athletics, and playtime (Kumar & Jat, 2023).

Respiratory complications are an additional prevalent manifestation of long COVID in adolescents. Even after the initial infection has subsided, children may continue to experience chest pain, coughing, or shortness of breath (Dobkin et al., 2021; Zheng et al., 2023). These respiratory symptoms can be distressing for both the child and their parents and may necessitate medical intervention.

Cognitive symptoms, including memory problems, difficulty concentrating, or brain fatigue, may also be experienced by children with long COVID (Rao et al., 2024). School-aged children may be particularly concerned about these symptoms, as they can affect their capacity to learn, concentrate, and retain information (Avittan & Kustovs, 2023).

Gastrointestinal symptoms are another prevalent manifestation of long COVID-19 in adolescents. Long after the initial infection has subsided, children may experience nausea, vomiting, diarrhea, or abdominal pain (Ha et al., 2023; Thallapureddy et al., 2022). A child's daily regimen may be disrupted and uncomfortable as a result of these symptoms.

Cardiovascular symptoms, including chest pain, palpitations, or vertigo, may also be experienced by certain children with long COVID-19 (Del Carmen Jamaica Balderas et al., 2023; Stephenson et al., 2022). Additional evaluation by a healthcare provider may be necessary to exclude any underlying cardiac issues, as these symptoms can be alarming.

Children with long COVID may also experience mental health symptoms, including anxiety, depression, or mood fluctuations, in addition to physical symptoms. A child's mental health can be negatively impacted by the stress of managing a protracted illness and the ambiguity that accompanies long-term COVID (Vartanian et al., 2023).

As indicated in recent studies, the symptoms of pediatric long COVID varied depending on the age group, and different phenotypic manifestations of long COVID were reported in a large-scale investigation. Researchers will be able to identify children and adolescents with a high probability of long COVID with the aid of the research indices created here. With the ultimate goal of enabling the best possible care for young people with long COVID, this work represents a significant step toward

the development of a clinically relevant diagnostic tool, even though these indices will need more investigation and confirmation (Blackwell et al., 2024; Iwashyna et al., 2024; Jaywant et al., 2024).

In general, the clinical presentation and symptoms of long-term COVID in children can be highly variable and may encompass a combination of physical, cognitive, gastrointestinal, cardiovascular, and mental health symptoms. It is crucial for healthcare providers and caregivers to be cognizant of the potential for long COVID symptoms in children who have previously contracted the virus, and to monitor for any newly developed or persistent symptoms. Early identification and treatment of long COVID in children are essential for guaranteeing the most favorable outcomes for these young patients.

Diagnosis and Differential Diagnosis

Children who have long COVID may experience headaches, muscle aches, exhaustion, shortness of breath, and difficulties concentrating (Sansone et al., 2023). The symptoms of long COVID in children might overlap with other illnesses, which is one of the main diagnostic problems (Fink et al., 2024). For instance, exhaustion and trouble focusing can be signs of a number of illnesses, including anxiety, depression, and other medical issues (Avittan & Kustovs, 2023). Therefore, in order to correctly identify long COVID and rule out other potential causes of the symptoms, healthcare providers must thoroughly evaluate the child's medical history, symptoms, and possible exposure to COVID-19.

Apart from the symptom overlap with other illnesses, the absence of established diagnostic criteria poses a barrier in the diagnosis of long COVID in children. As long COVID is still a relatively new illness, research is currently being done to learn more about COVID-19's long-term implications (Al-Aly & Topol, 2024). Because of this, it is challenging for medical professionals to establish precise protocols for diagnosing long COVID in pediatric patients. In order to make an appropriate diagnosis, healthcare professionals must therefore rely on their clinical judgment and expertise.

One of the most important aspects of diagnosing long COVID in children is differential diagnosis (Minotti et al., 2024). This entails separating long COVID from other illnesses that could exhibit symptoms that are comparable. In children, post-viral fatigue syndrome, depression, anxiety, or other chronic medical disorders are common differentials for long COVID (Cezar et al., 2024; Delogu et al., 2024; Fink et al., 2024; Toepfner et al., 2024). To rule out additional possible reasons of the child's symptoms, healthcare personnel must carefully analyze these differentials and do the necessary testing and examinations.

Children with long COVID may also benefit from diagnostic testing. Blood tests, imaging scans, and other diagnostic techniques may be used to evaluate organ function and rule out additional possible explanations for the child's symptoms (Calcaterra et al., 2024; Toepfner et al., 2024). For example, a chest x-ray can be done to evaluate lung function in children who are experiencing shortness of breath, and a complete blood count can be carried out to look for indicators of inflammation or infection.

Following a long COVID diagnosis, medical professionals can collaborate with the child's family to create a treatment plan. In order to help manage the child's symptoms and enhance their quality of life, a multidisciplinary approach may be used, involving physical therapy, occupational therapy, cognitive behavioral therapy, and other treatments (Fink et al., 2024; Mantziaris et al., 2024). Because long COVID can have a serious influence on a child's physical, emotional, and cognitive health, it is critical that healthcare providers give this child with continuing assistance and monitoring.

Impact on Physical and Mental Health

Children who have long COVID may experience a range of physical symptoms, such as exhaustion, headaches, muscle weakness, and breathing problems. A child's capacity to engage in regular activities, like going to school, exercising, and interacting with friends, may be impacted by these symptoms (Asadi-Pooya et al., 2021; Thallapureddy et al., 2022). Children who have a long COVID may also endure breathing difficulties, chest pain, and heart palpitations, all of which can be frightening and upsetting for the kid and their caregivers.

Additionally, research on the long-term physical effects of COVID-19 in children is ongoing, but preliminary findings indicate that the virus may cause persistent respiratory, cardiovascular, and neurological problems in certain kids (Burns et al., 2023; Coker et al., 2023; Scarselli et al., 2023). A child's physical health and capacity to enjoy a typical, active life may be impacted by these long-term issues and potential disabilities. In order to ensure that children with long COVID receive the proper therapy and treatments to address their ongoing symptoms and prevent further health concerns, healthcare providers must closely monitor and assist these children.

Long COVID can have serious effects on a child's emotional and mental health in addition to its physical effects. Children with long COVID may feel depressed, anxious, or frustrated because of their limits and continuing symptoms (Hassan et al., 2023; Jones & Yeralan, 2022; Thallapureddy et al., 2022). They can find it difficult to deal with the uncertainties surrounding their illness and how it might affect their long-term health and wellbeing. Furthermore, long COVID might worsen children's feelings of loneliness and emotional distress due to the social isolation and interruption to their daily routines (Wild et al., 2024).

Moreover, children with long COVID-19 may experience mental health difficulties as a result of the stigma and false information surrounding the virus (Brackel et al., 2021; Hassan et al., 2023). They can feel that people who don't completely understand the gravity and complexity of their condition are misinterpreting them or passing judgment on them. Their mental health and self-esteem may be further impacted by these emotions of loneliness, guilt, and humiliation (Schellekens & Lee, 2020). It is crucial that parents, guardians, and medical professionals provide kids the information and assistance they require to handle the difficulties of long COVID and preserve their mental health.

Furthermore, it is impossible to ignore the effects of long COVID on children's social and educational development. Children with long COVID may find it difficult to establish rela-

tionships with their peers, stay up with their homework, and participate in extracurricular activities (Raffagnato et al., 2021; Zimmermann et al., 2022). To overcome the obstacles posed by their condition and carry on succeeding in school and in their social lives, they could require modifications and assistance. The effects of long COVID on children must be recognized by communities and schools, and they must also give the tools and support required for these children to thrive.

Children and their families may also be affected by the financial costs of long COVID. Families that are already having difficulty making ends meet may experience additional stress and strain due to the continuous medical costs, missing school days, and possible loss of income (Coker et al., 2023; Irwin et al., 2021; Magnani et al., 2021). In order to ease financial problems and guarantee that children receive the treatment they require to recover and develop, it is critical that legislators and healthcare providers address these economic issues and offer assistance and resources to families affected by long COVID.

Treatment Options for Pediatric Long COVID

Symptomatic management is one of the main ways that pediatric long COVID is treated (Buonsenso et al., 2022; Ha et al., 2023). This could involve respiratory treatments to enhance breathing and oxygen levels, as well as drugs to reduce discomfort, fever, and inflammation. In order to assist youngsters, recover their strength and endurance and to address any movement impairments that may have developed as a result of the infection, physical therapy may also be advised (Sharma et al., 2023). Children who are having cognitive difficulties or speech and language issues may benefit from occupational therapy and speech therapy.

Support for mental health is just as vital to pediatric long COVID treatment as symptomatic management (Morrow et al., 2021; Mulkey et al., 2023; Schober et al., 2021). Children who have to cope with a chronic illness may suffer from anxiety, sadness, or other mental health problems as a result of the emotional toll that it can take. Children and their families can manage with the difficulties of having COVID-19 symptoms for a long time with the use of counseling, therapy, and other mental health services (Irwin et al., 2021; Shachar-Lavie et al., 2023).

Multidisciplinary care is an additional therapy option for pediatric long COVID (Sansone et al., 2023). With this strategy, children's physical, emotional, and cognitive issues are addressed by a group of healthcare providers collaborating on the case. Pediatricians, infectious disease experts, pulmonologists, physical therapists, occupational therapists, psychologists, and other medical professionals are examples of this group that can work together to create a thorough treatment plan specifically for each child.

Pediatric patients with long COVID may occasionally benefit from specialized clinics or programs created especially to meet the special requirements of kids and teenagers with COVID-19 symptoms that have persisted for a long time (Morello et al., 2023; Zimmermann et al., 2022). These programs may provide a variety of services, such as educational materials, mental health support, rehabilitation therapy, and medical examinations, to assist kids in maintaining their academic and social lives while managing their symptoms.

Family education and support is a critical component of Pediatric long COVID treatment (Mitchell, 2021). The role that parents and caregivers play in assisting their children in overcoming the difficulties associated with long COVID symptoms is vital. To learn more about the illness, its possible effects on their child's health and wellbeing, and the best ways to meet their child's physical, emotional, and cognitive needs, they might require tools and information.

As our understanding of pediatric long COVID develops, more research into the underlying causes of the illness may lead to the development of new therapeutic options. The effectiveness of numerous drugs, treatments, and interventions for children and adolescents with long COVID is now being studied in clinical studies (Calcaterra et al., 2024). Pediatric patients and their families can further our understanding of this difficult condition and help children with it have better lives.

To guarantee that children receive the best possible care and support, it is critical for healthcare professionals to remain up to date on the most recent advancements in the treatment of pediatric long COVID and to actively engage with families (Stephenson & Shafran, 2024; Sun et al., 2024). Collaboration among healthcare practitioners, researchers, families, and children can effectively address the multifaceted requirements of pediatric patients diagnosed with long COVID, leading to improved long-term outcomes and quality of life.

In sum, pediatric long COVID is a difficult and complex illness that necessitates a thorough and interdisciplinary approach to care. Healthcare professionals can contribute to better outcomes and a higher standard of living for children and adolescents with long COVID by attending to their physical, emotional, cognitive, and social needs. We may further our understanding of Pediatric long COVID and provide more potent medicines to meet the special needs of pediatric patients with long COVID symptoms with continued research, cooperation, and support.

Importance of Long-Term Monitoring and Follow-Up

Following up with children who have had long COVID is important because it allows for the tracking of symptom progression over time (Thallapureddy et al., 2022). Over time, some children may have changes in their current symptoms or the emergence of new ones; therefore, it's important to keep an eye on these changes and act quickly to address them. Healthcare professionals can better understand the course of children with long COVID and give the necessary therapies by routinely examining and monitoring these patients (Buonsenso et al., 2022; Del Carmen Jamaica Balderas et al., 2023).

Finding potential risk factors or comorbidities that could affect a child's recovery is a crucial part of long-term monitoring and follow-up for children with long COVID (Ashkenazi-Hoffnung et al., 2021; Zimmermann et al., 2022). Children who have certain risk factors or underlying medical disorders may be more likely to experience longer-lasting or more severe long-COVID symptoms (Lorman et al., 2023; Stephenson et al., 2021). Through attentive observation of these youngsters and the identification of relevant risk factors, healthcare providers can customize their interventions and treatment programs to

meet these unique requirements.

In addition, long-term observation and follow-up for kids with long COVID can aid medical professionals in determining how the illness affects the kid's physical and mental health (Sugiyama et al., 2024). The quality of life and everyday functioning of children with long COVID may be greatly impacted by a variety of physical symptoms, such as exhaustion, shortness of breath, or joint discomfort. Healthcare professionals can enhance the child's quality of life and help them manage the difficulties of long COVID by keeping an eye on these symptoms and how they affect the child's general health.

Long-term monitoring and follow-up for children with long COVID should prioritize mental health in addition to physical symptom monitoring. Children with long COVID may feel depressed, anxious, or socially isolated as a result of their illness, which can make their symptoms worse and make it more difficult for them to heal (Buonsenso et al., 2021; Ha et al., 2023; Stephenson et al., 2021). The kid's emotional wellbeing should be considered by healthcare professionals, who should also provide the right resources and mental health support to help the youngster deal with the psychological effects of long COVID.

Conclusion

Long COVID, the lingering symptoms experienced by individuals following a COVID-19 infection, has gained increased attention in recent months. While much of the focus has been on adults, it is crucial to also consider its impact on children. A comprehensive review of long COVID in children reveals a wide range of symptoms including fatigue, headache, respiratory issues, cognitive difficulties, and mood disturbances (Harris, 2024). Additionally, some children may experience multi-system inflammatory syndrome, a serious condition associated with prolonged inflammation following COVID-19 infection (Ashkenazi-Hoffnung et al., 2021; Bahrami et al., 2020; Caro-Domínguez et al., 2021; Fink et al., 2024; Jain et al., 2022; Jiang et al., 2020; Pain et al., 2020; Sá et al., 2021; Scarselli et al., 2023). Understanding the long-term effects of COVID-19 in children is essential for healthcare providers to adequately diagnose and treat affected individuals. This review highlights the need for ongoing research into long COVID in pediatric populations to better support and care for these vulnerable patients. ■

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