



COVID-19: Transdisciplinary Impact on Children and Adolescents

Grace Mucci^{1,2} · Eric Pierson³

Published online: 11 April 2024

© The Author(s), under exclusive licence to American Academy of Pediatric Neuropsychology 2024

Four years ago, the United States was in the midst of its first spring of COVID-19, and the first article was published citing the events that led up to the outbreak (Wang et al., 2020). The world's response was swift in many cases, and by the end of March 2020, the World Health Organization declared a global pandemic (WHO, 2020), forcing a cascade of responses, including the temporary closure of many schools. On March 12, 2020, Ohio became the first state in the US to shut down schools, and by March 25, 2020, all US public school buildings were closed (Education Week, 2020). Children became isolated at home, businesses closed, incomes were lost, schools transitioned to virtual learning, and the practice of medicine and neuropsychology became evermore challenging. This dramatic reshaping of the lives of children and neuropsychological services led many to wonder what the outcomes of the medical, psychological, educational, and social functioning of our children would be. We know research takes time to answer questions and that while some areas of research related to medicine and COVID-19 were moving forward at exceptional speed, other research activities were affected as funds dwindled (Nature Medicine, 2020). Much of the COVID-19 research that was taking place was oftentimes haphazard, with untested measurement instruments and biased sample selection. Today, this special issue provides insight into what we have learned about the time we were in, how children have responded to many of the stressors placed upon them and the protective factors that helped to mitigate negative reactions, and how we will continue to need to view the ramifications of this time on the lives of those children and families with whom we work.

While the pandemic has subsided, pediatric psychologists and neuropsychologists are now beginning to experience an increase in the number of referrals for children and adolescents who have mental health concerns and lingering symptoms from COVID-19, such as fatigue, attention difficulties, executive dysfunction, memory concerns, and academic difficulties. There is scant literature on the neuropsychological aspects of COVID-19 in youth, and many clinicians are struggling to make sense of the assessment results they are finding in the context of COVID-19 infection. Further, leading up to the pandemic, the state of children and adolescents' mental health was already in crisis (McNicholas, 2018). In October 2021, following a surge in the need for child mental health specialists, the American Academy of Pediatrics, American Academy of Child and Adolescent Psychiatry, and the Children's Hospital Association declared a national emergency in children's mental health, with an emphasis on the disparities resulting from structural racism impacting children from communities of color (AAP-AACAP-CHA Declaration of a National Emergency in Child & Adolescent Mental Health, 2021). This was a "call to arms" for all healthcare professionals.

This special issue of the Journal of Pediatric Neuropsychology addresses the many facets of COVID-19, including the medical and pathophysiological aspects of the disease in children and adolescents, how COVID-19 has affected neurocognitive, emotional, and psychosocial development, racial and ethnic disparities, the stress that the pandemic has caused on school settings, and treatment approaches that target the lingering effects. We are mindful that this special issue is not the end of the discussion of these topics. Nor is it the first point of scholarship on some of them. It is, however, a point where we can pause and reflect upon what we know and hope to learn in the coming years. As we continue to research the impact of COVID-19 and the pandemic on children and adolescents, it will be important to examine how this experience shaped the lives of those growing up as they did, how it impacted their developmental trajectories, and, ultimately, how it affected their brain development, learning capacities, social functioning, and mental health. There most

✉ Grace Mucci
gmucci@choc.org

Eric Pierson
eepierson@bsu.edu

¹ CHOC Children's Hospital, Orange, CA, USA

² University of California, Irvine, CA, USA

³ Ball State University, Muncie, IN, USA

likely will be a point in the future where our field will need to change how we evaluate children and adolescents and understand how to be better prepared to handle the next pandemic. We hope these lessons and insights will help guide future inquiries. Below, we review each of the articles, share the most salient findings, and add our concluding remarks.

Special issues only happen when a group of scholars and authors are willing to put in extra time and effort on a project that they see as vital. This one was no different. This special issue also could not have been completed without the generous support and patience of the Editor-in-Chief, Dr. Cecil Reynolds. His care and kind encouragement when the project hit delays or roadblocks cannot be overstated. It is also true that every peer-reviewed project depends upon the wisdom, feedback, and insight of knowledgeable reviewers and this was true here as well. While all of us have gained lived experience and knowledge about practice with those experiencing COVID-19 and how it influenced outcomes, this group of reviewers came through and gave guidance whenever we asked. In all, we would like to express our deep-felt appreciation to all who helped make this special issue possible.

As a personal extension of gratitude, I (EP) would like to thank Dr. Grace Mucci for agreeing to work on this special issue and taking the lead over the majority of it. It was a pleasure getting an opportunity to work with you on this project. And I (GM) would like to thank Dr. Eric Pierson for approaching me to collaborate on this endeavor. This labor of love comes from within, and I am grateful for sharing the project, from the initial concept to the choosing of topics and authors, and working with all who made it possible for this to come to fruition.

Summary of Articles

Neurological and Neuroimaging Implications of COVID-19 in the Pediatric Population

The article by Drs. Michael Kung, Felice Adler-Shohet, Holie Lai, and Rachel Pearson provides an excellent overview of the neurological burden of COVID-19 infection in the developing child. The SARS-CoV-2 virus, responsible for the COVID-19 pandemic, is highly infectious, and while older adults were found to be at greatest risk for significant morbidity and mortality, children were also a vulnerable group, particularly those with pre-existing conditions (Woodruff et al., 2022). Just like any other virus, the SARS-CoV-2 virus can affect the nervous system and does so with a higher burden compared to other viruses, such as the common cold. They review the pathophysiology of the virus, how it is spread through the respiratory route through

droplets released from an infected person, and how it can spread through contaminated surfaces.

A review of the literature suggests that 7% of children ages 2 months to 18 years who were hospitalized with COVID-19 had a neurologic complication (Antoon et al., 2022). These complications include seizures, acute encephalitis, demyelinating processes (i.e., Guillain Barre Syndrome and Acute Disseminated Encephalomyelitis), and transverse myelitis. Neuroimaging has shown restricted diffusion in the subcortical and deep white matter in the corpus callosum, brainstem, and spinal cord (Tenembaum et al., 2002). COVID-19 infection in children can also lead to cerebrovascular events (i.e., hemorrhagic and ischemic stroke) (Coronado Munoz et al., 2022). At times, although rare, children can develop multisystem inflammatory syndrome in children (MIS-C) and post-COVID condition (PCC). The authors conclude that our understanding of the neurological manifestations is limited and largely based on case reports and implications on the developing child may not be appreciated at this time. Further research and close follow-up are needed in youth with a history of severe COVID-19.

Neuropsychological Impact of COVID-19 on Children and Adolescents

This review by Drs. Christine Koterba, Gray Vargas, Rowena Ng, and Kristen Hoskinson provides a compelling conceptualization of how COVID-19 disease can impact the cognition, behavior, emotions, and quality of life in children and adolescents. Much of the research in this area has been focused on children who have more serious illnesses, such as MIS-C, or continue to have prolonged symptoms following a period of illness, and there is less research available at present that addresses those children with less severe disease burden. Confounding variables, such as pre-existing conditions, anxiety resulting from the pandemic, and social isolation from peers need to be taken into consideration. The authors address the acute complexities, such as hospitalization and pre-existing medical conditions and how they contribute to COVID-19-related cognitive issues. Assessment limitations further curtail our knowledge of the impact of COVID-19 on cognitive processes in children and adolescents. One of the studies by Frolli and colleagues (2021) was fairly comprehensive and found that non-hospitalized youth with COVID-19 infection had more executive function and visuospatial skills deficits compared to those without COVID-19, and those who were hospitalized had even more significant difficulties with perceptual reasoning, working memory, and processing speed. Youth with MIS-C may have greater difficulties, although the research is extremely limiting. Finally, the issue of “long COVID” is addressed, with the consideration that the overall prevalence in children and adolescents varies across studies, with estimates

ranging from 4 to 66% (Zimmermann et al., 2022). Symptoms commonly reported include “brain fog,” forgetfulness, and concentration problems, but these findings are subjective and often based on rating scales rather than observation or formal testing. Interestingly, there is emerging research suggesting striking similarities between long-COVID and post-concussion syndrome (Wang et al., 2022). Recent research indicates that 3–6% of youth with a history of symptomatic COVID-19 suffer from cognitive sequelae (Hanson et al., 2022; Lopez-Leon et al., 2022), although there is scant research with controlled groups to help with understanding the neurocognitive outcomes following COVID-19 infection. More research is needed in this area to help parcel out the contributing factors leading to reported neurocognitive symptoms, such as poor effort on testing, isolation, anxiety, sleep disturbances, learning disabilities, and the ethnic and racial differences, if any.

Bio-psycho-sociocultural Lens Highlights Racial and Ethnic Inequities in Neuropsychological Outcomes Following COVID-19

The article by Drs. Ailyn Diaz, Alana M. McNeill, Elizabeth S. Miceli, Jasmin Lagman, Jessica Bonatakis, and Meenal Pathak is an exceptional article that summarizes and promotes our understanding of the health and neuropsychological outcomes following COVID-19. It also helps to provide a model for case conceptualization of youth and how to place their functioning into the context of those differences. In it, the authors summarize the findings related to COVID, MIS-C, and long COVID and how these conditions place children from historically marginalized populations at greater health risk and with a greater likelihood of worse health outcomes. In addition, the article outlines how additional bio-psycho-sociocultural factors increase the likelihood of long-term risk factors that need attention in neuropsychology. This is an article that we anticipate many of us will revisit in the years to come as we consider the children and families with whom we work.

The Lost Years: An Integrative Review of the Mental Health, Educational, and Social Impact of the Pandemic on Children and Adolescents from 2019 to 2022

The COVID-19 pandemic profoundly impacted the mental health, academic achievement, and social functioning of children and adolescents globally, as evidenced by an integrative review by Mucci and colleagues (2024) encompassing 50 studies. The impact of the COVID-19 pandemic, its lockdown period, and subsequent restrictions on our youth were in the realms of psychological and social health, and family life with consideration to pre-existing conditions such

as mental illness or abuse. The literature suggests a trend of adolescents experiencing significant worry and emotional distress, with an increased risk of depression, particularly among females in the wake of the social isolation that followed school closures. Sedentary behavior exacerbated anxiety and depression symptoms, leading to deteriorating mental wellness in many cases and males were more prone to behavioral issues. The increased time spent online and on social media during the pandemic further contributed to adverse mental health outcomes and many with pre-existing mental health conditions experienced a worsening of symptoms. School closures and the shift to distance learning had varying effects, influenced by factors such as urban settings, socioeconomic status, and pre-existing learning challenges. Academic performance, especially in mathematics, declined particularly with younger children. The pandemic also raised concerns about child maltreatment, with those with pre-existing mental illness and special education needs at a higher risk. Telehealth emerged as a crucial tool for pediatric mental health care during the pandemic, offering continuity of care and increased access. However, challenges such as limited access to technology and privacy concerns were evident, particularly for minority populations and immigrant youth. Numerous variables, including protective factors, contribute to these findings, and they are systematically addressed and laid out for the reader. Of particular importance is that much of the research in these areas is cross-sectional and limited by methodological issues, such as time of data collection and subject recruitment practices. Nevertheless, it is clear that the pandemic in and of itself has caused a myriad of issues worldwide, and we do not yet know the long-term implications. Consistent with Diaz and colleagues (this issue), it will behoove researchers and clinicians to adopt a biopsychosocio-cultural lens that incorporates economic factors to better understand the implications of the pandemic on our children’s development, including the disparities in the expression of mental health symptoms. Longitudinal and controlled studies across ethnicities, ages, socioeconomic backgrounds, and neurodivergent youth are sorely needed for us to truly grasp the far-reaching implications the pandemic has had worldwide. Thus, comprehensive research and intervention strategies are urgently needed to address the multifaceted challenges children and adolescents face in the wake of the pandemic. This will aid in providing targeted, relevant, and effective interventions addressing the general health and well-being of children and adolescents.

Special Education Law: How the COVID-19 Pandemic Has Impacted FAPE, Child Find, and FERPA Laws

The article by Pierson and colleagues gives context and refreshes our minds on the varied needs of children in different schools and parts of the country. Specifically, the article

examines the literature surrounding how schools worked to implement rules and regulations for special education and how these did not always work as intended. It also provides an overview of how children and families experienced school stoppages and losses in learning during COVID-19 and how many times those with special education needs were the ones with the greatest needs and losses. Further, this article discusses and reviews how parents of children receiving special education needs were often asked to adopt additional roles that were new to them. This article will be an important piece for practitioners to consider as students age, as well as how the families of children in Special Education feel about their relationships with the schools and the services that were delivered during COVID-19.

Concluding Remarks

In summary, one psychological approach to dealing with a mass traumatic event such as COVID-19 is to close up the file, put it in its box, and go forward hoping to never revisit it. As trained specialists in neuropsychology, psychology, and medicine, we know this is not the healthiest approach. We also know that we would lose the opportunities to reflect and grow from the time we spent struggling to change our practices and meet the needs of the children and families who we serve. It is rare for a single special issue to be one that will help improve the way you think and work with every patient through your office doors; however, if you have the time and energy to engage with this research and scholarship, we hope that this one will positively impact your practices and the surrounding community. You won't be the only one grateful you did; your patients and their families will be too.

Data Availability No new data were created or analyzed during this study. Data sharing is not applicable to this article.

References

- American Academy of Pediatrics. (2021). *AAP-AACAP-CHA declaration of a national emergency in child and adolescent mental health*. <https://www.aap.org/en/advocacy/child-and-adolescent-healthy-mental-development/aap-aacap-cha-declaration-of-a-national-emergency-in-child-and-adolescent-mental-health/>. Accessed 3 Apr 2024.
- Antoon, J. W., Hall, M., Howard, L. M., Herndon, A., Freundlich, K. L., Grijalva, C. G., & Williams, D. J. (2022). COVID-19 and acute neurologic complications in children. *Pediatrics*, *150*, 5. <https://doi.org/10.1542/peds.2022-058167>
- Coronado Munoz, A., Tasayco, J., Morales, W., Moreno, L., Zorrilla, D., Stapleton, A., Pajuelo, P., Reyes, G., Estupiñan, M., Seminario, R., Ortiz, M., & Domínguez, J. (2022). High incidence of stroke and mortality in pediatric critical care patients with COVID-19 in Peru. *Pediatric Research*, *91*(7), 1730–1734. <https://doi.org/10.1038/s41390-021-01547-x>
- Education Week (2020). The coronavirus spring: The historic closing of U.S. school (a timeline). [https://www.edweek.org/leadership/the-coronavirus-spring-the-historic-closing-of-u-s-schools-a-timeline/2020/07ingofU.S.Schools\(ATimeline\)\(edweek.org\)](https://www.edweek.org/leadership/the-coronavirus-spring-the-historic-closing-of-u-s-schools-a-timeline/2020/07ingofU.S.Schools(ATimeline)(edweek.org)) Accessed 03/24/2024.
- Frolli, A., Ricci, M. C., Di Carmine, F., Lombardi, A., Bosco, A., Saviano, E., & Franzese, L. (2021). The impact of COVID-19 on cognitive development and executive functioning in adolescents: a first exploratory investigation. *Brain Sciences*, *11*(9), 1222.
- Hanson, S. W., Abbafati, C., Aerts, J. G., Al-Aly, Z., Ashbaugh, C., Ballouz, T., ... & Global Burden of Disease Long COVID Collaborators. (2022). Estimated global proportions of individuals with persistent fatigue, cognitive, and respiratory symptom clusters following symptomatic COVID-19 in 2020 and 2021. *Journal of the American Medical Association*, *328*(16), 1604–1615. <https://doi.org/10.1001/jama.2022.18931>
- Lopez-Leon, S., Wegman-Ostrosky, T., Ayuzo del Valle, N. C., Perelman, C., Sepulveda, R., Rebolledo, P. A., Cuapio, A., & Villapol, S. (2022). Long COVID in children and adolescents: A systematic review and meta-analyses. *Nature*, *12*, 9950. <https://doi.org/10.1038/s41598-022-13495-5>
- McNicholas, F. (2018). Child & adolescent emergency mental health crisis: a neglected cohort. *Irish Medical Journal*, *111*, 841.
- Nature Medicine (2020). How is biomedical research funding faring during the COVID-19 lockdown? <https://www.nature.com/articles/d41591-020-00010-4re.com>. (Accessed 03/24/2024).
- Tenembaum, S., Chamoles, N., & Fejerman, N. (2002). Acute disseminated encephalomyelitis: A long-term follow-up study of 84 pediatric patients. *Neurology*, *59*(8), 1224–1231. <https://doi.org/10.1212/WNL.59.8.1224>
- Wang, C., Horby, P. W., Hayden, F. G., & Gao, G. F. (2020). A novel coronavirus outbreak of global health concern. *The Lancet*, *395*(10223), 470–473.
- Wang, D. H., Trojjan, T., & Leddy, J. J. (2022). Post-COVID-19 neurological syndrome and concussion. *Clinical Journal of Sport Medicine*, *32*(6), 555–557.
- Woodruff, R. C., Campbell, A. P., Taylor, C. A., Chai, S. J., Kawasaki, B., Meek, J., Anderson, E. J., Weigel, A., Monroe, M. L., Reeg, L., Bye, E., Sosin, D. M., Muse, A., Bennett, N. M., Billing, L. M., Sutton, M., Talbot, H. K., McCaffrey, K., Pham, H., & Havers, F. P. (2022). Risk factors for severe COVID-19 in children. *Pediatrics*, *149*(1), e2021053418. <https://doi.org/10.1542/peds.2021-05341>
- World Health Organization. (2020). *WHO Director-General's opening remarks at the media briefing on COVID-19*, March 2020. World Health Organization. <https://www.who.int/directorgeneral/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>. Accessed 20 Sept 2023.
- Zimmermann, P., Pittet, L. F., & Curtis, N. (2022). The challenge of studying long COVID: An updated review. *Pediatric Infectious Disease Journal*, *41*(5), 424–426. <https://doi.org/10.1097/INF.0000000000003502>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.