



SEÇÃO: ARTIGO

## Avaliação neuropsicológica brasileira dos desfechos diretos e indiretos da COVID-19: uma revisão integrativa

*Brazilian Neuropsychological Assessment of Direct and Indirect Outcomes of COVID-19: An integrative review*

*Evaluación neuropsicológica brasileña de los efectos directos e indirectos del COVID-19: Una revisión integradora*

**Alessandra Gotuzo**

**Seabra<sup>1</sup>**

[orcid.org/0000-0002-8373-7897](https://orcid.org/0000-0002-8373-7897)  
[alessandragseabra@gmail.com](mailto:alessandragseabra@gmail.com)

**Alexandre Luiz de**

**Oliveira Serpa<sup>1</sup>**

[orcid.org/0000-0002-1924-2128](https://orcid.org/0000-0002-1924-2128)  
[serpa.alexandre@gmail.com](mailto:serpa.alexandre@gmail.com)

**Carlos Eduardo Nórté<sup>2</sup>**

[orcid.org/0000-0002-4068-5126](https://orcid.org/0000-0002-4068-5126)  
[cadulsn@gmail.com](mailto:cadulsn@gmail.com)

**Caroline de Oliveira**

**Cardoso<sup>3</sup>**

[orcid.org/0000-0002-3720-0845](https://orcid.org/0000-0002-3720-0845)  
[carolinecardoso@feevale.br](mailto:carolinecardoso@feevale.br)

**Emmy Uehara Pires<sup>4</sup>**

[orcid.org/0000-0002-3845-4839](https://orcid.org/0000-0002-3845-4839)  
[emmy.uehara@gmail.com](mailto:emmy.uehara@gmail.com)

**Recebido em:** 25 nov. 2024.

**Aprovado em:** 23 out. 2025.

**Publicado em:** 12 dez. 2025.



Este é um artigo de acesso aberto distribuído sob a licença [CC-BY 4.0](https://creativecommons.org/licenses/by/4.0/), que permite a cópia e redistribuição do material em qualquer formato e para qualquer finalidade, desde que a autoria original e os créditos de publicação sejam mantidos.

**Jonas Jardim de Paula<sup>5</sup>**

[orcid.org/0000-0001-5530-2346](https://orcid.org/0000-0001-5530-2346)  
[jonasjardim@gmail.com](mailto:jonasjardim@gmail.com)

**Maria Julia Hermida<sup>6</sup>**

[orcid.org/0000-0001-6835-7864](https://orcid.org/0000-0001-6835-7864)  
[julia.hermida@gmail.com](mailto:julia.hermida@gmail.com)

**Rochele Paz Fonseca<sup>4</sup>**

[orcid.org/0000-0001-6767-8439](https://orcid.org/0000-0001-6767-8439)  
[rochele.fonseca@gmail.com](mailto:rochele.fonseca@gmail.com)

**Luiz Renato Rodrigues Carreiro<sup>1</sup>**

[orcid.org/0000-0001-8249-1832](https://orcid.org/0000-0001-8249-1832)  
[luizrenato.carreiro@mackenzie.br](mailto:luizrenato.carreiro@mackenzie.br)

**Resumo:** Durante a pandemia, a avaliação neuropsicológica foi crucial para identificar alterações no sistema nervoso central e alvos para intervenção. Este estudo teve como objetivo caracterizar o papel da avaliação neuropsicológica no Brasil durante a pandemia, por meio de revisão científica integrativa não sistemática das produções desde 2020, comparando efeitos diretos e indiretos da COVID-19 em diferentes faixas etárias. Entre crianças e adolescentes, efeitos indiretos, como menor desempenho acadêmico e dificuldades executivas, foram mais pronunciados em indivíduos jovens de contextos socioeconômicos vulneráveis. Em adultos e idosos, efeitos diretos incluíram neuroinflamação, redução do fluxo sanguíneo cerebral, neuropatia autonômica e de fibras pequenas; efeitos indiretos mostraram déficits cognitivos, especialmente em memória episódica. A avaliação neuropsicológica mostrou-se necessária para detectar impactos cognitivos, acadêmicos e psicossociais da COVID-19 em diferentes idades, e orientar intervenções. Em síntese, esta revisão de estudos brasileiros mostrou que avaliações neuropsicológicas possibilitaram identificar impactos da COVID-19, o que evidenciou a necessidade de expansão da neuropsicologia no país.

**Palavras-chave:** Testes; Avaliação; Avaliação Neuropsicológica; Medidas Neuropsicológicas; Cognição.

<sup>1</sup> Universidade Presbiteriana Mackenzie (UPM), São Paulo, São Paulo, Brasil.

<sup>2</sup> Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Rio de Janeiro, Brasil.

<sup>3</sup> Federação dos Estabelecimentos de Ensino Superior (FEEVale), Novo Hamburgo, Rio Grande do Sul, Brasil.

<sup>4</sup> Universidade Federal Rural do Rio de Janeiro (UFRRJ), Seropédica, Rio de Janeiro, Brasil.

<sup>5</sup> Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, Minas Gerais, Brasil.

<sup>6</sup> Universidade Nacional de Hurlingham, Hurlingham, Argentina.

**Abstract:** During the pandemic, neuropsychological assessment became crucial for identifying central-nervous system alterations and intervention targets. This study aimed to characterize the role of neuropsychological assessment in Brazil during the pandemic, through a non-systematic integrative scientific review of productions since 2020, comparing COVID-19's direct and indirect effects across age groups. Among children and adolescents, indirect effects, such as lower academic achievement and executive functioning, were more pronounced in younger children from lower socioeconomic backgrounds. In adults and older adults, direct effects included neuroinflammation, reduced cerebral blood flow, autonomic neuropathy, and small-fibre neuropathy, while indirect effects showed cognitive deficits, especially in memory. Overall, neuropsychological assessment proved necessary for detecting COVID-19's cognitive, academic and psychosocial impacts across age groups, as well as to guide interventions. This review of Brazilian studies showed that conducting neuropsychological assessments allowed the identification of COVID-19's impacts and showed the need for neuropsychology to spread to the whole country.

**Keywords:** Testing; Evaluation; Neuropsychological Assessment; Neuropsychological Measures; Cognition.

**Resumen:** Durante la pandemia, la evaluación neuropsicológica se tornó crucial para identificar alteraciones y objetivos de intervención. Este estudio tuvo como objetivo caracterizar el papel de la evaluación neuropsicológica en Brasil, a través de una revisión integradora no sistemática de publicaciones desde 2020 que compara los efectos directos e indirectos del COVID-19 en distintas edades. Entre infantes y adolescentes, se observaron efectos indirectos (menor rendimiento ejecutivo y académico) más pronunciados en los más pequeños y socialmente vulnerables. En adultos y ancianos, los efectos directos incluyeron neuroinflamación, reducción del flujo sanguíneo cerebral, neuropatía autonómica y de fibras pequeñas; y los indirectos incluyeron déficits cognitivos, particularmente en memoria. En conclusión, la evaluación neuropsicológica demostró ser necesaria para detectar los impactos cognitivos, académicos y psicosociales del COVID-19 en todas las edades, así como para guiar las intervenciones. La realización de evaluaciones neuropsicológicas mostró la necesidad de expansión de la neuropsicología en el país.

**Palabras clave:** Pruebas; Evaluación; Evaluación Neuropsicológica; Medidas Neuropsicológicas; Cognición.

## Introduction

### COVID-19 pandemic

The COVID-19 pandemic has had a profound impact on Brazil, posing significant challenges for public health, social assistance and educational outcomes, with consequences still visible today and expected to be resolved only in the coming decades. Between 2020 and 2022, Brazil became

one of the countries most affected by the disease, both due to the high number of cases and the disproportionately high number of deaths (Ministério de Saúde, 2024). In addition to SARS-CoV-2 infections and their direct biological effects, the pandemic triggered economic, social, cognitive, labor, and educational changes that negatively affected the mental health of survivors (Torales et al., 2020).

In the following weeks of February 2020, the virus spread rapidly across the country, and by March and April, the first containment measures, such as quarantines and lockdowns, were implemented in several Brazilian regions. Despite initiatives at federal, state, and municipal levels, the increase in case numbers, coupled with difficulties accessing supplies and hospital infrastructure, led to a collapse of healthcare systems in various Brazilian states (Silva & Pena, 2021). By October 2020, the country had recorded over 5 million confirmed cases of COVID-19 and more than 150,000 deaths, excluding unconfirmed cases, making it one of the global epicenters of the pandemic (Carvalho et al., 2021). In approximately one year of the pandemic, there were over 11 million cases and more than 275,000 deaths in Brazil (Boschiero et al., 2021).

In early 2021, Brazil experienced a devastating second wave driven by new virus variants, such as the Gamma variant (P.1). During this period, the vaccination process began (Bichara et al., 2021). As vaccine availability increased and with greater mobilization of the Brazilian population with higher health literacy and public adherence, most adults received at least one dose by the second half of 2021 (Moura, et al., 2022). From that point on, Brazil began to see a significant reduction in case numbers and deaths. However, variants such as Delta (still in 2021) and later Omicron (early 2022) continued to cause localized outbreaks. By April 2024, Brazil had recorded over 38 million confirmed cases, and more than 700,000 deaths associated with the disease, ranking as one of the countries with the highest absolute and relative numbers of cumulative COVID-19 deaths (Berra et al., 2024).

Thus, considering the presented impact across various areas and the persistent effects on multiple organs, the World Health Organization (WHO), in a call for action, emphasized the importance of rehabilitation through the adoption of integrated care models. Additionally, Gloeckl et al. (2023) highlights the need for a comprehensive and continuous assessment to determine the most effective treatments for each patient, which may include respiratory physiotherapy, psychological support, social reintegration strategies, and personalized exercise programs. Beyond these direct effects, i.e., caused by SARS-CoV-2 infection, it is essential to understand the indirect effects of the COVID-19 pandemic resulting from social isolation and school closures. In studying these effects, neuropsychology has played a fundamental role by means of its assessment and intervention methods (Ritchie et al., 2020; Sozzi et al., 2020). Therefore, this integrative review aimed to identify and synthesize Brazilian studies published between 2000 and 2024 that investigated the direct and indirect neuropsychological effects of COVID-19 across different age groups. This review addresses a knowledge gap concerning the neurocognitive and psychosocial consequences of the pandemic within the Brazilian population, stratified by age and type of impact.

## Method

This study undertakes an integrative, non-systematic literature review to comprehensively synthesize Brazilian research on the cognitive, emotional, and behavioral changes observed in individuals who have experienced COVID-19 in Brazil.

The guiding question for this research was: "What are the direct and indirect neuropsychological impacts of COVID-19 contamination observed in the Brazilian population across the lifespan, as reported in the scientific literature?". To address this question, a literature selection process was implemented, focusing on publications between the years 2020 and 2024. A multi-database search strategy was employed,

encompassing the following scientific repositories: Scientific Electronic Library Online (SCIELO), Latin American and Caribbean Literature in Health Sciences (LILACS), Virtual Health Library (BVS), Google Scholar, and PUBMED. The search utilized a set of descriptors, including: "COVID-19," "neuropsychology," and "Brazil".

The inclusion criteria included scientific articles published in peer-reviewed journals, academic theses, dissertations, and monographs and book chapters, with no language restrictions and featuring research conducted specifically within Brazilian territory with its population.

Exclusion criteria included duplicate studies, and manuscripts that did not specifically address neuropsychological outcomes as a primary or secondary focus.

The synthesis of the selected articles involved a comprehensive narrative and descriptive presentation of key characteristics from each study. This included detailing the target population, age groups and the neuropsychological outcomes regarding its cognitive and behavioral alterations directly or indirectly linked to COVID-19.

## Indirect Outcomes, Particularly in Children and Adolescents

Beyond the direct effects of SARS-CoV-2 infection, the COVID-19 pandemic brought indirect impacts with profound consequences across various areas of daily life, including education and learning outcomes. The abrupt onset of the COVID-19 pandemic had a significant effect on education worldwide (UNESCO, 2020). Despite efforts by some governments and educational institutions to provide alternative learning opportunities, the extended periods away from the classroom have impacted on the cognitive and academic performance of children and adolescents (Engzell et al., 2021).

Some studies were conducted during and immediately after the pandemic to analyze the immediate harms caused by the disruption of in-person classes (Campos et al., 2023; Engzell et al., 2021; Tomasik et al., 2021). Some of these studies offered long-term projections, suggesting

that impacts on learning and cognitive development could extend for years, particularly in Latin American countries, potentially influencing the academic and professional future outcomes of children and adolescents (Gustafsson, 2021). However, significant gaps remain in the literature regarding whether these initial harms have persisted over time and how children and adolescents are currently coping with these consequences. This section of the present article reviews Brazilian studies that investigated the effects of post-pandemic school closures among student populations of varying age groups and socioeconomic backgrounds.

Studies by Alcantara (2024) and Santos (2024), for example, analyzed impacts among private school students, revealing that learning deficits were observed even in less vulnerable contexts. Specifically, Alcantara (2024) conducted a study with private school students from more favorable socioeconomic backgrounds, consisting of families of middle to upper-middle socioeconomic status in São Paulo. The study was conducted in 2023 and included 61 students aged 3 to 6 years old ( $M = 4.41$ ;  $SD = 0.90$ ) in preschool levels. Skills predictive of literacy, such as phonological awareness, rapid automatized naming, and letter and sound recognition, were analyzed. The overall performance of participants was above pre-pandemic normative samples in phonological awareness. However, no significant differences were observed between groups in alphabetic knowledge scales ( $p = 0.578$ ). In contrast, children's performance in object-naming speed at age 6 ( $p = 0.047$ ) and in naming speed and error rates in number naming at ages 3 and 6 ( $p = 0.709$  and  $p = 0.034$ , respectively) was lower than pre-pandemic norms. The greatest losses occurred among six-year-olds, potentially due to the extended period of remote learning and social isolation they had experienced. Thus, even in a sample of preschoolers from private schools, some lower performances were observed, especially among older children.

The study by Santos (2024) was conducted in a private bilingual school in the interior of São

Paulo. This study included 100 children aged 6 to 10 years old ( $M = 8.33$ ;  $SD = 1.35$ ) in primary school. The Raven's Colored Progressive Matrices were used to assess intelligence, and the School Achievement Test (TDE-II) measured reading, writing, and arithmetic performance. Additionally, a phonological awareness paradigm was administered. Students assessed post-pandemic showed significantly lower performance than the pre-pandemic normative sample in writing at 2nd, 4th, and 5th grades ( $p = 0.058$ ,  $0.003$ ,  $< 0.001$ , respectively) and in arithmetic at 3rd, 4th, and 5th graders ( $p = 0.007$ ,  $< 0.001$ ,  $< 0.001$ ). This assessment clarified which grades and skills presented deficits in comparison to expected performance. Students in upper elementary grades, who experienced early grades and literacy instruction during the pandemic, showed significantly lower performances compared to the pre-pandemic normative data, reinforcing the need for remedial actions in these grades.

Seabra et al. (2024) investigated the impact of COVID-19 on the writing skills of students in Embu das Artes, São Paulo, Brazil. Pre-pandemic research (Matos, 2023) indicated that student performance on a writing task (the same task used in this study) in this city was around the national average (45.6th percentile). In this large-scale study ( $n = 1,161$ ), conducted in 2022, fifth-grade students were assessed. They had engaged in remote learning during 2020 and 2021, when they were in third and fourth grades. Seabra et al. (2024) used the writing subtest of the School Achievement Test (TDE-II), finding significant learning losses, with nearly 16% of students scoring zero and over 50% scoring below the 10th percentile compared to pre-pandemic norms. School closures and inadequate remote learning infrastructure contributed to these poor academic outcomes, highlighting the importance of psychological assessment to guide public policies and targeted recovery strategies to address these learning gaps and support students' academic progression.

In addition, Ribeiro, Celeste, and Reis (2024) analyzed the neurocognitive abilities of 1st and

2nd-grade students in a public school in the Federal District during school reopening after the COVID-19 pandemic, as well as the influence of family and contextual factors on eight cognitive domains. The study included 117 students assessed with the Brief Child Neuropsychological Assessment Battery (NEUPSILIN-Inf), with parents answering an inventory about family environment resources and socioeconomic factors. There was a high prevalence of deficits or warnings in orientation, memory, language, visuospatial, arithmetic, and verbal fluency functions. Factors such as the predictability of family activities and resources promoting proximal interactions positively predicted performance in orientation and language abilities, respectively.

Moreover, Dalfovo (2024) conducted a study comparing school performance and cognitive abilities among 202 adolescents from public and private schools in Paraná and Rio Grande do Sul, Brazil, before and after school closures. Participants were divided into two groups: the first, evaluated pre-pandemic (2017, 2018, and 2019), with data from pre-pandemic databases, and the second, assessed post-school reopening (2022 and 2023). Results showed that the pre-pandemic group scored higher in academic performance and language tests compared to the post-pandemic group. In executive function tasks, some tests showed significant differences between group averages, while others did not. The greatest losses were observed in mathematics, writing, and reading, with reductions of 0.73, 0.70, and 0.48 standard deviations, respectively. Furthermore, the study revealed an average reduction of 24.71% in tests evaluating executive components such as thought organization and word retrieval strategies (Verbal Fluency Test),

suggesting that remote learning could not replace in-person instruction effectively, particularly in areas like mathematics and writing.

To complement this analysis, Dutra (2023) focused on a specific group: adolescents with attention deficit hyperactivity disorder (ADHD). The study aimed to assess the difficulties and even some positives reported by adolescents aged 12 to 16 with ADHD during online classes and the return to in-person learning. Significant challenges in remote classes, including difficulty assimilating content, low participation, and reduced interest in school activities were observed. In-person, students struggled to keep up with program content. Nonetheless, recorded classes allowed them to review lessons. Cognitive challenges during remote classes included sustained and focused attention, organization, and routine maintenance.

Collectively, these studies point to a common finding: neuropsychological assessment has enabled the identification of discrepancies in children and adolescents' performances in relation to expected benchmarks, both in academic tasks (reading, writing, and mathematics) and other cognitive domains (executive functions, language, orientation and memory). The post-pandemic effects on the development of children and adolescents are extensive and complex, affecting not only formal learning but also cognitive and emotional skills. Remote learning, while necessary, appears insufficient to fully replace in-person instruction, even in privileged settings like private schools. To date, we did not identify Brazilian studies that systematically characterize cognitive deficits directly attributable to COVID-19 infection in pediatric samples.

**Table 1** - *Indirect Outcomes, Particularly in Children and Adolescents*

Title (Year)	Author(s)	Purpose
Habilidades predictoras de alfabetização em crianças de educação infantil no período pós-pandemia. (2024)	Alcantara, S. A. S.	To assess the literacy predictor skills (phonological awareness, rapid automatized naming, letter and sound knowledge) in preschool children after the pandemic and compare them with pre-pandemic levels.
Executive functions and mental health in students during COVID-19 pandemic. (2023)	Campos, Seabra, & Carreiro	To analyze the executive functions and mental health of Brazilian schoolchildren in grades 3 to 5 (aged 8–9) before and during the COVID-19 pandemic, and to identify any variations and correlations between these two factors.
Desempenho escolar, habilidades cognitivas e saúde mental de adolescentes: rastreamento da relação com medidas de restrição social devido à pandemia do COVID-19. (2024)	Dalfovo, N. P.	To assess whether adolescents' academic performance, cognition, and mental health relate to pandemic, sociocultural, and socioeconomic factors, and to compare their results with pre-pandemic and normative data.
Adolescentes com TDAH e a pandemia da covid-19: aspectos escolares, cognitivos e sociais durante as aulas remotas e no retorno presencial. (2023)	Dutra, G. K. C. R.	To assess both the challenges and potential benefits reported by adolescents aged 12 to 16 with ADHD during online classes and the transition back to in-person learning.
Funções neuropsicológicas de escolares na reabertura das escolas brasileiras na pandemia da Covid-19. (2024)	Ribeiro, M. R. de C. P., Celeste, L. C., & Reis, V. de O. M.	To analyze the neuropsychological functions of students from a public school in Brazil, enrolled in the 1st and 2nd year of Elementary School at the time of the reopening of schools during the COVID-19 pandemic and to assess the influence of family and contextual information on the performance of these skills.
Leitura, escrita e aritmética após a pandemia: estudo com uma escola privada de Ensino Fundamental I (2024)	Santos, M. C. C.	To assess the reading, writing and mathematics in children from first to fifth grades after the pandemic and compare them with pre-pandemic levels.
Multicenter study on mitigating the pandemic's impact in the school setting: preliminary analysis of students' writing performance in a city in the state of São Paulo. (2024)	Seabra, A. G., Carreiro, L. R. R., Teixeira, M. C. T. V., Gooch, D., Amorim, G. Z. P., Zeballos, B. A. G., Giaquinto, C. R., Fonseca, R. P. & Guilherme, A. A.	To assess writing in 5th grade students from public school in Sao Paulo after the pandemic and compare them with pre-pandemic levels.

### Direct Outcomes in Adults and Elderly Populations

One of the consequences of COVID-19 has been the development of post-COVID syndrome, or long COVID, a multisystem condition affecting at least 65 million people (Davis et al., 2023). Long COVID is associated with significant neurological symptoms, including cognitive impairment,

fatigue, sleep disorders, and tinnitus, though the mechanisms underlying its development remain partially unclear. Cognitive deficits are of particular interest to neuropsychology, being commonly observed in Long COVID but difficult to categorize into a specific deficit pattern (Tavares-Júnior et al., 2022). It is estimated that around 20–25% of patients with Long COVID exhibit me-

asurable cognitive deficits in neuropsychological assessments (Ceban et al., 2022), particularly with memory, attention, and executive functions, often accompanied by mental health issues such as sleep and mood disturbances, fatigue, anxiety, and depression (Batista et al., 2024; Sudo et al., 2023). Neuroinflammatory processes, reduced cerebral blood flow, autonomic neuropathy, and small-fiber neuropathy are commonly associated mechanisms contributing to these symptoms (Davis et al., 2023).

Souza, Maranhão and Braga (2024) evaluated 49 patients referred for neuropsychological assessment due to post-COVID cognitive complaints using the MoCA, Verbal Fluency (animals), and the Trail Making Test. Of these, 29 were reassessed after 6 months, with some undergoing a cognitive stimulation protocol ( $n=19$ ) and others not ( $n=10$ ). The results indicate that 41% of the sample scored below the MoCA cutoff score in both evaluations. The intervention group showed a slight quantitative improvement in MoCA scores and in the number of errors on the Trail Making Test. Braga and colleagues (2022) assessed neuropsychiatric manifestations of COVID-19 in 614 adults, some of whom were hospitalized due to illness and others who were not. The authors reported deficits (performance 1 standard deviation below the mean) on the three cognitive tests used—BNIS, Clock Drawing Test, and Phonemic Verbal Fluency—with no significant differences between hospitalized and non-hospitalized patients. In a follow-up study, Braga et al. (2023) evaluated 208 post-COVID-19 patients roughly two years after infection using the BNIS, Clock Drawing Test, and Phonemic Verbal Fluency, noting improvements across all tests, particularly among those who received neuropsychological rehabilitation.

Lopes-Santos et al. (2024) assessed 42 participants (22 with a history of mild COVID-19 and 20 controls with no history of the disease), using an extensive neuropsychological assessment protocol that included the WASI (Intelligence), D2-R (Attention), Trail Making Test (Visual Attention and Alternation), Digit Span (Working Me-

mory), Stroop Test (Executive Functions), Verbal Fluency, Wisconsin Card Sorting Test (Executive Functions), RAVLT (Memory), Logical Memory, Visual Reproduction, Rey Complex Figures (Visual Perception and Memory), and the Boston Naming Test. COVID-19 patients scored lower than the control group on the WASI total and executive IQ scores, the Cubes and Vocabulary subtests of the same test, the reverse order of Digit Span, and visual recognition memory.

Scardua-Silva et al. (2024) evaluated 74 patients with a history of mild COVID-19 using a neuropsychological protocol consisting of the Mini-Mental State Examination, Semantic and Phonemic Verbal Fluency, Logical Memory, Rey Complex Figure, 9-Hole Peg Test, Five-Digit Test, and Color Trail Test. Based on the study's criteria for below-average or impaired performance ( $-1.32$  standard deviations below the mean), the most frequent deficits were found in Phonemic Verbal Fluency (43%) and Semantic Verbal Fluency (39%), Logical Memory (26%), Rey Complex Figure copy (22%), and the Five-Digit Test counting phase (20%). The authors documented white matter alterations when comparing patients to controls, though these did not correlate with cognitive difficulties.

Serafim et al. (2024) assessed 302 participants with a history of COVID-19 (mild, moderate, or severe) using Matrix Reasoning and Vocabulary (WASI), Digit Span and Coding (WAIS-III), the Sustained Attention Test, and Rey Complex Figure. The authors documented at least one cognitive difficulty in 46% of patients with severe cases, 40% with moderate cases, and 12% with mild cases. Averaging deficits across the three groups, the most affected test was the Rey Complex Figure copy (35%), followed by Digit Span (24%), Sustained Attention (12%), Coding (10%), and Rey Complex Figure recall (7%).

Gutman et al. (2024) evaluated the performance of 63 patients with a history of mild COVID-19 and self-reported cognitive decline using the Symbol-Digit Modalities Test (similar to the WAIS-III Coding task). The authors reported cognitive impairment (1 standard deviation below expected

performance) in 65% of the sample and identified an association between test performance and levels of neurofilament light chain, a biomarker of neuronal damage. Using the same test and the Mini-Mental State Examination - MMSE-2, Hammerle et al. (2023) compared COVID-19 patients divided based on the presence (n=68) or absence (n=59) of cognitive complaints. Patients with cognitive complaints performed worse on the short version of the MMSE-2 and the Symbol-Digit Modalities Test.

Damiano et al. (2023) assessed 710 patients with a history of COVID-19 (varying in severity) using temporal and spatial orientation tests from the Mini-Mental State Examination, Semantic Verbal Fluency, Trail Making Test, Digit Symbol Substitution Test (similar to the WAIS-III Coding task), and subtests from the CERAD Neuropsychological Battery. The authors used confirmatory factor analysis to model the data, identifying associations between pre-existing health conditions and demographic factors with cognitive performance overall and between COVID-19 severity and episodic memory deficits. They also documented associations between certain cytokines and performance in attention, language, episodic memory, and general cognition.

Tavares-Júnior et al. (2022) analyzed cognitive performance in 141 patients with a history of COVID-19 within a prospective cohort. Participants were categorized using the Clinical Dementia Rating (CDR) as healthy, with cognitive impairment, and with subjective cognitive complaints. The authors used the MMSE and Addenbrooke's Cognitive Examination Revised for cognitive assessment, reporting that 18% of the sample had cognitive impairment and 48% subjective cognitive complaints. Patients in the cognitive impairment group scored lower than others across all cognitive measures, with previously hospitalized patients showing a higher risk for cognitive deficits.

Sudo et al. (2023) evaluated 72 COVID-19-infected individuals aged 18 and older ( $M_{\text{age}} = 55.9 \pm 13.2$ , 63.4% male) hospitalized in Rio de Janeiro between May 2020 and March 2021. All

participants underwent cognitive, biochemical, clinical, and imaging assessments. Cognitive evaluation included the MMSE, Rey Auditory Verbal Learning Test (RAVLT), Trail Making Test (TMT), Hayling Test, Backward Digit Span Test, and Clock Drawing Test. Lower scores were observed in RAVLT encoding (A1-A5) and retrieval (A7), with small to small-to-medium effect sizes, as well as in Digit Span (small effect size). Additionally, a higher proportion of individuals showed impairment in the RAVLT (A1-A5 and A7) and Hayling Test (part B and B-A) compared to normative data. Risk factors for cognitive deficits included age over 70, female gender, and pre-existing diabetes, with diabetes most associated with memory and executive function issues. Identified risk factors for cognitive deficits include age over 70, female gender, and a prior diagnosis of diabetes, the latter being particularly associated with memory issues and executive function difficulties.

Due to the novelty of this syndrome and the absence of information to guide the construction of assessment batteries, there is significant variability in the instruments and tests selected for neuropsychological evaluations among studies. The assessment protocols or batteries used were comprehensive in terms of the functions evaluated, covering global cognitive impairment, executive functions, processing speed, intelligence, memory, motor abilities, attention, and language skills - both in a global sense and regarding specific features. The lack of psychometric parameters was another limiting factor in differentiating scores for characterizing long COVID from other conditions that could lead to cognitive deficits, such as dementia or cognitive overload due to emotional changes.

At the Federal University of Minas Gerais, a cohort of COVID-19 patients has been clinically monitored since 2020 (de Paula et al., 2023; Souza-Silva et al., 2024). The study includes over two hundred participants with a mean age of 35 years, all recently recovered from COVID-19 and with RT-PCR-confirmed infection. A comprehensive neuropsychological

assessment protocol was used (Rey Complex Figure Test, Alternating Verbal Fluency, Logical Memory, Trail Making Test, Five-Point Test, and Digit Span), along with structural neuroimaging (MRI), functional neuroimaging (18-FDG-PET), and a panel of neuroinflammatory biomarkers (de Paula et al., 2023). In a preliminary study, the authors reported specific deficits in the Rey Complex Figure Test, particularly in copying, where 26% of participants showed impairment ( $-1.5$  standard deviations based on normative standards). These findings were validated in a second case-control analysis ( $d = 1.31$ ) and remain consistent even when sociodemographic and mental health factors are considered. Furthermore, the authors noted a negative association between performance on the test's copying task and white matter volume, especially in the corpus callosum and bilateral cingulate gyrus, inferior frontal gyrus, lingual gyrus, and bilateral fronto-occipital fasciculus, as well as the fusiform gyrus in the right hemisphere. These regions are strongly associated with executive and visuospatial tasks. Functional imaging data indicate positive correlations between performance on the test and glucose metabolism in the lower regions of the left temporal and occipital lobes and negative correlations with metabolism in the frontal regions (right anterior dorsal cingulate, bilateral Rolandic operculum, bilateral ventrolateral frontal cortex, and left superior frontal cortex) and occipital regions (bilateral inferior occipital cortex and left calcarine/lingual gyrus). Supporting one of the neurobiological mechanisms of cognitive difficulties in these conditions, the authors reported a consistent association between visuospatial alterations and a panel of plasma biomarkers commonly linked to neuroinflammatory processes (de Paula et al., 2023).

Patients from the previous study were followed for up to 30 months and completed between two and five neuropsychological assessments during this period. Three additional studies discuss the results of these participants. In the first study (Paiva, 2023), from 6 to 18 months after infection, most patients had shown total or partial remission

of cognitive difficulties observed in neuropsychological tests. The second study suggests that the remission of cognitive difficulties seems linked to reduced neuroinflammatory processes in these patients (Souza-Silva et al., 2024). Later, di Fini (2024) re-analyzed the Rey Complex Figures of COVID-19 patients using a new scoring system that segregates scores related to location/space (linked to the dorsal attention network), accuracy/content (linked to the ventral attention network), and planning. The author documented that COVID-19 patients performed worse than the control group on measures of Accuracy and Planning but not Location. Structural imaging data suggest a more specific pattern of associations, occurring only between the Accuracy measure on the Rey Complex Figure Test and white matter in the right ventral anterior cingulate regions and glucose metabolism in the anterior regions of the right prefrontal cortex.

Older adults are especially vulnerable to the impacts of COVID-19, both from the disease's direct effects and the consequences of social restrictions. Isolation and mandatory quarantine during the pandemic have been associated with a significant increase in psychiatric symptoms, including stress, anxiety, insomnia, and depression, among the elderly. Furthermore, in patients with Neurocognitive Disorders, these conditions led to worsening pre-existing neuropsychiatric symptoms or the emergence of new psychological, cognitive, and behavioral issues (Alonso-Lana et al., 2020). These factors may act as confounding variables in constructing the neuropsychological profile of long COVID in the elderly, requiring a careful and multidisciplinary approach to address emerging challenges.

A study conducted at the Multidisciplinary Post-COVID Outpatient Clinic at the State University of Rio de Janeiro investigated the effectiveness of screening instruments for cognitive deficits in older adults with long COVID (Wöllner, 2023). The research included 71 older adults, with a mean age of 67.2 years, of whom 55 were women and 16 were men. Regarding the acute coronavirus infection, the mean symptom du-

ration was 25 days, and 64.78% of participants were not hospitalized during the infection. The results revealed that 38.02% of the sample (27 older adults) performed below expectations on the MoCA Total Score, suggesting possible global cognitive deficit. Additionally, 25.35% (18 older adults) had unsatisfactory performance on the MoCA Memory Index Score (MoCA-MIS).

When analyzing the influence of sociodemographic variables on cognitive performance in older adults with long COVID, significant differences were found between men and women. Women performed significantly better than men on the MoCA Total Score, Memory Index, Executive Functions Index, Attention Index, and Orientation Index. The study also identified an association between global cognitive performance in older adults and COVID-19 severity, as well as an inverse relationship between the duration of long COVID symptoms and performance in memory tasks (Wöllner, 2023).

However, not all studies found effects of COVID-19 on cognition in older adults. The study by Amaral (2024) investigated cognitive changes in 50 older adults residing in a long-term care facility in Belo Horizonte. The MMSE was administered before and after the COVID-19 outbreak. Results indicated long-term global cognitive decline among both older adults infected and those uninfected by the virus. Another Brazilian initiative investigating the effects of COVID-19 on cognitive function in older adults was conducted by Moraes (2023). The study evaluated a group of 151 older adults in southern Brazil, divided into two groups: the experimental group, consisting of individuals who tested positive for SARS-CoV-2 over three months prior, and the control group, comprising non-infected older adults. The MMSE, Clock Drawing Test, and Verbal Fluency Test were applied. Results did not indicate significant differences in cognitive performance between the infected and non-infected groups.

**Table 2** - *Direct Outcomes in Adults and Elderly Populations*

Title (Year)	Author(s)	Purpose
Um estudo dos idosos e de seus cuidadores em uma instituição de longa permanência antes e durante a pandemia: impactos da covid-19 na cognição, comportamento de agitação, funcionalidade e mortalidade. (2024)	Amaral, T. L. D.	To investigate if the Covid-19 outbreak that affected the long-term care institution for the elderly, and analyze whether there was a worsening of cognitive, agitation behavior, functionality and mortality in these elderly residents, with the Covid-19 outbreak in the institution.
Neuropsychological manifestations of long COVID in hospitalized and non-hospitalized Brazilian Patients. (2022)	Braga, L. W., Oliveira, S. B., Moreira, A. S., Pereira, M. E., Carneiro, V. S., Serio, A. S., Freitas, L. F., Isidro, H. B. L., & Souza, L. M. N.	To identify the cognitive and psychiatric disorders in patients with long COVID or Post-Acute Sequelae of COVID (PASC) and explore the association between disease severity during the acute phase and persistent neuropsychological manifestations.
Long COVID neuropsychological follow-up: Is cognitive rehabilitation relevant? (2023)	Braga, L. W., Oliveira, S. B., Moreira, A. S., Martins Pereira, M. E. M. da S., Serio, A. S., Carneiro, V. da S., Freitas, L. de F. P., & Souza, L. M. do N.	To describe the cognitive profile of patients with long COVID post-participation in a neuropsychological rehabilitation program and subsequent reassessment and identify the factors that influence recovery.

Title (Year)	Author(s)	Purpose
Cognitive impairment in long-COVID and its association with persistent dysregulation in inflammatory markers. (2023)	Damiano, R. F., Rocca, C. C. de A., Serafim, A. de P., Loftis, J. M., Talib, L. L., Pan, P. M., Cunha-Neto, E., Kalil, J., de Castro, G. S., Seelaender, M., Guedes, B. F., Nagahashi Marie, S. K., de Souza, H. P., Nitrini, R., Miguel, E. C., Busatto, G., & Forlenza, O. V.	To analyze the potential impact of sociodemographic, clinical and biological factors on the long-term cognitive outcome of patients who survived moderate and severe forms of COVID-19.
Selective visuoconstructional impairment following mild COVID-19 with inflammatory and neuroimaging correlation findings. (2023)	de Paula, J. J., Paiva, R. E., Souza-Silva, N. G., Rosa, D. V., Duran, F. L. D. S., Coimbra, R. S., ... & Romano-Silva, M. A.	To investigate adults at least four months after recovering from mild COVID-19, which were assessed by neuropsychological, ocular and neurological tests, immune markers assay, and by structural MRI and 18FDG-PET neuroimaging to shed light on putative brain changes and clinical correlations.
Análise de aspectos específicos do processamento visuo-espacial em pacientes com COVID-19 e sua correlação com biomarcadores. (2024)	di Fini, B. C.	To test the patterns of visuo-constructural impairment in COVID-19 patients in the dorsal vs. ventral visuospatial pathways framework.
Long COVID: plasma levels of neurofilament light chain in mild COVID-19 patients with neurocognitive symptoms. (2024)	Gutman, E. G., Salvio, A. L., Fernandes, R. A., Duarte, L. A., Raposo-Vedovi, J. V., Alcaraz, H. F., Teixeira, M. A., Passos, G. F., de Medeiros, K. Q. M., Hammerle, M. B., Pires, K. L., Vasconcelos, C. C. F., Leon, L. A. A., Figueiredo, C. P., & Alves-Leon, S. V.	To investigate the relationship between pNfL in patients with post-acute neurocognitive symptoms and the potential of NfL as a prognostic biomarker in these cases.
Cognitive complaints assessment and neuropsychiatric disorders after mild COVID-19 infection. (2023)	Hammerle, M. B., Sales, D. S., Pinheiro, P. G., Gouvea, E. G., de Almeida, P. I. F. M., de Araujo Davico, C., Souza, R. S., Spedo, C. T., Nicaretta, D. H., Alvarenga, R. M. P., Pires, K. L., Thuler, L. C. S., & Vasconcelos, C. C. F.	To analyze cognitive impairment associated with long-term coronavirus disease 2019 (COVID-19) syndrome and its correlation with anxiety, depression, and fatigue in patients infected with severe acute respiratory syndrome coronavirus.
How Mild Is the Mild Long COVID? A Comprehensive Neuropsychological Assessment of Patients with Cognitive Complaints. (2024)	Lopes-Santos, L. E., De Lacerda Ferreira, D., De Angelis, G., Foss, M. P., Trevisan, A. C., De Lacerda, K. J. C. C., Tumas, V., Bellissimo-Rodrigues, F., & Wichert-Ana, L.	To investigate the neuropsychological aspects of long-term COVID-19 in non-hospitalized adults compared with a control group.
Análise longitudinal dos perfis de piora, melhora e estabilidade na Avaliação neuropsicológica de pacientes com SARS-COV-2 (2023)	Paiva, R. E. R. P.	To analyze longitudinal changes in cognitive performance along 30 months in a sample of COVID-19 patients.

Title (Year)	Author(s)	Purpose
Microstructural brain abnormalities, fatigue, and cognitive dysfunction after mild COVID-19. (2024)	Scardua-Silva, L., Amorim da Costa, B., Karmann Aventurato, Í., Batista Joao, R., Machado de Campos, B., Rabelo de Brito, M., Bechelli, J. F., Santos Silva, L. C., Ferreira Dos Santos, A., Koutsodontis Machado Alvim, M., Vieira Nunes Ludwig, G., Rocha, C., Kaue Alves Silva Souza, T., Mendes, M. J., Waku, T., de Oliveira Boldrini, V., Silva Brunetti, N., Nora Baptista, S., da Silva Schmitt, G., ... Lin Yasuda, C.	To investigate cognitive dysfunction and brain changes in a group of mildly infected individuals
Cognitive performance of post-covid patients in mild, moderate, and severe clinical situations. (2024)	Serafim, A. P., Saffi, F., Soares, A. R. A., Morita, A. M., Assed, M. M., de Toledo, S., Rocca, C. C. A., & Durães, R. S. S.	To investigate the cognitive performance of adults who recovered from the novel coronavirus disease (COVID-19) without prior cognitive complaints, considering mild (not hospitalized), moderate (ward), and severe (intensive care unit) symptoms.
Follow-up of cognitive impairment and inflammatory profile in individuals with mild COVID-19. (2024)	Souza-Silva, N. G., Rosa, D. V., de Paula, J. J., Coimbra, R. S., Miranda, D. M., & Romano-Silva, M. A.	To analyze how longitudinal changes in inflammatory biomarkers influence the cognitive performance in COVID-19 patients.
Cognitive impairment and neuropsychiatric symptoms among individuals with history of symptomatic SARS-CoV-2 infection: a retrospective longitudinal study. (2024)	Sousa, N. M. F., Maranhão, A. C. P. F., & Braga, L. W.	To identify the main cognitive and neuropsychiatric symptoms in adults who had no cognitive complaints prior to the infection. Specifically, to observe the trajectory of cognitive and neuropsychiatric performance after 6 months.
Cognitive, behavioral, neuroimaging and inflammatory biomarkers after hospitalization for covid-19 in Brazil. (2023)	Sudo, F. K., Pinto TP, G Q Barros-Aragao F, Bramati I, Marins TF, Monteiro M, Meireles F, Soares R, Erthal P, Calil V, Assuncao N, Oliveira N, Bondarovsky J, Lima C, Chagas B, Batista A, Lins J, Mendonca F, Silveira de Souza A, Rodrigues FC, de Freitas GR, Kurtz P, Mattos P, Rodrigues EC, De Felice FG, Tovar-Moll F.	To conduct a prospective multi-method investigation of post-hospitalization COVID-19 patients in Rio de Janeiro, Brazil.
Long-covid cognitive impairment: Cognitive assessment and apolipoprotein E (APOE) genotyping correlation in a Brazilian cohort. (2022)	Tavares-Júnior, J. W. L., Oliveira, D. N., da Silva, J. B. S., Feitosa, W. L. Q., Sousa, A. V. M., Cunha, L. C. V., Gaspar, S. de B., Gomes, C. M. P., de Oliveira, L. L. B., Moreira-Nunes, C. A., Montenegro, R. C., Sobreira-Neto, M. A., & Braga-Neto, P.	To determine the relationship between COVID-19 and cognitive impairment and APOE gene polymorphisms in an outpatient public university hospital in Northeast Brazil.
Análise de sensibilidade do MoCA-BR no declínio cognitivo em idosos com Síndrome Pós-Covid (2023)	Wöllner, E. P. F.	To explore the possible relationship between cognitive dysfunctions and the severity of COVID-19, as well as to analyze the influence of sociodemographic variables on the cognitive performance of these older adults.

## Discussion

This study aimed to characterize the role of neuropsychological assessment in the pandemic and, specifically, in Brazil. Generally, national findings were in accordance with foreign studies (e.g., Sozzi et al., 2020; Wilson et al., 2020). Most studies had focused on adults and elderly direct injuries, although indirect impact in children and teenagers still need more specific neurocognitive and socioemotional impacts profiles.

For example, in children and adolescents, the main indirect effects were products of school closures. These effects were present even in children of high socioeconomic levels (Alcantara, 2024; Santos, 2024), although they were more pronounced for children of low socioeconomic levels (Seabra et al., 2024). In all cases, the greatest losses occurred in children starting primary school during the pandemic (6 years) (Alcantara, 2024; Santos, 2024). These losses are observed in several neuropsychological tests linked to language (Alcantara, 2024), but also linked to mathematics (Santos, 2024). Approximately half of the children in these studies scored below the 10th percentile in writing on the TDE-II when compared to pre-pandemic norms. This indicates a huge impact on children's academic development. Adolescents also showed similar patterns of loss, both in language (oral and written) and mathematics, as well as in executive functions (Dalfovo, 2024). In addition, adolescents with disorders such as ADHD suffered these impacts (Dutra, 2023). Taken together, results in children and adolescents show that virtual education was not a satisfactory substitute for face-to-face education.

In adults, neuroinflammatory processes, reduction in cerebral blood flow, autonomic neuropathy, and small-fibre neuropathy were mechanisms commonly associated with the symptoms identified as direct effects (Davis et al., 2023). As for indirect effects, 20 to 25% of patients with long COVID presented measurable cognitive deficits in neuropsychological assessment (Ceban et al., 2022), ranging from effects observed with screening techniques to effects observed with long

batteries such as WAIS-III (Serafim et al., 2024).

Regarding the direct effects on older adults, a global cognitive deficit associated with a long covid was observed, mainly in memory and affecting mostly men compared to women (Wöllner, 2023). However, other studies found no differences between those who had had the disease and those who had not (Amaral, 2024; Moraes, 2023), so it is not entirely clear to what extent COVID affected Brazilian older adults neuropsychologically. Older adults also experienced indirect effects: Isolation and mandatory quarantine during the pandemic were associated with a significant increase in psychiatric symptoms, including stress, anxiety, insomnia, and depression among the elderly. In addition, in patients with Neurocognitive Disorder, these conditions allow the worsening of pre-existing neuropsychiatric symptoms or the emergence of new psychological, cognitive and behavioral problems (Alonso-Lana et al, 2020).

In summary, because of the analysis of the works published in the country, we found that neuropsychological assessment played a fundamental role in detecting direct and indirect effects on the CNS in children, teenagers, adults, and older adults. Our first conclusion is that these effects could not have been observed if in recent decades Brazilian neuropsychology had not developed its own tests and scales that allowed comparison of the population affected by COVID-19 with previous normative data. In several studies, especially those of children and adolescents, having pre-pandemic measures of these populations, already standardized for the Brazilian population, allowed post-pandemic comparisons to measure the impact of COVID-19 on these abilities.

Our second conclusion is that neuropsychological assessment has quickly adapted to a new type of patient: the patient with neurological sequelae post-COVID. This profile was nonexistent a few years ago. However, neuropsychological tests have enabled us to address this profile in all its complexity. Indeed, one of the major challenges presented by the pandemic for neu-

ropsychological assessment is that the direct effects on the nervous system, together with the indirect effects (produced by social isolation), were presented together. This combination made differential diagnosis difficult and forced professionals to be more careful or to make consultations with other professionals to be able to make it. For example, in the child anamnesis or interview, neuropsychologists should ask about the emotional and educational support the child received during the pandemic, as well as how the child coped with social distancing, what the transition was like from face-to-face to remote education and how they adapted to returning to face-to-face classes. It is also important to consider the school year the child was in during the pandemic, especially critical moments such as literacy or the transition to primary or secondary school.

Our third conclusion is that neuropsychological assessment, far from being a mere application of tests, allows us to detect targets for intervention. To the extent that it provides a profile of residual abilities, it allows us to detect strengths on which to think about possible interventions or rehabilitation. This leads us to a fourth and last conclusion: there is a need for more clinical neuropsychologists given that the demand for neuropsychological rehabilitation has increased due to the pandemic in Brazil and in the world.

Based on the aforementioned conclusions, and from both clinical and public health perspectives, this review supports the implementation of minimum cognitive screening protocols, particularly targeting individuals in primary care, particularly for individuals presenting with post-COVID cognitive complaints. Considering the marked heterogeneity of cognitive deficits, such protocols should encompass the five major cognitive domains—memory and learning, executive functions, language and communication, perceptual-motor abilities, and complex attention—using standardized instruments with established evidence of validity and reliability in Brazil, as well as demographically adjusted normative data. In the educational context, structured as-

sessments of reading, writing, and mathematics using Brazilian tools, such as the TDE-II, should be prioritized to detect learning losses and to inform intervention planning.

Noteworthy, this review has some limitations that should be acknowledged. On one hand, the heterogeneity of studies included in this integrative review limited direct comparisons and the possibility of meta-analytic synthesis. That heterogeneity includes, first, studies with different methodological designs, going from cognitive evaluations administered months after hospital discharge and inferential statistics to detect associations with COVID duration (e.g., Damiano et al., 2023), to post-pandemic neurocognitive evaluations that were compared with pre-pandemic norms of the same test (e.g., Santos, 2024). In fact, most studies relied on pre-pandemic normative data (e.g., Santos, 2024) rather than matched control groups, which may have introduced bias. In line with this, the predominance of cross-sectional designs may have restricted the longitudinal understanding of COVID-19 neuropsychological consequences. Second, this integrative review includes different samples, in terms of ages – going from children (e.g., Alcantara et al., 2024; Campos et al., 2023) to elderly people (e.g., Alonso-Lana et al., 2020; Amaral et al., 2024) –, regions – from the Amazonia (e.g., Bichara, et al., 2021) to São Paulo (e.g., Campos et al., 2023) – and recruitment sites – i.e. clinical context (Braga et al., 2022) vs school context (Santos, 2024). Third, the assessment instruments also varied across studies, from executive functions' tasks (e.g., Campos et al., 2023) to psychiatric evaluations (e.g., Alonso-Lana et al., 2020). Those variations among studies impede more powerful analysis such as systematic reviews or meta-analysis. On the other hand, publication bias (the higher probability of publishing studies with positive results) is another potential limitation that could be leading to inflated results. Despite these limitations, the present review offers an important and timely contribution to the literature by synthesizing empirical evidence on cognitive and

psychosocial effects of the pandemic in different age groups of the Brazilian population.

## Conclusion

The COVID-19 pandemic represented a landmark in recent history, challenging both health and education systems. This integrative review synthesized the available evidence on the direct and indirect neuropsychological effects of COVID-19 in the Brazilian population, highlighting the relevance of neuropsychological assessment as a tool to understand and monitor these impacts. The results indicate that, among children and adolescents, the effects were predominantly indirect, related to isolation measures and school closures, with observable impairments in writing, reading, mathematics, language, and executive functions. Instead, in adults and older adults, the direct effects of infection were more evident, with cognitive deficits associated with neuroinflammatory mechanisms and persistent symptoms of long COVID. In sum, this review of Brazilian studies showed that conducting neuropsychological assessments allowed us to detect the direct and indirect impacts of COVID and showed the need for neuropsychology expansion in the country. Advancing in that direction will allow for a better understanding of the trajectory of deficits and the effectiveness of interventions.

## References

- Alcantara, S. A. S. (2024). *Habilidades predictoras de alfabetização em crianças de educação infantil no período pós-pandemia*. (Unpublished Master's Dissertation). Presbyterian University Mackenzie, São Paulo, São Paulo. <https://dspace.mackenzie.br/handle/10899/39636>
- Alonso-Lana, S., Marquié, M., Ruiz, A., & Boada, M. (2020). Cognitive and neuropsychiatric manifestations of COVID-19 and effects on elderly individuals with dementia. *Frontiers in Aging Neuroscience*, *12*, 588872. <https://doi.org/10.3389/fnagi.2020.588872>
- Amaral, T. L. D. (2024). *Um estudo dos idosos e de seus cuidadores em uma instituição de longa permanência antes e durante a pandemia: impactos da covid-19 na cognição, comportamento de agitação, funcionalidade e mortalidade*. (Doctorate Thesis). Biological Sciences Institute, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais. <http://hdl.handle.net/1843/73398>
- Batista, K. B. C., Fernandez, M. V., Barberia, L. G., Silva, E. T. da, Pedi, V. D., Pontes, B. M. L. M., Araujo, G., Moreira, R. da S., Pedrosa, M., Verotti, M. P., Henriques, C. M. P., Florêncio, A. C., & Amorim, M. M. R. de. (2024). Overview of long COVID in Brazil: a preliminary analysis of a survey to think about health policies. *Cadernos de Saúde Pública*, *40*(4), e00094623. <https://doi.org/10.1590/0102-311XPT094623>
- Berra, T. Z., Alves, Y. M., Popolin, M. A. P., da Costa, F. B. P., Tavares, R. B. V., Tártaro, A. F., Moura, H. S. D., Ferezin, L. P., de Campos, M. C. T., Ribeiro, N. M., Teibo, T. K. A., Rosa, R. J., & Arcêncio, R. A. (2024). The COVID-19 pandemic in Brazil: space-time approach of cases, deaths, and vaccination coverage (February 2020 - April 2024). *BMC Infectious Diseases*, *24*(1), 704. <https://doi.org/10.1186/s12879-024-09598-1>
- Bichara, C. D. A., Queiroz, M. A. F., da Silva Graça Amoras, E., Vaz, G. L., Vallinoto, I. M. V. C., Bichara, C. N. C., Amaral, I. P. C. do, Ishak, R., & Vallinoto, A. C. R. (2021). Assessment of anti-SARS-CoV-2 antibodies post-Coronavac vaccination in the Amazon region of Brazil. *Vaccines*, *9*(10), 1169. <https://doi.org/10.3390/vaccines9101169>
- Boschiero, M. N., Palamim, C. V. C., Ortega, M. M., Mauch, R. M., & Marson, F. A. L. (2021). One year of coronavirus disease 2019 (COVID-19) in Brazil: a political and social overview. *Annals of Global Health*, *87*(1). <https://doi.org/10.5334/aogh.3182>
- Braga, L. W., Oliveira, S. B., Moreira, A. S., Martins Pereira, M. E. M. da S., Serio, A. S. S., Carneiro, V. da S., Freitas, L. de F. P., & Souza, L. M. do N. (2023). Long COVID neuropsychological follow-up: Is cognitive rehabilitation relevant? *NeuroRehabilitation*, *53*(4), 517–534. <https://doi.org/10.3233/NRE-230212>
- Braga, L. W., Oliveira, S. B., Moreira, A. S., Pereira, M. E., Carneiro, V. S., Serio, A. S., Freitas, L. F., Isidro, H. B. L., & Souza, L. M. N. (2022). Neuropsychological manifestations of long COVID in hospitalized and non-hospitalized Brazilian Patients. *NeuroRehabilitation*, *50*(4), 391–400. <https://doi.org/10.3233/NRE-228020>
- Campos, A. P. S., Seabra, A. G., & Carreiro, L. R. R. (2023). Executive functions and mental health in students during COVID-19 pandemic. *Revista Psicopedagogia*, *40*(122), 159–167. <https://doi.org/10.51207/2179-4057.20230014>
- Carvalho, T. A., Boschiero, M. N., & Marson, F. A. L. (2021). COVID-19 in Brazil: 150,000 deaths and the Brazilian underreporting. *Diagnostic Microbiology and Infectious Disease*, *99*(3), 115258. <https://doi.org/10.1016/j.diag-microbio.2020.115258>
- Ceban, F., Ling, S., Lui, L. M. W., Lee, Y., Gill, H., Teopiz, K. M., Rodrigues, N. B., Subramaniapillai, M., Di Vincenzo, J. D., Cao, B., Lin, K., Mansur, R. B., Ho, R. C., Rosenblat, J. D., Miskowiak, K. W., Vinberg, M., Maletic, V., & McIntyre, R. S. (2022). Fatigue and cognitive impairment in Post-COVID-19 Syndrome: A systematic review and meta-analysis. *Brain, Behavior, and Immunity*, *101*, 93–135. <https://doi.org/10.1016/j.bbi.2021.12.020>

- Dalfovo, N. P. (2024). *Desempenho escolar, habilidades cognitivas e saúde mental de adolescentes: associações com medidas de restrição do convívio social impostas pela pandemia do COVID-19*. (Master's Dissertation). Post-Graduation Program of Psychology, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Rio Grande do Sul. <https://tede2.pucrs.br/tede2/handle/tede/11760>
- Damiano, R. F., Rocca, C. C. de A., Serafim, A. de P., Loftis, J. M., Talib, L. L., Pan, P. M., Cunha-Neto, E., Kalil, J., de Castro, G. S., Seelaender, M., Guedes, B. F., Nagahashi Marie, S. K., de Souza, H. P., Nitrini, R., Miguel, E. C., Busatto, G., & Forlenza, O. V. (2023). Cognitive impairment in long-COVID and its association with persistent dysregulation in inflammatory markers. *Frontiers in Immunology*, *14*, 1174020. <https://doi.org/10.3389/fimmu.2023.1174020>
- Davis, H. E., McCorkell, L., Vogel, J. M., & Topol, E. J. (2023). Long COVID: major findings, mechanisms and recommendations. *Nature Reviews Microbiology*, *21*(3), 133–146.
- da Silva, S. J. R., & Pena, L. (2021). Collapse of the public health system and the emergence of new variants during the second wave of the COVID-19 pandemic in Brazil. *One Health*, *13*, 100287. <https://doi.org/10.1016/j.onehlt.2021.100287>
- de Paula, J. J., Paiva, R. E., Souza-Silva, N. G., Rosa, D. V., Duran, F. L. D. S., Coimbra, R. S., ... & Romano-Silva, M. A. (2023). Selective visuoconstructional impairment following mild COVID-19 with inflammatory and neuroimaging correlation findings. *Molecular Psychiatry*, *28*(2), 553–563. <https://doi.org/10.1038/s41380-022-01632-5>
- di Fini, B. C. (2024). *Análise de aspectos específicos do processamento visuoespacial em pacientes com COVID-19 e sua correlação com biomarcadores*. (Master's Dissertation). Medicine School, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais. <https://cadtec.medicina.ufmg.br/acervo/items/show/42>
- Dutra, G. K. C. R. (2023). *Adolescentes com TDAH e a pandemia da covid-19: aspectos escolares, cognitivos e sociais durante as aulas remotas e no retorno presencial*. (Master's Dissertation). Post-Graduation Program of Developmental Disorders, Presbyterian University Mackenzie, São Paulo, São Paulo. <https://dSPACE.mackenzie.br/handle/10899/33450>
- Engzell, P., Frey, A., & Verhagen, M. D. (2021). Learning loss due to school closures during the COVID-19 pandemic. *Proceedings of the National Academy of Sciences (PNAS)*, *118*, e2022376118. <https://doi.org/10.1073/pnas.2022376118>
- Gloeckl, R., Leitl, D., Schneeberger, T., Jarosch, I., & Koczulla, A. R. (2023). Rehabilitative interventions in patients with persistent post COVID-19 symptoms—a review of recent advances and future perspectives. *European Archives of Psychiatry and Clinical Neuroscience*. <https://doi.org/10.1007/s00406-023-01631-9>
- Gustafsson, M. (2021). Pandemic-related disruptions to schooling and impacts on learning proficiency indicators: A focus on the early grades. *UNESCO Institute for Statistics*, *14*.
- Gutman, E. G., Salvio, A. L., Fernandes, R. A., Duarte, L. A., Raposo-Vedovi, J. V., Alcaraz, H. F., Teixeira, M. A., Passos, G. F., de Medeiros, K. Q. M., Hammerle, M. B., Pires, K. L., Vasconcelos, C. C. F., Leon, L. A. A., Figueiredo, C. P., & Alves-Leon, S. V. (2024). Long COVID: plasma levels of neurofilament light chain in mild COVID-19 patients with neurocognitive symptoms. *Molecular Psychiatry*, *29*(10), 3106–3116. <https://doi.org/10.1038/s41380-024-02554-0>
- Hammerle, M. B., Sales, D. S., Pinheiro, P. G., Gouvea, E. G., de Almeida, P. I. F. M., de Araujo Davico, C., Souza, R. S., Spedo, C. T., Nicaretta, D. H., Alvarenga, R. M. P., Pires, K. L., Thuler, L. C. S., & Vasconcelos, C. C. F. (2023). Cognitive complaints assessment and neuropsychiatric disorders after mild COVID-19 infection. *Archives of Clinical Neuropsychology*, *38*(2), 196–204. <https://doi.org/10.1093/arclin/acac093>
- Lopes-Santos, L. E., De Lacerda Ferreira, D., De Angelis, G., Foss, M. P., Trevisan, A. C., De Lacerda, K. J. C. C., Tumas, V., Bellissimo-Rodrigues, F., & Wichert-Ana, L. (2024). How Mild Is the Mild Long COVID? A Comprehensive Neuropsychological Assessment of Patients with Cognitive Complaints. *Archives of Clinical Neuropsychology*, *40*(2), 32–309. <https://doi.org/10.1093/arclin/aca071>
- Matos, L. M. B. de. (2023). *Intervenção baseada na ciência cognitiva da leitura em crianças com sinais de transtorno específico da aprendizagem*. (Doctorate Thesis). Post-Graduation Program of Developmental Disorders, Presbyterian University Mackenzie, São Paulo, São Paulo. <https://dSPACE.mackenzie.br/handle/10899/32230>
- Moraes, N. de S. (2023). *Avaliação da prevalência da funcionalidade global em idosos após a infecção por SARS-COV-2 no sul do Brasil*. (Master's Dissertation). Post-Graduation Program of Health Sciences, University of the Extreme South of Santa Catarina, Criciúma, Santa Catarina. <http://repositorio.unesc.net/handle/1/10650>
- Moura, E. C., Cortez-Escalante, J., Cavalcante, F. V., Barreto, I. C. D. H. C., Sanchez, M. N., & Santos, L. M. P. (2022). Covid-19: evolução temporal e imunização nas três ondas epidemiológicas, Brasil, 2020–2022. *Revista de Saúde Pública*, *56*, 105. <https://doi.org/10.11606/s1518-8787.2022056004907>
- Paiva, R. E. R. P. (2023). *Análise longitudinal dos perfis de piora, melhora e estabilidade na Avaliação neuropsicológica de pacientes com SARS-COV-2*. (Master's Dissertation). Post-Graduation Program of Neurosciences, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais. <https://hdl.handle.net/1843/80830>
- Ribeiro, M. R. de C. P., Celeste, L. C., & Reis, V. de O. M. (2024). Funções neuropsicológicas de escolares na reabertura das escolas brasileiras na pandemia da Covid-19. *Codas*, *36*(2), e20220334. <https://doi.org/10.1590/2317-1782/20232022334pt>
- Ritchie, K., Chan, D., & Watermeyer, T. (2020). The cognitive consequences of the COVID-19 epidemic: collateral damage? *Brain Communications*, *2*(2), fcaa069. <https://doi.org/10.1093/braincomms/fcaa069>

Santos, M. C. C. (2024). *Leitura, escrita e aritmética após a pandemia: estudo com uma escola privada de Ensino Fundamental I*. (Masters' Dissertation). Post-Graduation Program of Human Developmental Sciences, Presbyterian University Mackenzie, São Paulo, São Paulo. <https://dspace.mackenzie.br/handle/10899/38191>

Scardua-Silva, L., Amorim da Costa, B., Karmann Aventura, I., Batista Joao, R., Machado de Campos, B., Rabelo de Brito, M., Bechelli, J. F., Santos Silva, L. C., Ferreira Dos Santos, A., Koutsodontis Machado Alvim, M., Vieira Nunes Ludwig, G., Rocha, C., Kaue Alves Silva Souza, T., Mendes, M. J., Waku, T., de Oliveira Boldrini, V., Silva Brunetti, N., Nora Baptista, S., da Silva Schmitt, G., ... Lin Yasuda, C. (2024). Microstructural brain abnormalities, fatigue, and cognitive dysfunction after mild COVID-19. *Scientific Reports*, 14(1), 1758. <https://doi.org/10.1038/s41598-024-52005-7>

Seabra, A. G., Carreiro, L. R. R., Teixeira, M. C. T. V., Gooch, D., Amorim, G. Z. P., Zeballos, B. A. G., Giaquinto, C. R., Fonseca, R. P., & Guilherme, A. A. (2024). Multicenter study on mitigating the pandemic's impact in the school setting: preliminary analysis of students' writing performance in a city in the state of São Paulo. In: L. R. R. Carreiro, S. M. Blascovi-Assis & E. H. M. Brum (Eds.), *Ciências do desenvolvimento humano: Produção de conhecimento e impactos de pesquisas em psicologia, saúde e educação* (pp. 364–380). Editora CESMAC.

Serafim, A. P., Saffi, F., Soares, A. R. A., Morita, A. M., Assed, M. M., de Toledo, S., Rocca, C. C. A., & Durães, R. S. S. (2024). Cognitive performance of post-covid patients in mild, moderate, and severe clinical situations. *BMC Psychology*, 12(1), 236. <https://doi.org/10.1186/s40359-024-01740-7>

Sousa, N. M. F., Maranhão, A. C. P. F., & Braga, L. W. (2024). Cognitive impairment and neuropsychiatric symptoms among individuals with history of symptomatic SARS-CoV-2 infection: a retrospective longitudinal study. *Dementia & Neuropsychologia*, 18, e20230053. <https://doi.org/10.1590/1980-5764-DN-2023-0053>

Souza-Silva, N. G., Rosa, D. V., de Paula, J. J., Coimbra, R. S., Miranda, D. M., & Romano-Silva, M. A. (2024). Follow-up of cognitive impairment and inflammatory profile in individuals with mild COVID-19. *Journal of Neuroimmunology*, 389, 578327. <https://doi.org/10.1016/j.jneuroim.2024.578327>

Sozzi, M., Algeri, L., Corsano, M., Crivelli, D., Daga, M. A., Fumagalli, F., Gemignani, P., Granieri, M. C., Inzaghi, M. G., Pala, F., Turati, S., & Balconi, M. (2020). Neuropsychology in the times of COVID-19. The role of the psychologist in taking charge of patients with alterations of cognitive functions. *Frontiers in Neurology*, 11, 573207. <https://doi.org/10.3389/fneur.2020.573207>

Sudo, F. K., Pinto, T. P., G Q Barros-Aragao, F., Bramati, I., Marins, T. F., Monteiro, M., Meireles, F., Soares, R., Erthal, P., Calil, V., Assuncao, N., Oliveira, N., Bondarovsky, J., Lima, C., Chagas, B., Batista, A., Lins, J., Mendonca, F., Silveira de Souza, A., ... Tovar-Moll, F. (2023). Cognitive, behavioral, neuroimaging and inflammatory biomarkers after hospitalization for covid-19 in Brazil. *Brain, Behavior, and Immunity*, 115, 434–447. <https://doi.org/10.1016/j.bbi.2023.10.020>

Tavares-Júnior, J. W., de Souza, A. C., Borges, J. W., Oliveira, D. N., Siqueira-Neto, J. I., Sobreira-Neto, M. A., & Braga-Neto, P. (2022). COVID-19 associated cognitive impairment: A systematic review. *Cortex*, 152, 77–97. <https://doi.org/10.1016/j.cortex.2022.04.006>

Tavares-Júnior, J. W. L., Oliveira, D. N., da Silva, J. B. S., Feitosa, W. L. Q., Sousa, A. V. M., Cunha, L. C. V., Gaspar, S. de B., Gomes, C. M. P., de Oliveira, L. L. B., Moreira-Nunes, C. A., Montenegro, R. C., Sobreira-Neto, M. A., & Braga-Neto, P. (2022). Long-covid cognitive impairment: Cognitive assessment and apolipoprotein E (APOE) genotyping correlation in a Brazilian cohort. *Frontiers in Psychiatry*, 13, 947583. <https://doi.org/10.3389/fpsyt.2022.947583>

Tomasik, M. J., Helbling, L. A., & Moser, U. (2021). Educational gains of in-person vs. distance learning in primary and secondary schools: a natural experiment during the COVID-19 pandemic school closures in Switzerland. *International Journal of Psychology*, 56(4), 566–576. <https://doi.org/10.1002/ijop.12728>

Torales, J., O'Higgins, M., Castaldelli-Maia, J. M., & Ventriglio, A. (2020). The outbreak of COVID-19 coronavirus and its impact on global mental health. *International Journal of Social Psychiatry*, 66(4), 317–320. <https://doi.org/10.1177/002076402091521>

Wöllner, E. P. F. (2023). Análise de sensibilidade do MoCA-BR no declínio cognitivo em idosos com Síndrome Pós-Covid. (Monograph). Institute of Psychology, University of the State of Rio de Janeiro, Rio de Janeiro. <https://drive.google.com/file/d/1MIUToaAQ-g7Bb3PL7IRiTwwVfkFhzf3Gp/view?usp=sharing>

---

## Minibiografia

---

### Alessandra Gotuzo Seabra

Doutora, possui Pós-Doutorado em Psicologia Experimental pela USP. Sua afiliação institucional é com o Programa de Pós-graduação em Ciências do Desenvolvimento Humano da Universidade Presbiteriana Mackenzie, em São Paulo, SP.

---

### Alexandre Luiz de Oliveira Serpa

Doutor, com Pós-Doutorado em Ciências do Desenvolvimento Humano pelo Mackenzie. Está afiliado ao Programa de Pós-graduação em Ciências do Desenvolvimento Humano da Universidade Presbiteriana Mackenzie, em São Paulo, SP.

---

### Carlos Eduardo Nórté

Doutor em Saúde Mental pela UFRJ, está vinculado ao Programa de Pós-Graduação em Psicologia Social da Universidade do Estado do Rio de Janeiro (UERJ), no Rio de Janeiro, RJ.

---

**Caroline de Oliveira Cardoso**

Doutora em Psicologia pela PUCRS, atua institucionalmente na Universidade Feevale.

---

**Emmy Uehara Pires**

Doutora em Psicologia Clínica pela PUC-Rio, afiliada ao Programa de Pós-Graduação em Psicologia da Universidade Federal Rural do Rio de Janeiro, no Rio de Janeiro, RJ.

---

**Jonas Jardim de Paula**

Doutor, possui Pós-Doutorado em Medicina Molecular pela Faculdade de Medicina da UFMG. Está vinculado ao Departamento de Psiquiatria da Faculdade de Medicina da Universidade Federal de Minas Gerais, em Belo Horizonte, MG.

---

**Maria Julia Hermida**

Doutora em Psicologia pela Universidad Nacional de San Luis, Argentina. Possui dupla afiliação, atuando na Universidad Nacional de Hurlingham (UNAHUR) e no Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), na Argentina.

---

**Rochele Paz Fonseca**

Pós-Doutoranda em Ciências Biomédicas pela Université de Montréal, além de Doutorado em Psicologia pela UFRGS. Sua afiliação institucional é com o PPG Saúde da Criança e do Adolescente da UFMG.

---

**Luiz Renato Rodrigues Carreiro**

Doutor em Ciências pela USP, está afiliado ao Programa de Pós-graduação em Ciências do Desenvolvimento Humano da Universidade Presbiteriana Mackenzie, em São Paulo, SP.

---

**Endereço para Correspondência****Alessandra Gotuzo Seabra**

Universidade Presbiteriana Mackenzie

Programa de Pós-graduação em Ciências do Desenvolvimento Humano

Rua da Consolação, 930

Consolação, 01302-907

São Paulo, SP, Brasil

**Alexandre Luiz de Oliveira Serpa**

Universidade Presbiteriana Mackenzie

Programa de Pós-graduação em Ciências do Desenvolvimento Humano

Rua da Consolação, 930

Consolação, 01302-907

São Paulo, SP, Brasil

**Carlos Eduardo Nórté**

Universidade do Estado do Rio de Janeiro

Programa de Pós-graduação em Psicologia Social

Rua São Francisco Xavier, 524, 10º andar, bloco B

Maracanã, 20550-900

Rio de Janeiro, RJ, Brasil

**Caroline de Oliveira Cardoso**

Federação dos Estabelecimentos de Ensino Superior

Programa de Pós-graduação em Psicologia

ERS-239, 2755

Vila Nova, 93525-075

Novo Hamburgo, RS, Brasil

**Emmy Uehara Pires**

Universidade Federal Rural do Rio de Janeiro

Departamento de Psicologia

BR-465, Km 7

Zona Rural, 23897-000

Seropédica, RJ, Brasil

**Jonas Jardim de Paula**

Universidade Federal de Minas Gerais

Faculdade de Medicina

Departamento de Psiquiatria

Avenida Alfredo Balena, 190, sala 240

Santa Efigênia, 30130-100

Belo Horizonte, MG, Brasil

**Maria Julia Hermida**

Universidade Nacional de Hurlingham

Instituto de Educación

Avenida Vergara, 2222

Villa Tesei, 1688

Hurlingham, Argentina

**Rochele Paz Fonseca**

Universidade Federal de Minas Gerais

Rua Galha Azul, 555 – 176

Jardim Carvalho, 91430-835

Porto Alegre, RS, Brasil

**Luiz Renato Rodrigues Carreiro**

Universidade Presbiteriana Mackenzie

Programa de Pós-graduação em Ciências do Desenvolvimento Humano

Rua da Consolação, 930

Consolação, 01302-907

São Paulo, SP, Brasil

*Os textos deste artigo foram revisados por Bruno Schroeder dos Santos e submetidos para validação dos autores antes da publicação.*