Neuroscience and Biobehavioral Reviews 156 (2024) 105502

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

# Mental health during the COVID-19 pandemic in children and adolescents with ADHD: A systematic review of controlled longitudinal cohort studies

Amabel Dessain [a,b,*,1], Valeria Parlatini [a,1], Anjali Singh [a], Michelle De Bruin [a], Samuele Cortese [c,d,e,f,g,2], Edmund Sonuga-Barke [a,h,i,2], Julio Vaquerizo Serrano [a]

[a] Department of Child and Adolescent Psychiatry, Institute of Psychiatry, Psychology and Neuroscience, Kings College London, UK
[b] South London and Maudsley NHS Foundation Trust, London, UK
[c] Centre for Innovation in Mental Health, School of Psychology, Faculty of Environmental and Life Sciences, University of Southampton, Southampton, UK
[d] Clinical and Experimental Sciences (CNS and Psychiatry), Faculty of Medicine, University of Southampton, Southampton, UK
[e] Solent NHS Trust, Southampton, UK
[f] DiMePRe-J-Department of Precision and Rigenerative Medicine-Jonic Area, University of Bari "Aldo Moro", Bari, Italy
[g] Department of Child and Adolescent Psychiatry, New York University Grossman School of Medicine, New York, USA
[h] Department of Child & Adolescent Psychiatry, Aarhus University, Denmark
[i] University of Hong Kong, Hong Kong Special Administrative Region

ARTICLE INFO

*Keywords:*
Attention Deficit Hyperactivity Disorder
Children and adolescents
COVID-19 pandemic

ABSTRACT

Prior studies reported mixed effects of the COVID-19 pandemic on the mental health of children and adolescents with ADHD, but they were mainly cross-sectional and without controls. To clarify the impact, we searched Web of Science, EMBASE, Medline, and PsychINFO until 18/11/2023 and conducted a systematic review of controlled longitudinal cohort studies (Prospero: CRD42022308166). The Newcastle-Ottawa scale was used to assess quality. We identified 6 studies. Worsening of mental health symptoms was more evident in ADHD or control group according to symptom considered and context. However, those with ADHD had more persistent elevated symptoms and remained an at-risk population. Sleep problems deteriorated more significantly in those with ADHD. Lower pre-COVID emotion regulation skills and greater rumination were associated with worse mental health outcomes, and longer screen time with poorer sleep. Quality was rated as low in most studies, mainly due to self-report outcome measures and no information on attrition rates. Despite these limitations, results suggest a predominantly negative impact on youths with ADHD and may guide clinical practice and policy.

## 1. Introduction

The COVID-19 (SARS-CoV-2) outbreak was declared a global pandemic in March 2020 and led to worldwide, unprecedented upheaval. To try to contain this novel and evolving virus, countries initiated stringent social distancing measures and quarantine measures, including school and workplace closures, 'Stay at Home' orders, online schooling and cancelling of extracurricular activities (hence forth called *lockdowns*). Children are less likely to be infected with SARS-CoV-2 and, even if infected, usually have milder illness (Imran et al., 2020; Howe De La Torre et al., 2023). Yet the lives of most children and adolescents were radically changed. Increasing evidence indicates overall negative impacts of lockdowns on young people's mental health (Panchal et al., 2023; Newlove-Delgado et al., 2023), although some studies reported positive impact, such as improved sleep and health-related quality of life (Albrecht et al., 2022) and increased outdoor physical activity (Rossi et al., 2021). Although prior studies have suggested that some mental health symptoms may be related to the direct effect of the viral infection or the host's inflammatory response; the vast majority of mental health presentations have been linked to the effects of pandemic-related restrictions on education, peer interactions, and family circumstances (Howe De La Torre et al., 2023). Further, not everyone was affected equally (Panchal et al., 2023; Newlove-Delgado et al., 2023). For instance, there have been suggestions that those with pre-existing mental health or neurodevelopmental conditions may have been more effected than those in the general population, but studies have reported

* Correspondence to: Department of Child and Adolescent Psychiatry, Institute of Psychiatry, Psychology and Neuroscience, Kings College London, London, UK.
*E-mail address:* amabel.dessain@slam.ac.uk (A. Dessain).
[1] These authors equally contributed to the study.
[2] These authors equally contributed to the study.

https://doi.org/10.1016/j.neubiorev.2023.105502
Received 17 October 2023; Received in revised form 1 December 2023; Accepted 3 December 2023
Available online 7 December 2023

inconsistent findings (Mensi et al., 2021; Rothe et al., 2021).

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental conditions and, according to the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM-5-TR) (American Psychiatric Association and Association, 2022), is defined as a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development. Due to their intrinsic vulnerability and reliance on support networks (e.g., educational settings), individuals with ADHD might be disproportionally affected by disruption of routines and services, such as those caused by the COVID-19 pandemic.

Studies specifically investigating individuals with ADHD during the pandemic are limited and, crucially, most of them carried out a cross-sectional analysis during the first lockdown (spring-summer 2020) (Bruni et al., 2021; Shah et al., 2021; Zhang et al., 2020; Werling et al., 2021; Kara et al., 2021; Raffagnato et al., 2021; Wendel et al., 2020; Conti et al., 2020). For instance, a large UK study including more than 2500 children and families under Child and Adolescent Mental Health Services (CAMHS) showed that those with ADHD had greater behavioral and emotional deterioration during the first lockdown, as compared with their peers with emotional disorders. Worse outcomes were associated with younger age, poor parental mental health, challenges with education, and co-occurrent Autism Spectrum Disorder (Parlatini et al., 2023a). In agreement, prior systematic reviews highlighted that the COVID-19 pandemic was associated with a worsening of ADHD symptoms and associated psychological difficulties (Behrmann et al., 2022; Hollingdale et al., 2021), as well as with challenges of managing child behavior during lockdown (Mcgowan et al., 2020). These findings are of relevance but mostly based on cross-sectional studies during the first lockdown, which limits our understanding of pandemic-related changes over time. In addition to the cross-sectional design, Behrmann and colleagues noted other methodological limitations of their included studies, such as the use of convenience sampling and the limited age range of participants, which makes it difficult to comment on different developmental periods. More broadly there are common challenges to research on child and adolescent mental health during the COVID-19 era such as research being conducted in a small number of countries, and rarely relying on both parents' and young person's report and highlighting the need for longitudinal studies (Cortese et al., 2023; Solmi et al., 2022).

Adding to this complexity, prior research has also indicated positive impacts from the pandemic. For instance, a small study reported that most young people with ADHD experienced a stabilization or improvement in their wellbeing, which was related to a reduction in school-related anxiety and the more flexible schedule (Bobo et al., 2020). Although the sample of surveyed parents was self-selecting, which may limit generalizability, these findings suggest that outcomes may vary among those with ADHD. Further, the population went through cycles of response and adaptation during the alternating phases of lockdowns and easing of restriction (Gavin et al., 2021), thus it would be important to clarify the trajectories of mental health changes overtime. Finally, it remains unclear whether those with ADHD have been more impacted than their neurotypical peers.

Understanding the mental health impact on this at-risk population is of vital importance to inform clinicians, so that adverse outcomes can be mitigated against, as well as to support clinical guidelines, public health policy, and cost benefit analysis in case of future pandemics or other global crises. To address this need, this systemic review aimed to explore changes in mental health in youth with ADHD during the COVID-19 pandemic and, to overcome limitations inherent to a cross-sectional design, it only includes longitudinal cohort studies of children and adolescents with ADHD. To enhance clarity on the relationship between an ADHD diagnosis and mental health changes over time, we restricted study selection to only those conducting comparative analyses with neurotypical controls.

## 2. Methods

### 2.1. Search strategy and screening

This systematic review was pre-registered on Prospero (PROSPERO 2022 CRD42022308166) and followed the 2020 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (Page et al., 2021). One author (AD) searched the literature on the following electronic databases on the 24th October 2022 and 18th November 2023: Web of Science, EMBASE, Medline and PsychINFO for peer-reviewed articles published in English with no geographic restriction. Our key search terms were divided into three groups. Terms related to the study population (child* or adolecen* or "young people" or youth* or juvenile* or "school age*" or p?ediatric* or teen* or kid*), to COVID-19 (coronavirus or COVID-19 or CoV-19 or SARS-CoV-2 or "2019 nCoV" or 2019nCoV or "COVID 19" or 2019-nCoV or covid), and ADHD (ADHD or ADD or "attention deficit" adj3 hyperactivity or hyperkinetic adj3 (disorder* or condition* or diagnosis) or "attention deficit" adj3 (disorder* or condition* or diagnosis) were tailored to each database. Following the electronic search, an additional manual search of the references of all the included studies was conducted to retrieve any possible pertinent references missed with the electronic search.

Two authors (AD, AS) independently screened the title and abstract for eligible articles. Next, two authors (AD, VP) independently screened the full text of the selected articles to identify which studies fulfilled the eligibility criteria. Discrepancies were resolved among the two authors or with a third author (JVS).

### 2.2. Eligibility criteria

We included individual primary studies of longitudinal design with control arms, investigating the mental health impact of the pandemic on children up to and including the age of 18 years with a pre-existing ADHD diagnosis as defined by Diagnostic and Statistical Manual of Mental Disorders (DSM 4 onwards), or International Classification of Diseases (ICD 10 onwards). We considered the following mental health outcomes: ADHD symptoms, sleep problems, and other externalizing or internalizing symptoms (e.g., substance abuse, anxiety and mood symptoms). We only included studies with a prospective design and not relying on retrospective parent reports of pre-pandemic functioning. Although the original PROSPERO protocol did not include a control group, as we considered the pandemic a global phenomenon and we could not identify non-exposed youths as controls, in this paper we focused on studies that conducted comparative analyses between youths with/without ADHD to increase our ability to draw causal inference. There was no gender, ethnicity, physical health or geographic restriction. Studies that were not in English, did not evaluate mental health outcomes, or were non-peer reviewed/grey literature were not included.

### 2.3. Data extraction

Two researchers (AD, AS) independently extracted data from all included studies. Discrepancies were resolved among the two authors or with a third author (MDB). Data extracted were sample demographics, outcome questionnaires used, and key findings related to ADHD and to other mental health outcomes.

### 2.4. Quality assessment

Two reviewers (AD, VP) independently assessed the quality of studies using the Newcastle-Ottawa risk of bias tool adapted for longitudinal studies (Wells et al., 2000), and any disagreements that arose were discussed and resolved. This scale has three domains: selection, comparability, and outcome. The first domain includes representativeness, sample size, non-respondents, and exposure ascertainment. The second refers to bias. The final domain assesses outcome and use of

appropriate statistical tests. Each study can receive a maximum of 10 stars (which reflects the highest quality).

### 2.5. Data synthesis

Results are presented as a narrative synthesis. We planned to conduct a meta-analysis wherever there were at least 5 studies reporting the same outcome measure/timeframe (Parlatini et al., 2023b; Westwood et al., 2023).

## 3. Results

### 3.1. Included studies

The electronic search retrieved a total of 2127 records and ten additional records were identified manually. 663 of these were removed as duplicates, leaving 1464 records. Following screening of title, publication type and abstract, 1426 records were excluded as they did not meet the study inclusion criteria; and 38 were reviewed as full texts. Among these, 12 longitudinal studies were identified, however five did not conduct comparative analyses with neurotypical controls and were not included (de Laclause et al., 2022; Fattah et al., 2022; Valicenti-Mcdermott et al., 2021; Bulut et al., 2023; Summerton et al., 2023). One longitudinal case control study was excluded as the ADHD diagnosis was based on parent report only (Hall et al., 2023). List of excluded studies with reasons is reported in Supplementary Material. Please see Fig. 1 for PRISMA flowchart. Individual studies characteristics are reported in Table 1.

We present findings from the included studies as a narrative synthesis. We first discuss the results of the comparative analyses addressing potential differences between ADHD and neurotypical cohorts; we then describe additional findings from longitudinal data analysis on the ADHD cohort or the whole sample, including risk and protective factors to mental health. Due to the limited number of studies and their heterogeneity in terms of outcomes, we were unable to conduct meta-analyses.

### 3.2. Characteristics of the included studies

The selected six studies included 793 participants with ADHD and 972 neurotypical controls (Table 1). Five studies were conducted in the USA (Becker et al., 2021; Breaux et al., 2021; Dvorsky et al., 2022; Fredrick et al., 2022; Rosenthal et al., 2022), and one in Australia (Houghton et al., 2022). Three of the included studies used the same participant sample (Breaux et al., 2021; Dvorsky et al., 2022; Fredrick et al., 2022), however they each had different outcomes, hence were included. The sample size ranged from 58 to 620 participants with ADHD; the mean age from 12.4 years to 16.7 years; and the percentage of females from 30% to 45%. The length of follow up varied from 6 months to 4 years. All studies had a non-clinical comparison group. Five studies used a convenience sample from larger longitudinal studies which were ongoing prior to COVID-19 (Breaux et al., 2021; Dvorsky et al., 2022; Fredrick et al., 2022; Becker et al., 2021; Rosenthal et al., 2022). The other study recruited participants from a secondary school (Houghton et al., 2022). The ADHD diagnosis was based upon DSM- 4 TR or 5 criteria in all the studies. The diagnosis of ADHD was made using a validated questionnaire in five of the studies (Breaux et al., 2021; Dvorsky et al., 2022; Fredrick et al., 2022; Rosenthal et al., 2022; Becker et al., 2021). Among these, four recruited from a larger study (Becker et al., 2019) and used the parent report Children's Interview for Psychiatric Syndromes (Weller et al., 2000). A study (Rosenthal et al., 2022) used a computerised version of the Kiddie schedule for affective disorders and schizophrenia for DSM (Townsend et al., 2020). The remaining study (Houghton et al., 2022) relied upon diagnostic self-report with triangulation with school records.

As per protocol, all the studies had a longitudinal cohort design. Most focused on the first lockdown (spring/summer 2020), and only two studies extended data collection to 2021 (Fredrick et al., 2022; Rosenthal et al., 2022). Each of the included studies included either two or three time points, and, overall, data collection ranged from 2017 to April

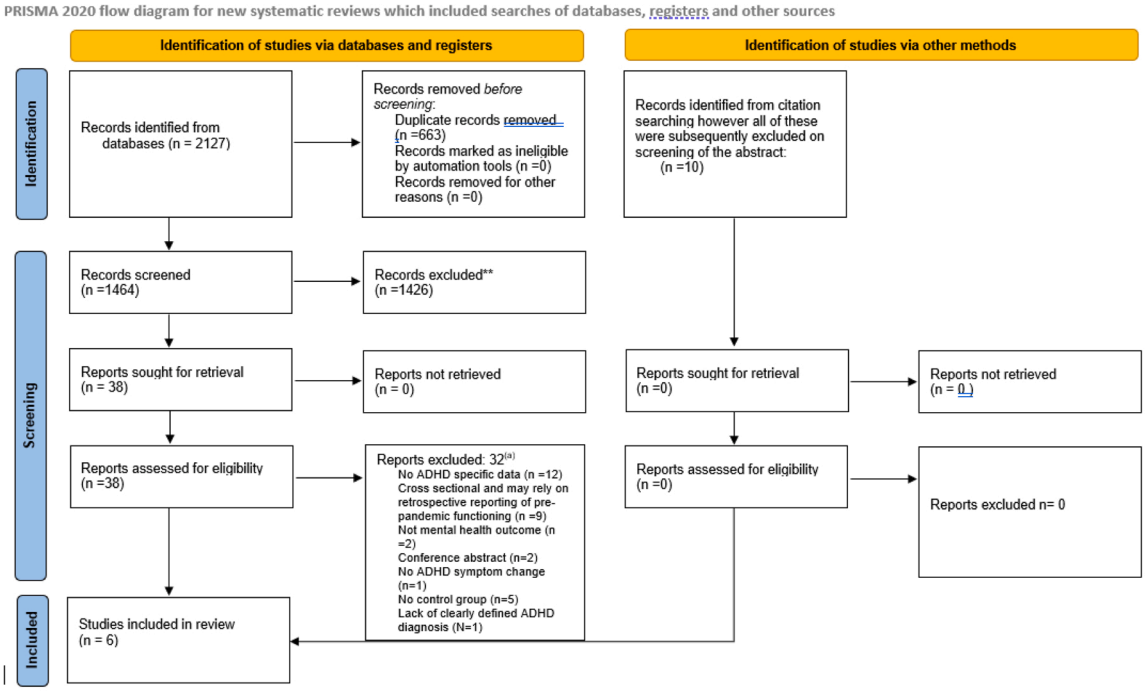


**Fig. 1.** PRISMA 2020 flow diagram.

**Table 1**
Studies characteristics.

| Author (Year) | Location | Study design | Sample size (N) | Demographics | Timepoints | Criteria ADHD diagnosis | Outcome measurement method | Key Findings |
|---|---|---|---|---|---|---|---|---|
| Becker (2021) | USA | Prospective longitudinal study including students with available pre-Covid data (Becker et al., 2019). | N = 122 (58 ADHD; 64 controls) | Mean age (years): ADHD: 16.2 Controls: 16.2 Sex (% females) ADHD: 31% Controls: 45.3 Ethnicity (% White; % Mixed) ADHD: 84.5%, 5.2% Controls: 84.4%, 7.8% | T1:09/2019–02/2020 T2: 05–06/2020 (Lockdown/remote learning) | DSM-5 (P-ChIPS) | SHS; SDSC; CRISIS; CASPE | ADHD vs controls: more difficulties initiating and maintaining sleep both before and during COVID-19. 41% had insufficient sleep duration (vs 31% controls). |
| Breaux (2021) | USA | Prospective longitudinal study including students with available pre-Covid data (Becker et al., 2019; Langberg et al., 2019). | N = 238 (118 ADHD; 120 controls) | Mean age (years): Whole sample: 16.7 Sex (% females): Whole sample: 45% Ethnicity (% White; % Mixed) Whole sample: 82%, 7% | T1: 09/2018–02/2020 T2: 05–06/2020 (Lockdown) T3: 07–08/2020 (No lockdown) | DSM-5 (P-ChIPS) | VADRS; Self-reported CCI-2; Self-reported RCADS; DERS | Initial increases in adolescent mental health symptoms observed following the start of the pandemic, do not on average appear to be maintained following the lifting of lockdown restrictions. ADHD status and poor baseline emotional regulation increase the risk for sustained negative mental health difficulties. |
| Dvorsky (2021) | USA | Prospective longitudinal study including students with available pre-Covid data (Becker et al., 2019; Langberg et al., 2019). | N = 238 (118 ADHD; 120 controls) | Mean age (years): Whole sample: 16.7 Sex (% females): Whole sample: 45% Ethnicity (% White; % Mixed) Whole sample: 82%, 7% | T1: 05–06/2020 (Stay at home order) T2: 07–08/2020 (No stay-at-home order) T3: 10–11/2020 (Level of restrictions not mentioned) | DSM-5 (P-ChIPS) | CRISIS, CASPE, ARQ | ADHD vs controls: By summer and autumn adolescents with ADHD had higher levels of mental health symptoms (ds = 0.26–0.29). Controls experienced greater worry about COVID-19 (ds = 0.21–0.51) in the spring and summer, compared to adolescents with ADHD. ADHD participants engaged in significantly less routines (ds = 0.75–0.92) and coping strategies (ds = 0.32–0.39) at all timepoints. |
| Frederick (2022) | USA | Prospective longitudinal study including students with available pre-Covid data (Becker et al., 2019). | N = 238 (118 ADHD; 120 controls) | Mean age (years): Whole sample: 16.7 Sex (% females): Whole sample: 45% Ethnicity (% White; % Mixed) Whole sample: 82%, 7% | T1:05–06/2020 (Lockdown) T2: 07–08/2020 (No lockdown) T3: 10–11/2020 | DSM-5 (P-ChIPS) | CASPE, RRS, RCADS | Adolescents with ADHD reported higher T3 parent-reported depressive symptoms ($\beta = 0.13$, $p = 0.022$). Baseline COVID-19 related stress was associated with T3 increased anxiety (ab = 0.10) and self and parent report depression (ab = 0.07 and ab = 0.09 respectively) via brooding rumination at T2. Baseline COVID-19 stress was uniquely associated with increased T2 brooding rumination. ($\beta = 0.48$, $p < 0.001$). |
| Houghton (2022) | Australia | Prospective longitudinal study including high school students with available pre-Covid data. | N = 476 participants (76 ADHD) | Age range (years): Whole sample: 10–16 Sex (% females): Whole sample: 45% | T1: 11/2018 – 04–05/2019 T2: 03/2020 (Lockdown) T3: 07–08/2020 (No lockdown, schools had re-opened) | DSM 4 TR or DSM 5 | PALs, CDI:SR [S] 2, WEMWBS, SDQ | ADHD v no ADHD cohort: No significant difference in internalizing symptoms, externalizing symptoms or depression for adolescents from pre-COVID-19 to school lockdowns to post schools re-opening. ADHD cohort: increases in |

(*continued on next page*)

**Table 1** (*continued*)

| Author (Year) | Location | Study design | Sample size (N) | Demographics | Timepoints | Criteria ADHD diagnosis | Outcome measurement method | Key Findings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | positive mental wellbeing and decreases in externalizing symptoms from pre-COVID-19 to post school re-opening. |
| Rosenthal (2022) | USA | Follow-up survey of parents/youths from the ABCD longitudinal study, which monitors health outcomes of 11000 children over 10 years (Barch et al., 2018). | N = 1234 (620 ADHD; 614 controls) | Mean age (years): ADHD: 12.4 Controls: 12.5 Sex (% females) ADHD: 31% Controls: 31.1% Ethnicity (% White; % Mixed) ADHD: 68.5%,19% Controls: 69.2%, 19.2% | T1: 2017–2018 T2: 05/2020 (First pandemic wave) T3: 03/2021 (Second pandemic wave) | DSM-5 (KSADS-5) | Pre-pandemic: KSADS-5, PMP, PMQ, SRPF During pandemic: RRR | ADHD v controls: increased trouble with remote learning (d = −0.54), sleep problems (d=−0.52), fear of COVID-19 infection in family members (d = −0.56), COVID-19 restriction rule breaking behaviors (d =−0.23), family conflict (d = −0.13), and were less ready for the upcoming school year (d = 0.38). ADHD v controls: more likely to experience behavioral, emotional, family, sleep, and school-related difficulties as a function of pandemic interruptions to daily life activities. Protective factors for example parental monitoring and school engagement did not appear to buffer pandemic response among children with ADHD to the same degree as youth without ADHD. |

Adolescent Resilience Questionnaire (ARQ), Child Concentration Inventory 2 (CCI-2), Children's Depression Inventory-2 (CDI:SR 2), Coronavirus Health Impact Survey (CRISIS), COVID-19 Adolescent Symptom and Psychological Experience Questionnaire (CASPE), COVID Rapid Response Research Survey (RRR), Difficulties in Emotion Regulation Scale (DERS), Perth A-Loneness Scale (PALs), Revised Children's Anxiety and Depression Scale (RCADS), Ruminative Responses Scale (RRS), Sleep Disturbance Scale for Children (SDSC), Sleep Habits Survey (SHS), Strengths and Difficulties Questionnaire (SDQ), Vanderbilt ADHD Diagnostic Rating Scale (VADRS), and Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS).

2021. Baseline data (T1) was collected pre-COVID in four studies (Becker et al., 2021; Breaux et al., 2021; Houghton et al., 2022; Rosenthal et al., 2022), and during the first lockdown (between April and June 2020) in two studies (Dvorsky et al., 2022; Fredrick et al., 2022).

Outcome measures were collected using online questionnaire-based surveys in all the studies. Five used both care giver and self-report measures (Becker et al., 2021; Breaux et al., 2021; Dvorsky et al., 2022; Fredrick et al., 2022; Rosenthal et al., 2022), whilst one included only self-reported measures (Houghton et al., 2022).

Four studies used questionnaires specifically designed to collect data on the effects of the pandemic, such as the Coronavirus Health Impact Survey (CRISIS), COVID-19 Adolescent Symptom and Psychological Experience Questionnaire (CASPE), and COVID-19 rapid response research survey (RRR) (Dvorsky et al., 2022; Becker et al., 2021; Fredrick et al., 2022; Rosenthal et al., 2022).

One study used validated questionnaires on ADHD symptoms and behavioural difficulties (Breaux et al., 2021), namely the Vanderbilt ADHD Diagnostic Rating Scale (VADRS) and the self-reported Child Concentration Inventory 2 (CCI-2).

Three studies measured mood and anxiety symptoms (Breaux et al., 2021; Fredrick et al., 2022; Houghton et al., 2022) using the Revised Children's Ruminative Responses Scale (RRS), Revised Childhood Anxiety and Depression Scale (RCADS), Difficulties in Emotion Regulation Scale (DERS), Perth A-Loneness Scale (PALs), Children's Depression Inventory-2 (CDI:SR 2), Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS), Strengths and Difficulties Questionnaire (SDQ).

One study used the Adolescent Resilience Questionnaire (ARQ) to assess coping (Dvorsky et al., 2022). Finally, another screened for sleep problems (Becker et al., 2021) using the Sleep Habits Survey (SHS) and the Sleep Disturbance Scale for Children (SDSC).

### 3.3. Main findings

#### 3.3.1. ADHD vs controls

We first present the results of the comparative analyses between the ADHD cohort and neurotypical controls.

Breaux et al. (2021) compared adolescents with and without ADHD on a range of mental health outcomes. They observed that young people with ADHD had significantly more inattention, hyperactivity/impulsivity, and oppositional/defiant symptoms at all timepoints (t ranges= 3.75–9.87, $p < .001$). They also had significantly more sluggish cognitive tempo symptoms but only pre-COVID ($t = 3.67$, $p < .001$) and in summer 2020 ($t = 2.92$, $p = .004$), however the difference was not significant in spring 2020, during the first lockdown, as only neurotypicals experienced a significant increase in these symptoms as compared to pre-COVID ($t = 3.95$, $p < .001$).

Dvorsky and colleagues (2021) reported that, although there was no significant group difference in mental health symptoms in spring 2020, adolescents with ADHD reported significantly higher levels of symptoms in summer and fall 2020 ($d = 0.26$ and 0.29 respectively). Similarly, although youths with/without ADHD reported similar levels of

substance abuse pre-COVID, those with ADHD progressively increased their use during spring and summer 2020, reaching significant group difference in summer 2020 ($d = 0.35$). Substance use was not reported for Fall/T3 time-period. However, neurotypical controls reported significantly higher levels of worries about COVID-19 in spring and summer ($d$= 0.31 and 0.51 respectively) and more COVID-19 related stress in summer 2020 ($d = 0.25$).

Houghton et al. (2022) reported that pre-COVID, adolescents with ADHD had significantly lower positive mental wellbeing (B = 0.22, p = .018) and higher externalizing symptoms (B = 3.015, p < .001), depression (B = 5.17, p = .013), and internalizing symptoms (B = 1.63, p = .005) than neurotypical peers. However, longitudinal data analysis from pre-COVID to post-school reopening showed that the former reported more evident improvement in wellbeing (B=0.23, p = .003) and reduction in externalizing symptoms (B = 3.015, p < .001) as compared to controls.

Conversely, Frederick et al. (2022) only noted that youths with ADHD had higher parent-reported depressive symptoms in spring 2021 ($\beta = 0.13$, p = 0.022). However, for all mental health symptoms, ADHD group status did not moderate the indirect effects of COVID-19 related stress, brooding rumination and internalizing symptoms.

Considering sleep, Becker et al. (2021) observed significant differences between adolescents with and without ADHD in the duration and quality of sleep both before and during the pandemic. Pre-COVID, adolescents with ADHD had significantly higher daytime sleepiness than those with ADHD (t = −2.33, p < .05); however, no significant difference was observed during the COVID-19 pandemic. In both study periods, those with ADHD had higher difficulties initiating and maintain sleep than those without ADHD, and this difference became more significant during the pandemic ($X^2$ =4.17, p < 0.05 before and $X^2$ =7.00, p < 0.01 during the COVID-19 pandemic). Finally, although pre-COVID, there was no significant group difference in the proportion of adolescents obtaining recommended sleep duration during school nights, those with ADHD had significantly lower recommended sleep duration during the pandemic ($\chi^{2=}$6.29, p < .05). No differences were observed in other quality of sleep parameters.

Similarly, Rosenthal and colleagues (2022) highlighted that youths with ADHD had significantly greater sleep problems than neurotypical controls ($d$=−0.52). They also had significant more fear and negative emotions to infection risk ($d$=−0.56), experienced more difficulties with remote education (d=−0.56), felt less prepared for the following school year (d=0.38), exhibited more restrictions rule-breaking behavior (d=−0.23), and suffered more often from family conflict ($d$=−0.13).

In summary, studies that compared youths with ADHD and controls over time yielded inconsistent results. For instance, although youths with ADHD tended to have worse pre-COVID mental health, both more and less evident deterioration has been reported as compared to neurotypical peers during restrictions. More consistent are the results regarding worsening of sleep quality, which was more evident in those with ADHD, although this outcome has been analyzed in only two studies. Finally, studies suggested that youths without ADHD developed more COVID-19 related worries whereas those with ADHD struggled more with complying with restrictions and had a more evident increase in drug use.

### 3.3.2. Changes in ADHD symptoms

Only one study considered ADHD symptoms before and after the onset of the pandemic in both youths with ADHD (N = 118) and controls (N = 120) (Breaux et al., 2021; de Laclause et al., 2022; Fattah et al., 2022; Valicenti-Mcdermott et al., 2021). They reported significant changes in inattention scores (d=0.31) but not in hyperactivity/impulsivity (d=0.19) across timepoints (from pre-COVID to spring and summer 2020) for the whole sample. The pattern of changes in inattentive symptoms paralleled that observed for sluggish cognitive tempo, anxiety, and depression, which higher effect size for the latter (d=0.75). Considering risk factors, lower levels of pre-COVID emotion regulation skills were significantly associated with more inattentive symptoms at all timepoints and more hyperactivity/impulsivity symptoms in spring and summer 2020. Further, they noted an interaction between ADHD status and lower pre-COVID emotion regulation skills, thus suggesting additive risk for youths with both characteristics. Finally, male sex was associated with higher levels of hyperactivity/impulsivity and low family income with more inattention (Breaux et al., 2021).

### 3.3.3. Changes in sleep

One study compared sleep problems before and after the onset of the pandemic (Becker et al., 2021) and another considered changes during the pandemic (Rosenthal et al., 2022). Negative affect, COVID-19 related poor concentration, and screen time were identified as risk factors for worse sleep problems during the pandemic.

Becker and co-workers (2021) included 122 adolescents, among whom 48% had ADHD. They reported a significant increase in parent-reported clinically elevated difficulties initiating and maintaining sleep from pre- to during lockdown (May-June 2020) in the whole sample. Further, there was a non-significant increase in the proportion of youths obtaining recommended sleep duration (8–10 h) during school nights; and a significant shift of bedtimes (to about an hour later). Ethnicity, sex, age, and social media use were not significantly associated with sleep quality outcomes. However, exercising and spending time outdoor had a positive effect on difficulties with initiating and maintaining sleep, whilst negative affect and COVID-19 related poor concentration were associated with more difficulties. Finally, Rosenthal and co-workers (2022) noted a strong positive association between screen time and sleep problems in those with ADHD (Rosenthal et al., 2022).

### 3.3.4. Changes in mood, anxiety, and other mental health symptoms

Three studies compared mood, anxiety and other mental health symptoms before and after the onset of the pandemic (Breaux et al., 2021; Houghton et al., 2022; Rosenthal et al., 2022); and two reported on changes during the pandemic (Dvorsky et al., 2022; Fredrick et al., 2022). Some studies provided longitudinal data for the ADHD cohort independently, whilst others described aggregated data only. Taken together, they suggest pandemic-related worsening of mental health symptoms, especially during the first lockdown. Poor pre-COVID emotion regulation skills and rumination were associated with worse outcomes, whilst use of routines and positive coping strategies with better outcomes.

In parallel to what previously reported for ADHD symptom changes, Breaux and co-workers (2021) reported significant changes in anxiety, depression, sluggish cognitive tempo and oppositionality in the whole sample (N = 238, of whom 118 with ADHD) from pre-COVID to spring and summer 2020. Effect sizes ranged from d= 0.26 (oppositionality) to d= 0.75 (depression). Of note, whist these symptom trajectories showed higher scores in spring 2020, as compared to pre-COVID and summer 2020, that of inattention scores showed persistent higher scores in spring and summer 2020. In terms of risk factors, pre-COVID emotion regulation skills were significantly associated with higher mood, anxiety and sluggish cognitive tempo symptoms at all timepoints, and higher oppositionality pre-COVID and in spring 2020. Unexpectedly, higher family income was associated with greater oppositionality. Finally, ethnicity was not associated with changes in mental health symptoms. (Breaux et al., 2021).

Houghton et al. (2022) reported symptom changes over time in each of the two cohorts, one including 238 youths with neurodevelopmental conditions (55 with ADHD) and one including matched neurotypical controls. They noted no significant changes in internalizing symptoms, externalizing symptoms and depression for adolescents with neurodevelopmental conditions from pre-COVID to post schools re-opening, although these were already elevated pre-pandemic. Symptom levels returned to pre-COVID levels or lower post school reopening.

Conversely, all mental health symptoms significantly worsened in the control group. The latter also reported greater isolation during lockdown, whereas no change was observed in the cohort with neurodevelopmental conditions. The results of comparative analyses are reported in the above section.

Rosenthal and co-workers (2022) noted that school involvement, parental monitoring, and lack of family conflict were more strongly associated with parent-reported preparation for the following school year in youths without ADHD. They concluded that youths with ADHD were less responsive to protective environmental factors, such as parental monitoring (Rosenthal et al., 2022).

Frederick et al. (2022) observed that baseline COVID-19 related stress was associated with Spring 2021 increased anxiety and self and parent reported depression, and that this association was mediated by brooding rumination as measured at Autumn 2020 in both youths with/without ADHD and in both males and females.

Finally, Dvorsky and colleagues (2022) analyzed relationships between COVID-19 related worries/stress and coping strategies and routines, and between these and mental health symptoms and substance use in 238 adolescents (118 with ADHD). They reported that initial levels of COVID-19 related stress/worries and mental health symptoms predicted increases in coping behaviors and use of routines, which in turn predicted decreased mental health symptoms, worry, and stress, only for adolescents with ADHD. Utilizing positive coping strategies and engaging in routines protected against increases in substance use and mental health problems for adolescents with ADHD. However, those with ADHD participated in significantly fewer routines and coping strategies than their neurotypical peers (Dvorsky et al., 2022).

### 3.4. Quality of the studies

Based on the Newcastle-Ottawa risk of bias tool adapted for longitudinal studies (Wells et al., 2000), 83% of studies were judged to be of overall low quality, mainly due to the use of self-reported outcome measures and for not providing any statement on attrition rates. The quality assessment of individual studies is reported in Table S1.

## 4. Discussion

This is the first systematic review focusing exclusively on longitudinal studies comparing children and adolescents with/without ADHD during the COVID-19 pandemic. In sum, adolescents with ADHD had higher pre-COVID levels of externalizing and internalizing symptoms and sleep problems as compared to neurotypical peers. However, the latter experienced significant greater worsening of sluggish cognitive tempo symptoms, COVID-19 related worries, depression, and externalizing symptoms during the first lockdown. Mental health symptoms remained elevated in those with ADHD, thus some group differences temporarily became unsignificant (e.g., sluggish cognitive tempo symptoms). In summer/fall 2020, those with ADHD tended to have more severe mental health symptoms and drug use, although a study noted an improvement in wellbeing and externalizing symptoms post-school reopening. A study extended the follow-up to spring 2021, when the only difference observed was higher levels of depressive symptoms in those with ADHD. Finally, two studies investigated changes in sleep problems, and both reported greater worsening in those with ADHD. Overall, these findings highlight that lockdown had a predominantly negative impact on the mental health of children and adolescents with ADHD, which perhaps became more evident after the initial phase of restrictions.

The identified deterioration may be due to several factors. Young people with ADHD may be less resilient and particularly affected by changes of routine and/ or unpredictable schedules (Barkley and Fischer, 2011). Given the pandemic led to a major upheaval in routines, this could have been a cause of deterioration. Furthermore, ADHD youth were less engaged in routines and the use of coping strategies (Dvorsky et al., 2022); and lack of motivation, loneliness and boredom were associated with increased risk of worsening mental health (Sibley et al., 2021). Similarly, a prospective study showed that baseline COVID-19 related stress (measured in May 2020) was significantly positively associated with increased ADHD symptom severity at 12 months (Summerton et al., 2023). COVID-19 related restrictions and uncertainties may have also contributed to a more difficult home environment and conflicts in relationships. Additionally, children with neurodevelopmental disorders are more at risk of abuse (Govindshenoy and Spencer, 2007). A longitudinal cohort study in ADHD highlighted that, compared to before COVID-19, 62.7% of the parents were verbally and physically abusive towards their children's behavioral difficulties (Fattah et al., 2022). Similarly, another study reported increased shouting at the child (43.8%), verbal abuse (25%), and punishment (27.1%) during lockdown (Shah et al., 2021). This increase in abuse may have contributed to worsening mental health in adolescents with ADHD. Parenting a child with ADHD can be challenging and more stressful than raising a child without this condition (Perez Algorta et al., 2018). As a result of COVID-19 related restrictions, it is likely that parents spent more time at home with their children, with limited opportunities to be outdoor or engage in meaningful activities. This may have negatively impacted parents' mental health and ability to support their children. It has been reported that parents of those with ADHD had higher levels of depressive symptoms than the parents of those without ADHD (Fredrick et al., 2022) during the COVID-19 pandemic. Overall, parents' and child's difficulties in response to the pandemic and restrictions may have contributed to a more difficult home environment and made more challenging for parents to support their child to access coping strategies and maintain routines. Finally, health care provision was mostly transferred to online or telephone for those with ADHD (Rosenthal et al., 2022). Increased barriers to accessing mental health services may also have contributed to worsening mental health during the pandemic.

It is striking that some of the results suggest that youths with ADHD were not impacted over and above their non-ADHD counterparts. For instance, Houghton et al. (2022) reported no significant group differences in increases in internalizing and externalizing symptoms and depression (Houghton et al., 2022). However, the authors noted that those with ADHD had higher pre-COVID difficulties and these remained elevated throughout the study period, thus they continued to be an at-risk population. Similarly, a secondary analysis of the Co-Space study noted an increase in hyperactivity and inattention in the control group during the first lockdown, and persistent elevated symptoms in the ADHD group, who showed higher levels of impairment (Hall et al., 2023). In addition, adolescents with ADHD had higher levels of loneliness pre-lockdown, and this could potentially explain why they were less affected by lockdown, as the restrictions did not lead to such a change in their social interactions as for their peers without ADHD.

Studies also differ regarding symptom variation over time. For instance, Houghton et al. (2022) noted increases in mental wellbeing and decreases in externalizing symptoms from pre-COVID to post school re-opening in summer 2020, suggesting a positive impact of lockdown (Breaux et al., 2021; Houghton et al., 2022). Conversely, Breaux et al. (2021) reported that an initial increase in adolescent mental health symptoms at the start of the pandemic was not maintained following the lifting of lockdown restrictions in summer 2020; and Dvorsky et al. (2021) indicated a more persisting negative impact. Differences among studies may be related to sample characteristics but also to varying levels of restrictions. The included studies were conducted in four different countries and two of them differed substantially in COVID-19 infection rates, lengths of lockdown and response to the COVID-19 pandemic. For instance, when considering Houghton's findings, it is important to note that it was conducted in Western Australia where rates of COVID-19 infection were lower than other parts of the world and the pandemic did not lead to the same level of health and social emergencies. Thus, the reported impact of the pandemic may vary due to country level factors, such as the severity of the lockdown, the number of

COVID-19 cases and deaths.

Sleep difficulties are common in adolescents with ADHD (Becker et al., 2019), however this appeared to be an area that was particularly negatively impacted during the COVID-19 pandemic. Adolescents with ADHD did not benefit from increased school night sleep like their non-ADHD counterparts during the pandemic. They were less likely to achieve the recommended amount of sleep. Interestingly, another longitudinal study in ADHD (without controls) reported higher symptom severity in youths with the longest bedtime delay (De Laclause et al., 2022). It is also known that anxiety and depression can affect sleep. Thus, we can hypothesize a bidirectional relationship between worsening sleep and worsening internalizing symptoms.

Considering risk factors, male sex was associated with higher levels of hyperactivity/impulsivity and low family income with more inattention but less oppositionality. Poor pre-COVID emotion regulation skills and rumination were associated with worse outcomes, whilst use of routines and positive coping strategies with better outcomes. Negative affect, COVID-19 related poor concentration, and screen time were identified as risk factors for worse sleep. Most of these were identified in the whole sample, including both youths with ADHD and controls, however, some studies also noted group differences. For instance, youths with ADHD appeared less responsive to protective environmental factors (such as parental monitoring), and engaged less with routines and coping strategies, although these had a beneficial effect. Identifying these patterns may be important to guide clinicians and the supportive network around the child on how to best support them.

### 4.1. Strengths and limitations

This systematic review benefits from the longitudinal design of the included studies, which more robustly pinpoints the impact of the COVID-19 pandemic; the comparative analyses with controls, which helped clarify the relationship between an ADHD diagnosis and the patterns of symptom changes over time; and the exclusion of studies relying on the retrospective recall of symptom severity, to avoid potential recall bias.

Limitations, mainly due to the nature of the included studies, should also be considered. First, the number of the eligible studies was limited. Due to this, and the heterogeneity in outcome measures and timeframes, it was not possible to carry out a meta-analysis. Second, the majority of the studies were conducted during 2020 and only few extended up to 2021. However, the pandemic, and lockdowns in parts of the world, continued well into 2021, so the full impact of the pandemic is not captured. Prolonged social distancing measures may induce an adaptation or create a cumulative negative impact in individuals. Longer longitudinal studies are therefore needed to clarify the longer-term impact of the pandemic on children and adolescents with ADHD. Third, its impact may also vary with the different waves of restrictions. Unfortunately, not all the included studies provided information on the types of restrictions in place at the time of data collection. This limits comparability among studies and does not allow us to capture the specific effects of varying intensity and types of social restrictions. For instance, prior work conducted in the UK has shown that the severity of mental health symptoms fluctuated accordingly to lockdown phases in healthy children and young people, whereas it remained more stable in those with neurodevelopmental disorders/special education needs (Waite et al., 2021). It would therefore be important to clarify the potential restriction-related variation of symptom severity in those with ADHD. Fourth, most of the studies relied upon carer or self-reports, instead of an assessment by a mental health professional, thus outcome measures may be biased by the subjective nature of the assessment tool. For instance, a carer report may be biased by their own mental health difficulties or the housing and financial circumstances of the family. Finally, some studies did not use standardized questionnaires to measure outcomes, which may limit validity and reliability.

### 4.2. Conclusion and clinical implications

Our results suggest that children with ADHD are vulnerable to changes in their environment and education, and may be negatively affected by high-level restrictions.

These findings should guide clinicians to help youths to mitigate the effects of the pandemic and build resilience, for instance by developing emotion regulation skills and routines. In the event of future scenarios, clinicians may need to monitor youths with ADHD more closely, especially those at higher risk of deterioration. Supporting the family and young person to uphold a structured routine and utilize positive coping strategies is essential to reducing the risk to the young person's mental health. Working with parents can also reduce family conflicts and enable them to better support their child, while reducing the risk of episodes of abuse. Finally, interventions that focus on reducing rumination in the young person may help to reduce anxiety and depressive symptoms.

These findings may also inform clinical guidelines and policies, as they highlight the vulnerabilities of youths with ADHD and the importance to address their needs to limit the negative effects of possible future restrictions. For instance, allocating additional educational or social support may be beneficial, especially when parents are less able to support their children due to their own mental health difficulties or family circumstances. The risk of future pandemic/epidemics remains. Should restrictions be considered again, it is important that public health strategies holistically consider the collateral impacts of lockdowns in cost-benefit analyses and introduce means to mitigate the impact.

## Funding

VP was recipient of a Clinical Lectureship funded by the Department of Child and Adolescent Psychiatry, IoPPN, KCL; and of the Starter Grant for Clinical Lecturers, which is supported by Academy of Medical Sciences (AMS), the Wellcome Trust, the Medical Research Council (MRC), the British Heart Foundation, Versus Arthritis, Diabetes UK, the British Thoracic Society (Helen and Andrew Douglas bequest), and the Association of Physicians of Great Britain and Ireland (AoP) [SGL024\1092]. This is independent research and was supported in part by the Maudsley Biomedical Research Centre (BRC). The views expressed are those of the authors and not necessarily those of the BRC, the NIHR or the Department of Health and Social Care.

## Declaration of Competing Interest

SC declares honoraria and reimbursement for travel and accommodation expenses for lectures from the following non-profit associations: Association for Child and Adolescent Central Health (ACAMH), Canadian ADHD Alliance Resource (CADDRA), and British Association of Pharmacology (BAP), for educational activity on ADHD. ESB declares lecture and conference support from Takeda and MEDICE. ESB declares research support from Qbtech. The other authors have no conflicts of interest to declare.

## Acknowledgements

We thank all the contributors and reviewers for their constructive comments.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neubiorev.2023.105502.

## References


Albrecht, J.N., Werner, H., Rieger, N., Widmer, N., Janisch, D., Huber, R., Jenni, O.G., 2022. Association between homeschooling and adolescent sleep duration and health during COVID-19 pandemic high school closures. JAMA Netw. Open 5 e2142100.

American Psychiatric Association, D., Association, A.P., 2022. Diagnostic and Statistical Manual of Mental Disorders: DSM-5-TR. American psychiatric association,, Washington, DC.

Barch, D.M., Albaugh, M.D., Avenevoli, S., Chang, L., Clark, D.B., Glantz, M.D., Hudziak, J.J., Jernigan, T.L., Tapert, S.F., Yurgelun-Todd, D., Alia-Klein, N., Potter, A.S., Paulus, M.P., Prouty, D., Zucker, R.A., Sher, K.J., 2018. Demographic, physical and mental health assessments in the adolescent brain and cognitive development study: Rationale and description. Dev. Cogn. Neurosci. 32, 55–66.

Barkley, R.A., Fischer, M., 2011. Predicting impairment in major life activities and occupational functioning in hyperactive children as adults: self-reported executive function (EF) deficits versus EF tests. Dev. Neuropsychol. 36, 137–161.

Becker, S.P., Langberg, J.M., Eadeh, H.M., Isaacson, P.A., Bourchtein, E., 2019. Sleep and daytime sleepiness in adolescents with and without ADHD: differences across ratings, daily diary, and actigraphy. J. Child Psychol. Psychiatry 60, 1021–1031.

Becker, S.P., Dvorsky, M.R., Breaux, R., Cusick, C.N., Taylor, K.P., Langberg, J.M., 2021. Prospective examination of adolescent sleep patterns and behaviors before and during COVID-19. Sleep 44 (8).

Behrmann, J.T., Blaabjerg, J., Jordansen, J., De Lopez, K.J.M., 2022. Systematic Review: Investigating the Impact of COVID-19 on Mental Health Outcomes of Individuals With ADHD. J. Atten. Disord. 26, 959–975.

Bobo, E., Lin, L., Acquaviva, E., Caci, H., Franc, N., Gamon, L., Picot, M.C., Pupier, F., Speranza, M., Falissard, B., Purper-Ouakil, D., 2020. How do children and adolescents with Attention Deficit Hyperactivity Disorder (ADHD) experience lockdown during the COVID-19 outbreak? Enceph. 46 (3 Suppl.), S85–S92.

Breaux, R., Dvorsky, M.R., Marsh, N.P., Green, C.D., Cash, A.R., Shroff, D.M., Buchen, N., Langberg, J.M., Becker, S.P., 2021. Prospective impact of COVID-19 on mental health functioning in adolescents with and without ADHD: Protective role of emotion regulation abilities. J. Child Psychol. Psychiatry 62, 1132–1139.

Bruni, O., Giallonardo, M., Sacco, R., Ferri, R., Melegari, M.G., 2021. The impact of lockdown on sleep patterns of children and adolescents with ADHD. J. Clin. Sleep. Med. 17 (9), 1759–1765.

Bulut, G.C., Gokce, S., Gumustas, F., 2023. Adapting to a New Normal: Changes in Behavioral Symptoms in Children with ADHD During Online Education. Konuralp Tip. Derg. 15 (3), 377–382.

Conti, E., Sgandurra, G., De Nicola, G., Biagioni, T., Boldrini, S., Bonaventura, E., Buchignani, B., Vecchia, S.D., Falcone, F., Fedi, C., Gazzillo, M., Marinella, G., Mazzullo, C., Micomonaco, J., Pantalone, G., Salvati, A., Sesso, G., Simonelli, V., Tolomei, G., Troiano, I., Cioni, G., Masi, G., Muratori, F., Milone, A., Battini, R., 2020. Behavioural and emotional changes during covid-19 lockdown in an italian paediatric population with neurologic and psychiatric disorders. Brain Sci. 10 (12), 1–15.

Cortese, S., Solmi, M., Correll, C.U., 2023. Commentary: The impact of Covid-19 on psychopathology in children and young people worldwide - reflections on Newlove-Delgado et al. (2023). J. Child Psychol. Psychiatry 64, 641–644.

De Laclause, A.P., Getin, C., Konofal, E., Cortese, S., Lecendreux, M., 2022. Short Research Article: Impact of a prolonged lockdown on the symptoms of paediatric ADHD and common associated disorders. Child Adolesc. Ment. Health 27, 312–317.

Dvorsky, M.R., Breaux, R., Cusick, C.N., Fredrick, J.W., Green, C., Steinberg, A., Langberg, J.M., Sciberras, E., Becker, S.P., 2022. Coping with COVID-19: Longitudinal Impact of the Pandemic on Adjustment and Links with Coping for Adolescents with and without ADHD. In: Research on child and adolescent psychopathology, 50, pp. 605–619.

Fattah, N.R.A., Yousef, A.M., Mohamed, A.E., Amin, S.I., 2022. Behavioral symptoms among children and adolescents with attention deficit hyperactivity disorder during COVID-19 outbreak: a retrospective prospective cohort study. Middle East Curr. Psychiatry-Mecpsych 29.

Fredrick, J.W., Nagle, K., Langberg, J.M., Dvorsky, M.R., Breaux, R., Becker, S.P., 2022. Rumination as a Mechanism of the Longitudinal Association Between COVID-19-Related Stress and Internalizing Symptoms in Adolescents. Child Psychiatry Hum. Dev. 08.

Gavin, W., Campbell, E., Zaidi, S.A., Gavin, N., Dbeibo, L., Beeler, C., Kuebler, K., Abdel-Rahman, A., Luetkemeyer, M., Kara, A., 2021. Clinical characteristics, outcomes and prognosticators in adult patients hospitalized with COVID-19. Am. J. Infect. Control 49, 158–165.

Govindshenoy, M., Spencer, N., 2007. Abuse of the disabled child: a systematic review of population-based studies. Child Care Health Dev. 33, 552–558.

Hall, C.L., Partlett, C., Valentine, A.Z., Pearcey, S., Sayal, K., 2023. Understanding the Impact of Home Confinement on Children and Young People with ADHD and ASD During the COVID-19 Pandemic. Child Psychiatry Hum. Dev. 1–15.

Hollingdale, J., Adamo, N., Tierney, K., 2021. Impact of COVID-19 for people living and working with ADHD: A brief review of the literature. Aims Public Health 8, 581–597.

Houghton, S., Kyron, M., Lawrence, D., Hunter, S.C., Hattie, J., Carroll, A., Zadow, C. & Chen, W. 2022. Longitudinal trajectories of mental health and loneliness for australian adolescents with-or-without neurodevelopmental disorders: The impact of covid-19 school lockdowns. *Journal of Child Psychology and Psychiatry*.

Howe De La Torre, S., Parlatini, V., Cortese, S., 2023. Long-term central nervous system (CNS) consequences of COVID-19 in children. Expert Rev. Neurother. 23, 703–720.

Imran, N., Zeshan, M., Pervaiz, Z., 2020. Mental health considerations for children & adolescents in COVID-19 Pandemic. Pak. J. Med Sci. 36. S67-s72.

Kara, O.K., Tonak, H.A., Kara, K., Ulu, H.S., Kose, B., Sahin, S., Kara, M.Z., 2021. Home participation, support and barriers among children with attention-deficit/hyperactivity disorder before and during the COVID-19 pandemic. Public Health 196, 101–106.

Mcgowan, G., Conrad, R., Potts, H., 2020. 51.2 Challenges with Managing Children and Adolescents with Adhd during the Covid-19 Pandemic: A Review of the Literature. J. Am. Acad. Child Adolesc. Psychiatry 59 (10 Supplement). S251.

Mensi, M.M., Capone, L., Rogantini, C., Orlandi, M., Ballante, E., Borgatti, R., 2021. COVID-19-related psychiatric impact on Italian adolescent population: A cross-sectional cohort study. J. Community Psychol. 49, 1457–1469.

Newlove-Delgado, T., Russell, A.E., Mathews, F., Cross, L., Bryant, E., Gudka, R., Ukoumunne, O.C., Ford, T.J., 2023. Annual Research Review: The impact of Covid-19 on psychopathology in children and young people worldwide: systematic review of studies with pre- and within-pandemic data. J. Child Psychol. Psychiatry 64, 611–640.

Page, M.J., Mckenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., Mcdonald, S., Mcguinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372, n71.

Panchal, U., Salazar De Pablo, G., Franco, M., Moreno, C., Parellada, M., Arango, C., Fusar-Poli, P., 2023. The impact of COVID-19 lockdown on child and adolescent mental health: systematic review. Eur. Child Adolesc. Psychiatry 32, 1151–1177.

Parlatini, V., Frangou, L., Zhang, S., Epstein, S., Morris, A., Grant, C., Zalewski, L., Jewell, A., Velupillai, S., Simonoff, E., Downs, J., 2023a. Emotional and behavioral outcomes among youths with mental disorders during the first Covid lockdown and school closures in England: a large clinical population study using health care record integrated surveys. Soc. Psychiatry Psychiatr. Epidemiol.

Parlatini, V., Itahashi, T., Lee, Y., Liu, S., Nguyen, T.T., Aoki, Y.Y., Forkel, S.J., Catani, M., Rubia, K., Zhou, J.H., Murphy, D.G., Cortese, S., 2023b. White matter alterations in Attention-Deficit/Hyperactivity Disorder (ADHD): a systematic review of 129 diffusion imaging studies with meta-analysis. Mol. Psychiatry.

Perez Algorta, G., Kragh, C.A., Arnold, L.E., Molina, B.S.G., Hinshaw, S.P., Swanson, J. M., Hechtman, L., Copley, L.M., Lowe, M., Jensen, P.S., 2018. Maternal ADHD Symptoms, Personality, and Parenting Stress: Differences Between Mothers of Children With ADHD and Mothers of Comparison Children. J. Atten. Disord. 22, 1266–1277.

Raffagnato, A., Iannattone, S., Tascini, B., Venchiarutti, M., Broggio, A., Zanato, S., Traverso, A., Mascoli, C., Manganiello, A., Miscioscia, M., Gatta, M., 2021. The covid-19 pandemic: A longitudinal study on the emotional-behavioral sequelae for children and adolescents with neuropsychiatric disorders and their families. Int. J. Environ. Res. Public Health 18 (18).

Rosenthal, E., Franklin-Gillette, S., Jung, H.J., Nelson, A., Evans, S.W., Power, T.J., Yerys, B.E., Dever, B.V., Reckner, E., Dupaul, G.J., 2022. Impact of COVID-19 on Youth With ADHD: Predictors and Moderators of Response to Pandemic Restrictions on Daily Life. J. Atten. Disord. 26 (9), 1223–1234.

Rossi, L., Behme, N., Breuer, C., 2021. Physical Activity of Children and Adolescents during the COVID-19 Pandemic-A Scoping Review. Int J. Environ. Res Public Health 18.

Rothe, J., Buse, J., Uhlmann, A., Bluschke, A., Roessner, V., 2021. Changes in emotions and worries during the Covid-19 pandemic: an online-survey with children and adults with and without mental health conditions. Child Adolesc. Psychiatry Ment. Health 15, 11.

Shah, R., Raju, V.V., Sharma, A., Grover, S., 2021. Impact of COVID-19 and Lockdown on Children with ADHD and Their Families-An Online Survey and a Continuity Care Model. J. Neurosci. Rural Pract. 12 (1), 71–79.

Sibley, M.H., Ortiz, M., Gaias, L.M., Reyes, R., Joshi, M., Alexander, D., Graziano, P., 2021. Top problems of adolescents and young adults with ADHD during the COVID-19 pandemic. J. Psychiatr. Res. 136, 190–197.

Solmi, M., Cortese, S., Correll, C.U., 2022. Editorial Perspective: Challenges of research focusing on child and adolescent mental health during the COVID-19 era: what studies are needed? J. Child Psychol. Psychiatry 63, 122–125.

Summerton, A., Bellows, S.T., Westrupp, E.M., Stokes, M.A., Coghill, D., Bellgrove, M.A., Hutchinson, D., Becker, S.P., Melvin, G., Quach, J., Efron, D., Stringaris, A., Middeldorp, C.M., Banaschewski, T., Sciberras, E., 2023. Longitudinal Associations Between COVID-19 Stress and the Mental Health of Children With ADHD. J. Atten. Disord. 27, 1065–1074.

Townsend, L., Kobak, K., Kearney, C., Milham, M., Andreotti, C., Escalera, J., Alexander, L., Gill, M.K., Birmaher, B., Sylvester, R., Rice, D., Deep, A., Kaufman, J., 2020. Development of three web-based computerized versions of the kiddie schedule for affective disorders and schizophrenia child psychiatric diagnostic interview: preliminary validity data. J. Am. Acad. Child Adolesc. Psychiatry 59, 309–325.

Valicenti-Mcdermott, M., Rivelis, E., Bernstein, C., Cardin, M.J., 2021. The impact of the COVID-19 pandemic on the mental health of youth with developmental disabilities. J. Child Adolesc. Psychopharmacol. 31, 697–698.

Waite, P., Pearcey, S., Shum, A., Raw, J.A.L., Patalay, P., Creswell, C., 2021. How did the mental health symptoms of children and adolescents change over early lockdown during the COVID-19 pandemic in the UK? JCPP Adv. 1, e12009.

Weller, E.B., Weller, R.A., Fristad, M.A., Rooney, M.T., Schecter, J., 2000. Children's Interview for Psychiatric Syndromes (ChIPS). J. Am. Acad. Child Adolesc. Psychiatry 39, 76–84.

Wells, G.A., Shea, B., O'connell, D., Peterson, J., Welch, V., Losos, M. & Tugwell, P. 2000. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses.

Wendel, M., Ritchie, T., Rogers, M.A., Ogg, J.A., Santuzzi, A.M., Shelleby, E.C., Menter, K., 2020. The association between child ADHD symptoms and changes in

parental involvement in kindergarten children's learning during COVID-19. Sch. Psychol. Rev. 49, 466–479.
Werling, A.M., Walitza, S., Drechsler, R., 2021. Impact of the COVID-19 lockdown on screen media use in patients referred for ADHD to child and adolescent psychiatry: An introduction to problematic use of the Internet in ADHD and results of a survey. J. Neural Transm. 128, 1033–1043.
Westwood, S.J., Parlatini, V., Rubia, K., Cortese, S., Sonuga-Barke, E.J.S, 2023. Computerized cognitive training in attention-deficit/hyperactivity disorder (ADHD): a meta-analysis of randomized controlled trials with blinded and objective outcomes. Mol. Psychiatry 28, 1402–1414.
Zhang, J.S., Shuai, L., Yu, H., Wang, Z.Y., Qiu, M.H., Lu, L., Cao, X., Xia, W.P., Wang, Y. Y., Chen, R.S., 2020. Acute stress, behavioural symptoms and mood states among school-age children with attention-deficit/hyperactive disorder during the COVID-19 outbreak. Asian J. Psychiatry 51.