Artigo de Revisão

https://www.revistardp.org.br https://doi.org/10.25118/2763-9037.2023.v13.792

How the COVID-19 pandemic has affected children and adolescents' sleep habits: a systematic review

Como a pandemia de COVID-19 afetou os hábitos de sono das crianças e dos adolescentes: uma revisão sistemática

Cómo la pandemia de COVID-19 ha afectado nos habitos de sueño de niños y adolescentes: una revisión sistematica

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Abstract

Introduction: Sleep is a multimodal construct related to the quality of life of children and adolescents. Therefore, sleep problems might affect attention, internalizing and externalizing behaviors. During the pandemic, children were pointed as a risk group for sleep problems compared to other age groups. **Objective:** We aimed to conduct a systematic search in the literature, in order to investigate the effects of the COVID-19 pandemic on sleep habits in children and adolescents, addressing changes on sleep duration, bedtime and wake-up time, risk and protective factors, and the particularities of children and adolescents with neurodevelopmental disorders. **Methods:** The search was conducted in PubMed, Scopus, and Cochrane Library databases. After the full reading evaluation a total of 133 articles, comprising 234,852 participants from 45 countries, met inclusion criteria. **Results:** An increase in week sleep hours and delay in sleep and wake-up time were observed as well as a worse quality of sleep. Among the emerging risk factors were evaluated confinement, age, gender, previous diagnosis, screen use, and physical activities. For children with neurodevelopmental disorders, heterogeneity in methodology and

sampling constraints do not allow generalizations. **Conclusion:** The most important problem in children and adolescents about sleep during the pandemic was not the number of hours, but the increase in disorders related to sleep and to changes in sleep rhythm. The understanding of sleep changes might shed light on long-term effects and consequences related to the pandemic and the relationship with stress and disorders, which deserves attention to rethink the youths' routines.

Keywords: sleep, child, adolescent, neurodevelopmental disorders

Resumo

Introdução: O sono é um construto multimodal que se relaciona à qualidade de vida de crianças e adolescentes. Portanto, problemas ligados ao sono podem afetar a atenção, comportamentos *externalizadores e internalizadores.* Durante a pandemia, crianças e adolescentes foram apontados como grupos de risco para o desenvolvimento de problemas de sono comparados com outros grupos etários. **Objetivo:** Realizar uma busca sistemática na literatura médica para investigar os efeitos da pandemia de COVID-19 sobre os hábitos de sono de crianças e adolescentes. **Metodologia:** A busca foi realizada nas bases de dados PubMed, Scopus e Cochrane Library. Após processo de seleção e leitura, 133 artigos, com 234.852 participantes de 45 países, preencheram os critérios de inclusão. Analisamos dados de duração do sono, horas de acordar e de dormir, fatores de risco e as particularidades de indivíduos com transtornos do neurodesenvolvimento. **Resultados:** Observou-se aumento nas horas de sono, atraso na hora de acordar, e queda na qualidade do sono. Entre os fatores de risco, foram analisados idade, gênero, diagnóstico prévio, tempo de tela e sedentarismo. Para crianças com transtornos do neurodesenvolvimento, a heterogeneidade das metodologias e as limitações da amostragem inviabilizam generalizações. **Conclusão:** O principal problema identificado não foram as horas de sono, mas o aumento da frequência de transtornos relacionados ao sono e mudanças no seu ritmo. O entendimento dessas mudanças pode auxiliar no esclarecimento dos efeitos de longo prazo e das consequências relacionadas à pandemia, à relação entre sono e estresse e outros transtornos, necessários para repensar a rotina dessa população.

Palavras-chave: sono, crianças, adolescentes, transtornos do neurodesenvolvimento.

Resumen

Introducción: El sueño es una construcción multimodal relacionada a la calidad de vida. Así que problemas de sueño pueden afectar atención, comportamentos internalizadores y externalizadores. Durante la pandemia, los niños han sido reconocidos como un grupo de riesgo para problemas de sueño en comparación con otros rangos de edad. **Objetivo:** Realizar una búsqueda en la literatura para investigar los efectos de la pandemia de COVID-19 en los hábitos de sueño de niños y adolescentes. **Metodología:** Realizamos la búsqueda en PubMed, Scopus y Cochrane Library. Tras lectura y análisis, 133 artículos, con 234.852 participantes de 45 países, cumpliron los criterios de inclusión. Hemos analizado datos de duracción de sueño, horarios para acostarse y despertarse, factores de riesgo y las particularidades de indivíduos con trastornos del neurodesarrollo. **Resultados:** Se observó aumento en las horas de sueño, retraso en la hora de despertarse y reducción en la calidad de sueño. Entre los factores de riesgo, analizamos aislamento social, edad, género, diagnostico previo, tiempo de pantalla y sedentarismo. Para los trastornos del neurodesarrollo, la hetereneidad metodologica y las limitaciones en los metodos de muestreo no permiten generalizaciones. **Conclusión:** El principal problema relacionado al sueño de niños y adolescentes durante la pandemia no ha sido la cantidad de horas, sino el aumento en los trastornos de sueño y los cambios de ritmo. Comprender esos cambios puede aclarar los efectos duraderos y las consecuencias de la pandemia sobre el sueño y su relación entre estrés y trastornos, necesarios para reflexionar sobre la rutina desta población.

Palabras clave: sueño, niños, adolescentes, transtornos del neurodesarrollo.

Como citar: Athanasio BS, Oliveira ACS, Argelaz RL, Silva ACS, Miranda DM. How the COVID-19 pandemic has affected children and adolescents' sleep habits: a systematic review. Debates em Psiquiatria, Rio de Janeiro. 2023;13:1-85. https://doi.org/10.25118/2763-9037.2023.v13.792

Conflito de interesses: declaram não haver

Fonte de financiamento: declaram não haver

Parecer CEP: não se aplica

Recebido em: 14/06/2023
Aprovado em: 16/06/2023
Publicado em: ??/06/2023

Introduction

Habits related to healthy lifestyle behavior have been associated with good quality of life and health outcomes for children and adolescents, among them are listed less exposure to screen time, good eating pattern, and daily activity behavior [1, 2]. Physical and social isolation is a known risk factor for children and adolescents to have emotional problems, sleep habits, and physical activity changes [2]. Bedtime routines are intrinsically related to a good lifestyle and they should be preserved and established for children and adolescents to obtain positive health outcomes [3]. In children, sleep has important characteristics that might be related to health outcomes [4].

Sleep takes a third of the day and is considered a multimodal construct based on information about its duration, bedtimes, latency, awakenings, efficiency, sleepiness, and presence of specific disorders, which modulates the neuronal network and behavior [4]. Therefore, sleep problems might affect attention and other internalizing and externalizing behaviors [5]. Attentional control takes a long time to mature, being susceptible to the effects of sleep deprivation in early life. In the first 24 months of life, sleep problems were related to the presence of inattention and hyperactivity later in the preschool age [6]. Children with neurodevelopmental disorders, such as attention deficit and hyperactivity disorder (ADHD) and autism spectrum disorder (ASD), commonly have sleep disorders [7]. In toddlers with early exposure to screens and in children with neurodevelopmental disorders, sleep reduction has been associated with screen-use and stressful conditions, it seems also to be associated with significantly more sleep problems [8].

In a systematic review, it was established that long hours of sleep in childhood were associated with lower adiposity, better emotional regulation, better academic performance, and higher quality of life [6, 9, 10]. In a meta-analysis, sleep duration showed an association with adiposity and emotional outcomes in children [4]. Functional and behavioral consequences of sleep habits and problems should be understood in longitudinal studies and preferentially combining parental

information about child's sleeping problems, and children's history of sleep added with objective measures of sleep [11] to understand if sleep restriction/extension interventions are necessary [4] to improve health outcomes.

During the pandemic, there is a rupture of families' routines and habits, which might affect attention, memory, learning, and sleep characteristics having the potential to imply long-term consequences [12, 13]. In a meta-analysis about sleep problems during the pandemic, an estimated prevalence of 40% was observed for the general population, with disturbances being highly frequent in children and adolescents [14]. In this study, we have searched the literature aiming to investigate the effects of the COVID-19 pandemic on children and adolescents' sleep habits. To carry out a systematic review on the subject, we have examined data on the effects of the pandemic on sleep duration, bedtime and wake-up time, sleep quality and risk and protective factors for typically developing children as well as the particularities that children and adolescents with neurodevelopmental disorders may present concerning these outcomes.

Methods

This is a systematic review in which the search was carried out by three authors, ACSO, BSA, and RLA, on April 11th, 2022 in three databases: PubMed, Scopus, and Cochrane Library.

This systematic review was registered in OSF under the protocol (https://doi.org/10.17605/OSF.IO/8KXJW) [15] and followed PRIMA guidelines.

Search terms utilized were: (pandemic OR social isolation OR lockdown OR quarantine OR COVID-19 OR SARS-CoV-2) AND (sleep OR insomnia) AND (children OR adolescent OR teen). Search strategies on PubMed, Scopus, and Cochrane Library, respectively were: *(pandemic OR social isolation OR lockdown OR quarantine OR COVID-19 OR SARS-CoV-2) AND (sleep OR insomnia) AND (children OR adolescent OR teen); TITLE-ABS-KEY (pandemic OR social AND isolation OR lockdown OR quarantine OR covid-19 OR sars-cov-2 AND sleep OR insomnia AND children OR adolescent OR teen) "Trials" filter was applied; and pandemic OR social isolation OR lockdown OR quarantine OR COVID-19 OR SARS-CoV-2 in All Text AND*

sleep OR insomnia in All Text AND children OR adolescent OR teen in All Text - (Word variations have been searched).

We searched for observational studies that investigated sleep habits changes during the pandemic, such as case-control, cross-sectional, and cohort studies that addressed changes in sleep patterns in children and adolescents during the COVID-19 pandemic. We included: (1) articles that described sleep habits of healthy children and/or adolescents; (2) articles that described children and/or adolescents with neurodevelopmental disorders (i.e. ADHD and ASD), which were presented separately, since these patients usually might have sleep patterns change.

The exclusion criteria were: (1) articles published in a language other than English, Spanish, or Portuguese; (2) articles that addressed the impact of the pandemic exclusively on adults' sleep habits; (3) articles that not included original data, such as guidelines, editorials; comments, narrative reviews, and systematic reviews; (4) case reports; (5) articles that addressed sleep problems in children with other disorders or diseases rather than neurodevelopmental; (6) duplicates; (7) articles published before 2020; (8) studies that included children and adults, but did not separate data according to age; (9) studies that did not included sleep duration, sleep quality or its association with screen time or physical activity as an outcome.

After excluding duplicates, the remaining articles were initially extracted for the title and abstract screening. Articles that did not fulfill inclusion criteria were excluded, while those found relevant were retrieved for full text read. Disagreements on eligibility were resolved in discussions between the authors. Figure 1 shows the search of the studies.

Main findings of the selected studies were systematically extracted according to a data sheet including information about study quality, sample size, country, study design, age of participants, number of hours of sleep, quality of sleep, main findings, and outcomes. Studies considered eligible were critically evaluated regarding the quality of evidence by using standardized critical appraisal instruments from the Joanna Briggs Institute, according to study design: Checklist for Cohort Studies was used for cohort studies and Checklist For Analytical Cross Sectional Studies, for cross-sectional studies.

Results were presented in regard to the most common outcomes described in the studies (sleep hours, quality and disorders, risk factors) [Table 1] [Figure 1].

Results

The studies varied in ways of assessing sleep hours and sleep quality.

1. Sleep habits

1.1 Hours of sleep

Seventy-four studies screened hours of sleep among children and adolescents, and 52 compared the total of sleep time before and during confinement. Except for the studies with ADHD and ASD individuals, which will be discussed forward, sleep hours ranged from 7.5 to 10.3hrs before, and from 8.5 to 11.01hrs during the pandemic. Thirty six studies reported an increase in sleep hours, three showed no change, four reported a decrease, and nine stated the percentage of "increase", "no change", and "decrease" of sleep hours instead of comparing sleep time before and during confinement [Table 2].

Among the studies that reported an increase in sleep time, thirteen found a significant difference before and during the confinement. One of them reported an increase in sleep time during weekdays (from 9 ± 0.85hrs to 9.26 ± 1.06hrs; p-value = 0.02) and a decrease during weekends (from 9.58 ± 1.3 hrs to 9.53 ± 1.33 hrs; p-value = 0.11) [18], while the other found a significant increase only during the weekend (from 9.4 ± 1.1 to 10.1 ± 1.6; p-value = 0.035) [90]. Another study compared sleep time before, during strict confinement and during relaxed confinement: the authors found higher mean value during strict confinement (9.3 ± 1.6hrs), followed by before confinement (9.1 ± 1.2hrs), and during relaxed confinement (9.0 ± 1.7hrs) [84].

Between the studies that reported a decrease of sleep time, one included ADHD patients only [44], other evaluated babies only [19], and the last did not find a significant difference between sleep time before and during the pandemic (p-value = 0.386) [119]. Among those studies that stated the percentage of "increase", "no change", and "decrease": the percentage of “decrease” of sleep time reported ranged from 5.3% to 17.3%; “increase” from 18.5% to 62%, and “no change” from 40.7% to 70.7% [Table 1].

One study assessed sleeping time among children and adolescents that self-reported change in mental wellbeing, between those who reported a worse mental wellbeing, 42.8% were sleeping slightly less, and between those who reported a better mental wellbeing, 31.5% were sleeping slightly more [124].

1.2 Bedtime and wake up time

Thirty-four studies assessed sleep and wake-up time before and during confinement [17, 18, 24, 26, 38, 41, 48, 52, 61, 62, 72, 79 – 82, 100, 102, 113, 115, 118 – 120, 125, 133, 134, 137]. Ten studies reported delay in sleep and wake-up time mean: delay in bedtime ranged from 15 min to 2h; and in wake-up time, from 12 min to 2h38min [17, 18, 33, 35, 42, 52, 60, 79, 81]. However, only nine found a significant difference in bedtime and/or wake-up time before and during confinement [17, 18, 42, 79, 82, 132], one study did not find [117], and another found a significant difference only on weekdays [52]. One study found haste in sleep and wake-up time, however, subjects were 8.5 ± 4.6 months old [72]. In addition, one study found that the difference in the sleep duration between weekdays and weekends disappeared, while others that assessed the difference did not compare weekdays and weekends, only before and during quarantine [26].

1.3 Sleep quality and sleep disorders

Sixty-two studies have investigated sleep quality and the presence of sleep disorders in children without neurodevelopmental disorders before and during the pandemic. However, only thirty-five have utilized previously validated questionnaires or criteria [Table 3] and six studies did not use or did not report the use of known assessment instruments [25, 50, 52, 80, 92].

The designs of the studies that utilized validated tools to assess sleep time were variable. Twelve studies have provided comparisons between data collected before and after the pandemic, comparing results from two or more cross-sectional studies [17, 18, 24, 36, 41, 62, 76, 79, 82, 101, 119, 147]. Six studies have collected data on sleep behaviors retrospectively, by children or their caregivers about changes in sleep quality before and after the COVID-19 outbreak and home confinement [20, 22, 32, 35, 42, 43, 49, 91, 123]. Ten studies have collected data on children and adolescents' sleep quality and presence of sleep disorders, during the

pandemic without providing comparisons with periods prior to the pandemic [55, 78, 86, 97, 118, 122, 130, 136, 145].

Studies that compared data from two or more cross sectional studies, before and during confinement, differed in assessment tools utilized, as well as in age range studies. Six studies included children below 12 years old [18, 41, 76, 79, 82, 119].

A French study asked 316 mothers of 29 months old children to complete the Sleep Disturbance Scale for Children [148] in 2018 and compared the results with answers to the same questionnaire provided in 2020 as soon as the lockdown ended, by a group of 110 mothers of children matched for sex and age with the first group. In this study, several differences were found before and after the pandemic. The mean SDSC score increased from 35.7 to 42.1 (p>.001), while the proportion of children that scored above the pathologic threshold (>37) increased from 40% before the pandemic to 62% after the pandemic. The frequency of parasomnias have also increased (6.0 vs 7.1; p = .003). This study also measured difficulties of initiating and maintaining sleep, which also increased (15.7 vs 19.8; p > .001) [79].

A Japanese study has followed 513 children from 6 to 11 years old (1st to 6th grade) and utilized Pediatric Daytime Sleepiness Scale (PDSS) [149] to assess self-reported experiences of sleepiness through three surveys conducted in June 2019, January 2020 and June 2020. Scores can range from 0 to 32, with higher scores indicating more daytime sleepiness. In this study, scores of daytime sleepiness decreased in 57% of the students during the school closure period between January 2020 and June 2020. In both time periods, scores were significantly higher in children from 5th and 6th grade when compared to younger ones [18].

Another study has compared data obtained from parents' answers to the interactive sleep awareness application "Nenne Navi" [150], developed by Osaka University. Data were collected from 2017 caregivers of children in March 2019 and from 295 in March 2020. Children were 18 to 30 months old and did not differ in mean age, gender, income or number of siblings. Across the two time periods, the only difference found in terms of sleep status was in sleep latency, which increased in 2020 (21.8 ± 14.9 min vs. 24.1±18.3 min, p= 0.037). No difference was found in sleep irregularity between the two years [119].

A Chinese study has compared answers to the Children's Sleep Habit Questionnaire (CSHQ) [151] given by caregivers of 436 children from 4 to 6 years old in December 2018 with answers of 1619 children ohe same age in February 2020. CSHQ is an instrument used to screen sleep disturbances and a score of >41 is considered a pathologic threshold. This study found that the COVID-19 sample had overall sleep disorders at a significantly lower scale (55.6% vs 77.7%, p<0.001). When compared with the 2018 sample, children from the COVID-19 sample had lower total scores of CSHQ (51.87 vs 44.28, p<0,001) as well as its subscales: bedtime resistance, sleep onset delay, sleep anxiety, and parasomnias were also decreased in the COVID-19 sample [82]. However, a study from Germany with 362 children from 6 to 7 years old, that also utilized CSHQ, did not find any significant difference in sleep quality during the pandemic when compared with before the pandemic [76].

A Spanish study utilized the Brief Infant Sleep Questionnaire (BISQ) in order to assess sleep quality in children from 3 to 36 months old in before (2017-2018, n=1380) and during (March-May of 2020, n= 254). BISQ classifies children as poor sleepers if they present more than three awakenings a night, nocturnal awakenings longer than 1h or a total sleep time in the 24-h period of less than 9 hours. This study found that sleep latency longer than 30 min was more frequent during the pandemic (p<0.001), and also an increase in the proportion of individuals that showed criteria for classifying as poor sleepers during confinement.

Eight studies included children and adolescents above 12 years old. Four of these studies utilized the PSQI scale to assess sleep quality. PSQI is a self-rated questionnaire that aims to evaluate subjective sleep quality in the past month. The total score ranges from 0 to 21, where higher values indicate poorer sleep quality.

A study from China found a decrease of sleep quality during confinement when compared with before confinement [135]. On the other hand, two studies from Brazil and one from Ireland found that sleep quality did not differ for this age range [17, 101, 113]. Another Chinese study, however, found that the prevalence of insomnia symptoms decreased with time [147]. Two studies utilized the School Sleep Habits Survey [24, 125].

In a study from Switzerland, trouble falling asleep and sleeping through the night more than 4 times in the previous 2 weeks were more prevalent in the lockdown group [24].

An Australian study, however, found that daytime sleepiness seems to be reduced during lockdown [125].

A Canadian study that applied actigraphy associated with the Modified Epworth Sleepiness Scale found similar results: daytime sleepiness was reduced, as well as the discrepancy between week and weekend sleep patterns, which is known as social jet lag.

Nine studies have retrospectively collected data on sleep behavior before the COVID-19 outbreak and during home confinement by asking children and adolescents' main caregivers or themselves about changes in their sleep patterns across the two time periods [20, 22, 32, 35, 42, 43, 49, 91, 123]. These behaviors were assessed through different scales.

Four studies have utilized Sleep Disturbance Scale for Children (SDSC) in order to ask children's main caregivers to compare their child's sleep patterns before and after the pandemic [32, 35, 42, 49]. Only two studies have provided SDSC scores, but did not find statistically significant differences between scores or in proportion of children with disturbed sleep before and after home confinement during COVID-19 outbreak. Samples in these studies had 299 and 245 individuals, from 6 to 10 years old and from 2 to 5 years old, respectively [42, 49].

In the two remaining studies, SDSC scores were not provided. One of them found that 46% out of a sample of 253 parents of children aged 3 to 15 years old answered that the child's sleep quality was unchanged [32]. A fourth study, with 4314 Italian caregivers of children and adolescents from 1 to 18 years old, found significant differences in children's sleep when it comes to prevalence of sleep disorders. In this cross sectional study, subjects were analyzed in four age groups: 1-3 (n=1263); 4-5 (893); 6-12 (n=1848); 13-18 (n=310) years old. Main findings included an increase in sleep latency that was observed across all age groups. The three younger groups have also shown an increase in the frequency of nightmares, daytime sleepiness, anxiety at bedtime and in 2 or more night awakenings [35].

Two articles utilized the Pittsburgh Sleep Quality Index (PSQI) [123, 152]. One of them studied the sleep quality of 100 Tunisian children aged 5 to 12 years old and asked participants (children assisted by a caregiver) to compare their current sleep behaviors with those before the pandemic. It has found that home confinement was significantly associated with subjective sleep quality, sleep latency, sleep disturbances and daytime dysfunction ($p<0.001$). Also, girls scored significantly higher than boys in PSQI during confinement, suggesting worse sleep quality among females ($p=0.01$) [20].

Another study, conducted with adolescents from 12 to 21 years old found that home confinement had different effects in different age ranges. While sleep quality of students from 12 to 17 years olds seemed to improve, individuals from 18 to 21 years old reported significant increase in sleep difficulties associated with nightmares [123].

One cross sectional study asked caregivers of 3157 children from 1 to 5 years old living in Chile about their movement behaviors before and after the pandemic and provided, therefore, a retrospective overview. The questionnaire was based in the International Study of Movement Behaviors in the Early Years (SUNRISE), which aims to investigate how physical activity (PA), sedentary behavior (SB), and sleep are associated with child health and development. The original questionnaire was adapted in order to detect changes caused by the COVID-19 pandemic. Results showed a decline of sleep quality in the early phase of the pandemic, mostly in younger children. Children who lived in homes with more square meters per person, who had a smaller decrease in physical activity or had higher income showed better sleep quality [22].

One study from Canada utilized the BEARS scale and found out that, although the proportion of children and adolescents sleeping less than 7 hours per night decreased, the energy level status decreased from 55.4% to 7.7% [91].

An Italian study utilized the Children's Sleep Habits Questionnaire (CSHQ) to study sleep quality of children from 0-5 years old and found out that CSHQ score was unchanged among toddlers and decreased in preschoolers, suggesting improvement in sleep quality [43].

Ten studies have assessed sleep quality and the presence of sleep disorders in children and adolescents during the pandemic, without comparing with time prior to the COVID-19 outbreak [55, 78, 86, 97, 145]. One of them has compared its results with average scores found in the applied test's manual [55, 78, 86, 97, 118, 122, 130, 136, 141, 145].

Two studies utilized the "Sleep Disturbance Scale for Children" (SDSC) to assess sleep disorders. A study with 114 children from 6 to 16 years old. The SDSC scores were found to be significantly higher in girls than in boys. No significant relationship was found between age and SDSC scores [55].

A Spanish study, however, found that confined children under 6 years of age had a higher DIMS score [118]. One study used three questions of the Insomnia Severity Index to compare the presence of sleep problems in 583 adolescents (mean age: 15.8 ± 1.4) with 4326 adults (mean age: 43.6 ± 16.1), and found that the former group was significantly more likely to report sleep problems than the latter (69% vs 57%, $p < 0.001$) [97].

Three studies utilized the Pittsburgh Sleep Quality Index [152] to measure sleep quality in children and adolescents. One study assessed 11,835 teenagers and young adults from 12 to 29 years old, who were separated in three age groups: junior high school, senior high school, and college. In this study, insomnia, sleep disturbance, daytime dysfunction and use of sleep medication were significantly more frequent in older teenagers (senior high school) than younger teenagers (in junior high school) ($p<0.05$). In all groups, the incidence of insomnia symptoms decreased as the perceived knowledge about COVID-19 increased [145].

Another study, with 153 adolescents from 13 to 18 years old from a state capital in Brazil found that 58.2% of the sample reported worsening in their sleep quality. Such worsening was significantly more frequent among females than males (67% vs 44.1%).

Another Chinese study with 10569 adolescents from 12 to 20 years old found that adolescents aged 16 or more reported worse sleep compared with adolescents under 16 years old [141].

One Chinese cross sectional study utilized Youth Self-Rating Insomnia Scales (YSIS) [153] YSIS score ranges from 8 to 40, where a score above 22 indicates the presence of insomnia symptoms. The study included 965

individuals from 15 to 17 years old, where 34.9% of participants reported insomnia [86].

A Spanish cross sectional study with 1028 children and adolescents from 6 to 18 years old utilized the BEARS [154] sleep screening tool in order to detect sleep disorders. BEARS consists of sleep screening instruments that aims to identify sleep problems in the primary care setting through the acronymous: (B=Bedtime Issues, E=Excessive Daytime Sleepiness, A=Night Awakenings, R=Regularity and Duration of Sleep, S=Snoring). Findings were compared with the average scores available in the test's manual, taken from a non-confined population. Results have shown deterioration of children's sleep quality during confinement. Mean BEARS scores were higher in confined children when compared to unconfined ones (13.18 vs 7.4). Besides, 40% of participants obtained an average score in the BEARS test, and approximately 36.4% obtained a high score [78].

A study from Turkey with 1040 children from 6 to 12 years old found that 55% achieved a score above the total CSHQ cut-off score.

A study from Brazil that utilized the Brief Infant Sleep Questionnaire (BISQ) found out that 58.6% of children aged 0 to 3 years old have abnormal BISQ scores, while 56.6% of adolescents had a PSQI global score higher than 5 [136].

The remaining studies that assessed sleep quality and sleep disorders did not utilize previously validated questionnaires or criteria [25, 26, 47, 48, 50–53, 59, 64, 67, 75, 80, 87, 92, 99, 103, 104, 107, 112, 121, 127, 131, 155–157].

2 Risk factors and protective factors to sleep disorders

2.1 Neurodevelopmental disorders: ADHD and ASD

Seventeen included studies that screened sleep patterns of children with neurodevelopmental disorders (NDDs), seven of them included ADHD children and twelve ASD children [Table 4] [Table 5].

A study with 152 parents of children with NDDs showed that 41.9% of children had changed sleep rhythm (late bedtime, late bedtime and late waking time or late-waking time) compared with the pre-COVID-19 pandemic conditions based on parental observation [134].

Another study [36] conducted in Italy with parents of 100 ASD, 236 ADHD and 340 healthy children showed that during lockdown ADHD children tended to have a later bedtime and risetime than ASD and controls, while ASD children tended to maintain similar bedtime and risetime. Anxiety at bedtime, difficulties in falling asleep, and daytime sleepiness increased in all groups during the lockdown. Hypnic jerks, rhythmic movement disorders, night awakenings, restless sleep, sleepwalking, and daytime sleepiness increased in ASD and ADHD patients, in particular. Before and after the lockdown, both clinical groups had a significantly higher percentage of children sleeping less than 7 h, compared with the control group. Generally children and adolescents with ADHD showed greater instability of their sleep schedule and increased delay in weekday sleep schedule, when compared with ASD and controls, during lockdown [36].

Even in normal conditions, sleep disorders are very frequent in children with Attention Deficit Hyperactivity Disorder (ADHD), appearing in 25-50% of cases and being five times more frequent than in TDC children [158]. Thus, it was expected that children with ADHD experience significant difficulties regarding sleep under the COVID-19 pandemic. Becker et al. [33] compared TDC and children with ADHD during the pandemic and verified that adolescents without ADHD had increased school night sleep duration, but adolescents with ADHD did not experience this benefit. In addition, adolescents with ADHD were less likely to obtain recommended sleep duration (8-10 hours) during COVID-19, while 69% of adolescents without ADHD obtained recommended sleep. Only 59% of adolescents with ADHD followed this recommendation. Both groups did not differ on school night or weekend bedtime or rise time either before or during COVID-19.

In addition, no significant effects were reported in the ADHD group regarding chances in initiating/maintaining sleep, delayed sleep/wake behaviors, and daytime sleepiness. Another study conducted in Canada with 587 children (5-18 years old) with ADHD reported that 77.5% had sleeping habits changed during the pandemic, in particular 64.6% reported going to bed later and 44.6% reported waking up later [126]. Rosenthal et al. [110] showed that youth with ADHD had greater sleep problems than matched controls.

A cross-sectional study with 76 children with ADHD and their parents found out that chronotype plays an important role in the negative effects of home confinement of ADHD children during the COVID-19 outbreak [44]. The

eveningness type children (E-type) with ADHD exhibited significantly higher trauma symptoms and sleep problems compared to children with non-E-type ADHD. They experienced more problems related to falling asleep, sleep resistance, parasomnias, and maintaining sleep.

Some hypotheses were that media exposure may be higher and parental control may be less common in E-type Children. Also, the social rhythms of these children at nighttime may increase social isolation during the pandemic period, consequently increasing the traumatic perception and sleep problems. Another study compared a confined ADHD group with an unconfined one [78]. The authors found that the confined group had high levels of state anxiety and problems with sleep and execution functions. Autism Spectrum Disorder (ASD) is often associated with sleep problems [159]. This assumption raised questions whether the pandemic would further alter the sleep of this population.

A Turkish study with a longitudinal design utilized the CSHQ in a cohort of 46 individuals with ASD from 4 to 17 years old reported a statistically significant increase in CSHQ scores during home confinement. This study also assessed participants for their chronotype - preferred sleep-wake schedule of an individual - and found that particularly E-type children exhibited more sleep problems during the confinement period than during the normal (non-home confinement) state. In addition, it was found that sleep problems of the children with ASD during the home confinement period mediated the relationship between chronotype score and severity of autism symptoms [133].

Scarselli et al. [116] reported that twenty-five children among 28 (89.3%) had a score above 41 during the pandemic in the CSHQ, indicating clinically significant sleep disturbances. Of these, 11 children also had clinically significant scores before the pandemic. This study showed that sleep habits in this population seemed to improve or not change significantly during the COVID-19 pandemic in a population with a high prevalence of clinically significant sleep disturbances.

Similarly, a cross sectional study from Turkey with 87 in individuals with ASD from 3 to 29 years old assessed changes of sleep habits with the Pittsburgh Sleep Quality Index (PSQI). It was found that 36% of parents reported a decrease in their children's sleep quality, while 44% reported

sleep changes during the pandemic, when compared with a period prior to the pandemic [98].

A cross sectional study from France asked parents of 240 individuals with ASD from 2 to 21 years old about changes in their children's sleep habits through a 3-point Likert scale (unchanged, improved, worse). In this study, 55.5% reported no changes reported no changes regarding sleep during the confinement due to COVID-19. Nevertheless, greater improvement in sleep was reported for younger subjects (median= 7.0, IQR [4.5–10.0], n = 28), and for those with lower ASD symptom severity. This study also suggests that living in a single-parent family is related to more variability (improvement or worsening) in sleep [34].

A cross sectional study conducted in China from May 12 to May 31, 2020, with 406 parents of ASD children (mean age-4.6), showed that 50.3% reported one or more sleep problems, including difficulty falling asleep (29.3%), waking up at night (14.3%), and difficulty in falling asleep again after waking (16.5%) [65].

A study from Israel with 25 children with ASD after one month of lockdown reported that many children found it difficult to fall asleep and/or suffered from frequent awakenings and night terrors [77]. A study conducted with 111 parents of children and adolescents with ASD [13] showed that the lockdown changed significantly the bedtime on weekdays in 57.8% of participants with ASD (56.9% delayed; 0.9% advanced) and the rise time in 69.2% (61.7% delayed and 7.5% advanced). Sleep duration varied on weekdays in 49.1% (24.1% increased; 25% decreased). During the lockdown, participants with ASD showed a significant increase of sleep disturbances, compared to the preceding period, especially falling asleep (35.1% vs 22.5%), anxiety at bedtime (22.5% vs 10.8%), sleep terrors (5.4% vs 0%), and daytime sleepiness (14.4% vs 3.6%).

Two studies corroborate with these data, one conducted in Bangladesh with 150 children with ASD [106], and another conducted with thirty children with ASD in India [74], both of them showed that sleep disturbance during lockdown time.

Finally, one study conducted in the United States with 9 adolescents (14-19 years) with ASD reported no changes in sleep duration when comparing before and during the pandemic [58].

2.2 Physical activity

Seven of the included studies have analyzed the relationship between physical activity and sleep during home confinement. One study found that participants with high physical activity time were less likely to present insomnia symptoms [86]. Corroborating this data, a study conducted in China [142] with 1355 children showed that children's physical activity was negatively related to children's insomnia.

Another study with similar results found that adolescents who reported exercise were less likely to have parent-reported difficulties to initiate and to maintain sleep, as well as self-reported delayed sleep/wake behaviors [33].

A study that investigated the importance of establishing routines and schedules found that this behavior was associated with more time of daily physical activity, while the absence of schedules was related to longer sleep duration and longer screen time [39]. A single study found that exercise was associated with decrease of sleep duration [33, 39, 81]. A study conducted across different continents [71] related "less physical activity" to both increased (p=0.1) and decreased (p=0.02) sleep duration on weekends as compared to no change, but not on weekdays [76].

2.3 Screen time

When it comes to the effect of screen time in sleep quality or sleep duration, seventeen studies have analyzed the relationship between these variables, in spite of reporting them in heterogeneous ways. Positive and negative correlations between screen time and sleep were found in different articles.

Two studies, one of them with 20967 children from 6-16 years old [108] and another with 251 adolescents and young adults from 14 to 24 years old [25] found an increase in hours of sleep as well as an increase in use of digital screens.

A study from India with 153 children and adolescents from 8 to 16 years old has asked participants about their time of exposure to screens on weekdays and on weekends before and during lockdown. Results suggest that screen exposure time during lockdown was similar to screen exposure time during weekends before lockdown, which is typically higher than on weekdays. Regarding sleep duration, participants reported an increase in

sleep duration during lockdown on weekdays and on weekends when compared to period prior to the lockdown. Also, before lockdown sleep duration on weekends was longer than on weekdays [52]. Other studies reported negative correlations between hours of sleep and screen time.

A study from Spain with 437 children from 0 to 12 years old found an indirect association between daily use of digital screens and hours of sleep per day (r = -0,395, p=0,01) [39].
In another Spanish study with 437 children from 0 to 5 years old, daily sleeping hours were indirectly related to time expend in exposed to video game consoles (r = -.173; p<0.01), television (r = -.308; p<0.01), and tablets (r = -.231; p<0.01). No statistically significant correlation was found for personal computers [30].

A study from Singapore with 593 children and adolescents from 3 to 16 years old has measured non academic screen time instead of total screen time, and compared it during and before the confinement period. Results show a negative correlation between non-academic screen time and sleep duration before confinement ($r^2 = -0.41$; p<0.01) and after ($r^2 = -0.34$; p<0.01) [81].

A study conducted in Lebanon with children between 3-7 years old showed that screen time of ≥2 h in children was associated with sleep problems [73]. Children with ≥2 h of screen time had higher scores in the Children Sleep Habit Questionnaire-Abbreviated (CSHQ-A) (NICHD SECCYD-Wisconsin) compared with children with <2h of screen time on smartphones (p=0.008) and TV/PlayStation/Xbox (p= 0.021). Concerning sleep behavior, this study reported that children using smartphones and TV/PlayStation/Xbox for more than 2 h were more prone to sleep problems.

Additionally, sleep disturbance in children was significantly correlated with the possession of their own electronic devices. Approximately 60% of children with sleep problems had their own electronic devices [73]. A survey across different continents reported that more time on social media was significantly associated with decreased sleep duration on weekends [71].

A Chinese study with 1355 children demonstrated that screen time was positively associated with insomnia [142]. Other Chinese study associated

spending time on electronics with higher odds of having poor sleep quality [141].

Ratifying this data, a study conducted in Italy showed that screen time and an increase in the time spent watching television negatively influenced sleep habits and attention in children between 6-10 years old [104]. Windiani et al. also reported an association between screen time and sleep disorders that occur in adolescents during the COVID-19 pandemic era [139]. In addition, the prolonged use of smartphones for leisure is negatively linked to sleep quality (SQ) [131]. Despite the data presented, other studies found no correlation between screen time and sleep.

A study conducted in Brazil reported that the vast majority of the children (93.5%) answered they used their cell phones before sleeping, but there was no association with sleep quality [122]. Argiansya et al. conducted a study with 157 participants of 14 to 17 years old and found out that most adolescents have used electronic media for more than 6 years with a median use of 10 hours per day for non educational purposes [28]. Despite findings that most of them experience sleep disturbances, there was no statistically significant association between electronic media use and sleep disturbances in adolescents.

Discussion

In this review, we have searched the literature to investigate the impact of the COVID-19 pandemic on children and adolescents' sleep habits. Besides the effort to understand about the children and adolescents sleep, one limitation of our study is that many of the included studies that compared sleep patterns before and during the pandemic are subject to memory bias, since they asked participants or their caregivers about perceived changes in sleep habits without any objective measure to assess in the different timepoints. Another limitation is that most of the included studies had a cross-sectional design and did not provide comparisons with periods before home confinement limiting the observation of change.

Hours of sleep and bedtime and wake up time

The majority of studies that screened sleep hours had a cross-sectional design and did not compare hours of sleep before and during the pandemic. Among the ones that did compare (20 studies), only four had a longitudinal design, and four were cohort studies [Table 2].

Despite the methodology heterogeneity and the potential memory bias, most studies reported an increase in sleep hours and delay in bedtime and wake-up time, showing a change in circadian rhythm. Changes in rhythm are commonly studied in health professionals and are associated with health and cognitive impairment [160, 161], however in adolescents it seems to be one more transitional feature. Adolescents usually tend to sleep and awake later as observed in 5,308 Switzerland students who approved the late start of morning classes to preserve the sleep hours and biology [162, 163]. However, the late bedtime in adolescents might be associated with more emotional and behavioral difficulties [164].

Sleep quality and sleep disorders

When it comes to the analysis of sleep quality before and after the pandemic in typically developing children, one important limitation was the difference between scales utilized in different studies. In fact, many of the included articles did not use or did not report having applied a previously validated questionnaire to assess sleep quality or the presence of sleep disorders. Besides, none of them have utilized a direct tool of measurements, such as actigraphy.

Also, only thirty three studies available in the literature have utilized previously validated questionnaires in order to carry out an analysis of children and adolescents' sleep quality and frequency of sleep disorders before and after home confinement. Nine of them had a retrospective design and five of them found that home confinement had a negative impact on sleep quality [20, 22, 35]. It is worth mentioning that two of these studies had the highest sample sizes among included articles with a retrospective design, which may enhance the probability of an informative sample about population condition. However, an important limitation of this group of studies is that they are, due to their retrospective design, subject to memory bias.

There is an evaluation of 17000 children and adolescents in lockdown in England showing most had worsening in quality of life and mental health, but for about 33% there was an improvement in sleep, academic performance, physical exercises and relationships. Our findings combined with this study suggest the sleep changes might be a symptom of more complex features such as the routine and wellbeing [124].

Fourteen studies have provided data from cross sectional studies before and after quarantine. Studies with higher samples suggest an overall worsening in sleep quality of typically developing children and adolescents. However, daytime sleepiness seems to have decreased during home confinement, which may be explained by changes in schools' schedules.

Neurodevelopmental disorders

Compared to typically developing children (TDC), children with neurodevelopmental disorders (NDDs) are more likely to suffer mental and physical difficulties during a disaster, such as a pandemic, because of the unpredictable changes and alterations of routines [165–167].

Attention Deficit Hyperactivity Disorder

The available literature on ADHD children and adolescents shows that this population is more vulnerable to the negative impact of the pandemic on their sleep habits: they were found to be less likely to obtain recommended sleep duration during COVID-19 compared to non-ADHD children [33], and they scored poorly on BEARS compared to non-ADHD children [12].

However, the available studies vary not only in methodology, but mainly on objectives: one of them compared ADHD and non-ADHD children during the pandemic [12], the second ADHD and non-ADHD before and during the pandemic [33], other the reaction of chronotypes on ADHD children during the pandemic [44], and finally the ADHD childrens' response during the confinement [168]. Therefore, more robust studies are needed to access ADHD children and adolescents' sleep patterns in reaction to the pandemic.

Autism Spectrum Disorder

So far, available literature on this subject suggests that children and adolescents with ASD may exhibit changes in their sleep patterns, such as overall decrease in sleep quality, increased bedtime resistance and sleep latency [34, 58, 65, 98, 133].

However, studies conducted with more robust methods and larger sample sizes are still needed in order to confirm this hypothesis. Few studies have assessed sleep habits in this population and most of them have not assessed these habits and the presence of sleep disorders with a validated scale or questionnaire, which may compromise comparison between studies. Besides, most of the included studies did not report diagnostic criteria utilized and inclusion criteria for patients with ASD, which may also

be a source of bias. Finally, most of the included studies, except for two of them [58, 133], had a cross sectional design, and asked patients' caregiver or themselves to compare their perceived sleep quality before and after the confinement period, and are, therefore, subject to memory bias.

Physical activity

Results of the included studies, although limited, seem to reinforce the importance of physical activity in the regulation of sleep duration and sleep quality. Children and adolescents that exercised during home confinement were found less likely to present insomnia symptoms [86], decreased sleep latency [33] and longer sleep duration [39]. Only one of included studies found that exercise was associated with decrease in sleep duration, but this effect may be explained by the increased number of children doing none exercise and the reduced amount of exercise done during confinement [81].

Screen time

Since school closure has forced children and adolescents to study from home, mostly through online classes, increase in screen time was an expected finding. Also, home confinement and limitation to leisure outdoor activities probably favored an increase in time spent in front of digital screens.

However, available evidence is not consistent when it comes to the effect such an increase had on sleep duration. While some studies have shown an increase in both screen time and sleeping hours [25, 52, 108], other studies found a negative correlation between these variables [30, 39, 81]. It is also worth mentioning that in future studies a qualitative analysis of how screen time is spent may be useful, since increase in screen time may be due to activities related to online classes or to internet gaming or social media usage, for instance.

Limitations of this systematic review

This systematic review has several limitations. First, the selected studies are very heterogeneous, since they have utilized different tools in order to assess changes in sleep habits of children and adolescents. In fact, measurement bias occurred in several studies, as many of them did not use previously validated standardized measurement tools for assessment of these outcomes, which may limitate the validity and reliability of these studies' findings. The quality assessment revealed selection bias in many

studies, since many of them did not make clear their inclusion and exclusion criteria, as displayed in Table 1. Finally, the exceptionality of the circumstances of the pandemic hindered in many cases the presence of appropriate, matched control groups, which explains the inclusion of articles that analyzed change in children and adolescents' in studies with retrospective designs that are, therefore, subject to recall bias.

Conclusion

In conclusion, childrens and adolescents' sleep was affected directly and indirectly by the pandemic. There are plenty of controversies but the most important problem in children and adolescents about sleep during the pandemic was not the number of hours but the increase in disorders related to sleep and the sleep rhythm changes. The detailed view about sleep habits might shed light on long-term consequences related to the pandemic and the sleep relationship with stress and disorders which deserves attention to rethink the youths' routine.

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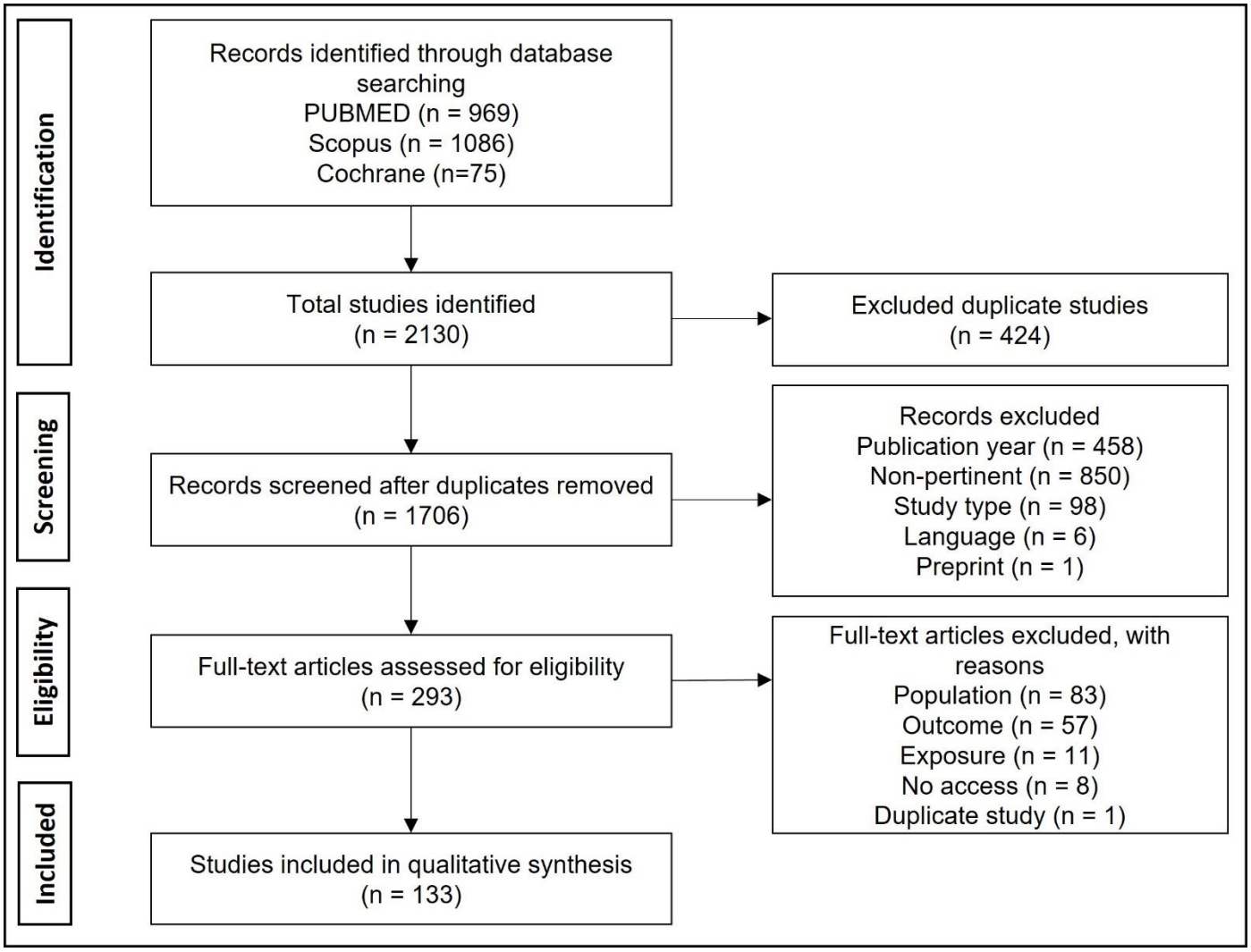

Figure 1. Flowchart of Search

https://doi.org/10.25118/2763-9037.2023.v13.792

Table 1. Critical appraisal of included studies according to JBI critical appraisal instruments

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	S
Cohort												
[15]	Y	Y	Y	Y	N	U	Y	Y	U	U	Y	7
[16]	N	Y	Y	Y	N	Y	Y	Y	Y	N	Y	8
[17]	Y	Y	Y	N	N	Y	Y	Y	Y	N	Y	8
[18]	Y	U	Y	Y	N	N	Y	Y	N	N	Y	6
Cross Sectional												
[19]	N	N	N	Y	Y	N	Y	Y	N/A	N/A	N/A	4
[20]	N	Y	Y	Y	Y	Y	N	Y	N/A	N/A	N/A	6
[21]	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	8
[22]	Y	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[23]	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	8
[24]	Y	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	6
[25]	Y	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[26]	Y	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	6
[27]	N	N	Y	Y	N	N	N	N	N/A	N/A	N/A	2
[28]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[29]	N	N	Y	Y	N	N	N	Y	N/A	N/A	N/A	3
[30]	Y	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	5
[31]	Y	Y	N	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[32]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	5
[33]	Y	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	6
[34]	N	Y	N	Y	Y	N	Y	Y	N/A	N/A	N/A	5
[35]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[13]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[36]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[37]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[38]	N	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	4
[39]	Y	Y	N	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[40]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[41]	N	Y	Y	Y	Y	Y	N	Y	N/A	N/A	N/A	5
[42]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[43]	Y	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	7
[44]	N	Y	N	Y	Y	N	N	Y	N/A	N/A	N/A	4
[45]	Y	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	7
[46]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[47]	Y	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	5
[48]	N	N	Y	Y	N	N	N	Y	N/A	N/A	N/A	2
[49]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[50]	Y	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[51]	N	N	Y	Y	Y	N	N	Y	N/A	N/A	N/A	4

https://doi.org/10.25118/2763-9037.2023.v13.792

[52]	Y	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	5
[53]	Y	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	7
[54]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[55]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[56]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[57]	Y	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	0
[58]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[59]	N	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5
[60]	N	N	Y	Y	Y	N	N	Y	N/A	N/A	N/A	4
[61]	N	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	4
[62]	Y	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	5
[63]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[64]	N	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5
[65]	Y	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	6
[66]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[67]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[68]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[69]	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	8
[70]	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	8
[71]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[72]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[73]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[74]	N	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	4
[75]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[76]	Y	Y	Y	Y	N	N	N	N	N/A	N/A	N/A	4
[77]	Y	N	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[78]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	0
[79]	N	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5
[80]	Y	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	6
[81]	N	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	7
[82]	Y	N	Y	Y	N	N	N	Y	N/A	N/A	N/A	4
[83]	N	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5
[84]	N	N	Y	Y	N	N	N	Y	N/A	N/A	N/A	2
[85]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[86]	N	Y	Y	Y	Y	Y	N	Y	N/A	N/A	N/A	6
[87]	N	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	7
[88]	N	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	7
[89]	Y	N	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5
[90]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[91]	Y	N	Y	Y	Y	Y	N	Y	N/A	N/A	N/A	6
[92]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[93]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[94]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[95]	N	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5

https://doi.org/10.25118/2763-9037.2023.v13.792

[96]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[97]	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	8
[98]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[21]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[99]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[100]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[101]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[102]	N	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5
[103]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[104]	N	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	4
[105]	N	Y	Y	Y	Y	N	N	Y	N/A	N/A	N/A	5
[106]	N	Y	Y	Y	N	N	N	N	N/A	N/A	N/A	3
[107]	N	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	4
[108]	N	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	4
[109]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[110]	Y	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[111]	N	Y	Y	Y	N	N	N	Y	N/A	N/A	N/A	4
[112]	N	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	7
[113]	Y	N	Y	Y	N	N	N	Y	N/A	N/A	N/A	0
[114]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[115]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[116]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[117]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[118]	N	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	4
[119]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[120]	N	N	Y	Y	Y	N	N	Y	N/A	N/A	N/A	0
[121]	Y	N	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[122]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[123]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[124]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[125]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[126]	Y	Y	Y	Y	Y	Y	N	Y	N/A	N/A	N/A	7
[127]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[128]	N	Y	Y	Y	N	N	N	N	N/A	N/A	N/A	3
[129]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[130]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[131]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[132]	Y	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[133]	Y	N	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[134]	Y	Y	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	8
[135]	N	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	5
[136]	N	Y	Y	Y	Y	Y	N	Y	N/A	N/A	N/A	6
[137]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[138]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6

[139]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[140]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[141]	Y	Y	Y	Y	N	N	Y	Y	N/A	N/A	N/A	6
[142]	N	Y	Y	Y	Y	N	N	N	N/A	N/A	N/A	4
[143]	Y	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	7
[144]	N	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	6
[145]	Y	Y	Y	Y	Y	N	Y	Y	N/A	N/A	N/A	7

For cohort studies:
Q1 = Were the two groups similar and recruited from the same population?; **Q2** = Were the exposures measured similarly to assign people to both exposed and unexposed groups?; **Q3** = Was the exposure measured in a valid and reliable way?; **Q4** = Were confounding factors identified?; **Q5** = Were strategies to deal with confounding factors stated?; **Q6** = Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?; **Q7** = Were the outcomes measured in a valid and reliable way?; **Q8** = Was the follow up time reported and sufficient to be long enough for outcomes to occur?; **Q9** = Was follow up complete, and if not, were the reasons to loss to follow up described and explored?; **Q10** = Were strategies to address incomplete follow up utilized?; **Q11** = Was appropriate statistical analysis used?
For cross sectional studies:
Q1 = Were the criteria for inclusion in the sample clearly defined?; **Q2** = Were the study subjects and the setting described in detail?; **Q3** = Was the exposure measured in a valid and reliable way?; **Q4** = Were objective, standard criteria used for measurement of the condition?; **Q5** = Were confounding factors identified?; **Q6** = Were strategies to deal with confounding factors stated?; **Q7** = Were the outcomes measured in a valid and reliable way?; **Q8** = Was appropriate statistical analysis used?

Table 2. Children and adolescent' sleep hours before and during confinement

Reference	Country	Study design	Sample Size	Age [mean ± SD / range]	Sleep hours		
					Before Confinement	During Confinement	p-value
[89]	Spain	Cross-sectional	291/112 (before/during confinement)	12.0 ± 2.6yrs	Weekday = 9.1 ± 0.9hrs Weekend = 9.4 ± 1.1	Weekday = 9.9 ± 1.2hrs Weekend = 10.1 ± 1.6	p-value = 0.431 p-value = 0.035
[57]	USA	Cohort	9 (ASD)	14-19yrs	Weekday = 8.72 ± 1.77hrs Weekend = 9.47 ± 2.03 hrs	Weekday = 9.36 ± 1.5hrs Weekend = 10 ± 1.37 hrs	p-value = 0.16 p-value = 0.2
[138]	China	Cross-sectional	20082	17,5 ± 1,2yrs	Workdays = 8.0 [7.0, 9.0] Weekend = 8.4 [7.5, 10.0]	Workdays = 8.0 [7.0, 9.3] Weekend = 8.5 [7.5, 10.0]	- -
[81]	China	Cross-sectional	1619	4-6yrs	Weekday = 9.47 ± 0.63hrs Weekend = 9.88 ± 0.78hrs	10.38 ±1.05	- -
[83]	Spain	Cross-sectional	860	9.6 ± 3.9yrs	9.1 ± 1.2hrs	During Strict Confinement = 9.3 ± 1.6hrs During Relaxed Confinement = 9.0 ± 1.7hrs	-
[21]	Chile	Cross-sectional	3157	1-5yrs	10.92 ± 1.80hrs	11.01 ± 1.86hrs	p-value = 0.001

https://doi.org/10.25118/2763-9037.2023.v13.792

[15]	Spain	Cohort	21	4-6yrs	9.51 ± 0.74hrs	9.54 ± 1.30hrr	p-value = 0.914
[59]	Israel	Cross-sectional	382	5-11yrs	8.56 ± 0.79hrs	9.17 ± 0.72hrs	p-value < 0.001
[19]	Tunisia	Cross-sectional	100	5-12yrs	8.72 ± 0.85hrs	8.73 ± 0.87hrs	p-value = 0.97
[118]	Japan	Cross-sectional	295 (March 2019) 2017 (March 2020)	23.8 ± 3.8mths (March 2019) 24.2 ± 3.8mths (March 2020)	11.44 ± 0.71hrs	11.39 ±0.72hrs	p-value = 0.386
[78]	France	Longitudinal study	92	29.6mths (mean)	10.3 ± 0.9hrs	10.9 ± 1.5hrs	p-value < 0.001
[119]	Israel	Longitudinal study	36 (mele)	11.5 ± 0.9yrs	8.4 ± 0.6hrs	8.5 ± 0.7hrs	p-value > 0.99
[82]	USA	Cross-sectional	19	57 ± 10mos	594.8 ± 37.1min	622.3 ± 36.4min	p-value = 0.006
[114]	Norway	Cross-sectional	2022	16.5 ± 1.1yrs	6.7 ± 1.45hrs	7.46 ± 1.63hrs	p-value = 0.49
[65]	Japan	Longitudinal study	301	3.6 ± 0.3yrs	1285.2 ± 38.0min	1287.9 ± 37.4min	p-value=0.541
[16]	Brasil	Longitudinal study	94	16.4 ± 1.1yrs	7.4 ± 1.1hrs	7.4 ± 1.1hrs	p-value = 0.92
[132]	Turkey	Cross-sectional	46 (ASD)	4-17yrs	3.23 ± 0.79hrs	4.23 ± 1.47hrs	-

[41]	Italy	Cohort	299	6-10yrs	9.73 ± 0.05hrs	10.21 ± 0.05hrs	-
[16]	Brazil	Longitudinal study	94	14-18yrs	7.4 ± 1.1hrs	7.4 ± 1.1hrs	-
[51]	India	Cross-sectional	153	8-16yrs	7.5hrs	8.5hrs	-
[71]	USA	Cohort	1518	8.5 ± 4.6mos	9.3 ± 0.08hrs	9.9 ± 0.07hrs	
[19]	Tunisia	Cross-sectional	100	8.66 ± 3.3yrs	8.78 ± 0.95hrs	8.71 ± 0.93hrs	
[69]	Mexico	Cross-sectional	631	3.3 ± 0.1yrs	13.8hrs [13.8, 13.9]	13.6hrs [13.5, 13.7]	
[61]	Canada	Longitudinal study	62	13.38 ± 1.3yrs	9.12 ± 1.44hrs	10.03 ± 1.44hrs	
[99]	Hong Kong	Longitudinal study	25	4.4 ± 0.3yrs	580min	627min	
[87]	New Zealand	Cross-sectional	146	16.6 ± 0.7yrs	9.0hrs	9.8hrs	
[34]	Italy	Cross-sectional	4314	1-3yrs = 1263 (29.3%) 4-5yrs = 893 (20.7%) 6-12yrs = 1848 (42.8%) 13-18years = 310 (7.2%)	1-3yrs 7-8hrs = 52.87% 5-6yrs 7-8hrs = 64.94% 6-12yrs 7-8hrs = 60.99% 13-18yrs 6-7hrs = 56.31%	1-3yrs 8-9hrs = 35.32% 5-6yrs 8-9hrs = 39.29% 6-12yrs 8-9hrs = 42.85% 13-18yrs 8-9hrs = 44.55%	-

[26]	Greece	Cross-sectional	397	2-18yrs	8h = 15.4% 8–10h = 71.3% >10h = 13.3%	8h = 4.8% 8–10h = 71.0% >10h = 24.2%	-
[17]	Japan	Longitudinal study	687	6–7yrs	Weekdays Jun19 = 9 ± 0.85hrs Weekends Jun19 = 9.58 ± 1.3hrs	Weekdays Jan20 = 9.16 ± 0.86hrs Jun20 = 9.26 ± 1.06hrs Weekends Jan20 = 9.66 ± 1.25hrs Jun20 = 9.53 ± 1.33hrs	p-value = 0.02 p-value = 0.11
[86]	Poland	Cross-sectional	1016	10.51 ± 2.13yrs	Weekdays = 8.83 ± 1.64hrs Weekend = 10.11 ± 1.45hrs	Weekdays = 8.55 ± 1.17hrs Weekend = 9.52 ± 1.36hrs	p-value = 0.0009 p-value < 0.0001
[122]	Canada	Cross-sectional	498	18.17 ± 3.72yrs	Weekdays = 7:42 ± 1:25 Weekends = 9:06 ± 1:41	Weekdays = 8:44 ± 1:32 Weekends = 9:10 ± 1:40	
[94]	Slovenia	Cross-sectional	62	11.6 ± 1.5yrs	Weekday = 533.0 ± 57.0min Weekend = 594.0 ± 74.9min	Weekday = 461.4 ± 130.9min Weekend = 516.0 ± 139.3min	
[23]	Switzerland	Case-control	8972	15-17yrs	Scheduled days = 7.75hrs [7.08, 8.33] Free days = 9.50hrs [8.50, 10.50]	Scheduled days = 9.00hrs [8.25, 9.75] Free days = 9.75hrs [9.00, 10.50]	

[101]	Australia, Bangladesh, China, Hong Kong, India, Indonesia, Malaysia, Morocco, Pakistan, Spain, Sri Lanka, Sweden, USA, and Vietnam	Longitudinal study	948	4.4 ± 0.6/5.2 ± 0.6yrs	Proportion of children meeting sleep guideline = 84.2%	Proportion of children meeting sleep guideline = 79.3%	p-value = 0.055

https://doi.org/10.25118/2763-9037.2023.v13.792

[18]	65% European, 0.3% Asian, 0.3% North African, 0.8% North American, 0.1% Central merican, 2% South American, 0.9% Slavic and 0.3% Middle Eastern	Longitudinal study	452 babies 412 preschool children	Babies = 1.5 ± 0.8yrs 0-35mths Preschool children = 4.5 ± 1yrs 36-71mths	-	Shortening of sleep duration (by 6 ± 53 min) during the confinement in comparison to the time before.	-
[80]	Singapore	Cross-sectional	593	3-16yrs	-	Weekdays = 9.01 ± 1.18hrs Weekends = 9.99 ± 0.94hrs	- -
[145]	Israel	Cross-sectional	264	31.27 ± 17.39mths 6–72mths	-	10.33 ± 1.34hrs	-
[39]	Canada	Cross-sectional	310	18 months-5yrs	-	10.9 ±0.7hrs	-
[29]	Spain	Cross-sectional	280	0-4yrs	-	10.73 ± 1.72hrs	-

[131]	Hong Kong	Cross-sectional	29202 families	2-12yrs	-	10.76 ± 1.08hrs 2–5yrs = 10.83 ± 0.93hrs 6–12yrs = 10.87 ± 0.88hrs	-
[44]	India	Cross-sectional	313	7-17yrs	-	7–17yrs = 7.91hrs [7.77, 8.11] 18–22yrs = 7.94hrs [7.82, 8.06] 23–59yrs = 7.51hrs [7.28, 7.73] 7–59yrs = 7.87hrs [7.77, 7.96]	-
[64]	China	Cross-sectional	406 (ASD)	4.6 ± 2.3yrs	-	9.6 ± 1.3hrs Increase = 18.5% No change = 70.7% Decrease = 10.8%	-
[38]	Spain	Cross-sectional	837	0-12yrs	-	Boy = 9.82 ± 1.48hrs Girl 10.04 ± 1.53hrs	p-value = 0.033
[143]	China	Cross-sectional	4805 (female)	11–18yrs	-	<6hrs = 4.5% 6–8hrs = 59.4% >8hrs = 36.1%	-
[142]	China	Cross-sectional	2010 (738 students, 1062 parents (or guardians), and 210 techers)	11.0 ± 1.7yrs	-	<7hrs = 7.1% 7–8hrs = 29.7% 9–10hrs = 53.4% >10hrs = 9.6%	-

[107]	Iran	Cross-sectional	20697	13.76yrs (mean)	-	<5hrs = 13.4% 6-8hrs = 13% 9-10hrs = 2.8% 11-12hrs = 7.3% >12hrs = 53.5%	-
[27]	Colombia	Cross-sectional	1139	1-17yrs	-	<8h = 11.7% 9-10h = 58.9% 10-13h = 15.7% >13h = 13,7%	-
[143]	China	Cross-sectional	11835	12-29yrs	-	Junior high school <7hrs = 22.7% 7-9hrs = 66.4% >9hrs = 10.9% Senior high school <7hrs = 50.1% 7-9hrs = 47.0% >9hrs = 2.9% College <7hrs = 27.7% 7-9hrs = 63.2% >9hrs = 27.4%	-

[30]	Italy	Cross-sectional	2361	0-12yrs	-	Age 0-2 years <7h = 8.8% 7-9h = 55.9% 9-11h = 35.3% >11h = 0 Age 3-5 <7h = 3.0% 7-9h = 37.4% 9-11h = 57.1% >11h = 2.5% Age 6-12 years <7h = 2.3% 7-9h = 45.2% 9-11h = 50.6% >11h = 2.0%	-
[91]	Canada	Cross-sectional	1472	5-17yrs	-	5-11yrs Decrease = 8.7% Increase = 27.1% 12-17yrs Decrease = 5.3% Increase = 54.0%	-
[139]	Turkey	Cross-sectional	309	9-12yrs	-	Increased = 46.4% Decrease = 7.5%	-
[56]	Italy, Spain and Portugal	Cross-sectional	1480	3-18yrs	-	During weekdays significantly increased	p-value < 0.001
[84]	Spain and Brazil	Cross-sectional	1099	3–17yrs	-	Sleep duration was higher during the COVID-19 lockdown	p-value < 0.001

[110]	Japan	Cross-sectional	78 (School closure group) 113 (School reopening group)	11.4 ± 1.7yrs (School closure group) 11.6 ± 1.8yrs (School reopening group)	-	62% increased hours of sleep	-
[25]	USA, UK, Australia, Canada, Israel, Germany, France, Ukraine, Russia, India, Uzbekistan	Cross-sectional	3078 adolescents (total sample was 14000)	15-18yrs	-	The total sleep time increased in duration up to 910 ± 116 to the end of the quarantine/stay-at-home	p-value = 0.02
[93]	Canada	Cross-sectional	1568	5-17yrs	-	Proportion of children meeting sleep guideline on Oct 2020: 5 to 11yrs = 54.9% 12 to 17yrs = 59.5%	
[146]	China	Longitudinal study	831	15.87 ± 0.74yrs	-	Wave 1 = 6.73 ± 0.05hrs Wave 2 = 7.18 ± 0.06hrs	

						Wave 3 = 6.70 ± 0.06hrs	
[124]	Australia	Longitudinal study	58	12.8 ± 0.4yrs	-	Increase of 22 ± 10min in sleep duration	p-value < 0.0001
[168]	Bangladesh	Cross-sectional	64	4.5 [4.4, 4.7]	-	Proportion of children meeting sleep guideline = 59.7%	
[67]	Wales	Cross-sectional	6214	10.7 ± 2.39yrs	-	Increase = 78.97%	
[62]	China	Cross-sectional	10416	13.0yrs [10.0, 16.0]	-	Increase = 35.7% No change = 47.5% Decrease = 16.8%	
[36]	Poland	Cohort study	3000	3-5yrs	-	Increase in sleep duration of 10-18%	
[90]	Egypt	Cross-sectional	672	6-18yrs	-	Increase = 50% No change = 31.8% Decrease = 18.2%	
[20]	Turkey	Cross-sectional	597	7-13yrs	-	34.2% of the parents reported an increase in sleep as a result of lockdown due to the pandemic	-

[70]	Asia, Europe, Middle East, North America, South America and Oceania	Cross-sectional	845	3-17yrs	-	Weekdays Decrease = 15.4% No change = 43.0% Increase = 24.0% Missing = 17.6% Weekends Decrease = 17.3% No change = 46.2% Increase = 15.9% Missing = 20.7%
[84]	Brazil	Cross-sectional	495	10.7 ± 4.3yrs	-	9.84 ± 1.34hrs
[120]	Greece	Cross-sectional	482	8.1 ± 2.2yrs	-	10.5 ± 1.2hrs
[136]	USA	Cross-sectional	590	15 ± 1.9yrs	-	8.2 ± 1.5hrs
[21]	Chile	Cross-sectional	1727	2.9 ± 1.36yrs	-	Overall chance, mean ± (SD) = 0.03 ± 1.62hrs
[134]	China	Cross-sectional	1952	13.56 ± 1.46yrs	-	Significant worsening of sleep duration (OR = 1.47, 95% CI = 1.35, 1.60)

[35]	Italy	Cross-sectional	100 ASD 236 ADHD 340 controls	4-18yrs	ADHD <7hrs = 11.5% 7–8hrs = 27.2% 8-9hrs = 40% 9–10hrs = 17% >10hrs = 4.3% ASD <7hrs = 11.2% 7–8hrs = 36.7% 8–9hrs = 28.6% 9–10hrs = 18.4% >10hrs = 5.1% Controls <7hrs = 4.7% 7–8hrs = 24.4% 8–9hrs = 40% 9–10hrs = 21.8% >10hrs = 9.1%	ADHD <7hrs = 12.8% 7–8hrs = 18.8% 8-9hrs = 37.6% 9–10hrs = 23.5% >10hrs = 7.3% ASD <7hrs = 20.2% 7–8hrs = 24.2% 8–9hrs = 29.3% 9–10hrs = 20.2% >10hrs = 6.1% Controls <7hrs = 5.9% 7–8hrs = 16.5% 8–9hrs = 38.9% 9–10hrs = 25.7% >10hrs = 13%	
[32]	USA	Cohort	122 (58 ADHD)	15-17yrs	School night 7.7hrs (mean) <8h = 42.9% 8–10h = 57.1% ≥11h = 0.0% Weekend 9.2hrs (mean) <8h = 11.7%	School night 8.1hrs (mean) <8h = 33.3% 8–10h = 64.1% ≥11h = 2.6% Weekend 9.2hrs (mean) <8h = 14.5%	p-value = 0.004 p-value > 0.05

					8–10h = 73.3% ≥11h = 15.0%	8–10h = 70.1% ≥11h = 15.4%	
[43]	Turkey	Cross-sectional	76 (ADHD)	10.09 ± 2.23yrs 8-12yrs	-	Eveningness type = 4.44 ± 1.54hrs Non-eveningness type = 3.61 ± 1.05hrs	-

ASD: Autism Spectrum Disorder
ADHD: Attention Deficit Hyperactivity Disorder

Table 3. Children and adolescent' sleep quality and sleep disorders before and during confinement

Reference	Country	Study design	Informant	Assessment tool for sleep quality and sleep disorders	Sample size	Age (mean)	Main findings
[78]	France	Compared two or more cross sectional studies, before and during the pandemic	Caregivers answered	Sleep Disturbance Scale for Children (SDSC)	316 +110	4-6yrs	Increase in the proportion of children above the pathologic threshold and increase in the frequency of parasomnias
[17]	Japan	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	Pediatric Daytime Sleepiness Scale (PDSS)	513	6-11yrs	Decrease in daytime sleepiness during school closure
[118]	Japan	Compared two or more cross sectional studies, before and during the pandemic	Caregivers answered	Nene Navi	2017 + 295	18-30mths	Increase in sleep latency during school closure.

[81]	China	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	Children's Sleep Habit Questionnaire (CSHQ)	436 + 1619	4-6yrs	Statistically significant decrease in CSHQ scores and lower rates of sleep disorders.
[23]	Switzerland	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	School Sleep Habits Survey	5308 + 3664	15 - 17 yrs	Sleep problems were significantly more frequent in the lockdown sample than in the control sample. Difficulties falling asleep and problems sleeping through the night more than 4 times in the previous 2 weeks were more prevalent in the lockdown group (falling asleep: 1237 [33.8%] vs 1645 [30.9%]; problems sleeping: 437 [11.9%] vs 439 [8.3%]).
[134]	China	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	Pittsburgh Sleep Quality Index (PSQI)	1952 + 1831 + 1790	13.56 (SD: 1.46)	Mean PSQI score of sleep quality at Wave 1, Wave 2, and Wave 3 was 4.94 (SD: 2.44), 4.66 (SD: 2.84), and 5.08 (SD: 2.91), respectively; the difference between Wave 3 and Wave 2 was statistically significant (OR = 1.55, P < 0.001); When compared to Wave 1, Wave 3 exhibited significant worsening in sleep disturbance (OR = 2.11, 95% CI = 1.86–2.38), use of sleep

							medication (OR = 1.48, 95% CI = 1.10–1.99), daytime dysfunction (OR = 3.59, 95% CI = 3.22–4.00); Significant Increase in the proportion of students with poor sleep quality from Wave 1 to Wave 3 (OR = 1.37, p = 0.001) and from Wave 2 to Wave 3 (OR = 1.29, P < 0.001) , but not from Wave 1 to Wave 2 (OR = 1.05, P = 0.471)
[112]	Brazil	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	Pittsburgh Sleep Quality Index (PSQI) and Pediatric Daytime Sleepiness Scale (PDSS)	259	15.5 years	Sleep quality did not differ (p=0.92); Daytime sleepinees was decreased when compared with the classroom (p<0.001);
[100]	Ireland	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	Pittsburgh Sleep Quality Index (PSQI)	281	12-14 yrs	Overall, sleep quality was similar before and during lockdown (Table 3). Before lockdown, 38% of pupils were classed as “poor sleepers” (score greater than 5)32 compared with 41% during lockdown
[40]	Spain	Compared two or more cross	Caregivers	Brief Infant Sleep Questionnaire (BISQ)	1380 + 254	3-36 months old	Increased sleep latency during the pandemic when compared to before the pandemic (p<0.001);

		sectional studies, before and during the pandemic	anwered				Increased proportion of children that exhibited criteria for classifying as poor sleepers (p<0.001)
[16]	Brazil	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	Pittsburgh Sleep Quality Index Questionnaire	94	14-17	Sleep latency, sleep duration, daytime sleepiness, and sleep quality as assessed by the PSQI remained unchanged.
[24]	China	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	Pittsburgh Sleep Quality Index Questionnaire + Insomnia Severity Index of 7-item (ISI)	831	14-19 yrs old	The prevalence of poor sleeper (76.4%, 55%, 49.7%) and insomnia symptoms (21.7%, 21.1%, 14.8%) tended to decrease across three waves (p < 0.001).
[124]	Australia	Compared two or more cross sectional studies, before and during the pandemic	Self-rated	School Sleep Habits Survey (SSPH) + Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD)	59	12.8 ± 0.4 years	Daytime sleepiness (ESS) was significantly lower during remote learning (β [95% CI] = −0.97 [−1.86, −0.09], P = .03, d = 0.31; Figure 4C)

[75]	Germany	Compared two or more cross sectional studies, before and during the pandemic		Children's Sleep Habits Questionnaire (CSHQ)	362	6-7 yrs old	There were no significant differences in sleep quality during vs. before the pandemic.
[61]	Canada	Compared two or more cross sectional studies, before and during the pandemic	Self-rated + actigraphy	actigraphy (AW-64 series) + Modifed Epworth Sleepiness Scale	62	12-16 yrs old	Daytime sleepiness was lower during the pandemic compared to the levels seen pre-pandemic; Discrepancy between week and weekend sleep patterns was eliminated;
[21]	Chile	Retrospectively collected data on change of sleep patterns and sleep quality	Caregivers anwered	based in SUNRISE study	3157	1-5yrs	Decline in sleep quality in the early phase of the pandemic
[19]	Tunisia	Retrospectively collected data on change of sleep	Self-rated	Pittsburg Sleep Quality Index (PSQI) 0-21	100	5-12yrs	Significant association between home confinement and decrease of sleep quality.

		patterns and sleep quality					
[31]	Brazil and Portugal	Retrospectively collected data on change of sleep patterns and sleep quality	Caregivers anwered	Sleep Disturbance Scale for Children (SDSC)	253	3-15yrs	Sleep quality was unchanged
[34]	Italy	Retrospectively collected data on change of sleep patterns and sleep quality	Caregivers anwered	Sleep Disturbance Scale for Children (SDSC)	4314	1-18yrs	Significant increase in sleep latency across all age groups. Significant decrease in sleep quality in younger groups.
[41]	Italy	Retrospectively collected data on change of sleep patterns and sleep quality	Caregivers anwered	Sleep Disturbance Scale for Children (SDSC)	299	6-10yrs	No statistically significant difference was found in SDSC scores
[49]	Italy	Retrospectively collected data on change of sleep patterns and sleep quality	Caregivers anwered	Sleep Disturbance Scale for Children (SDSC)	245	2-5yrs	No statistically significant difference was found in SDSC scores

[122]	Canada	Retrospectively collected data on change of sleep patterns and sleep quality	Self-rated	Pittsburg Sleep Quality Index (PSQI)	583	12-25 yrs	Sleep quality significantly improved for 12-14 year olds (p = 0.01) and for 15-17 year olds (p < 0.001). 18-21 years olds exhibited increase in sleep difficulties associated with nightmares (p=0.003)
[90]	Egypt	Retrospectively collected data on change of sleep patterns and sleep quality	Self-rated	BEARS	672	6-18 yrs	Decrease in the % of sleeping less than 7 hours from 41.4% to 5.4%; Increase in the % of sleeping more than 10 hours from 4.8% to 49.7% (p<0.001); Decrease energy level status of being energized from 55.4% to 7.7%; Increased in the lazy state from 3.6% to 54.8% (p<0.001);
[42]	Italy	Retrospectively collected data on change of sleep patterns and sleep quality	caregivers answered and self-rated	Children's Sleep Habits Questionnaire (CSHQ)	61 (0-3 yrs); 51 (4-5 yrs);	0-5 yrs	All differences between groups (including both the CSHQ total score and its sub-scores) disappeared during the lockdown. CSHQ total score was unchanged during the lockdown in toddlers but decreased in pre-schoolers (indicating improved sleep quality, p = 0.020).

[77]	Spain	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Caregivers anwered	BEARS	1028	6-18yrs	40% of participants obtained average scores in BEARS test and 36.4% obtained a high score.
[85]	China	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Self-rated	Youth Self-Rating Insomnia Scales (YSIS)	965	15-17yrs	34,9% of participants reported insomnia

[54]	Turkey	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Caregivers anwered	Sleep Disturbance Scale for Children (SDSC)	114	6-16yrs	No significant relationship was found between age and sleep disturbance
[96]	USA	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Self-rated	Insomnia Severity Index	583	15.8 ± 1.4yrs	Adults were more likely to report sleep problems than teenagers

[143]	China	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Self-rated	Pittsburg Sleep Quality Index (PSQI)	11835	12-29 yrs	Older teenagers were more likely to present sleep problems than younger ones.
[135]	Brazil	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Self-rated	Pittsburg Sleep Quality Index (PSQI)	153	13-18 yrs	58.2% answered that their sleep worsened during the pandemic (p=0.015)

[117]	Spain	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Self-rated	Sleep Disturbance Scale for Children (SDSC)	3454	6-16 yrs	Children under 6 years of age had a higher DIMS score and were more frequently suspected of disorders in initiating and maintaining sleep
[129]	Turkey	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Caregivers anwered	Children's Sleep Habits Questionnaire (CSHQ)	1040	6-12 yrs	55% of the children achieved a score above the total CSHQ cut-off score; >50% scored higher than the cut-off for the three subscales of bedtime resistance (51.9%), sleep onset delay (61.4%), and sleep duration (90.2%);

[135]	Brazil	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Caregivers answered and self-rated	Brief Infant Sleep Questionnaire (BISQ) or Sleep Disturbance Scale for Children (SDSC) or Pittsburgh Sleep Quality Index (PSQI)	173 (0-3 yrs); 254 (4-12 yrs); 150 (13-17 yrs)	0-17 yrs old	For children aged 0-3 years, 126 (58,6%) have abnormal BISQ scores and among children, 4-12 years old, 99 (33,9%) children have scores that indicate disorders of initiating and maintaining sleep, and 54 (18,5%) children presented sleep-wake transition disorders. For adolescents, 85 (56,6%) had poor sleep quality (PSQI global score ≥ 5).
[140]	China	Assessed sleep quality and the presence of sleep disorders during home confinement without providing comparison or retrospective view	Self-rated	Pittsburg Sleep Quality Index (PSQI)	10569	12-20 yrs	Sleep latency was the highest PSQI domain score; Use of sleeping medication was the lowest PSQI domain score; Mean score of the PSQI was 3.39. Adolescents aged 16 years or more reported worse sleep quality, except for the sleep efficiency, compared with adolescents under 16 years

Table 4. Sleep habits of children with Attention Deficit Hyperactivity Disorder during the pandemic

Reference	Country	Study design	Assessment tool for sleep quality and sleep disorder	Sample size	Age (mean ± SD / range)	Main findings
[21]	Spain	Cross-sectional	BEARS sleep-screening tool for sleep disorders in childhood	117	12.12 ± 3.36yrs 6-18yrs	The study shows a statistically significant difference between the ADHD and non-ADHD groups in state anxiety (p=0.004), sleep (p=0.005), and executive functioning (p=0.001)
[32]	USA	Cohort	Sleep Habits Survey (SHS)	122 (58 ADHD)	16.28 ± 0.35 15-17yrs	Adolescents with ADHD did not experience an increase in school night sleep duration and were less likely to obtain recommended sleep duration during COVID-19
[43]	Turkey	Cross-sectional	Children's Sleep Habits Questionnaire (CSHQ)	76	10.09 ± 2.23yrs 8-12yrs	E-type children with ADHD exhibited significantly higher trauma symptoms and sleep problems compared to children with non-E-type ADHD
[133]	Japan	Cross-sectional	Did not use a previously validated questionnaire	86	11.7 ± 2.2yrs 8-17yrs	The study found that 41.9% of children with changed sleep rhythm (32 children with late bedtime, 24 children with late bedtime and late waking time, and 1 child with late waking time)

Table 5. Sleep habits of children with Autism Spectrum Disorder during the pandemic

Reference	Country	Study design	Assessment tool for sleep quality and sleep disorders	Age (mean ± SD)	Sample size	Main findings
[97]	Turkey	Cross sectional design wit a retrospective view	Pittsburgh Sleep Quality Index (PSQI)	13.96 ± 6.1yrs	87	36% reported decrease in sleep quality 44% reported sleep changes
[132]	Turkey	Longitudinal design	Children's Sleep Habits Questionnaire (CSHQ)	7.9yrs	46	Statistically significant increase in CSHQ scores (p=0.001), bedtime resistance (p<0.001), delay in falling asleep (p<0.001) and sleep duration (p<0.001).
[64]	China	Cross sectional design	Did not use a previously validated questionnaire	4.6 ± 2.3yrs	406	50.3% reported one or more sleep problems. Difficulty falling asleep (29.3%), waking up at night (14.3%), and difficulty in falling asleep again after waking (16.5%)
[33]	France	Cross sectional design	Did not use a previously validated questionnaire	9.11 ± 4.0yrs	240	55.5% reported no changes during confinement. Some younger individuals showed improvement
[57]	USA	Longitudinal design	Survey adapted from the National Survey of Children's Health.	16.87 ± 1.36yrs	9	No statistically significant difference was found in sleep duration

https://doi.org/10.25118/2763-9037.2023.v13.792