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# Sleep Problems in Youth During COVID-19: A Narrative Review

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### ABSTRACT

The prevalence of sleep problems in youth during COVID-19 has ranged widely across different countries from 19% to 66%. Some researchers reported different prevalence for the different types of sleep problems including difficulties initiating sleep or maintaining sleep. Others reported as many as 49% failing to meet WHO global guidelines for sleep. Surprisingly, only a few effects studies were found suggesting that stress, anxiety, depression and suicidal ideation had occurred following sleep disturbances. In contrast, most of the research in this literature has focused on risk factors/predictors of sleep problems. Several risk factors have been noted for sleep problems in youth during COVID-19 including excessive screen time, snacking and lack of physical activity. Negative mood states were also predictors or correlates including worrying about COVID, being bored, lonely, anxious and depressed. Limitations of the literature include that many studies are cross-sectional so that causality cannot be determined, the studies are highly variable on age of the youth and assessment measures and parents have typically been the reporters of their youth's sleep problems. Nonetheless, the literature has highlighted sleep problems in youth that can inform potential intervention protocols.

**Keywords:** Sleep problems, Youth, COVID-19

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Sleep problems have been reported for adults during COVID-19 in many publications focused on sleep or comorbid problems including anxiety and depression (Field et al. 2021). A more recent COVID-19 literature has revealed similar sleep problems in youth. This narrative review involved entering the terms sleep and youth into PubMed and PsycINFO. The search yielded 118 papers, but following exclusion criteria including case studies and non-English papers, this review summarizes the research reported in 61 papers. Most of that literature has highlighted prevalence data (15 papers) and risk factors/predictor variables (39 papers) for sleep problems. This review is accordingly divided into sections on those topics as well as effects of sleep problems, potential underlying mechanisms and methodological limitations of the literature.

### **Prevalence of Sleep Problems**

Prevalence of sleep problems has been reported in 15 of the 61 studies in this review. Prevalence has ranged from a low of 19% in China (Zhai et al. 2021) to a high of 66% in Egypt, although the authors of the latter study also reported a prevalence of somnolence (excessive sleeping) in as many as 16% (El Refay et al. 2021). Significant variability has occurred even within countries. For example, the five studies from China reported a prevalence ranging from 19 to 64% (Guo et al. 2021; Lian et al. 2021; Zhai et al. 2021; Zhang et al. 2021; Zhou et al. 2020). This variability might relate to the data coming from different regions of China, although the researchers also used different descriptors of sleep problems. For example, in the sample with the lowest prevalence at 19%, quality of sleep was noted to decline in youth during the pandemic (Zhai et al. 2021). In the study reporting the large range of 21 to 64%, the sleep problem was referred to as insufficient sleep (Lian et al. 2021).

In the third study from China, sleep problems were labeled inadequate sleep that occurred in 40% of the sample (Guo et al. 2021). And, in the remaining two studies from China, insomnia was reported as the problem with 23% for insomnia

in general (Zhou et al. 2021) but more than twice the prevalence (48%) in a sample where different types of sleep problems were measured (Zhang et al. 2021). These included 15% for unrefreshing sleep, 10% for sleep insufficiency, 17% for insomnia and 6% for clinical insomnia.

These studies also varied on the age of the sample with some being young children and others being junior and senior high school students and still others being university students. The literature is mixed on age effects on the prevalence of sleep problems inasmuch as both younger (Bruni et al. 2021) and older (Aguilar-Farias et al. 2020) youth have been noted to have greater problems sleeping. In most of the studies, sleep scales were completed or sleep time was reported by parents, although older students sometimes self-reported. Notable differences would be expected between ratings by adolescents and ratings by parents given that parents typically only know the time spent in bed, while the students would be more accurate about reporting insomnia and night wakings, for example. None of these studies compared the ratings by parents and adolescents on the adolescents' sleep.

Different scales were also used in these studies including the Youth Self Rating Insomnia Scale (Zhang et al. 2021) and the Pittsburgh Sleep Quality Index (Zhou et al. 2020). And the Youth Self Rating Insomnia Scale yielded a greater prevalence in these two different samples from China (48% vs. 23%) (Zhang et al. 2021 but the more prevalent sample was also older college students versus both senior high and college students in the less prevalent sample (Zhou et al. 2020).

The most commonly used scale was the Sleep Disturbance Scale for Children (26 items) which includes a subscale called the Disorders of Initiation and Maintenance of Sleep (7 items). This parent rating scale yielded large differences in prevalence across cultures. The greatest prevalence was noted in Egypt where 66% of children and adolescents (N=765)

showed sleep disturbances, with initiating and maintaining sleep being the most common (33%) (El Refay et al. 2021). In a smaller, younger sample (4-14-year-olds) from Canada (N=85), 40% showed sleep worsened during the pandemic while as many as 14% showed improved sleep (Mackenzie et al. 2021). In a sample from the U.S. (N= 122) on adolescents (15 - 17-year-olds), a comparison between the pre-pandemic year and the first pandemic year suggested that the prevalence of sleep problems increased from 24 to 36% (Becker & Gregory, 2020). Although the parents reported a longer sleep duration for their adolescents during the pandemic, the adolescents were especially noted to have problems initiating sleep.

At least one study reported different prevalence for different types of sleep problems. In this sample of adolescents from Italy (N=6,210), 69% had difficulty falling asleep, 30% staying asleep and 19% having nightmares (19%) (Dondi et al. 2021). And, not meeting sleep guidelines or recommendations is still another measure that has been used. For example, in a sample from Brazil (N=495), 49% of 3-17- year-olds had sleep problems, but only 12% failed to meet WHO global guidelines (Lopez-Gil et al. 2021). In a review of 16 studies, surprisingly as many as 49 % failed to meet guidelines (Sharma et al. 2021). But in another similar review on 15 studies, only 21 % had sleep disturbances across the studies (Panda et al. 2021).

Another COVID sleep literature has focused on shifts in sleep measures between the time of school closures and the return to school days. Generally the data suggest later onset of sleep (a shift in the chronotype toward eveningness) as well as later rise time, amounting to longer duration sleep. For example, in a study from Iran (N=20,697), 54% of the sample slept more than 12 hours throughout the day (Ranjbar et al. 2021). The shift in chronotype has been fairly consistent across studies. For example, in a study on high school students (N=94) from Brazil, the bedtime delay was 1.5 hours and the wake-up delay was 2 hours (Genta et al. 2021).

This shift to eveningness was assessed by the Morningness-Eveningness Questionnaire. A similar shift was noted in a larger sample study (N=2,022) from Norway (46 minutes later bedtime and 1.35 hours later rise time) (Saxvig et al. 2021).

School closures led to more sleep in many countries. For example, in a study from the U.S. (N=590) for grades six through 12, waking time was 2.1 to 2.9 hours later during school closures amounting to nine hours of sleep (Weingart et al. 2021). High school students had a later wake-up time than middle school students and later class start times leading to a later wake-up time and more hours of sleep (Weingart et al. 2021). And, in Italy, a later than 11pm bedtime and a later than 8 am wake time occurred in 64% of adolescents during the lockdown and 12% of students after the lockdown (Bruni et al, 2022). In Singapore, where the lockdown was called a “circuit breaker” (N=593) weekday sleep averaged nine hours and weekend sleep averaged 10 hours and in private schools with later start times, sleep duration was greater (Aishworiya et al. 2021).

In a comparison of online/synchronous, online/asynchronous and in person school periods in the U.S. (N=5,245 racially and geographically diverse students), bedtimes and wake times were earliest for in-person classes followed by online-synchronous classes (Meltzer et al, 2021). In a study from Switzerland (N=12,238), 3 cross-sectional surveys (2017 before COVID, 2020 during school closure and 2021 return to school) yielded different sleep durations (Albrecht et al, 2022). Students were averaging nine hours during the closure and 8 hours during the other years. Interestingly, students expressed more health problems and depressive symptoms after the return to school. In contrast, a sample of adolescents from Germany (N=2022) was averaging 45 minutes more sleep on school nights versus the last 10 nights of the 60-day lockdown ( Saxvig et al, 2022).

These very different findings between sleep during lockdowns, school closures and return to school may relate to several factors. The school closures sometimes included lockdowns but were typically more prolonged and included periods when students did not have school schedules but also did not have confinement to the home for lockdowns. Many of the lockdown data have suggested that sleep problems during lockdowns were significantly correlated with physical inactivity, excessive screen time and poor diet. Sleep problems were related to being on lockdown confined at home spending significantly more time on social media (more screen time) and engaging in significantly more snacking which negatively affected sleep.

In contrast, in the sleep studies during school closures, sleep time was significantly longer. And sleep shifted to eveningness where sleep onset times were later and awake times were correspondingly later. At these non-lockdown/school closure times, youth were free to move about suggesting that inactivity, excessive screen time and snacking were less likely to occur, enabling better and longer sleep. Several have suggested that the take-home message from these data is that school hours at least for adolescents might be later to serve their more natural eveningness and need for longer duration sleep. In the U.S. study students had sufficient sleep with later school start times (Meltzer et al, 2021). Generally, the studies highlight the negative effects of inactivity, excessive screen time and snacking.

The data also suggest some buffering effects. For example, in a sample of Indian/Alaska Native Adolescents (N=118, mean age =14), increased sleep duration occurred during the early months of COVID (Troxel et al, 2022). Delays in bedtimes and awake times and sleep disturbances occurred, but greater family cohesion and engagement in traditional practices moderated those problems, highlighting potential intervention protocols. Surprisingly, however, no intervention studies

appeared in this recent literature on sleep problems in adolescents during COVID.

### **Effects of Sleep Problems**

Unlike much of the literature on other problems in youth during COVID-19, the research on sleep problems in youth is lacking effects studies. The only sleep effects studies that could be found included one on stress, one on comorbid anxiety and depression and one on suicidal ideation. These longitudinal data highlight the severity of sleep disturbance effects on mental health.

In one of the rare pre-to-during pandemic longitudinal studies, the research protocol included actigraphy and sleep logs with Canadian adolescents (N=62) taken at home for seven consecutive nights (Gruber et al. 2021). Shorter duration sleep and greater arousal at bedtime at time one led to greater stress at time two. And greater arousal at bedtime and lower sleep quality at time two was highly related to stress at time two even after controlling for pre-pandemic levels.

In a study on two waves of data from 10 schools in Shanghai, the first wave in January 2021 was followed by a second wave two months later (N=2427) (Zhao et al, 2022). Shorter sleep duration, referred to as a disturbed sleep-wake cycle, led to a greater prevalence of stress (15%), anxiety (25%) and depressive symptoms (20%).

Given the rate of anxiety and depression reported for students in Shanghai, it's not surprising that sleep disturbances have also predicted suicidal ideation in a similar longitudinal study on Chinese college students (N=67,905) (Wang et al. 2021). These researchers assessed sleep at time one during the COVID outbreak and again at time two during remission of that outbreak. Shorter sleep duration and sleep disturbances at time one led to suicidal ideation at time two after correcting for pandemic factors and depression at time one.

### **Predictors/Risk Factors for Sleep Problems**

Several risk factors have been noted for sleep problems in youth during COVID-19. These

include demographic factors such as gender and age, excessive screen time, snacking and lack of physical activity which have been noted in many papers on sleep issues during COVID-19. Negative mood states are also involved including worrying about COVID, being bored, lonely, anxious and depressed. Finally, pre-existing conditions including ADHD and ASD are exacerbated by sleep problems. Given that most of the research is cross-sectional as opposed to longitudinal, it's not clear whether these are risk factor/predictor variables or correlates/comorbid factors.

### **Demographic Variables**

**Gender.** In at least three of the studies on sleep problems in youth during COVID-19, being female gender has been cited as a risk factor/predictor variable. These include a study from Turkey in which parents (N=114) completed the Sleep Disturbance Scale for Children and data analysis revealed that girls had greater sleep problems. (Fidanci et al. 2021). Female gender was also a significant risk factor in two different studies from China (Li et al. 2021; Zhai et al. 2021).

**Age.** Data on age as a risk factor/predictor variable are difficult to interpret given that age only emerges in two studies as being significant, and in one study the children ranged from 1 to 5 years and in the other study the sample included both children and adolescents. In the study on young children, the older group had more sleep problems (Aguilar-Farias et al. 2020). But in this sample from Chile (N=3157), the children also had older parents and were living in apartments which may be risk factors in themselves. In the study that included both children and adolescents, the children from this Italian sample (N= 4,314) had a greater change in sleep based on the Sleep Disturbance Scale for Children completed by their parents (Bruni et al. 2021). The specific problems included difficulty falling asleep, anxiety at bedtime, nightwakings and nightmares. An increase in sleep disturbances occurred in all age groups except adolescents.

**Parental Influences.** Other demographic risk factors include low socioeconomic status and loss of work in, for example, the Italian sample (Dondi et al. 2021). And in the sample from Singapore, children of parents who changed from working outside to working at home had the greatest increases in sleep duration (Aishworiya et al. 2021). In contrast, children of health workers who clearly worked away from home had compromised sleep (Bucak et al. 2021). This was noted in the Turkish sample despite the greater education and income of those parents. The significance of parents is further highlighted by data from the Singapore study on 3-17-year-olds (N=573) suggesting that the fathers' and mothers' increased sleep duration was positively correlated with increased sleep duration in children especially in preschool and grade school age children (Aishworiya et al. 2021). And, in data from 24 countries on the sleep of 3-to-5-year-olds pre-COVID and during COVID (N=948), those children of parents with greater stress were less likely to meet WHO global guidelines for adequate sleep (10-13 hours/day) (Okely et al. 2021).

### **Increased Screen Time and Decreased Physical Activity**

**Increased Screen Time.** Increased screen time and decreased physical activity have been considered separate risk factors for sleep problems in youth during COVID-19. In the study from Egypt, screen usage was entered into a linear stepwise regression and was noted to contribute to sleep disturbances, but physical activity was not considered in this regression (El Refay et al. 2021). In the study from Iran, the relationship between screen time and sleep time was measured during school closures (Ranjbar et al, 2021). In this case, an increase in screen time led to an increase in sleep time instead of a decrease. Screen time in this study included TV watching by 14%, computer games by 30% and screen time for studying by 27%. In the study from Italy, the increased duration of sleep time was related to increased screen time (Bruni et al, 2022). In a study on adolescents from four high

schools in Canada (N=258 adolescents 14-18-years-old), recreational screen time and concurrent use was associated with sleep quality, but it only explained 16% of the variance (Vezina et al, 2022). In a study from Italy that suggested that the prevalence of insomnia increased from 12% during lockdown to 23% one year later, both time periods featured late bed time, poor sleep hygiene and electronic device use at bedtime (Bacaro et al, 2022). In a systematic review and meta-analysis on 29 studies from 16 countries, the analysis of data from 8 studies suggested that increased sleep duration was related to reduced sleep efficiency (Richter et al, 2023). Based on parents' reports, increased screen time and greater use of electronic devices was associated with worse sleep quality. But changes in family routines were also risk factors.

**Decreased Physical Activity.** In those studies that considered physical activity as a risk factor for sleep problems without considering screen time, physical activity was noted to decrease from before the pandemic to during the pandemic. In the study from Poland, for example, physical activity was reduced to 60 minutes on three days per week during the pandemic from 60 minutes on four days per week prior to the pandemic (Brzek et al, 2021). And, in the study from the US, less time outside was given as the reason for adolescents having more difficulty initiating and maintaining sleep (Weingart et al, 2021). In a small sample study (N=16) but one that monitored sleep by actigraphy for seven days, delayed weekday onset of sleep and increased duration were related to lower physical activity levels (Rynders et al, 2022). Being cross-sectional data, the direction of effects cannot be determined.

**Screen Time and Physical Activity.** In most of the studies on risk factors/predictors of sleep problems, both screen time and physical activity have been combined in the same data analysis to determine their relationship to sleep problems in youth during COVID-19. In those studies, the authors have generally attributed the decreased

physical activity to increased screen time, although it's conceivable that because of confinement, there has been less physical activity resulting in more time available for social media.

In one of these studies, the WHO global guidelines were given for sleep time, screen time and physical activity (Guo et al. 2021). They were 10 to 13 hours per day for sleep, 3 hours per day for physical activity including 1 hour for moderate or vigorous activity and less than one hour per day for screen time. These guidelines are likely specific for 3 to 5-year-olds given that this study was focused on that age group from 14 countries. Presumably these guidelines would be conservative for adolescents.

In a study on prevalence in ten elementary schools in China (N=10,933), a 77% increase was noted in screen time during the pandemic (Guo et al. 2021). At this time, 45% of the sample spent more than five hours screen time per day and 59% of the sample engaged in less physical activity as compared to their pre-pandemic activity. In another study on very young children (1 to 5-year-olds), those children who engaged in more screen time and less physical activity had more sleep problems (Aguilar-Farias et al. 2020). In still another study on very young children (3 to 5-year-olds) from Poland, the children (N=3000) slept 10 to 13 hrs. per day which was an increase of 10 to 18% during the pandemic (Brzek et al. 2021). However, only 31% complied with the WHO guidelines on sleep before the pandemic. And, failure to meet the guidelines was related to greater screen time and less physical activity.

In a study from Australia (N=2290) during early 2021, twice as many adolescents had sleep problems including insomnia, nightmares and daytime sleepiness (Bothe et al, 2022). These problems were correlated with irregular bedtimes, reduced physical activity, increased media consumption and anxiety.

In a sample from Canada, 40% were noted to have worsened sleep during the pandemic based on the Sleep Disturbance Scale for

Children (Mackenzie et al. 2021). The Increased sleep problems were once again related to increased screen time and decreased exercise. It is then not surprising that a meta-analysis on sleep problems including 31 papers suggested that the strongest relationships with sleep problems were increased screen time and decreased physical activity (Janssen et al. 2020).

**Table 1. Prevalence of sleep problems in youth during COVID-19.**

Country	Prevalence (%)	First Author
China	19	Zhai
China	21-64	Lian
China	40	Guo
China	23	Zhuo
China	48	Zhang
U.S.	36	Becker
Canada	40	Mackenzie
Italy	69	Dondi

**Table 2. Risk factors for sleep problems in youth during COVID-19.**

Risk factor	First author
Demographic factors	
Female gender	Fidanu, Li, Zhai
Older youth	Aguilar-Fairas
Socioeconomic status	Dondi
Loss of work	Bucek
School closure	Albrecht, Meltzer
Increased screen time	Bacaro, Bruni, ElRefay, Guo, Jenssen, Mackenzie, Richter, Vezina
Decreased physical activity	Aguilar-Fairas, Bothe, Brzek, Moitra, Rynders, Weingart
Negative mood states	
Loneliness	Becker, Dondi
Worrying about COVID	Jenssen, Zhai
Anxiety	ElRefay, Panda, Zhai
Depression	Albrecht, Li, Liao, Panda, Zhao
Pre-existing conditions	
ADHD	Cetin
Autism	Turkoyl
Biological markers	
Low melatonin	Cheka-Ros, Koken
Elevated cytokines	Silva

In a study whose title implies screen time causing physical activity, sleep and depression symptoms, 65% of adolescents reported social networking for 2–3 hours per day (Moitra et al, 2022). In this sample (N= 1298), 71% agreed that screen time occupied the majority of their leisure time. Only 12% said they engaged in moderate to vigorous activity and as many as 53%

had high scores on the Pittsburgh Sleep Quality Index while 9% had high scores on the Patient Health Questionnaire indicating depressive symptoms. Screen time was associated with less physical activity and more sleep problems as well as poor eating habits.

Another study included quality of diet along with exercise time and screen time. In this sample of

Chinese junior and senior high school students (N= 10,569), poor sleep quality was associated with not only screen and exercise time but with the quality of diet that had worsened (Zhai et al. 2021). In a logistic regression study from Brazil on 3-17-year-old youth (N=495), 49% of these youth had sleep problems, although only 12% failed to meet the WHO guidelines (Lopez-Gil et al. 2021). A decline in diet quality that related to sleep problems was specified as eating fewer fruits and veggies per week and more sweets.

### **Negative Mood States**

Negative mood states are frequent correlates of sleep disturbances in this literature on youth during COVID-19. The research has typically focused on the negative mood states and their contributions to sleep problems. Fewer studies have been focused on negative mood states as risk factors for poor sleep. In a review on sleep and its relationship to negative mood states, 15 studies (N=2296) were included. In this review, 21% of the sample were said to have sleep disturbances, 35% boredom, 35% anxiety, 42% depression and 42% irritability (Panda et al. 2021). Combined data from these studies suggested that 52% of the parents also experienced anxiety and 27% reported being depressed. Likely some experienced both anxiety and depression given the high comorbidity rates of these negative mood states (Field et al. 2010).

**Loneliness.** Loneliness has surprisingly been entered into a regression on sleep problems in only one study in this literature. This is surprising given the prevalence of studies focused on loneliness in the COVID literature (Field, 2021). In the study from Italy, loneliness was the most frequently reported problem for 78% of the sample and 69% had difficulty falling asleep, 30% staying asleep and 19% having nightmares (Dondi et al. 2021). In a regression analysis, loneliness was one of the primary predictors of sleep problems.

**Worrying about COVID.** Worrying about COVID has been another negative mood state for youth during COVID-19 and has typically

been specified as worrying about getting infected, although in at least one study worrying extended to family or friends becoming infected (Zhai et al. 2021). This is not surprising since this was a sample of junior and senior high school students who might be expected to have well-developed empathy.

In a study from Australia, lower sleep quality and longer sleep onset latency were associated with worrying and ruminating about COVID (Jameson et al. 2021). In the study from the U.S., greater worrying about COVID, greater loneliness and less time outside explained a significant amount of the variance in difficulties initiating and maintaining sleep based on the Sleep Disturbance Scale for Children (Becker & Gregory, 2020). In that study, sleep problems increased from 24% prior to the pandemic to 36% during the pandemic.

**Anxiety.** Although anxiety might be expected to derive from worrying about the pandemic, that link surprisingly has not been made in this literature. Several studies on adults have attributed sleep problems to anxiety during COVID (Field et al. 2021). However, anxiety has rarely been considered a risk factor for sleep problems in youth during COVID. In one of the studies from China, 19% of junior and senior high school students reported poor sleep quality which, in turn, was associated with high anxiety levels (Zhai et al. 2021). In the study from Egypt, 66% of children and adolescents showed sleep disturbances primarily in initiating and maintaining sleep (33%) (El Refay et al. 2021). In a linear stepwise regression on their data, anxiety was the most significant predictor of sleep problems.

**Depression.** Depression has also been a prevalent negative mood state. For example, in a review on 15 studies (N= 2296), 21% of the sample had sleep disturbances, but twice as many had depression symptoms (42%) (Panda et al. 2021). Other correlates of sleep problems in this review were anxiety (35%), boredom (35%) and irritability (42%).



A longitudinal study conducted before, during and after a quarantine period in China (N=831 14-19-year-old adolescents) suggested that during the quarantine there was delayed sleep onset and offset times amounting to greater sleep duration (Li et al. 2021). The eveningness type experienced greater depression and anxiety as well as poorer sleep quality and more insomnia. Depression and sleep problems were correlated throughout, and depression predicted sleep problems but not the reverse.

In another longitudinal study from China, assessments were conducted before and during the pandemic with adolescents from 3 junior high schools (N=2,496) (Liao et al. 2021). The authors reported a decrease in sleep duration during the pandemic along with an increase in depression. Depression before the pandemic predicted shorter sleep duration during the pandemic and shorter sleep duration before the pandemic contributed to increased depression during the pandemic. The author referred to these complex results as bilateral associations.

**ADHD and ASD.** Pre-existing conditions have not been considered in this literature except in the case of children with ADHD and those with ASD. The same group of investigators explored sleep in both of these groups. Multiple questionnaires were given on the children's sleep habits, their chronotype and their experience with trauma as well as their sleep problems. In the study on children with ADHD, sleep problems were a mediator between trauma and severity of ADHD symptoms (Cetin et al. 2020). In the study on children (4-17-years-old) with ASD (autism spectrum disorder), the same questionnaires were used as in the study on children with ADHD (Turkoyla et al. 2020). The children with ASD were noted to have a greater eveningness chronotype. Their sleep problems mediated the relationship between their chronotype and the severity of ASD symptoms. It is not surprising that children with ADHD and ASD had sleep problems during the pandemic inasmuch as they typically have sleep problems.

Given that these were not longitudinal studies, it is not clear how much the pandemic exacerbated their already-existing sleep problems. It seems rather that these investigators were more focused on trauma and chronotype effects on children with these problems. It is surprising that studies on sleep problems deriving from pre-existing conditions such as these have rarely appeared in the COVID-19 literature.

### Potential Underlying Mechanisms

Biological correlates are often viewed as potential underlying mechanisms for a condition. Biological correlates of sleep problems have been studied in youth during COVID-19. These have included melatonin and immune function.

**Melatonin.** In one of the melatonin studies, children with and without COVID infection (N=106) were compared on their melatonin levels (Koken et al. 2021). Melatonin was higher in the non-COVID group, suggesting that melatonin might be a protective factor. Inasmuch as melatonin plays a significant role in the circadian rhythm of sleep, these data were not surprising.

In research by a different group, youth (N=14) were given melatonin therapy for three months (Checa-Ros et al. 2018). The increase in melatonin concentrations led to recovery of the circadian rhythm with shorter sleep onset latency, fewer night wakings and longer sleep duration. These effects are not surprising given that melatonin is frequently taken as a sleep medication by adults. These data are suggestive of a potential intervention for youth who are experiencing sleep disturbances.

**Immune Function.** Immune function is also affected by sleep deprivation or it may lead to sleep deprivation. In a review on sleep deprivation and immune function, cytokines were notably elevated in those with sleep problems (Silva et al. 2020). These included interferon (IFN), tumor necrosis factor alpha (TNF-alpha) and the inflammatory marker C-reactive protein (CRP). It is not clear how much

the sleep deprivation and how much the related depression contributed to these inflammatory effects or vice versa.

Surprisingly, during a viral pandemic, very little research has been conducted on the relationship between sleep deprivation and immune function and even on sleep deprivation in those youth who are actively experiencing the infection. Youth were only experiencing COVID-19 during more recent stages of the pandemic, resulting in very little current research on those relationships.

### **Methodological Limitations**

The COVID-19 literature on sleep in youth has varied across countries but has been consistent in reporting risk factors for sleep problems. Sleep disturbances have been more prevalent in females and in older youth from low socioeconomic status parents who have lost work. Sleep disturbances have been accompanied by increased screen time, reduced physical activity and negative mood states including loneliness, worrying about COVID, anxiety and depression. It is possible that increased screen time and reduced activity have led to sleep disturbances and, in turn, negative mood states, as directionality cannot be determined from cross-sectional data. Sleep problems were also exacerbated by COVID in children with pre-existing conditions including ADHD and ASD. Some underlying biological mechanisms were also implicated in sleep problems during COVID including low melatonin and elevated cytokines.

Despite the informative data from these 61 studies on sleep problems for youth during COVID-19, several methodological limitations can be noted regarding this literature. The types of studies are limited. For example, very few negative mood as risk studies met inclusion criteria and only a few potential mechanism studies. Although a few longitudinal studies appeared in the literature, most studies were cross-sectional in design. With no baseline data, directionality of effects could not be determined, although most of the studies were considered

risk factor /predictor variable studies whose authors seemingly arbitrarily selected variables as predictors.

Other variability included the different time periods that studies were conducted including some that occurred across the pandemic and others that were limited to lockdown/quarantine periods and still others that occurred during school closures that followed lockdowns. Assessments at different time periods yielded different results. For example, sleep duration was generally shorter during lockdowns, reputedly due to excessive screen time, snacking and inactivity, and longer duration sleep was noted during school closures when the youth were not necessarily confined by limited activity and their sleep duration was not limited by school hours.

In addition, the measures have been heterogeneous across studies including the use of different scales with different reliability data. And different types of sleep problems including initiation and maintenance were rarely specified. Further, by virtue of being survey studies, measures like actigraphy or bitnit watches were not used as more objective measures of activity and sleep. Variability also occurred on the ages of the youth (young adolescents and university students) Being at different developmental ages/stages suggested variation in chronotypes, sleep needs and WHO guidelines.

Although parents were typically the reporters of sleep problems of their youth, adolescents were sometimes the reporters. No studies were conducted to determine the concordance of parent and adolescent report even though adolescents would presumably be more aware of their actual sleep time and nightwakings. In addition, only one study reported the relationship between parent sleep and adolescent sleep which presumably would be a significant variable.

The variability on so many factors limited the number of meta-analyses for more valid, reliable conclusions to be made about these data.

Nonetheless, some general conclusions were made by authors of these papers, highlighting different types of sleep disturbances and related problems experienced by youth during COVID-19. Although further research is needed to address these questions, the already existing data will likely inform future research and potential interventions for reducing sleep problems in youth during pandemics.

## Conclusion

Most of the research in this literature has focused on risk factors/predictors of sleep problems. Several risk factors have been noted for sleep problems in youth during COVID-19 including excessive screen time, snacking and lack of physical activity. Negative mood states were also predictors or correlates including worrying about COVID, being bored, lonely, anxious and depressed. Limitations of the literature include that many studies are cross-sectional so that causality cannot be determined, the studies are highly variable on age of the youth and assessment measures and parents have typically been the reporters of their youth's sleep problems. Nonetheless, the literature has highlighted sleep problems in youth that can inform potential intervention protocols.

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