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Bedtime Screen Use Behaviors and Sleep Outcomes in Early Adolescents: A Prospective Cohort Study

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A B S T R A C T

Purpose: To determine prospective associations between bedtime screen use behaviors and sleep outcomes one year later in a national study of early adolescents in the United States.
Methods: We analyzed prospective cohort data from 9,398 early adolescents aged 11–12 years (48.4% female, 45% racial/ethnic minority) in the Adolescent Brain Cognitive Development Study (Years 2–3, 2018–2021). Regression analyses examined the associations between self-reported bedtime screen use (Year 2) and sleep variables (Year 3; self-reported sleep duration; caregiver-reported sleep disturbance), adjusting for sociodemographic covariates and sleep variables (Year 2).
Results: Having a television or Internet-connected electronic device in the bedroom was prospectively associated with shorter sleep duration one year later. Adolescents who left their phone ringer activated overnight had greater odds of experiencing sleep disturbance and experienced shorter sleep duration one year later, compared to those who turned off their phones at bedtime. Talking/texting on the phone, listening to music, and using social media were all prospectively associated with shorter sleep duration, greater overall sleep disturbance, and a higher factor score for disorders of initiating and maintaining sleep one year later.
Discussion: In early adolescents, several bedtime screen use behaviors are associated with adverse sleep outcomes one year later, including sleep disturbance and shorter weekly sleep duration. Screening for and providing anticipatory guidance on specific bedtime screen behaviors in early adolescents may be warranted.

IMPLICATIONS AND CONTRIBUTION

In a demographically diverse nationwide sample of 9,398 early adolescents aged 11–12 years in the United States, bedtime screen use including social media, texting, video games, music, and television was prospectively associated with shorter sleep duration and more sleep disturbance one year later.

Excessive screen use in adolescence has been recognized as a major public health issue [1], and the United States Surgeon General issued a 2023 Advisory on Social Media and Youth Mental Health [2]. The Advisory cited research demonstrating associations between social media and poor sleep but noted

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important evidence gaps, as most studies have been cross-sectional rather than longitudinal and focused on adults or young adults rather than adolescents [2]. Screen use encompasses many modalities, such as television, computers, tablets, mobile phones, social media, and video games [3]. Device ownership starts to increase in early adolescence (ages 10–15) and screen time in early adolescence has been associated with academic difficulties, mental health concerns, and poor sleep, highlighting early adolescence as an important developmental period for further research [4–8]. Adequate sleep duration and quality are important for adolescents' emotional, behavioral, and cognitive development [9]. Studies have shown that sleep issues in early life predict emotional and behavioral concerns as well as weight gain later in life [10–12].

With an increase in screen time during adolescence, there is also an increased risk of screen use around bedtime. One area of interest is the relationship between bedtime screen use and sleep outcomes. Most prior research has focused on daily screen time and sleep rather than screen time, specifically around bedtime (e.g., screen use while in bed); systematic reviews have found that a majority of such studies show associations between screen time and poor sleep [13,14]. A selected number of studies have focused on screen use around bedtime and sleep outcomes. One such study in 2017 that cross-sectionally surveyed parents of 234 children found that using any device at bedtime was associated with reduced sleep quantity and quality; however, this study was limited to one state and included children from a wide age range of 8–17 years [15] rather than examining early adolescence specifically, when device ownership starts to increase [6,7]. Another study surveyed adolescents aged 12–17 years and found an association between electronic media use in bed before sleep and sleep disturbance; however, this study was cross-sectional, the mean age of participants was 14.8 years, the sample size was small (N = 362), and the study took place in Switzerland [16]. A separate cross-sectional study of 6,616 11–12-year-olds found consistent associations between night-time screen use and poor sleep outcomes, but this study focused on adolescents in the United Kingdom [17]. Similarly, a cross-sectional study of 9,846 Norwegian adolescents aged 16–19 years found that bedtime screen use was related to an increased risk of decreased sleep duration, increased sleep deficiency, and longer sleep onset latency [18]. Overall, most of the research in this area has been cross-sectional and originated from Europe.

Similar to other studies, we have previously shown that greater bedtime screen use and having a device in the bedroom were associated with sleep disturbance in a cross-sectional analysis of the large, diverse cohort of 11–12-year-old US participants in Year 2 of the Adolescent Brain and Cognitive Development (ABCD) Study [19]. However, as this was a cross-sectional analysis, we were limited in our ability to demonstrate temporal relationships between bedtime screen use and sleep outcomes.

The purpose of this study was to determine prospective associations between screen use around bedtime and sleep outcomes one year later, in early adolescents participating in the ABCD study. We hypothesized that bedtime screen use would be prospectively associated with adverse sleep outcomes one year later.

Methods

The ABCD Study is the largest longitudinal study of adolescent health and brain development in the United States, recruiting 11,875 children from 21 sites in 2016–2018 (baseline). The ABCD Study sample, protocol, recruitment, and measures have previously been described in detail [20–22]. Participants were predominantly aged 11–12 years during the Year 2 follow-up (2018–2020), the time point of the exposures. Nine thousand three hundred ninety eight participants had complete data available for inclusion in this analysis (See Appendix A for a comparison of included and excluded samples). Centralized institutional review board approval was received by the University of California, San Diego and the institutional review boards of each respective study site. Participants provided written assent, and caregivers of participants provided written informed consent.

Measures and study variables

Independent variables

Screen usage around bedtime. A nine-item measure, which was adapted from questionnaires from two prior studies examining adolescent night-time technology use [16,23], was administered to participants to measure screen use while already in bed before going to sleep in the past week at Year 2. The following categories were assessed, with options provided on a five-point Likert scale ranging from 1 (never) to 5 (every night): watching movies, videos, or television (TV) shows; playing video games; playing music; talking on the phone or texting; spending time online on social media; participating in chat rooms; browsing the Internet; using a computer/laptop for studying; and reading. Participants were also asked four additional items related to screen use and sleep, adapted from National Sleep Foundation poll questions: whether there was a TV set or an Internet-connected device in their bedroom (yes/no); what they did with their phone when they were ready to go to sleep (e.g., turn the phone off, put the ringer on silent or vibrate, leave the ringer on, put the phone outside of the room); how often they had phone calls, text messages, or e-mails that woke them after trying to go to sleep; and how often they used their phone or another device when they woke up during the night [24]. Participants were asked all Screen Usage Around Bedtime questions regardless of their response choices to prior questions.

Overall screen usage. As part of the Youth Screen Time Survey, total recreational screen time was collected using adolescents' self-reported hours on a typical weekday and weekend. Screen use types measured included multiplayer gaming; single-player gaming; texting; social media; video chatting; browsing the Internet; and watching/streaming movies, videos, or TV [25]. The weighted sum of the weekday and weekend average ([weekday average × 5] + [weekend average × 2]/7) was used to determine the total typical daily screen use time.

Dependent variables

Sleep disturbance scale for children. Caregivers completed a 26-item measure to assess sleep disturbance symptoms and the presence of sleep disorders in the adolescent, including disorders of initiating and maintaining sleep, sleep breathing disorders, disorders of arousal, sleep-wake transition disorders, disorders of excessive somnolence, and sleep hyperhidrosis within the past six months at Years 2 and 3. An overall sleep-wake disturbance score (sum of all items) was

calculated and used in this analysis, with higher scores reflecting greater clinical severity of sleep disturbance. The disorders of initiating and maintaining sleep subscale score (seven items) were specifically analyzed since insomnia is the most common sleep disorder. Caregivers completed each item using a five-point Likert scale ranging from 1 (never) to 5 (daily). Based on the recommendations of the developers of the survey, a cutoff of 39 had the best diagnostic confidence as determined by the intersecting point of sensitivity and specificity and was used to indicate the presence of sleep disturbance [26]. The cutoff also shows acceptable performance compared to actigraphy-determined sleep disturbance [27]. The sleep disturbance scale for children is a widely used and accepted pediatric sleep measure, with the clinical cutoff being applied in many populations and situations, including the COVID-19 pandemic, to identify significant sleep disturbance [28].

Munich Chronotype questionnaire. Participants completed the Munich Chronotype questionnaire in Years 2 and 3 to assess sleep duration and sleep behaviors, such as the time at which they go to bed, fall asleep, and wake up [29]. In this analysis, the weighted average sleep duration (weekdays and weekends) was used, which was calculated using the sleep durations from both the free days and school days recorded in the Munich Chronotype questionnaire.

Confounders. Potential confounders for the association between screen use and sleep outcomes were selected based on previous theory and literature [24,30–32]. Sex assigned at birth (female or male) and race/ethnicity (White, Latino/Hispanic, Black, Asian/Pacific Islander, Native American, other) were recorded from the baseline demographic survey. Age (years), household income (US dollars, more than or less than $75,000—the approximate median US household income), and highest parent education (high school or less vs. college or more) were collected at the Year 2 assessment. The study site, use of melatonin, number of adverse childhood experiences [33,34], and depression symptoms as measured by the Child Behavior Checklist [35,36] were also included as potential confounders.

Statistical analyses

Data analysis was performed using Stata 18 (StataCorp, College Station, TX). Descriptive statistics were calculated by measuring the mean, standard deviation, and percentages of each variable. Logistic regression models were used to estimate the associations between screen usage around bedtime and overall screen use at Year 2 and binarized total sleep disturbance at Year 3, adjusting for confounders and total sleep disturbance at Year 2. Ordinal logistic regression models were used to estimate associations between screen usage around bedtime at Year 2 and the disorders of initiating and maintaining sleep subscale score at Year 3, adjusting for confounders and the disorders of initiating and maintaining sleep subscale score at Year 2. Multiple linear regression models were conducted to estimate the associations between the aforementioned exposures and weekly sleep duration at Year 3, adjusting for confounders and the respective sleep variable at Year 2. Propensity weights were applied based on the American Community Survey from the US Census.

Results

Table 1 describes the sociodemographic characteristics of the 9,398 early adolescents included in the study. Nearly half (48.4%) of the participants were female and 45% were non-White. The mean age of participants was 12.02 years (standard deviation = 0.66) in Year 2.

Table 2 displays descriptive statistics and frequencies of bedtime screen behaviors in the study population at Year 2. A majority of participants had a TV or electronic device in their bedroom (62.5%) and turned their phones off when they were ready to go to sleep (54.9%). In the past week, 16.2% reported that they had been woken up by phone calls, text messages, or e-mails while sleeping at least once, and 19.3% reported using their phone or another device if they woke up during the night. Appendix B shows descriptive statistics and frequencies of bedtime screen behaviors in Years 2 and 3. In general, bedtime screen behaviors were more frequent in Year 3 compared to Year 2.

Table 3 shows associations between bedtime electronic device usage and sleep outcomes (self-reported sleep duration and caregiver-reported sleep disturbance) one year later. Having a TV or electronic device in the bedroom was prospectively associated with shorter weekly sleep duration (B = −0.21; 95% confidence interval [CI] −0.28, −0.13). Leaving the ringer on, compared to turning the phone off, was prospectively associated with sleep disturbance (binary) (odds ratio [OR] = 1.25; 95% CI 1.00, 1.56) and shorter weekly sleep duration (B = −0.27; 95% CI -0.40, −0.13); putting the ringer on silent or vibrate, compared to turning the phone off, was prospectively associated with shorter weekly sleep duration (B = −0.15; 95% CI -0.26, −0.05).

Table 1
Sociodemographic, behavioral, and sleep characteristics of Adolescent Brain Cognitive Development (ABCD) Study participants (N = 9,398)

Sociodemographic, behavioral, and sleep characteristics	Mean (SD)/%
Age (years)	12.02 (0.66)
Sex (%)	
Female	48.4%
Male	51.6%
Race/ethnicity (%)	
White	54.9%
Latino/Hispanic	19.6%
Black	15.4%
Asian	5.5%
Native American	3.1%
Other	1.4%
Household income (%)	
$24,999 or less	15.9%
$25,000 to $49,999	19.9%
$50,000 to $74,999	18.0%
$75,000 to $99,999	14.2%
$100,000 to $199,999	24.3%
$200,000 and more	7.7%
Parents' highest education (%)	
High school education or less	17.5%
College education or more	82.5%
Number of adverse childhood experiences	1.84 (1.70)
Depression symptoms at Year 2 (CBCL t-score)	53.89 (6.07)
Melatonin use at Year 2 (%)	4.4%
Total recreational screen time at Year 2 (hours per day)	7.02 (5.71)
Total sleep disturbance at Year 3 (%)	25.5%
Disorders of initiating and maintaining sleep score at Year 3	12.30 (4.01)
Sleep duration at Year 3 (hours per night)	8.94 (1.62)

ABCD propensity weights were applied based on the American Community Survey from the US Census.
CBCL = Child Behavior Checklist; SD = standard deviation.

Table 2
Bedtime screen usage in the Adolescent Brain Cognitive Development (ABCD) Study at Year 2 (N = 9,398)

Is there a TV set or an Internet connected electronic device (computer, iPad, phone) in your bedroom?	Yes	No		
	62.5%	37.5%		
What do you usually do with your phone when you are ready to go to sleep?	Turn the phone off	Put the ringer on silent or vibrate	Leave the ringer on	Put it outside of the room where I sleep
	54.9%	18.4%	11.2%	15.5%
How many nights in the past week did you engage in the following activities involving electronic devices while already in bed before going to sleep?	0 nights	1–2 nights	3–4 nights	5–7 nights
Watch or stream movies, videos, or TV shows	49.4%	26.9%	10.3%	13.4%
Play video games	71.4%	16.3%	6.5%	5.8%
Play music	54.0%	22.0%	10.0%	14.1%
Talk on the phone or text	66.7%	19.6%	7.4%	6.3%
Spend time online on social media (e.g., Facebook)	70.1%	16.5%	7.1%	6.2%
Spend time in chat rooms	89.4%	7.0%	2.1%	1.5%
Browse the Internet, Google-ing (not school-related)	79.2%	15.7%	3.6%	1.5%
Use a computer/laptop for studying	71.5%	16.6%	7.4%	4.5%
Reading	40.0%	26.7%	15.5%	17.8%
In the past week, how often have you had phone calls, text messages, or e-mails that wake you after trying to go to sleep?	83.8%	10.6%	3.4%	2.2%
In the past week, when you woke up during the night, how often have you used your phone or other device to send messages/play games/search or browse the internet/use social media/read or write e-mails?	80.7%	12.2%	4.4%	2.6%

ABCD propensity weights were applied based on the American Community Survey from the US Census.

The use of electronic devices for various activities before going to sleep was prospectively associated with shorter weekly sleep duration for all activities. Talking on the phone or texting, playing music, and spending time on social media before going to sleep were prospectively associated with overall sleep disturbance and higher scores for the subscale of disorders of initiating and maintaining sleep. Results for all activities are shown in Table 3. Higher total daily recreational screen time was also prospectively associated with sleep disturbance (OR 1.02; 95% CI 1.01, 1.04) and shorter weekly sleep duration (B = −0.03; 95% CI -0.04, −0.02), although these results were weaker in magnitude than the results for the bedtime-specific screen activities.

Being woken up by phone calls, text messages, or e-mails after trying to go to sleep on one or more nights in the past week was prospectively associated with shorter weekly sleep duration (B = −0.16; 95% CI -0.24, −0.08). Using an electronic device when awake during the night was associated with both sleep disturbance (OR 1.11; 95% CI 0.99, 1.24) and shorter weekly sleep duration (B = −0.18; 95% CI -0.25, −0.10).

In supplemental analyses, bedtime screen use was not associated with change in sleep duration from Year 2 to Year 3 (Appendix C). In ordinal logistic regression analyses, total recreational screen time and playing music before going to sleep, but not other bedtime screen use behaviors, were associated with a higher total sleep disturbance score (Appendix D).

Discussion

In this large, diverse cohort of US early adolescents, we found that bedtime screen use for a range of activities (e.g., playing music, talking or texting on the phone, using social media) and leaving the ringer on were prospectively associated with sleep disturbance (binary), as reported by caregivers, one year later. Additionally, all modalities of bedtime screen use were associated with lower self-reported sleep duration one year later. Adolescents who left the ringer on experienced more sleep disturbance and lower sleep duration than those who turned the phone off, indicating a possible area for behavioral intervention. In addition to the above findings, being woken up by electronic devices and using electronic devices after waking up during the night were found to be prospectively associated with shorter sleep duration. Altogether, these findings build upon our prior cross-sectional study in this sample by showing associations with adverse sleep outcomes one year later [19].

Our findings are in line with the hypothesis that screen use around bedtime is associated with sleep disturbance and shorter sleep duration. Our findings are consistent with previous cross-sectional studies that found associations between bedtime screen use and sleep problems [15–18,23,32]. The findings are also consistent with a prospective cohort study of 843 Swiss children (of whom a majority were aged 13–15 years), which found a prospective association between screen time (although not specifically bedtime screen time) and sleep problems [37]. The present study advances our understanding of bedtime screen use by demonstrating a prospective relationship between bedtime screen use and sleep problems in early adolescents in the United States.

Bedtime screen use may be associated with poor sleep outcomes via multiple mechanisms. Time spent using the screen around bedtime may displace time that could otherwise be used for sleep [16]. Specifically, we found that being woken up by electronic devices or using electronic devices when woken up during the night were prospectively associated with shorter sleep duration. In addition, bedtime activities involving screens

Table 3
Associations between bedtime screen usage and sleep in the Adolescent Brain Cognitive Development (ABCD) study (N = 9,398)

Bedtime Screen Use Exposures	Total sleep disturbance		Disorders of initiating and maintaining sleep		Weekly sleep duration	
	OR (95% CI)	*p*	B (95% CI)	*p*	B (95% CI)	*p*
TV set or an Internet-connected electronic device in bedroom	1.08 (0.94, 1.25)	.281	−0.03 (−0.18, 0.12)	.729	**−0.21 (−0.28, −0.13)**	**< .001**
Phone action when ready to go to sleep						
Turn the phone off	reference	reference	reference	reference	reference	reference
Put the ringer on silent or vibrate	0.96 (0.80, 1.16)	.668	−0.06 (−0.27, 0.15)	.563	**−0.15 (−0.26, −0.05)**	**.005**
Leave the ringer on	**1.25 (1.00, 1.56)**	**.046**	0.15 (−0.10, 0.40)	.237	**−0.27 (−0.40, −0.13)**	**< .001**
Put it outside of the room where I sleep	1.11 (0.92, 1.34)	.292	**0.20 (0.01, 0.39)**	**.043**	0.05 (−0.03, 0.14)	.227
Past week engagement in bed before going to sleep						
Watch or stream movies, videos, or TV shows	1.06 (0.99, 1.13)	.096	0.00 (−0.08, 0.07)	.915	**−0.10 (−0.14, −0.06)**	**< .001**
Play video games	1.08 (0.98, 1.18)	.111	0.00 (−0.10, 0.11)	.926	**−0.14 (−0.19, −0.08)**	**< .001**
Play music	**1.10 (1.04, 1.17)**	**.002**	**0.11 (0.03, 0.18)**	**.004**	**−0.10 (−0.14, −0.07)**	**< .001**
Talk on the phone or text	**1.13 (1.05, 1.23)**	**.002**	**0.12 (0.03, 0.22)**	**.012**	**−0.17 (−0.22, −0.12)**	**< .001**
Spend time online on social media (e.g., Facebook)	**1.10 (1.01, 1.20)**	**.025**	0.09 (−0.00, 0.19)	.058	**−0.21 (−0.26, −0.16)**	**< .001**
Spend time in chat rooms	1.14 (0.99, 1.31)	.067	0.15 (−0.02, 0.32)	.082	**−0.21 (−0.30, −0.11)**	**< .001**
Browse the Internet, Google (not school-related)	0.99 (0.88, 1.11)	.813	0.03 (−0.11, 0.17)	.668	**−0.16 (−0.24, −0.09)**	**< .001**
Use a computer/laptop for studying	1.01 (0.93, 1.10)	.857	0.00 (−0.10, 0.09)	.923	**−0.06 (−0.11, −0.00)**	**.034**
Reading	0.97 (0.91, 1.03)	.352	0.05 (−0.02, 0.12)	.140	**0.07 (0.03, 0.10)**	**< .001**
Woken up by phone calls, text messages, or e-mails after trying to go to sleep	0.98 (0.87, 1.11)	.788	−0.06 (−0.20, 0.07)	.357	**−0.16 (−0.24, −0.08)**	**< .001**
Used phone or other device when woke up during the night	1.11 (0.99, 1.24)	.081	0.13 (−0.01, 0.27)	.076	**−0.18 (−0.25, −0.10)**	**< .001**
Total Recreational Screen Time	**1.02 (1.01, 1.04)**	**.002**	**0.02 (0.00, 0.03)**	**.019**	**−0.03 (−0.04, −0.02)**	**< .001**

Bold indicates $p < .05$. B = coefficient from ordered logistic model (disorders of initiating and maintaining sleep) or linear regression model (weekly sleep duration). Models represent the abbreviated output from the regression models including adjustment for age, sex, race/ethnicity, household income, parent education, adverse childhood experiences, depression symptoms, melatonin use, study site, and the respective sleep variable at Year 2. Total sleep disturbance and disorders of initiating and maintain sleep are based on caregiver report and sleep duration is based on adolescent report. Propensity weights from the Adolescent Brain Cognitive Development Study were applied based on the American Community Survey from the US Census.

(e.g., talking or texting on the phone and using social media) may increase physiological and cognitive arousal, hindering the ability to fall asleep [38,39]. Bedtime screen use, as part of bedtime habits, can contribute to habit formation and reinforcement [40]. If these habits persist, they might lead to consistent patterns of poor sleep hygiene, which can have prolonged effects on sleep quality and overall health.

This study should be considered within the context of its strengths and limitations. The study uses a large, demographically diverse, population-based sample, providing strong external validity. Additional strengths include the study's prospective nature and focus on early adolescents. The study was subject to recall bias and social desirability bias, as measurements were based on adolescent self-reports and caregiver reports. However, we would expect underestimations of bedtime screen use if social desirability bias factored into participant and caregiver reports, which would have favored the null. In terms of study sample, there was heterogeneity between the sample included and excluded (N = 2,564), which could lead to selection bias. The bedtime screen use questionnaire also did not ask about the context or content of the screen use (e.g., whether they were interacting with others and the type of social media or video game), which could influence subsequent sleep quality measures. Dynamic changes of screen use patterns across a year were not assessed. Also, due to the use of a binary sleep disturbance outcome variable, there is a possibility of misclassification. Furthermore, the present study does not focus on other aspects of sleep health that could be influenced by bedtime screen use, such as sleep quality and sleep timing.

This study's findings have significant implications for clinical practice, public policy, and public health. Clinicians can consider inquiring about bedtime screen use, especially in early adolescence, and provide education to parents and adolescents on bedtime screen use. Parents can consider implementing a Family Media Use Plan [41], which could include limiting screen use before bedtime. This study also further informs our understanding of bedtime screen use and its implications for sleep, indicating the potential benefits of limiting screen use around bedtime, especially for those experiencing sleep difficulties. Further research should attempt to elucidate the mechanisms underlying the association between bedtime screen use and sleep outcomes, as well as use objective measures of screen use and sleep outcomes. In addition, it would be worthwhile to examine the relationship between bedtime screen use and sleep outcomes as the cohort ages to mid and late adolescence.

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Supplementary Data

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