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Social epidemiology of bedtime screen use behaviors and sleep outcomes in early adolescence

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ABSTRACT

Objectives: The current study aimed to determine sociodemographic associations of bedtime screen use behaviors and the sociodemographic differences in the associations between bedtime screen use and sleep outcomes in a national (US) study of early adolescents.
Methods: We analyzed cross-sectional data from 10,305 early adolescents (12-13 years, 48.4% female) in the Adolescent Brain Cognitive Development (ABCD) Study (Year 3, 2019-2021). Multiple regression analyses examined associations between (1) sociodemographic factors (age, sex, race and ethnicity, sexual orientation, household income, parental education, and number of siblings) and adolescent-reported bedtime screen use and (2) bedtime screen use and sleep outcomes (caregiver-reported sleep disturbance and self-reported sleep duration).
Results: Older age, female sex, sexual minority status, lower household income, and lower parent education were associated with more bedtime screen use. Black, Native American, and Latino/Hispanic race/ethnicity were associated with more bedtime screen use compared with White race, regardless of household income or parent education. More bedtime screen use was linked to greater sleep disturbances, with stronger effects observed in male adolescents. More bedtime screen use was also associated with shorter sleep duration, particularly among female adolescents and individuals from households with higher income and parental education levels. Although sexual minority identification was associated with more bedtime screen use, it was not associated with worse sleep outcomes among these adolescents.
Conclusions: Given sociodemographic differences in bedtime screen use, digital literacy education and anticipatory guidance could focus on at-risk early adolescent populations. Findings can inform targeted counseling by pediatricians and family media plans for diverse populations.

Introduction

Appropriate sleep is vital during adolescence in which many physiological, cognitive, and psychological processes are maturing. In addition, poor sleep patterns in adolescents can impair overall well-being, lead to physical and psychiatric disorders, and negatively impact academic performance.[1] For early adolescents aged 10-14 years undergoing puberty, sleep has profound impacts on mental and physical health and development.[1,2] A large number of early adolescents are not meeting daily sleep recommendations of 9-12 hours each night for 6-12-year-olds and 8-10 hours for 13-18-year-olds, largely due to the use of electronic devices in the evening or at night, which has been shown to have adverse effects on sleep duration and quality.[3,4] Daily screen time among adolescents has increased dramatically in recent times, posing the risk of increased bedtime screen use.[5] Almost all adolescents report having at least one electronic device in their bedrooms, including a television, video games, computers, phones, and music players.[5,6]

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Social epidemiology focuses on the intersection of social and structural factors that can influence health, such as demographic (e.g., sex, race and ethnicity, sexual orientation, etc.) and socioeconomic (e.g., income, education, etc.) factors that could be associated with health outcomes.[7,8] Identifying the prevalence and sociodemographic associations of bedtime screen use and associated sleep outcomes plays an important role in implementing and guiding targeted efforts to optimize sleep health for adolescents and their families. Sociodemographic factors may affect bedtime screen use behaviors through several mechanisms, including access to devices and education on the impacts of screen use and sleep. One such sociodemographic factor is age. One study of 738 adolescents in the United Kingdom in 2010 examined the association between the use of six different technologies and a variety of sleep parameters in a cohort of adolescents (11-13 years) and found that frequent use of all technology types (bedtime television viewing, video gaming, mobile telephones, music, computer or laptop studying, and the Internet) was associated with shorter sleep duration. However, this study did not specifically examine sleep disturbances as outcomes.[9]

Socioeconomic status may also impact bedtime screen use. Children from lower-income households have been found to have greater media access in their bedrooms, including TVs and video games.[10] One study analyzing the association between socioeconomic status and screen time in children aged 8-17 living in China found higher parental education was associated with higher rates of screen time guideline adherence. However, this investigation has limited generalizability to adolescents in the United States.[11]

Bedtime screen use may also differ based on race and ethnicity. Existing literature has pointed to race and ethnicity differences in total screen time in adults, younger children (up to 7 years old), and youth ranging from 6-19 years old.[12-14] A limited number of studies have considered sex differences in bedtime screen use. A 2015 Italian study of 850 adolescents ranging from 11-16 years old found that female adolescents reported more phone usage and lower total sleep time.[15] Similarly, a study of 362 male and female adolescents from Switzerland in 2012-2013 found that female adolescents were more likely to call or text before sleep than male adolescents, who were more likely to play video games or watch TV. The study found that watching television or videos, calling or texting, and being online at bedtime were correlated with sleep difficulties. Across the group, electronic media use at bedtime was related to sleep disturbances and more depressive symptoms.[16] A 2016-2017 study in New Zealand that considered bedtime screen activities and attitudes toward screen use in female and male adolescents (13-17 years) found female adolescents were more likely to perceive the detrimental effects of screens on health and sleep than male adolescents.[17]

One US-based study found that bedtime screen use was associated with difficulties falling asleep and nonrestorative sleep; however, this study included a wide age range (13-64 years) without a specific focus on adolescents with data collected in 2011.[17] Given the constantly evolving nature of digital technology devices and use patterns in the past decade, it is important to update these prior findings. Using prior data releases from the Adolescent Brain Cognitive Development Study (ABCD), we previously found associations between bedtime screen use and sleep at ages 11-12 years.[18,19] We anticipate bedtime screen use, particularly social media, to increase around age 13 (included in the present study), given that the minimum social media age requirement is 13 years. Additionally, our prior studies assessed the association between bedtime screen use and sleep but did not examine sociodemographic differences in bedtime screen use or sociodemographic differences in the association between bedtime screen use and sleep outcomes.[18,19] Though there is existing literature indicating sociodemographic disparities in daily screen use in adolescents, few studies have examined sociodemographic associations, particularly in early adolescence with screen use specifically at bedtime, which is most relevant for affecting sleep.[20] Additionally, to our knowledge, there are currently no studies investigating the relationship between sexual orientation and bedtime screen use in early adolescents.

The present study therefore aims to fill this gap by examining sociodemographic associations with bedtime screen use and the sociodemographic differences in the associations between bedtime screen use and sleep outcomes in a demographically diverse and population-based sample of early adolescents in the United States. We hypothesize that female adolescents, sexual minorities, racial and ethnic minorities, and adolescents from lower-income households will have more bedtime screen use, and screen use specifically at bedtime will be linked to more sleep disturbance and shorter sleep duration.

Participants and methods

The Adolescent Brain Cognitive Development (ABCD) Study is the largest longitudinal study of adolescent health and brain development in the United States, following 11,875 children from 21 recruitment sites across the country for 10 years across adolescence. The ABCD Study details have been previously described, including the study sample, recruitment, protocol, and measures.[21] Briefly, the ABCD Study recruited a sample reflecting the diversity of the US population by using epidemiologically informed strategies via school systems. Participants were all 9-10 years old at baseline and proficient in English. Exclusion criteria included the presence of a major medical or neurological condition, history of traumatic brain injury, diagnosis of schizophrenia, moderate/severe autism spectrum disorder, intellectual disability, alcohol/substance use disorder, premature birth (gestational age < 28 weeks), and contraindications to MRI scanning.

We conducted cross-sectional analyses of data from the Year 3 follow-up, when participants were predominantly 12-13 years of age. Participants missing responses on their screen usage around bedtime were excluded from the study, leaving 10,305 participants in our analysis (see Appendix A for a comparison of included and excluded samples). A complete case analysis was used to address missing data. Centralized institutional review board approval was received from the University of California, San Diego, as well as each individual study site. Written assent was obtained from the study participants, and written consent was obtained from their parents/guardians. As part of the consenting and assenting process, the parent or guardian first completed a Permission form, which granted permission for their child to participate in the study, and a Consent form, which allowed the parent or guardian to be a participant in the study. After the parent or guardian signed the forms, the child completed the assenting process separately from the parent or guardian. The child then signed an Assent form if they agreed to participate in the study.

Sociodemographic variables

The sociodemographic variables of sex (female or male), race and ethnicity (White, Latino, Black, Asian, Native American, and Other), household income, parental education status, number of siblings in household, and COVID-19 pandemic time period were self-reported by the caregiver at the baseline assessment. The age of the participant and sexual orientation were self-reported by the adolescent and analyzed using the Year 3 assessment of the ABCD Study. Adolescents were asked “Are you gay or bisexual?,” with response options: “Yes, Maybe, No, Don’t understand the question, or Decline to answer” to determine sexual orientation. Caregivers were asked about their annual income through the question, “What is your total combined household income for the past 12 months? This should include income (before taxes and deductions) from all sources, wages, rent from properties, social security, disability and/or

veteran's benefits, unemployment benefits, workman's compensation, help from relatives (include child payments and alimony), and so on." Response options were classified into 6 categories: $24,999 or less, $25,000-$49,999, $50,000-$74,999, $75,000- $99,999, $100,000-$199,999, or $200,000 and greater. To assess education, caregivers were asked, "What is the highest grade or level of school you [or your partner] have completed or the highest degree you have received?" Responses were categorized into "College education or higher" or "High School education or lower." To determine the number of siblings, caregivers reported the number of biological, adopted, step, and foster children living in their household. Collection before vs. during the COVID-19 pandemic was determined by interview dates before or after March 13, 2020.

Screen use variables

Bedtime screen usage

A questionnaire on screen usage behavior around bedtime was administered to adolescents. Eleven items on the questionnaire asked adolescents about their electronic media use while already in bed before going to sleep in the past week. This questionnaire was adapted from prior studies that used validated measures of technology use.[9,16,22] Adolescents were asked, "Is there a TV set or an Internet connected electronic device (computer, iPad, phone) in your bedroom?" with response options "Yes, No, or Decline to answer." The questionnaire then asked adolescents what they did with their phone when they were ready to go to sleep with response options "turn the phone off, put the ringer on silent or vibrate, leave the ringer on, or put it outside of the room." The following items provided a five-point Likert scale ranging from one (never) to five (every night) and asked participants how many nights in the past week they engaged in the following while already in bed before going to sleep: watching movies, videos, or TV shows; playing video games; playing music; talking on the phone or texting; spending time online on social media; browsing the Internet; and using a computer/laptop for studying. A mean scale score across the seven devices was calculated. The last 2 items asked adolescents with the same five-point Likert scale: how often they had phone calls, text messages, or emails 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.

Overall screen usage

Adolescents were given the Youth Screen Time Survey and self-reported the hours of their total recreational screen time 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.[23] The weighted sum of the weekday and weekend average ([weekday average x 5] + [weekend average x 2])/7 was used to determine the total typical daily screen use time.

Sleep variables

Sleep Disturbance Scale for Children (SDSC)

Caregivers completed a 26-item measure regarding the presence of sleep disorders in adolescents by rating each item using a 5-point Likert-type scale ranging from 1 (never) to 5 (daily). A total of six sleep disorders included disorders of initiating and maintaining sleep, sleep breathing disorders, disorders of arousal, sleep-wake transition disorders, disorders of excessive sleepiness, and sleep hyperhidrosis. A SDSC total score was calculated by taking the sum of all responses, in which a higher SDSC score reflects more severe sleep disturbance. The presence or absence of sleep disturbance was determined by a cutoff score of 39 based on recommendations by the survey developers.[24] Sleep disturbance was assessed as a binary variable in our statistical analysis as the absence (SDSC score less than 39) or presence (SDSC score greater than or equal to 39) of sleep disturbance.

Munich Chronotype Questionnaire (MCTQ)

Sleep duration was assessed using the Munich Chronotype Questionnaire,[25] completed by adolescents. Adolescents answered a 19-item questionnaire regarding what time they go to bed and wake up on weekdays and weekends, which was used to calculate sleep duration on weekdays and weekends. Average weekly sleep duration was calculated by weighting sleep duration on weekdays (7) and weekends (2) by the number of days in a week. A higher value reflects a longer sleep duration.

Statistical analysis

Data analyses were conducted in 2024 using Stata 18 (StataCorp, College Station, TX). We performed descriptive statistics by examining the means, standard deviations, and percentages of the individual categories within each of the sociodemographic and bedtime screen usage variables. Modified Poisson regression was conducted to estimate the associations between the predictors (age, sex, race and ethnicity, sexual orientation, household income, parental education, and number of siblings in the household) and the presence of an electronic device in the bedroom, adjusting for study site and data collection period (before or during the COVID-19 pandemic). The modified Poisson regression model was chosen for this binary outcome since the presence of an electronic device in the bedroom is common (70%).[26] We used multivariable Poisson regression to analyze the association between the sociodemographic exposure variables and how many nights in the past week adolescents engaged in various screen use behaviors while already in bed before going to sleep. Multivariable linear regressions were conducted to estimate the associations between the exposure variables and continuous outcomes: bedtime screen use mean score and total screen time. We tested for interactions between (1) race/ethnicity and household income and (2) race/ethnicity and parental education for bedtime screen use outcomes.

To assess sleep outcomes, we used multivariable logistic regression to assess the association between bedtime screen use and sleep disturbance, and we used multivariable linear regression to assess the association between bedtime screen use and sleep duration. We ran interaction tests to assess effect modification between sociodemographic factors (sex, race/ethnicity, sexual orientation, household income, and highest parental education) and screen use (bedtime screen use mean score and total screen time) for sleep outcomes. If there was evidence of significant interaction, we present stratified analyses. Given that there were sex differences in bedtime screen use types (e.g., video games vs. social media), we examined sex interactions with each bedtime screen use type in addition to the mean score. For all multivariate models analyzed, a two-sided alpha was set at $<.05$. Sample weights were applied to match key sociodemographic variables in the ABCD Study to the American Community Survey from the US Census.[27]

Results

Table 1 describes the sociodemographic characteristics of 10,305 participants included in this study. Nearly half (48.4%) of the participants were female and 45.1% were from racial and ethnic minority groups. Table 2 shows descriptive characteristics and frequencies of total recreational and bedtime screen use in the sample.

Table 3 shows associations between sociodemographic variables and bedtime screen usage. Older age, sexual minority or questioning (e.g., responded "maybe,") identification, lower household income, low parental education, and Latino/Hispanic, Black, and Native

Table 1
Sociodemographic characteristics of Adolescent Brain Cognitive Development (ABCD) Study participants (N = 10,305)

Sociodemographic characteristics	Mean (SD)/%
Age at Year 3 (y)	12.93 (0.65)
Sex (%)	
Female	48.4%
Male	51.6%
Race and ethnicity (%)	
White	54.9%
Latino/Hispanic	19.6%
Black	15.4%
Asian	5.5%
Native American	3.1%
Other	1.4%
Sexual minority identification (%)	
No	82.6%
Yes	8.7%
Maybe	5.5%
Don't understand the question	1.7%
Decline to answer	1.5%
Household income (%)	
$24,999 or less	15.9%
$25,000-$49,999	19.9%
$50,000-$74,999	18.0%
$75,000-$99,999	14.2%
$100,000-$199,999	24.3%
$200,000 and greater	7.7%
Parent's highest education (%)	
College education or more	17.5%
High school education or less	82.5%
Number of siblings (%)[a]	
No siblings	3.3%
1 sibling	12.8%
2 siblings	38.2%
3 siblings	27.4%
4 or more siblings	18.4%
COVID-19 pandemic (%)	
Before COVID-19 pandemic	15.7%
During COVID-19 pandemic	84.3%

ABCD sample weights were applied based on the American Community Survey from the US Census.
[a] Includes biological, adopted, step, and foster siblings.

American race/ethnicity (compared with White race) were associated with a higher bedtime screen use mean score and total overall screen time. Having four or more siblings compared with no siblings was associated with lower bedtime screen use mean score and total overall screen use. Asian race was associated with lower total screen use compared with White race. Male sex was associated with a lower bedtime screen use mean score, but more total overall screen time in comparison to female sex. Additionally, older age, male sex, sexual minority identification, low household income, low parental education, and Latino/Hispanic, Black, and Native American race/ethnicity (compared with White race) were associated with higher odds of having an electronic device in the bedroom (Table 3).

Sociodemographic associations with each individual bedtime screen modality are shown in Appendix B. Across the individual bedtime screen modalities, male sex generally was associated with a lower risk of engaging in bedtime screen use compared with female sex, except for playing video games. After conducting interaction tests with sociodemographic associations with bedtime screen usage, we found no significant interactions with either household income and race/ethnicity groups or highest parental education and race/ethnicity groups (not shown in tables).

Greater engagement in bedtime screen use (overall and across individual modalities) and total screen time were generally associated with higher odds of sleep disturbance and lower sleep duration (Table 4). Bedtime screen use associations with sleep outcomes stratified by sex, household income, and highest parental education are shown in Tables 5, 6, and 7, respectively, where there is evidence of significant interactions between those sociodemographic characteristics and bedtime screen use. We found no significant interactions between bedtime screen use and race/ethnicity or sexual orientation for sleep outcomes. The effect size of bedtime screen use on sleep disturbance was larger among male compared with female adolescents. Additionally, the association between bedtime screen use and sleep duration was stronger among female compared with male adolescents. Household income was an effect modifier in the association between bedtime screen use mean score and sleep duration (Table 6). Among participants with a household income of $75,000 or more, the effect size for bedtime screen use and sleep duration was larger compared with the effect size among participants with a household income of less than $75,000. There was a stronger association between bedtime screen use and shorter sleep duration among college-educated or more parent households compared with among high school–educated or less households.

Discussion

In this population-based, demographically diverse sample of early adolescents in the United States, several notable sociodemographic factors were associated with bedtime screen use. Girls had more bedtime screen use compared with boys in all modalities, except for playing video games. We found that Latino/Hispanic, Black, Native American, and other race/ethnicity adolescents had greater total bedtime screen use when compared with White adolescents, whereas Asian adolescents had a lower total bedtime screen use on average when compared with White adolescents. Adolescents who identified as sexual minorities also had a greater bedtime screen use when compared with their heterosexual peers. Age, lower household income, and lower parental education levels were also associated with greater bedtime screen use. Additionally, more bedtime screen use activities were associated with greater sleep disturbance and shorter sleep duration.

Sex

It is noteworthy that bedtime screen use was overall greater in female than male adolescents but total screen time was higher in male than female adolescents. The only bedtime screen use activity greater in male than female adolescents was video games, which is consistent with previous literature.[5,28] Notably, a prior investigation conducted in an Australian cohort of adolescents aged 10 years old found that daily electronic gaming increased in male adolescents over 4 years by over 40 minutes per day on average in comparison to female adolescents who decreased their daily electronic gaming by over 15 minutes per day on average over the same period.[29] Girls' elevated bedtime screen use for all other activities could be related to the "fear of missing out" (FoMO), a concept describing the apprehension that enjoyable or rewarding experiences and events are occurring and that one may be missing them.[30] Among university-age young adults, female students have been found to have higher rates of FoMO and bedtime screen use.[31] Additionally, the association between total screen time and sleep disturbance was stronger in male adolescents, whereas the association between bedtime screen use and sleep duration was stronger in female adolescents. The finding of elevated bedtime screen use in young female adolescents may relate in complex ways to the higher risk of insomnia that emerges during adolescence in this demographic, in which difficulty sleeping results in additional screen use that further adversely impacts sleep.[28,32]

Race and ethnicity

With regard to race and ethnicity, Black, Latino/Hispanic, and Native American adolescents were found to have greater bedtime

Table 2
Bedtime electronic device usage in the Adolescent Brain Cognitive Development (ABCD) Study in Year 3 (N = 10,305)

	Mean (SD)/%			
Total recreational screen time (h/week)	9.13 (8.87)			
Excessive use of screen time (%)				
0-2 h/day	7.8%			
2-4 h/day	18.1%			
4-6 h/day	18.8%			
6-8 h/day	13.9%			
8-10 h/day	10.8%			
10-12 h/day	7.7%			
12 or more hours/day	22.9%			
Is there a TV set or an Internet-connected electronic device (computer, iPad, and phone) in your bedroom?	Yes	No		
	70.80%	29.20%		
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
	48.0%	24.0%	12.0%	15.9%
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	38.7%	28.1%	15.7%	17.5%
Play video games	65.6%	18.7%	8.8%	7.0%
Play music	46.5%	23.1%	12.7%	17.8%
Talk on the phone or text	54.4%	23.4%	12.5%	9.7%
Spend time online on social media (e.g., Facebook)	56.1%	20.2%	12.6%	11.2%
Browse the Internet, Google-ing (not school-related)	72.9%	18.9%	5.3%	2.9%
Use a computer/laptop for studying	64.6%	20.5%	9.5%	5.5%
In the past week, how often have you had phone calls, text messages, or emails that wake you after trying to go to sleep?	75.5%	16.2%	5.5%	2.8%
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 emails?	71.7%	16.8%	7.6%	3.9%

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

screen use compared with White adolescents, and Asian adolescents were found to have lower bedtime screen use. These findings from Year 3 are similar to our findings of total daily average screen time in the ABCD sample.[5] There was no interaction with education or parent education, although previous findings showed that daily screen time was greater in minority groups with some interaction with education and socioeconomic status.[5] These associations may be attributed to systemic inequities disproportionately impacting minority race/ethnicity adolescents resulting in more bedtime screen use.[33] Racial differences in screen time use may be related to neighborhood environments, including fewer opportunities for outdoor physical activity in predominantly Black neighborhoods.[34] Prior studies have shown that lower perceptions of neighborhood safety were associated with lower physical activity and more screen time.[4] In addition, minority groups may be using screens more to form online connections with others of similar backgrounds if they are minorities in their local schools and communities.[35] Minority adolescents may also turn to technology's vast entertainment and social networking features as an accessible way to cope with everyday stressors.[4] Asian children reported lower levels of all types of screen time. It is possible that lower screen time use reflects less representation and content marketing for Asian American youth and thus less relatable content for this population.[4] There were no differences in associations between bedtime screen use and sleep outcomes across race and ethnicity groups, indicating that regardless of racial and ethnic differences in bedtime screen use, these differences did not result in worse sleep outcomes.

Sexual orientation

This is the first study to our knowledge to show that sexual minority identification and questioning one's sexual identity are associated with more bedtime screen use. These findings are consistent with findings in general screen use, as sexual minority adolescents in the ABCD Study reported nearly four more hours of daily total screen time and greater problematic use when compared with their heterosexual peers.[36] Existing literature suggests that sexual minority individuals may browse the Internet more when compared with heterosexual individuals, given that LGBT-focused social media increases access to self-relevant information that is not as easily accessed offline.[37,38] Particularly during puberty, access to LGBT-centered media may be especially valuable to identity formation and education. Additionally, increased time on social media, phone calls, or texting with friends may also help sexual minority adolescents find empowerment and connection through supportive communities.[39-41] There were also no differences in associations with sleep among sexual minorities, further indicating that more bedtime screen use in sexual minority adolescents was not associated with worse sleep outcomes. Given that sexual minority adolescents can leverage increased screen time for identity formation and community building without significantly worsened sleep outcomes, this may suggest potential positive aspects of screen use in sexual minority youth.

Socioeconomic status

Adolescents also had varying bedtime screen use based on socioeconomic status, encompassing household income and parent education. Adolescents with higher family income and with higher parental education levels had lower bedtime screen use, which could be from greater access to screen use guidelines, higher knowledge about health concerns surrounding high screen use, and positive role modeling.[37,42] However, there was a stronger association in higher-income (> $75,000) households between bedtime screen use and shorter sleep duration and between total screen time and more sleep disturbance and shorter sleep duration. With regard to parental education, among adolescents with parents who are college graduates and beyond, there was a stronger association with bedtime screen use, total screen time, and shorter sleep duration. These findings suggest that while higher income and parental education

Table 3
Sociodemographic associations with bedtime screen use in the Adolescent Brain Cognitive Development (ABCD) Study in Year 3 (N = 10,305)

	Is there a TV set or an Internet-connected electronic device (computer, iPad, and phone) in your bedroom?		Bedtime screen use mean score (average of movies/videos/TV, video games, music, phone/text, social media, Internet, and computer/laptop for studying)		In the past week, how often have you had phone calls, text messages, or emails that wake you after trying to go to sleep?		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 emails?		Total screen time	
Sociodemographic characteristics	IRR (95% CI)	*p*	B (95% CI)	*p*	IRR (95% CI)	*p*	IRR (95% CI)	*p*	B (95% CI)	*p*
Age (y)	**1.07 (1.04, 1.10)**	**< .001**	**0.13 (0.11, 0.15)**	**< .001**	1.02 (0.99, 1.04)	.201	**1.02 (1.00, 1.05)**	**.049**	**1.10 (0.80, 1.40)**	**< .001**
Sex										
Female	Reference		Reference		Reference		Reference		Reference	
Male	**0.96 (0.93, 0.99)**	**.006**	**−0.11 (−0.14, −0.08)**	**< .001**	**0.97 (0.94, 1.00)**	**.022**	0.98 (0.95, 1.01)	.171	**0.77 (0.38, 1.16)**	**< .001**
Race and ethnicity										
White	Reference		Reference		Reference		Reference		Reference	
Latino/Hispanic	**1.10 (1.04, 1.15)**	**< .001**	**0.12 (0.07, 0.18)**	**< .001**	**1.08 (1.03, 1.14)**	**.002**	**1.09 (1.03, 1.15)**	**.004**	**1.19 (0.51, 1.87)**	**.001**
Black	**1.16 (1.11, 1.21)**	**< .001**	**0.31 (0.26, 0.36)**	**< .001**	**1.25 (1.19, 1.30)**	**< .001**	**1.31 (1.25, 1.37)**	**< .001**	**4.43 (3.64, 5.22)**	**< .001**
Asian	0.97 (0.89, 1.07)	.567	−0.01 (−0.08, 0.06)	.827	0.95 (0.90, 1.01)	.081	0.95 (0.89, 1.00)	.052	**−0.63 (−1.24, −0.03)**	**.041**
Native American	**1.15 (1.07, 1.25)**	**< .001**	**0.16 (0.07, 0.25)**	**< .001**	1.07 (0.97, 1.18)	.181	**1.13 (1.03, 1.25)**	**.012**	**2.32 (0.72, 3.91)**	**.004**
Other	1.09 (0.92, 1.30)	.329	0.20 (0.00, 0.41)	.052	1.02 (0.90, 1.17)	.736	**1.24 (1.02, 1.51)**	**.029**	2.26 (−1.25, 5.78)	.207
Sexual minority status										
No	Reference		Reference		Reference		Reference		Reference	
Yes	**1.11 (1.06, 1.16)**	**< .001**	**0.20 (0.14, 0.25)**	**< .001**	1.05 (1.00, 1.11)	.075	**1.09 (1.04, 1.16)**	**.001**	**2.62 (1.76, 3.48)**	**< .001**
Maybe	1.03 (0.97, 1.10)	.294	**0.09 (0.03, 0.15)**	**.002**	1.04 (0.98, 1.12)	.212	1.02 (0.96, 1.09)	.441	**1.28 (0.49, 2.08)**	**.002**
Don't understand the question	0.86 (0.74, 1.00)	.055	**−0.22 (−0.30, −0.14)**	**< .001**	0.92 (0.82, 1.03)	.162	**0.83 (0.75, 0.91)**	**.000**	**−1.72 (−2.90, −0.54)**	**.004**
Decline to answer	0.92 (0.79, 1.07)	.282	0.00 (−0.12, 0.13)	.993	1.07 (0.93, 1.23)	.351	1.09 (0.95, 1.24)	.227	0.83 (−1.24, 2.89)	.432
Household income										
$24,999 or less	Reference		Reference		Reference		Reference		Reference	
$25,000- $49,999	1.03 (0.98, 1.09)	.193	−0.02 (−0.08, 0.04)	.561	0.96 (0.90, 1.01)	.134	0.95 (0.90, 1.00)	.064	−0.87 (−1.82, 0.08)	.074
$50,000- $74,999	1.01 (0.95, 1.06)	.844	−0.04 (−0.10, 0.02)	.167	**0.93 (0.87, 0.98)**	**.011**	0.94 (0.89, 1.00)	.057	**−1.61 (−2.53, −0.69)**	**.001**
$75,000- $99,999	**0.93 (0.87, 0.99)**	**.023**	**−0.10 (−0.17, −0.04)**	**.001**	**0.92 (0.86, 0.97)**	**.004**	**0.94 (0.89, 1.01)**	**.076**	**−2.31 (−3.23, −1.38)**	**< .001**
$100,000- $199,999	**0.93 (0.88, 0.99)**	**.016**	**−0.16 (−0.21, −0.10)**	**< .001**	**0.90 (0.84, 0.95)**	**< .001**	**0.86 (0.81, 0.92)**	**< .001**	**−3.23 (−4.10, −2.36)**	**< .001**
$200,000 and greater	**0.89 (0.83, 0.96)**	**.002**	**−0.17 (−0.23, −0.10)**	**< .001**	**0.88 (0.83, 0.94)**	**< .001**	**0.86 (0.81, 0.92)**	**< .001**	**−3.65 (−4.55, −2.74)**	**< .001**
Parent's highest education										
College education or more	Reference		Reference		Reference		Reference		Reference	
High school education or less	**1.07 (1.03, 1.12)**	**.002**	**0.11 (0.06, 0.16)**	**< .001**	1.05 (0.99, 1.10)	.088	**1.07 (1.02, 1.13)**	**.007**	**1.43 (0.58, 2.28)**	**.001**
Number of siblings (%)[a]										
No siblings	Reference		Reference		Reference		Reference		Reference	
1 sibling	1.08 (0.99, 1.18)	.080	−0.07 (−0.17, 0.02)	.143	0.95 (0.87, 1.04)	.245	0.93 (0.85, 1.02)	.132	−0.25 (−1.83, 1.33)	.759
2 siblings	1.04 (0.95, 1.13)	.418	−0.06 (−0.15, 0.03)	.219	0.98 (0.90, 1.07)	.683	0.94 (0.86, 1.02)	.140	−0.74 (−2.22, 0.74)	.329
3 siblings	1.01 (0.93, 1.10)	.841	−0.06 (−0.16, 0.03)	.187	1.01 (0.92, 1.10)	.872	0.95 (0.87, 1.04)	.232	−0.71 (−2.20, 0.78)	.349
4 or more siblings	0.95 (0.86, 1.03)	.216	**−0.11 (−0.20, −0.01)**	**.027**	0.98 (0.90, 1.07)	.649	0.96 (0.87, 1.05)	.356	**−1.62 (−3.12, −0.11)**	**.035**

Abbreviations: B, coefficient from linear regression models; IRR, incidence rate ratio from modified Poisson regression model.
Models represent the abbreviated output from the modified Poisson and linear regression models, including adjustment for age, sex, race and ethnicity, sexual orientation, household income, parent education, number of siblings, COVID-19 pandemic, and study site in addition to all variables listed. Sample weights from the Adolescent Brain Cognitive Development Study were applied based on the American Community Survey from the US Census.
Bold indicates $p < .05$.
[a] Includes biological, adopted, step, and foster siblings.

Table 4
Bedtime screen use associations with sleep outcomes in the Adolescent Brain Cognitive Development (ABCD) Study in Year 3 (N = 10,305)

	Sleep disturbance scale		Sleep duration	
Bedtime screen use	OR (95% CI)	*p*	B (95% CI)	*p*
Is there a TV set or an Internet-connected electronic device (computer, iPad, and phone) in your bedroom?	1.03 (0.90, 1.17)	.676	**−0.39 (−0.47, −0.30)**	**< .001**
Bedtime screen use mean score (average of movies/videos/TV, video games, music, phone/text, social media, Internet, and computer/laptop for studying)	**1.36 (1.23, 1.50)**	**< .001**	**−0.43 (−0.52, −0.34)**	**< .001**
Watch or stream movies, videos, or TV shows	**1.11 (1.05, 1.17)**	**< .001**	**−0.20 (−0.24, −0.16)**	**< .001**
Play video games	**1.15 (1.08, 1.23)**	**< .001**	**−0.15 (−0.21, −0.09)**	**< .001**
Play music	**1.19 (1.13, 1.25)**	**< .001**	**−0.11 (−0.15, −0.07)**	**< .001**
Talk on the phone or text	**1.11 (1.05, 1.18)**	**.001**	**−0.20 (−0.24, −0.15)**	**< .001**
Spend time online on social media (e.g., Facebook)	**1.08 (1.02, 1.15)**	**.007**	**−0.25 (−0.29, −0.20)**	**< .001**
Browse the Internet, Google-ing (not school-related)	**1.12 (1.04, 1.22)**	**.005**	**−0.13 (−0.20, −0.06)**	**< .001**
Use a computer/laptop for studying	1.04 (0.97, 1.11)	.322	−0.02 (−0.08, 0.04)	.482
In the past week, how often have you had phone calls, text messages, or emails that wake you after trying to go to sleep?	1.10 (1.00, 1.21)	.053	**−0.21 (−0.29, −0.13)**	**< .001**
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 emails?	**1.25 (1.14, 1.36)**	**< .001**	**−0.25 (−0.33, −0.17)**	**< .001**
Total screen time	**1.02 (1.01, 1.02)**	**< .001**	**−0.02 (−0.03, −0.01)**	**< .001**

Abbreviations: B, coefficient from linear regression model; OR, odds ratio from logistic regression model.
Models represent the abbreviated output from the modified Poisson and linear regression models, including adjustment for age, sex, race and ethnicity, sexual orientation, household income, parent education, number of siblings, COVID-19 pandemic, and study site in addition to all variables listed. Sample weights from the Adolescent Brain Cognitive Development Study were applied based on the American Community Survey from the US Census.
Bold indicates $p < .05$.

Table 5
Bedtime screen use associations with sleep outcomes stratified by sex in the Adolescent Brain Cognitive Development (ABCD) Study in Year 3 (N = 10,305)

	Sleep disturbance		Sleep duration	
Bedtime screen use	OR (95% CI)	*p*	B (95% CI)	*p*
Bedtime screen use mean score (average of movies/videos/TV, video games, music, phone/text, social media, Internet, and computer/laptop for studying)				
Overall	**1.36 (1.23, 1.50)**	**< .001**	**−0.43 (−0.52, −0.34)**	**< .001**
Female	**1.21 (1.04, 1.40)**	**.012**	**−0.53 (−0.64, −0.42)**	**< .001**
Male	**1.49 (1.30, 1.72)**	**< .001**	**−0.34 (−0.47, −0.20)**	**< .001**
Interaction *p*-value	—	**.006**	—	**.036**
Watch or stream movies, videos, or TV shows				
Overall	**1.11 (1.05, 1.17)**	**< .001**	**−0.20 (−0.24, −0.16)**	**< .001**
Female	1.03 (0.95, 1.11)	.459	—	
Male	**1.18 (1.10, 1.27)**	**< .001**	—	
Interaction *p*-value	—	**.001**	—	.887
Play video games				
Overall	**1.15 (1.08, 1.23)**	**< .001**	**−0.15 (−0.21, −0.09)**	**< .001**
Female	1.07 (0.96, 1.19)	.252	—	
Male	**1.19 (1.09, 1.29)**	**< .001**	—	
Interaction *p*-value	—	**.043**	—	.367
Talk on the phone or text				
Overall	**1.11 (1.05, 1.18)**	**.001**	**−0.20 (−0.24, −0.15)**	**< .001**
Female	—		**−0.25 (−0.31, −0.19)**	**< .001**
Male	—		**−0.13 (−0.20, −0.05)**	**.001**
Interaction *p*-value	—	.077	—	**.023**
Spend time online on social media (e.g., Facebook)				
Overall	**1.08 (1.02, 1.15)**	**.007**	**−0.25 (−0.29, −0.20)**	**< .001**
Female	1.03 (0.95, 1.12)	.472	**−0.29 (−0.35, −0.24)**	**< .001**
Male	**1.16 (1.06, 1.27)**	**.001**	**−0.19 (−0.27, −0.12)**	**< .001**
Interaction *p*-value	—	**.016**	—	**.040**
Use a computer/laptop for studying				
Overall	1.04 (0.97, 1.11)	.322	−0.02 (−0.08, 0.04)	.482
Female	0.98 (0.89, 1.08)	.642	**−0.08 (−0.15, −0.01)**	**.018**
Male	1.10 (1.00, 1.22)	.055	0.05 (−0.04, 0.15)	.285
Interaction *p*-value	—	**.045**	—	**.018**
Total recreational screen time (hours per week)				
Overall	**1.02 (1.01, 1.02)**	**< .001**	**−0.02 (−0.03, −0.01)**	**< .001**
Female	1.01 (1.00, 1.02)	.061	—	
Male	**1.02 (1.01, 1.04)**	**< .001**	—	
Interaction *p*-value	—	**.007**	—	

Abbreviations: B, coefficient from linear regression model; OR, odds ratio from logistic regression model.
Models represent the abbreviated output from the modified Poisson and linear regression models, including adjustment for age, sex, race and ethnicity, sexual orientation, household income, parent education, number of siblings, COVID-19 pandemic, and study site in addition to all variables listed. Sample weights from the Adolescent Brain Cognitive Development Study were applied based on the American Community Survey from the US Census.
Bold indicates $p < .05$.

Table 6
Bedtime screen use associations with sleep outcomes stratified by household income in the Adolescent Brain Cognitive Development (ABCD) Study in Year 3 (N = 10,305)

	Sleep disturbance		Sleep duration	
Bedtime screen use	OR (95% CI)	*p*	B (95% CI)	*p*
Is there a TV set or an Internet-connected electronic device (computer, iPad, and phone) in your bedroom?				
Overall	1.03 (0.90, 1.17)	.676	**−0.39 (−0.47, −0.30)**	**<.001**
<$75,000	0.91 (0.74, 1.12)	.360	—	
≥$75,000	1.15 (0.98, 1.35)	.080	—	
Interaction *p*-value	—	**.032**	—	
Bedtime screen use mean score (average of movies/videos/TV, video games, music, phone/text, social media, Internet, and computer/laptop for studying)				
Overall	**1.36 (1.23, 1.50)**	**<.001**	**−0.43 (−0.52, −0.34)**	**<.001**
<$75,000	—		**−0.34 (−0.48, −0.19)**	**<.001**
≥$75,000	—		**−0.54 (−0.61, −0.47)**	**<.001**
Interaction *p*-value	—			**.002**
Total recreational screen time (hours per week)				
Overall	**1.02 (1.01, 1.02)**	**<.001**	**−0.02 (−0.03, −0.01)**	**<.001**
<$75,000	**1.01 (1.01, 1.02)**	**.002**	**−0.01 (−0.02, 0.00)**	**.058**
≥$75,000	**1.03 (1.02, 1.04)**	**<.001**	**−0.04 (−0.05, −0.03)**	**<.001**
Interaction *p*-value	—	**.019**	—	**<.001**

Abbreviations: B, coefficient from linear regression model; OR, odds ratio from logistic regression model.
Models represent the abbreviated output from the modified Poisson and linear regression models, including adjustment for age, sex, race and ethnicity, sexual orientation, household income, parent education, number of siblings, COVID-19 pandemic, and study site in addition to all variables listed. Sample weights from the Adolescent Brain Cognitive Development Study were applied based on the American Community Survey from the US Census.
Bold indicates $p < .05$.

Table 7
Bedtime screen use associations with sleep outcomes stratified by parent's highest educational attainment in the Adolescent Brain Cognitive Development (ABCD) Study in Year 3 (N = 10,305)

	Sleep duration	
Bedtime screen use	B (95% CI)	*p*
Bedtime screen use mean score (average of movies/videos/TV, video games, music, phone/text, social media, Internet, and computer/laptop for studying)		
Overall	**−0.43 (−0.52, −0.34)**	**<.001**
College education or more	**−0.48 (−0.56, −0.40)**	**<.001**
High school education or less	−0.17 (−0.52, 0.18)	.351
Interaction *p*-value	—	**.029**
Total recreational screen time (hours per week)		
Overall	**−0.02 (−0.03, −0.01)**	**<.001**
College education or more	**−0.02 (−0.03, −0.01)**	**<.001**
High school education or less	0.00 (−0.02, 0.01)	.652
Interaction *p*-value	—	**.029**

Abbreviation: B, coefficient from linear regression model.
Models represent the abbreviated output from the modified Poisson and linear regression models, including adjustment for age, sex, race and ethnicity, sexual orientation, household income, parent education, number of siblings, COVID-19 pandemic, and study site in addition to all variables listed. Sample weights from the Adolescent Brain Cognitive Development Study were applied based on the American Community Survey from the US Census.
Bold indicates $p < .05$.

may protect against bedtime screen use, the negative association between bedtime screen use and sleep duration is stronger in adolescents in these families.

Limitations and strengths

Several limitations of our study should be noted. Given the cross-sectional nature of the dataset and the possibility of confounding variables beyond the variables we adjusted for, we cannot make conclusions on causal relationships or directionality between the investigated variables. In particular, bedtime screen use has a complex, likely bidirectional, relationship with sleep outcomes, as we have reported previously.[18,19] Additionally, measures in the ABCD Study were based on self-reported data that are subject to recall and reporting bias. The ABCD Study does not collect information on the bedroom status of the adolescents (e.g., if they shared a bedroom), so we were unable to examine bedroom status in the analysis. Regarding the number of siblings, the ABCD Study oversampled participants with siblings and twins to better understand the contribution of genetics and shared family environment to adolescent development.[43] Additionally, the ABCD Study does not quantify the duration of bedtime screen use, so we are unable to assess the impact of screen use length on the outcome variables. The overall screen usage, or total recreational screen time, is the sum of separately reported screen activities, and many of these activities may overlap as there may be media multitasking. Limitations to complete case analysis of missing data must also be noted. By excluding participants with incomplete predictor and outcome data, we may have selection bias. However, we have applied sample weights based on the American Community Survey from the United States Census to account for selection bias from missing data. The effect sizes for bedtime screen use and sleep outcomes were relatively small. However, screen use at bedtime is an important exposure because it is modifiable and effects could accumulate over longer periods of time.

Moreover, this study coincided with the COVID-19 pandemic, which may have impacted adolescent screen use and sleep patterns. For example, during the pandemic, US adolescents reported significantly higher screen time, associated with later bedtimes and poorer sleep quality (e.g., longer sleep onset latency, more frequent

awakenings).[44] At the same time, longer total sleep duration was observed during the pandemic, potentially due to factors related to lockdowns and remote schooling, such as later start times, the absence of commuting, and more flexible routines.[45] These changes may have introduced variability in sleep outcomes diverging from typical, prepandemic patterns. Although we adjusted for data collection period (before or during the COVID-19 pandemic), unmeasured pandemic-related influences may still confound the observed associations.

Conclusion

These findings have several clinical and policy implications with regard to bedtime screen use guidelines. For instance, the American Academy of Pediatrics Family Media Use Plan can further explicate the importance of limiting screen use before bedtime.[46] Additionally, targeted guidance from clinicians serving racial, ethnic, and sexual minority communities may help limit bedtime screen use. Community and school-based efforts can also include employing culturally specific messaging to engage children in alternative prebedtime activities beyond screen use. Future investigations should incorporate objective measures for screen use and sleep, study the effects of bedtime screen use and sleep on mental health outcomes, and investigate ways to reduce bedtime screen use in these populations.

Author contributions

Jason M. Nagata: Writing – review and editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Joan Shim**: Formal analysis, Writing – original draft, Writing – review and editing. **Sapna Ramappa**: Writing – original draft, Writing – review and editing. **Ishani Deshpande**: Writing – original draft, Writing – review and editing. **Patrick Low**: Writing – original draft, review and editing. **Orsolya Kiss**: Conceptualization, Writing – revisions. **Kyle T. Ganson**: Writing – review and editing. **Alexander Testa**: Writing – review and editing. **Jinbo He**: Writing – review and editing. **Fiona C. Baker**: Writing – review and editing, Data curation. All authors have approved the final article.

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Declaration of conflicts of interest

The authors have no conflict to declare.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sleh.2025.05.005.

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