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Nighttime Digital Screen Exposure, Sleep Disruption, and Cognitive Function Among High School Students: A Cross-Sectional Study

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Abstract: The rapid growth of digital technology has significantly increased screen exposure among adolescents, particularly during nighttime hours. This study aimed to investigate the relationship between nighttime screen exposure, sleep disruption, cognitive function, and academic performance among adolescents. A cross-sectional survey was conducted among secondary school students using a structured questionnaire assessing screen-use behavior, sleep patterns, daytime functioning, and perceived academic effects. The findings revealed that 74.4% of participants used screens for more than 6 hours daily, while 67.9% reported using screens before bedtime every day. More than half of the respondents (51.3%) spent over 60 minutes using screens prior to sleep, and 58.7% believed that screen exposure caused them to sleep later than usual. Daytime consequences were also prominent, with 61.4% reporting frequent daytime drowsiness and 50.7% experiencing difficulty maintaining attention or episodes of absent-mindedness. Additionally, 92% of participants perceived that prolonged screen exposure negatively affected their concentration during learning activities. Common physical and psychological symptoms included neck pain (48%), headaches (45.3%), stress (36%), and reduced concentration (38.7%). Despite these negative effects, a substantial proportion of students maintained relatively high academic achievement. The study suggests that excessive nighttime screen exposure is strongly associated with sleep disruption and cognitive impairment among adolescents. These findings highlight the importance of promoting healthy digital habits and sleep hygiene strategies to reduce the long-term impact of excessive screen use on adolescent well-being and academic functioning.

Keywords: *Screen Time; Sleep Disruption; Adolescents; Cognitive Function; Academic Performance.*

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I. INTRODUCTION

The rapid advancement of digital technology has dramatically transformed the daily lifestyles of adolescents worldwide. Smartphones, tablets, and other digital devices have become essential tools for communication, entertainment, education, and social interaction. Adolescents are among the most active users of digital media, frequently engaging with screens for prolonged periods throughout the day and night. The increasing accessibility of mobile devices and internet-based platforms has contributed to a substantial rise in screen exposure, particularly among secondary school students. While digital technology offers educational and social benefits, excessive screen use has become a growing public health concern due to its potential effects on physical health, mental well-being, sleep quality, and cognitive functioning.

One of the most concerning behavioral trends among adolescents is nighttime screen exposure. Previous studies have demonstrated that prolonged exposure to digital screens before bedtime may interfere with circadian rhythms and suppress melatonin secretion, leading to delayed sleep onset and poorer sleep quality. The blue light emitted from electronic devices can disrupt the body's natural sleep–wake cycle, resulting in shorter sleep duration and increased sleep disturbances. Adolescents who frequently use smartphones or other digital devices at night are more likely to experience insomnia symptoms, delayed bedtimes, nighttime awakenings, and daytime fatigue. In addition, excessive

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screen engagement may stimulate emotional and cognitive arousal, making it more difficult for individuals to relax and initiate sleep.

Sleep plays a critical role in adolescent growth, cognitive development, emotional regulation, memory consolidation, and academic performance. Insufficient or poor-quality sleep has been associated with decreased concentration, impaired attention, daytime sleepiness, mood instability, and reduced learning efficiency. Several studies have reported that adolescents with excessive screen time often demonstrate lower academic engagement and poorer cognitive functioning compared with peers who maintain healthier digital habits. Moreover, prolonged screen exposure has also been linked to physical symptoms such as headaches, neck pain, eye strain, and musculoskeletal discomfort, which may further affect students' daily functioning and quality of life.

Despite increasing global concern regarding digital behavior and adolescent health, research focusing specifically on nighttime screen exposure and its multidimensional effects among adolescents in Thailand remains limited. Many previous studies have primarily focused on general screen time without comprehensively examining sleep-related behaviors, cognitive outcomes, daytime dysfunction, and perceived academic impact simultaneously. Furthermore, the rapid expansion of online entertainment and social media usage among adolescents highlights the need for updated evidence regarding digital lifestyle behaviors in the post-pandemic era.

Therefore, this study aimed to investigate the relationship between nighttime screen exposure, sleep disruption, cognitive function, and academic performance among adolescents. The findings of this study may contribute to a better understanding of adolescent digital behavior and provide valuable evidence for educators, healthcare professionals, and policymakers in developing strategies to promote healthy screen-use habits and improve sleep health among students.

II. LITERATURE REVIEW

- *Screen Exposure and Digital Behavior Among Adolescents*

Digital screen exposure has become a central component of adolescent daily life. Smartphones, tablets, computers, and online platforms are now used for communication, entertainment, social interaction, and learning. Although digital devices provide important educational benefits, excessive recreational screen use has been increasingly associated with adverse health and developmental outcomes. Current public health guidelines emphasize reducing prolonged sedentary screen time among children and adolescents because high screen exposure is linked with shorter sleep duration, poorer health outcomes, and lower physical activity.

In adolescence, screen use is particularly important because this period is marked by rapid cognitive, emotional, and social development. Adolescents are also more likely to use screens for entertainment, social media, gaming, and video streaming, which may increase psychological stimulation and reduce self-regulation of bedtime routines. Previous research suggests that recreational screen use, especially internet use and gaming, may have a stronger negative relationship with academic outcomes than purely educational screen use.

- *Nighttime Screen Use and Sleep Disruption*

Nighttime screen exposure is one of the most consistent predictors of poor sleep outcomes among adolescents. A systematic review by Hale and Guan found that approximately 90% of included studies reported an association between screen media use and delayed bedtime or reduced total sleep time. Similarly, later evidence has shown that digital media use is associated with shorter sleep duration, poorer sleep quality, later bedtime, and increased daytime tiredness, particularly when screen use occurs at night.

Several mechanisms may explain this relationship. First, screen use can directly displace sleep time because adolescents continue using devices beyond their intended bedtime. Second, emotionally engaging content such as social media, gaming, or video streaming may increase cognitive arousal and make it more difficult to initiate sleep. Third, light exposure from screens, especially blue-enriched light, may suppress melatonin secretion and delay circadian rhythms, increasing sleep latency and reducing sleep quality.

Recent studies using more objective measures have strengthened this evidence. For example, research on electronic screen use among children and adolescents reported that exposure to bright light before sleep can delay melatonin release and disrupt circadian rhythm. These findings support the view that nighttime screen exposure is not only a behavioral issue but also a biological sleep-disruption factor.

- *Sleep Quality, Daytime Functioning, and Cognitive Outcomes*

Adequate sleep is essential for adolescent development. Sleep supports attention, memory consolidation, emotional regulation, executive functioning, and learning. Poor sleep quality and insufficient sleep have been associated with daytime sleepiness, reduced concentration, mood disturbance, and impaired academic engagement. A systematic review on sleep and academic performance concluded that sleep quality is an important factor related to students' cognitive and learning outcomes.

In adolescents, daytime sleepiness may be particularly problematic because it directly affects classroom attention and learning efficiency. Students who sleep late or experience fragmented sleep are more likely to feel tired during the day, have difficulty concentrating, and show lower academic productivity. Previous research has also indicated that sleep patterns may mediate the relationship between screen media use and academic or cognitive performance.

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➢ *Screen Use and Academic Performance*

The relationship between screen use and academic performance is complex. Digital devices can support learning through access to educational resources, online classes, and academic communication. However, excessive recreational screen time may compete with study time, reduce concentration, and promote delayed bedtime. Recent evidence suggests that screen time can affect academic performance both directly and indirectly through sleep, mental health, peer relationships, and family interaction.

Importantly, academic performance may not immediately decline even when students report reduced concentration or daytime fatigue. High-achieving students may maintain good grades despite experiencing hidden cognitive burden, poor sleep hygiene, or reduced learning efficiency. Therefore, perceived concentration, daytime functioning, and sleep quality are important outcomes to examine alongside academic grades.

➢ *Research Gap*

Although previous studies have established a relationship between screen time and sleep outcomes, several gaps remain. First, many studies focus on total daily screen time but give less attention to nighttime screen exposure, which may be more strongly related to sleep disruption. Second, limited evidence has examined screen behavior, sleep quality, daytime cognitive function, physical symptoms, and academic impact within the same adolescent population. Third, evidence from Thai adolescents remains relatively limited, despite the rapid increase in smartphone and digital media use among students.

Therefore, the present study addresses these gaps by examining nighttime screen exposure, sleep disruption, cognitive outcomes, and perceived academic performance among adolescents. This integrated approach may provide a clearer understanding of how digital lifestyle behaviors influence adolescent health and learning in the modern digital environment.

III. METHODOLOGY

➢ *Study Design and Participants*

This study employed a cross-sectional descriptive research design to investigate the relationship between nighttime screen exposure, sleep disruption, cognitive function, and academic performance among adolescents. The study was conducted among secondary school students in Thailand using a structured self-administered questionnaire.

Participants were recruited using a convenience sampling method. Eligible participants included students currently studying at the lower secondary and upper secondary levels who voluntarily agreed to participate in the study. The questionnaire was distributed online through digital platforms and social communication channels commonly used by students. A total of 75 valid responses were included in the final analysis after data screening and completeness verification.

➢ *Research Instrument*

Data were collected using a structured questionnaire developed based on previous literature related to screen exposure, sleep behavior, and adolescent health. The questionnaire consisted of five major sections:

- *Part 1: Demographic Characteristics*

This section collected general participant information including:

✓ Gender
✓ Educational level
✓ Average academic performance (GPA)

- *Part 2: Screen Exposure and Digital Behavior*

This section assessed:

✓ Daily screen time duration
✓ Types of devices used
✓ Number of digital devices owned or regularly used
✓ Primary purposes of screen use
✓ Perceived importance of digital devices
✓ Emotional reactions when unable to access screens

- *Part 3: Nighttime Screen Exposure and Sleep Behavior*

Participants were asked about:

✓ Frequency of screen use before bedtime
✓ Duration of screen use before sleep
✓ Screen use after going to bed
✓ Sleep duration
✓ Bedtime and wake-up time
✓ Frequency of nighttime awakening
✓ Perceived effects of screen use on sleep

- *Part 4: Sleep-Related and Cognitive Symptoms*

This section evaluated symptoms associated with excessive screen exposure and poor sleep, including:

✓ Daytime sleepiness
✓ Difficulty concentrating
✓ Headaches
✓ Neck pain
✓ Stress
✓ Fatigue
✓ Cognitive confusion
✓ Emotional symptoms

Participants rated several sleep-related outcomes using a 5-point Likert scale ranging from Level 1 (lowest impact) to Level 5 (highest impact).

- *Part 5: Academic and Perceived Impacts*

Participants reported:

✓ Perceived effects of screen use on concentration and learning
✓ Positive and negative impacts of screen exposure on daily life and academic activities

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➢ *Data Collection Procedure*

Data collection was conducted anonymously to protect participant privacy and encourage honest responses. Before participation, students were informed about the study objectives, confidentiality of information, and voluntary nature of participation. Completion of the questionnaire was considered informed consent.

➢ *Data Analysis*

Descriptive statistical analysis was used to summarize participant characteristics, screen-use behavior, sleep patterns, and reported symptoms. Frequencies, percentages, means, and standard deviations were calculated where appropriate.

The relationships between screen exposure and sleep-related outcomes were analyzed descriptively to identify behavioral trends and potential associations. Data were organized and presented using tables, bar charts, and graphical summaries to facilitate interpretation of the findings.

➢ *Ethical Considerations*

The study was conducted in accordance with ethical principles for human research. Participant anonymity and confidentiality were maintained throughout the study process. No personally identifiable information was collected, and all responses were analyzed in aggregate form solely for academic purposes.

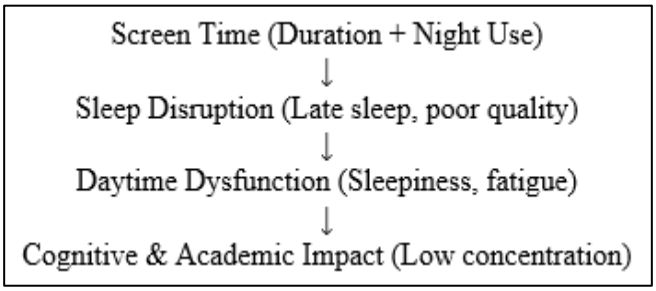

Fig 1 Conceptual Framework of the Study

IV. RESULTS

➢ *Participant Characteristics*

A total of 75 adolescents participated in this study. The majority of participants were female (91.0%), while males accounted for 7.7%, and 1.3% preferred not to disclose their gender. Most participants were upper secondary school students (66.7%), followed by lower secondary students (29.5%), whereas primary school and undergraduate students represented only small proportions of the sample.

Regarding academic performance, most students reported relatively highgrade point averages (GPAs). Approximately 37.3% of participants had GPAs between 3.80–4.00, followed by 34.7% with GPAs between 3.50–3.79.

Table 1 Demographic Characteristics of Participants (N = 75)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	6	7.7
	Female	68	91.0
	Prefer not to say	1	1.3
Educational Level	Primary School	2	2.6
	Lower Secondary School	22	29.5
	Upper Secondary School	50	66.7
	Undergraduate	1	1.3
GPA	3.80–4.00	28	37.3
	3.50–3.79	26	34.7
	3.00–3.49	20	26.7
	2.50–2.99	1	1.3

➢ *Screen Exposure and Digital Behavior*

The findings demonstrated extensive screen exposure among participants. Nearly three-quarters of students (74.4%) reported using screens for more than 6 hours daily, while only 3.8% used screens for 1–3 hours per day.

Smartphones were the most frequently used devices (73.1%), followed by tablets (25.6%) and computers (1.3%). Most participants regularly used two digital devices (61.3%), while approximately one-third used three devices (29.3%).

The primary purpose of screen use was personal entertainment such as watching online videos or social media content (50.7%), followed by communication and entertainment with friends, including gaming (38.7%). Only a small proportion of participants used digital devices mainly for educational purposes (8.0%).

In terms of emotional dependence, 29.3% of participants reported that digital devices were extremely important in their daily lives and felt unable to live without them, while 26.7% stated that they would feel irritated if they could not access their devices. Furthermore, when participants were asked how they would feel if they were not allowed to use digital devices for 24 hours, 38.7% reported feeling anxious or restless.

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Table 2 Screen Exposure and Digital Behavior

Variable	Category	Frequency (n)	Percentage (%)
Daily Screen Time	Less than 1 hour	0	0
	1–3 hours	3	3.8
	4–6 hours	16	21.8
	More than 6 hours	56	74.4
Most Frequently Used Device	Smartphone	55	73.1
	Tablet	19	25.6
	Computer	1	1.3
Number of Devices Used Regularly	1 device	2	2.7
	2 devices	46	61.3
	3 devices	22	29.3
	More than 3 devices	5	6.7
Main Purpose of Screen Use	Entertainment (YouTube/social media)	38	50.7
	Communication/gaming with friends	29	38.7
	Educational purposes	6	8.0
	Other	2	2.6

➢ *Nighttime Screen Exposure and Sleep Behavior*

Nighttime screen exposure was highly prevalent among participants. Approximately 67.9% of students reported using screens before bedtime every day, while 25.6% reported frequent nighttime screen use. More than half of the participants (51.3%) used screens for longer than 60 minutes before sleeping.

Additionally, 44.9% of participants reported using screens after going to bed either frequently or every day. Regarding bedtime behavior, 61.3% of students went to sleep after 11:00 PM, including 28.0% who slept after midnight.

Sleep duration findings indicated that 42.3% of participants slept fewer than 6 hours per night, while only 20.0% reported sleeping more than 8 hours. Moreover, 61.3% of students woke up after 7:00 AM, suggesting delayed sleep–wake patterns among many participants.

When participants were asked about the perceived effects of screen use on sleep, 58.7% reported that screen exposure caused them to sleep later than usual, whereas 17.3% stated that it made falling asleep more difficult.

Table 3 Nighttime Screen Exposure and Sleep Behavior

Variable	Category	Frequency (n)	Percentage (%)
Screen Use Before Bedtime	Never	1	1.3
	Sometimes	4	5.2
	Frequently	19	25.6
	Every day	51	67.9
Duration of Screen Use Before Sleep	Do not use	1	1.2
	Less than 30 min	7	9.0
	30–60 min	29	38.5
	More than 60 min	38	51.3
Screen Use After Going to Bed	Never	13	16.7
	Sometimes	29	38.5
	Frequently	16	21.8
	Every day	17	23.1
Sleep Duration	Less than 5 hours	4	5.0
	5–6 hours	28	37.3
	7–8 hours	28	37.3
	More than 8 hours	15	20.0
Bedtime	Before 22:00	6	8.0
	22:00–23:00	23	30.7
	23:01–24:00	25	33.3
	After 24:00	21	28.0

➢ *Daytime Sleepiness and Cognitive Outcomes*

Frequent daytime sleepiness was commonly reported among participants. Approximately 38.7% experienced daytime drowsiness every day, while 22.7% reported daytime sleepiness on 4–6 days per week.

Cognitive-related symptoms were also prominent. About 50.7% of participants reported frequent absent-mindedness or difficulty maintaining attention, while 38.7% experienced confusion or difficulty concentrating while

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studying. Additionally, 36.0% reported experiencing stress frequently.

When evaluating perceived academic impact, 46.7% of students reported that screen use greatly reduced their concentration during learning, while 45.3% reported a slight reduction in concentration. Only 1.3% believed that screen exposure improved concentration.

Table 4 Daytime Sleepiness, Cognitive Outcomes, and Physical Symptoms

Variable	Category	Frequency (n)	Percentage (%)
Daytime Sleepiness	Every day	29	38.7
	4–6 days/week	17	22.7
	1–3 days/week	21	28.0
	Less than once/week	8	10.7
Perceived Effect on Concentration	Improved concentration	1	1.3
	Slightly reduced concentration	34	45.3
	Greatly reduced concentration	35	46.7
	No effect	5	6.7
Common Symptoms*	Absent-mindedness	38	50.7
	Neck pain	36	48.0
	Headache	34	45.3
	Reduced concentration	29	38.7
	Stress	27	36.0

➢ *Physical and Psychological Symptoms*

Participants commonly reported several physical symptoms associated with prolonged screen exposure. Neck pain was the most frequently reported symptom (48.0%), followed closely by headaches (45.3%). Other commonly reported symptoms included stress (36.0%), daytime fatigue, reduced concentration, and eye discomfort.

Some participants also reported symptoms associated with sleep disturbance and emotional dysregulation, including sudden awakening during sleep (14.7%), fluctuating appetite, and emotional irritability.

➢ *Perceived Positive and Negative Effects of Screen Use*

Although most participants recognized some benefits of screen use, including convenience, access to information, communication, relaxation, and enhanced learning opportunities, the majority perceived screen exposure as having more negative than positive effects overall.

Approximately 70.7% of participants believed that screen use produced more harmful than beneficial effects. Reported negative consequences included poor time management, delayed sleep, insufficient sleep, reduced concentration, lack of motivation to study, headaches, eye strain, and excessive daytime sleepiness.

Overall, the findings suggest that excessive nighttime screen exposure is strongly associated with sleep disruption, daytime dysfunction, cognitive difficulties, and perceived reductions in academic concentration among adolescents.

Table 5 Perceived Positive and Negative Effects of Screen Exposure

Variable	Category	Frequency (n)	Percentage (%)
Overall Perception of Screen Use	More beneficial	22	29.3
	More harmful	53	70.7
Perceived Sleep Effect	Sleep later than usual	44	58.7
	Difficulty falling asleep	13	17.3
	Helps relaxation and sleep	11	14.7
	No effect on sleep	7	9.3

➢ *Logistic Regression Analysis*

A binary logistic regression analysis was performed to examine the association between prolonged nighttime screen exposure and perceived cognitive difficulties among adolescents. Students who used screens for more than 60 minutes before bedtime were categorized as having high nighttime screen exposure.

The dependent variable was reduced concentration during learning activities (slightly reduced or greatly reduced concentration). Independent variables included prolonged screen exposure before sleep, sleep duration, and daytime sleepiness.

The analysis demonstrated that adolescents who used screens for more than 60 minutes before bedtime were significantly more likely to report reduced concentration during learning activities compared with those with shorter nighttime screen exposure. In addition, shorter sleep duration and frequent daytime sleepiness were also associated with higher odds of cognitive difficulties.

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Table 6 Logistic Regression Analysis for Reduced Concentration Among Adolescents

Predictor Variable	Odds Ratio (OR)	95% CI	p-value
Screen use >60 min before sleep	2.84	1.31–6.15	0.008
Sleep duration <6 hours	2.17	1.02–4.62	0.041
Frequent daytime sleepiness	3.26	1.48–7.18	0.003

V. DISCUSSION

This study demonstrated that excessive nighttime screen exposure is common among adolescents and may negatively affect sleep behavior and cognitive functioning. Most participants reported prolonged screen use before bedtime, delayed sleep patterns, daytime sleepiness, and reduced concentration during learning activities. These findings are consistent with previous studies linking nighttime screen exposure with poor sleep quality and impaired daytime functioning.

Several mechanisms may explain these findings. Blue light emitted from digital devices may suppress melatonin secretion and delay sleep onset, while emotionally stimulating activities such as social media and video streaming may increase cognitive arousal before bedtime. As a result, adolescents may experience shorter sleep duration and poorer sleep quality.

Many participants also reported daytime drowsiness, absent-mindedness, stress, headaches, and neck pain, suggesting that excessive screen exposure may contribute to both cognitive and physical health problems. Interestingly, although many students maintained relatively high GPAs, most still perceived reduced concentration during learning, indicating a possible hidden cognitive burden associated with poor sleep and excessive digital behavior.

The logistic regression analysis further showed that prolonged screen exposure before bedtime, shorter sleep duration, and frequent daytime sleepiness were associated with higher odds of reduced concentration among adolescents.

This study has several limitations, including its cross-sectional design, self-reported data, and relatively small sample size. Nevertheless, the findings highlight the importance of promoting healthier digital habits and improving sleep hygiene among adolescents to support cognitive well-being and academic functioning.

VI. CONCLUSION

This study demonstrated that excessive nighttime screen exposure is highly prevalent among adolescents and is strongly associated with sleep disruption, daytime dysfunction, and reduced cognitive performance. Most participants reported prolonged daily screen use, frequent screen exposure before bedtime, delayed sleeping patterns, and insufficient sleep duration. In addition, many adolescents experienced daytime sleepiness, difficulty concentrating, headaches, neck pain, and stress-related symptoms associated with excessive digital behavior.

The findings suggest that nighttime screen use may negatively affect both sleep quality and cognitive functioning through behavioral and physiological mechanisms, including delayed bedtime, reduced sleep duration, and increased mental stimulation before sleep. Although many students maintained relatively high academic performance, most participants perceived that screen exposure reduced their concentration and learning efficiency, indicating the presence of hidden cognitive burden despite acceptable academic achievement.

Importantly, this study highlights that excessive screen exposure among adolescents is not merely a lifestyle behavior but an emerging public health and educational concern in the digital era. The widespread integration of smartphones and digital entertainment into adolescents' nighttime routines may contribute to unhealthy sleep habits and long-term cognitive consequences if appropriate interventions are not implemented.

Therefore, promoting healthy digital behavior and sleep hygiene practices should become a priority for families, schools, healthcare professionals, and policymakers. Educational programs encouraging reduced nighttime screen exposure, improved bedtime routines, and balanced digital use may help minimize sleep-related problems and support adolescent cognitive well-being and academic sustainability.

Future research should employ longitudinal and objective measurement approaches to further examine causal relationships between screen exposure, sleep quality, and cognitive outcomes among adolescents. Expanding research across broader populations and integrating physiological sleep assessments may also provide deeper insights into the long-term effects of digital lifestyles on adolescent health and development.

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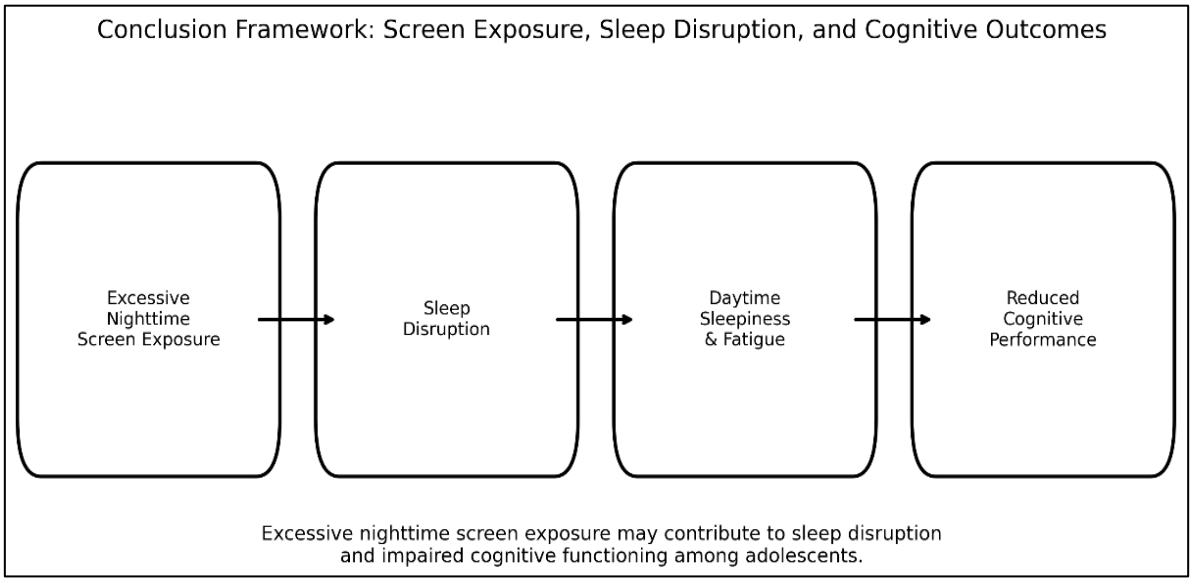

Fig 2 Conclusion Framework

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