

# Daily Screen Exposure and Sleep Quality Among University Students: Night-Time Smartphone Use as a Mediating Pathway

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## ABSTRACT

Screen-based technologies are embedded in contemporary university life for academic work, communication, entertainment and social interaction. Although greater screen exposure has repeatedly been associated with adverse sleep outcomes, the timing of exposure may be as important as total duration. Night-time smartphone use may represent a particularly important behavioural pathway linking overall daily screen exposure with impaired sleep. To synthesize high-quality pre-2021 evidence concerning the relationship between screen exposure, night-time smartphone behaviour and sleep among university students and young adults, and to evaluate night-time smartphone use as a plausible mediating pathway. A structured evidence synthesis was conducted using peer-reviewed literature published no later than 31 December 2020. Evidence was restricted to studies published in first-quartile journals within relevant sleep medicine, psychiatry, behavioural science, public health, psychology and multidisciplinary categories. University-student and young-adult studies were prioritized, supplemented by mechanistic and adolescent evidence where necessary. Outcomes included sleep quality, sleep duration, sleep-onset latency, sleep efficiency and sleep disturbance. Across the evidence base, greater smartphone and social-media exposure was consistently associated with poorer sleep outcomes. Importantly, night-time exposure appeared more proximal to sleep impairment than general daytime exposure. Objective student data demonstrated associations between nocturnal smartphone checking and poorer sleep quality. Studies of young adults also identified relationships between bedtime social-media use and disturbed sleep. Mechanistic evidence supported four principal pathways: displacement of sleep time, cognitive and emotional arousal, circadian effects of short-wavelength light exposure and sleep interruption through notifications. A university-based mediation study further demonstrated that bedtime procrastination and reduced self-regulation transmitted part of the relationship between problematic smartphone use and impaired sleep. Night-time smartphone use is a plausible behavioural pathway through which high daily screen exposure contributes to poor sleep among university students. Interventions should therefore focus not solely on reducing overall screen time, but on modifying the timing, context and behavioural characteristics of smartphone use around bedtime.

**Keywords:** smartphone; screen time; sleep quality; university students; bedtime procrastination; social media; night-time smartphone use; sleep hygiene

## 1. Introduction

Sleep is fundamental to cognitive function, emotional regulation, learning and physical health. University students represent a population particularly vulnerable to irregular sleep because academic workload, social demands, changing schedules and increased personal autonomy frequently disrupt stable sleep-wake routines.

At the same time, smartphones have become integrated into almost every aspect of university life. Unlike television or desktop computing, smartphones allow continuous access to communication, entertainment and academic resources and can remain physically accessible throughout the night.

Early university-based evidence demonstrated a relationship between smartphone-use severity and impaired sleep. Demirci et al. examined 319 university students and observed poorer sleep quality among those with greater smartphone-use severity [1]. Subsequent evidence has increasingly suggested that simply measuring total daily technology exposure may obscure an important distinction: when the screen is used.

Exelmans and Van den Bulck demonstrated that bedtime mobile-phone use was associated with poorer sleep outcomes in adults [2]. Among young adults, Levenson et al. reported an association between greater social-media exposure and sleep disturbance [3],

while a subsequent study found that social-media use specifically during the 30 minutes before bedtime was independently associated with greater sleep disturbance [4].

More direct evidence emerged in university populations by 2020. Zhang and Wu demonstrated that smartphone addiction was associated with impaired sleep through behavioural pathways involving reduced self-regulation and bedtime procrastination among 427 Chinese undergraduates [5]. Shoval et al., using objective as well as subjective measures of night-time smartphone use, observed that more frequent nocturnal checking was associated with poorer sleep quality and psychological well-being among students [6].

These findings suggest a pathway in which high overall screen exposure increases opportunities for night-time smartphone engagement, which subsequently affects sleep through behavioural and physiological mechanisms.

The present review therefore aimed to examine the relationship between daily screen exposure and sleep outcomes among university students and young adults; determine whether night-time smartphone use appears to be a particularly important component of this association; identify mechanisms through which night-time smartphone use may impair sleep; and develop a conceptual framework for university-level prevention strategies.

## 2. Methods

### 2.1 Review Design

A structured evidence synthesis was undertaken rather than a quantitative meta-analysis because the available studies varied substantially in exposure definitions, device types, age groups, measures of problematic use and sleep outcomes.

The evidence cutoff was 31 December 2020.

Literature was identified from PubMed-indexed records and journal and publisher databases using combinations of the terms:

smartphone, screen time, mobile phone, social media, night-time use, bedtime use, university students, college students, young adults, sleep quality, sleep duration, sleep disturbance, sleep onset, and bedtime procrastination.

University and college populations were prioritized. Young-adult and adolescent studies were used when they contributed direct evidence concerning mechanisms highly applicable to university populations.

*The eligibility framework for the evidence synthesis is summarised in Table 1.*

The Pittsburgh Sleep Quality Index and comparable validated sleep measures were preferentially considered when interpreting subjective sleep quality [16].

## 3. Results

### 3.1 Daily Smartphone Exposure and Sleep

Evidence published before 2021 consistently suggested that heavier smartphone involvement was associated with poorer sleep, although causality could not generally be established.

Demirci et al. examined 319 university students and categorized participants according to smartphone-use severity. Students with higher smartphone-use severity demonstrated poorer sleep quality in addition to greater depressive and anxiety symptoms [1].

A broader quantitative synthesis by Yang et al. subsequently examined problematic smartphone use across observational studies and reported a significant association with poor sleep quality as well as depression and anxiety [7].

These findings indicate that high levels of smartphone involvement identify a population at increased risk for sleep disturbance. However, the total amount of screen exposure alone does not explain how this relationship develops.

Screen exposure occurring at midday, for example, is unlikely to have the same immediate effect on sleep as prolonged interactive use immediately before intended sleep onset.

This distinction supports examination of temporal exposure rather than screen duration alone.

*Key pre-2021 evidence relevant to university and young-adult populations is summarised in Table 2.*

### 3.2 Night-Time Smartphone Use as the Proximal Exposure

Night-time smartphone use differs conceptually from general screen time because it competes directly with the biological and behavioural processes required for sleep.

Exelmans and Van den Bulck found that bedtime mobile-phone behaviour was negatively related to adult sleep outcomes [2]. This is important because it places smartphone exposure within the sleep period rather than merely establishing that heavy smartphone users sleep poorly.

Levenson et al. reached a similar conclusion in a nationally representative young-adult population. Greater overall social-media exposure was associated with sleep disturbance [3]. Their subsequent analysis specifically targeting social-media use within

30 minutes before bed demonstrated an independent association with sleep disturbance [4].

The temporal specificity of these findings suggests that night-time digital behaviour may partly explain why individuals with high total daily screen exposure experience impaired sleep.

Shoval et al. strengthened this interpretation by objectively monitoring smartphone behaviour after sleep onset [6]. Participants frequently underestimated or inaccurately recalled their nocturnal checking behaviour. Objective nighttime checking was associated with lower sleep quality and poorer psychological well-being.

Thus, self-reported total screen exposure may underestimate a clinically important phenomenon: device engagement occurring during periods conventionally reserved for sleep.

*The conceptual model of night-time smartphone use as a pathway linking daily screen exposure with sleep is presented in Figure 1.*

### 3.3 Bedtime Procrastination and Self-Regulation

Behavioural displacement appears to be one of the strongest explanations for the relationship between smartphones and sleep.

Zhang and Wu studied 427 Chinese undergraduate students and directly examined potential mediating mechanisms [5]. Approximately one-third of the participants reported poor subjective sleep quality. Smartphone addiction was positively associated with bedtime procrastination, while self-regulation was inversely associated with poor sleep outcomes.

Importantly, indirect effects through both self-regulation and bedtime procrastination were statistically significant even when direct effects were not.

This finding changes the interpretation of smartphone-related sleep disturbance. The problem may not simply be that the smartphone physiologically prevents sleep; the device may facilitate voluntary delay of bedtime.

Students may intend to use the device briefly but continue interacting with social media, entertainment, messaging or other content beyond their planned bedtime.

Poor self-regulation can further amplify this process. Smartphone applications frequently provide continuously updated content, social reinforcement and immediate rewards that make disengagement difficult.

Night-time use can therefore extend waking activity without the individual making an explicit decision to sacrifice sleep.

### 3.4 Social Media and Pre-Sleep Arousal

The content of screen exposure is also important.

Social-media activity is interactive, socially meaningful and frequently emotionally stimulating. Unlike passive exposure to a static screen, social-media use may involve anticipation of responses, interpersonal evaluation, fear of missing out, emotionally charged information or repeated checking.

Levenson et al. identified robust relationships between social-media exposure and sleep disturbance among young adults [3,4]. Woods and Scott similarly reported that greater night-time social-media use was associated with poorer sleep quality in adolescents [11].

These associations may operate through cognitive arousal. A student who closes a social-media application may remain mentally engaged with its content after the screen itself is switched off.

This distinguishes interactive smartphone exposure from purely photic exposure.

### 3.5 Sleep-Time Displacement

The simplest mechanism is chronological displacement.

Time spent using a smartphone after the intended bedtime is time that cannot simultaneously be spent sleeping.

Cain and Gradisar's review of electronic media and sleep showed consistent associations between technology exposure and delayed

bedtime or reduced sleep duration [14]. Hale and Guan similarly concluded that screen exposure was adversely related to sleep outcomes across the majority of studies evaluated in their systematic review [8].

Although much of this early evidence involved adolescents rather than university students, the displacement principle becomes particularly relevant during university years because external parental restrictions are reduced and academic schedules frequently allow irregular bedtimes.

Lemola et al. demonstrated that night-time electronic-media exposure was inversely associated with sleep duration and positively associated with sleep difficulties [10].

The distinction between total daily use and bedtime use therefore becomes clinically meaningful. Two students may each accumulate five hours of daily screen exposure, yet the student concentrating two hours of that exposure around midnight may experience greater sleep disruption than one whose exposure primarily occurs during daytime.

### 3.6 Light-Mediated Circadian Effects

Screens also produce a biological pathway capable of influencing sleep.

Human circadian timing is sensitive to light, particularly wavelengths capable of suppressing melatonin and altering physiological preparation for sleep.

Cajochen et al. demonstrated that evening exposure to an LED-backlit computer screen altered circadian physiology and cognitive performance [13].

Chang et al. subsequently conducted a controlled experimental comparison of evening reading using light-emitting electronic devices with printed books [12]. Evening exposure to the light-emitting device suppressed melatonin, delayed circadian timing, increased the time required to fall asleep and reduced next-morning alertness.

These experimental findings provide physiological plausibility for observational associations between night-time smartphone use and sleep disturbance.

Nevertheless, light exposure should not be regarded as the sole explanation. Modern smartphone use simultaneously produces behavioural displacement and cognitive engagement, making the exposure multidimensional.

### 3.7 Sleep Fragmentation and Notifications

Smartphones may affect sleep even after initial sleep onset.

Unlike traditional desktop devices, smartphones remain close to the user and continue receiving alerts throughout the night. Notifications, vibrations, screen illumination or habitual checking can interrupt consolidated sleep.

Shoval et al.'s objective data are particularly important in this context because smartphone activity was measured after sleep onset [6]. A substantial proportion of students engaged with their phones during the night, and objective checking behaviour was associated with poorer sleep outcomes.

Repeated brief awakenings may not always be accurately remembered the following morning. Consequently, traditional questionnaires may underestimate this pathway.

*The mechanisms through which night-time smartphone use may impair sleep are presented in Figure 2.*

### 3.8 Integrated Pathway

The available literature therefore supports a multimechanistic model rather than a single causal explanation.

*The mechanistic pathways between night-time smartphone exposure and sleep are summarised in Table 3.*

The pathways are unlikely to be mutually exclusive.

For example, a student may begin using social media at 23:00, remain engaged for an additional hour because of bedtime procrastination, receive short-wavelength light exposure throughout that period, experience emotional arousal from social interaction and then awaken later to check notifications.

The resulting sleep disturbance represents the cumulative effect of several mechanisms.

## 4. Discussion

The principal conclusion of this evidence synthesis is that night-time smartphone use is likely to be more informative than total screen exposure alone when evaluating sleep risk in university students.

Greater daily screen exposure remains relevant because it reflects overall engagement and increases the probability that technology use extends into the night. However, the evidence indicates that timing, behavioural context and device accessibility may determine whether exposure directly interferes with sleep.

Three findings deserve particular emphasis.

First, the relationship between smartphones and sleep was repeatedly demonstrated across university, young-adult and broader populations before the end of 2020 [1-7]. The association therefore cannot reasonably be treated as an isolated finding from one cultural or educational context.

Second, evidence exists for an identifiable behavioural pathway. Zhang and Wu demonstrated indirect relationships through bedtime procrastination and self-regulation [5]. This suggests that interventions need to address the behavioural process of disengaging from technology rather than merely informing students that excessive screen exposure may be harmful.

Third, objective night-time data reveal behaviours that questionnaires can miss. Shoval et al. demonstrated discrepancies between subjective reports and actual night-time smartphone checking [6]. Future research should therefore prioritize objectively logged device activity where ethically and technically feasible.

### 4.1 Night-Time Use as a Mediating Pathway

A formal mediator must lie on the pathway between an exposure and an outcome.

The conceptual sequence proposed in this review is:

greater daily screen exposure → greater probability or duration of night-time smartphone use → impaired sleep.

The literature available through 2020 supports each link, but direct statistical testing of the complete mediation model remained limited.

Consequently, night-time smartphone use should currently be interpreted as a strongly plausible partial mediator, rather than an established universal mediator.

The relationship is also likely bidirectional. Students experiencing insomnia may use smartphones because they are unable to sleep, meaning disturbed sleep can increase night-time screen exposure as well as result from it.

Such reverse causation is one of the major limitations of cross-sectional research.

## 5. Implications for Universities and Students

A blanket recommendation to minimize all screen exposure is increasingly unrealistic because university education itself requires extensive digital engagement.

A more targeted intervention strategy would focus on protecting the pre-sleep period.

*Evidence-informed interventions and research priorities are presented in Table 4.*

University health programs could therefore combine conventional sleep-hygiene advice with digital sleep hygiene.

Students should be encouraged to select a consistent device-disengagement time, disable non-essential notifications, avoid using the smartphone in bed and separate academic messaging from the sleep period.

Universities themselves also influence these behaviours. Late-night learning-platform announcements, messaging expectations and digitally intensive assessment schedules may reinforce nocturnal engagement.

Sleep promotion should therefore not be framed entirely as an individual responsibility.

## 6. Strengths and Limitations

This review focused specifically on the distinction between total screen exposure and night-time smartphone use and integrated behavioural, epidemiological and experimental evidence.

Restriction to high-ranking Q1 journals reduced dependence on lower-quality observational literature, while the strict 2020 evidence cutoff maintained temporal consistency.

Several limitations remain.

First, most available studies were cross-sectional and therefore cannot demonstrate directionality. Poor sleepers may use smartphones more frequently, creating reverse causation.

Second, definitions differed substantially between general screen time, smartphone addiction, problematic use, social-media frequency and actual recorded screen exposure.

Third, many studies relied on self-report. Objective device monitoring was comparatively uncommon.

Fourth, several mechanistic studies involved adolescents or general adult populations rather than university students specifically.

Fifth, night-time smartphone use is unlikely to explain the complete association between daily screen exposure and sleep. Mental health, sedentary behaviour, academic workload, chronotype and physical activity may also contribute.

Finally, mediation should not be interpreted as definitively established from the present evidence. Prospective studies directly measuring total daily exposure, night-time exposure and objective sleep are required.

## 7. Future Research

Future studies should distinguish at least four dimensions of smartphone exposure: total daily screen time, pre-bedtime screen time, smartphone activity after intended sleep onset, and problematic or compulsive use.

Objective smartphone logs should be linked with actigraphy or other objective sleep measurements whenever feasible.

Longitudinal mediation models could then test whether increased total daily exposure predicts subsequent night-time use and whether night-time use predicts later changes in sleep quality.

Experimental studies could randomize university students to interventions such as smartphone removal from the bedroom, notification suppression or predetermined digital curfews.

This would permit determination of whether modifying night-time behaviour improves sleep even when overall daytime screen exposure remains unchanged.

## 8. Conclusion

The pre-2021 literature provides substantial evidence linking smartphone and screen exposure with poorer sleep among university students and young adults.

However, the timing of exposure appears particularly important.

Night-time smartphone use provides a plausible pathway connecting heavy overall screen exposure to delayed bedtime, shorter sleep, increased sleep-onset latency and reduced sleep quality. This pathway operates through interacting behavioural and

physiological mechanisms including bedtime procrastination, impaired self-regulation, sleep-time displacement, cognitive arousal, circadian effects of screen light and nocturnal checking.

Accordingly, efforts to improve university-student sleep should move beyond broad recommendations to reduce screen time.

The more practical target is to protect the period immediately before and during sleep from unnecessary smartphone engagement.

## Declarations

### Author Contributions

The authors contributed to study conceptualization, evidence synthesis, interpretation and manuscript preparation.

### Funding

No external funding was received for this evidence synthesis.

### Ethical Approval

Ethical approval was not required because this study analyzed previously published literature and involved no direct recruitment of human participants.

### Consent to Participate

Not applicable.

### Data Availability

All evidence evaluated in this manuscript was derived from published literature.

### Conflicts of Interest

The authors declare no conflict of interest.

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**Table 1. Eligibility framework for evidence synthesis**

| Domain           | Inclusion                                                                                        | Exclusion                                                       |
|------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| Publication date | ≤31 December 2020                                                                                | 2021 onward                                                     |
| Journal quality  | Q1 journal in at least one relevant disciplinary category                                        | Non-Q1 journals                                                 |
| Population       | University/college students, young adults; mechanistically relevant adolescent/adult populations | Populations without relevance to screen-related sleep behaviour |
| Exposure         | Screen time, smartphone use, social media, bedtime/night-time device use                         | Non-screen behaviours without digital exposure                  |
| Outcomes         | Sleep quality, duration, latency, efficiency, disturbance, bedtime                               | Outcomes unrelated to sleep                                     |
| Study type       | Observational, experimental, longitudinal, systematic review or meta-analysis                    | Editorials and unsupported opinion pieces                       |
| Primary focus    | Timing, intensity, problematic use or behavioural mechanism                                      | Purely technological research                                   |

**Table 2. Key pre-2021 evidence relevant to university and young-adult populations**

| Study                        | Population                      | Exposure                                 | Principal sleep-related finding                                                    |
|------------------------------|---------------------------------|------------------------------------------|------------------------------------------------------------------------------------|
| Demirci et al. [1]           | 319 university students         | Smartphone-use severity                  | Greater severity associated with poorer sleep quality                              |
| Exelmans & Van den Bulck [2] | 844 adults                      | Bedtime mobile-phone use                 | Bedtime use associated with adverse sleep outcomes                                 |
| Levenson et al. [3]          | 1,788 young adults              | Daily social-media use                   | Higher frequency and duration associated with greater sleep disturbance            |
| Levenson et al. [4]          | Young adults                    | Social media during 30 min before bed    | Pre-sleep social-media use independently associated with sleep disturbance         |
| Zhang & Wu [5]               | 427 university students         | Smartphone addiction                     | Indirect effects on poor sleep through self-regulation and bedtime procrastination |
| Shoval et al. [6]            | 40 healthy students             | Objective night-time smartphone checking | More frequent checking associated with poorer sleep quality                        |
| Yang et al. [7]              | Systematic review/meta-analysis | Problematic smartphone use               | Significant association with poor sleep quality                                    |
| Lemola et al. [10]           | 362 adolescents                 | Electronic media at night                | Greater night-time use associated with shorter sleep and sleep difficulties        |
| Woods & Scott [11]           | 467 adolescents                 | Overall and night-time social-media use  | Night-time use associated with poorer sleep quality                                |

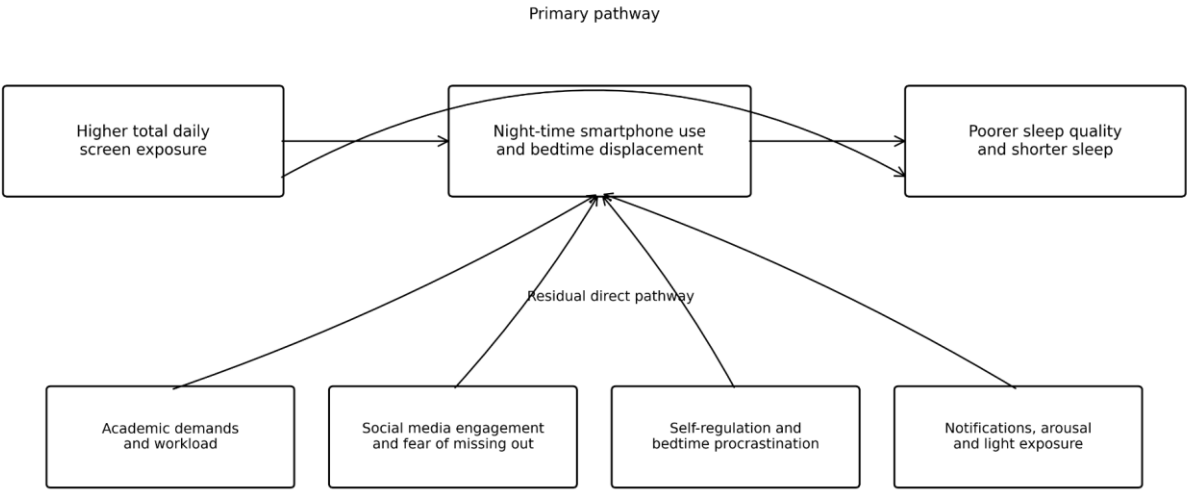
**Table 3. Mechanistic pathways between night-time smartphone exposure and sleep**

| Mechanism               | Exposure characteristic                              | Intermediate process                    | Expected sleep consequence    | Supporting evidence |
|-------------------------|------------------------------------------------------|-----------------------------------------|-------------------------------|---------------------|
| Time displacement       | Continued use after intended bedtime                 | Bedtime delay                           | Shorter sleep duration        | [5,8,10,14]         |
| Bedtime procrastination | Difficulty terminating smartphone use                | Deliberate/unintentional delay of sleep | Later sleep onset             | [5]                 |
| Cognitive arousal       | Social media, messaging, emotionally salient content | Persistent mental activation            | Longer sleep latency          | [3,4,11]            |
| Light exposure          | Illuminated screen near bedtime                      | Melatonin suppression/circadian delay   | Delayed sleep timing          | [12,13]             |
| Notifications           | Alerts after sleep onset                             | Brief awakenings                        | Sleep fragmentation           | [6]                 |
| Habitual checking       | Smartphone immediately accessible                    | Automatic device engagement             | Reduced continuity of sleep   | [6]                 |
| Problematic use         | High behavioural dependence                          | Multiple pathways simultaneously        | Globally poorer sleep quality | [1,5,7]             |

**Table 4. Evidence-informed interventions and research priorities**

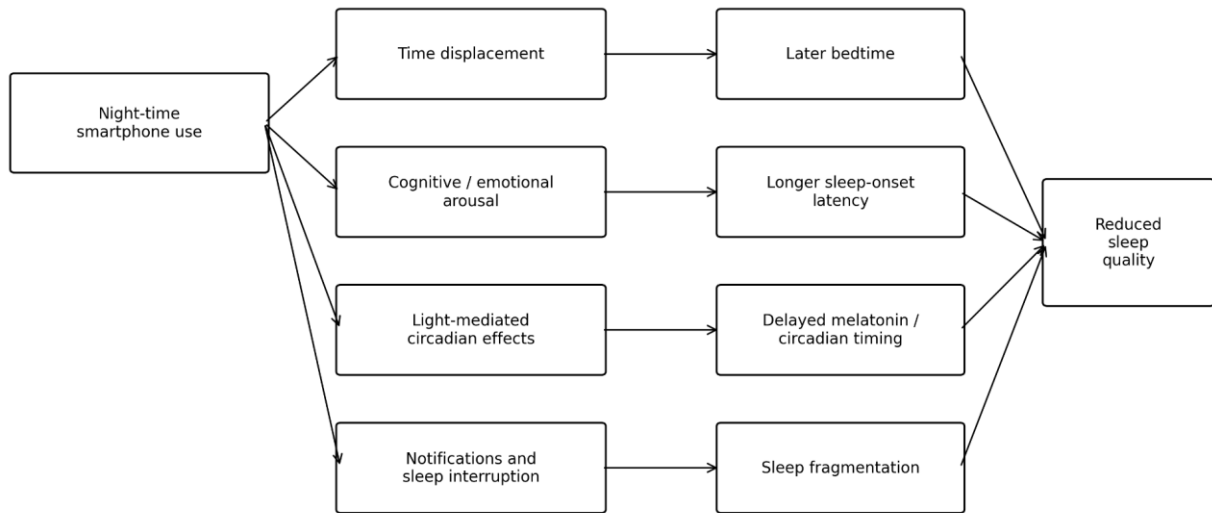
| Target                      | Recommended approach                                                   | Rationale                                                                   |
|-----------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Bedtime smartphone exposure | Establish a 30–60 minute device-reduction period before intended sleep | Removes the most temporally relevant exposure                               |
| Smartphone accessibility    | Keep the device beyond arm’s reach or outside the bed                  | Reduces automatic checking                                                  |
| Notifications               | Activate night-time notification suppression                           | Reduces sleep fragmentation                                                 |
| Academic communication      | Avoid expectations of immediate late-night responses                   | Reduces externally driven checking                                          |
| Bedtime procrastination     | Behavioural goal setting and planned device-disengagement time         | Targets identified mediation pathway                                        |
| Light exposure              | Reduce evening brightness/night-mode settings when use is unavoidable  | May reduce circadian effects, although does not address behavioural arousal |
| Student education           | Emphasize timing rather than total screen time alone                   | More actionable than general abstinence advice                              |
| Future studies              | Collect device-logged screen time and timing                           | Reduces recall bias                                                         |
| Mediation research          | Test daily exposure → night-time use → sleep prospectively             | Establishes temporal mediation                                              |
| Experimental research       | Randomize bedtime smartphone restriction                               | Improves causal inference                                                   |

Figure 1. Conceptual model of night-time smartphone use as a pathway linking daily screen exposure with sleep



**Figure 1. Conceptual model of night-time smartphone use as a pathway linking daily screen exposure with sleep.**  
*Conceptual mediation framework in which greater overall screen exposure increases opportunities for continued smartphone engagement near bedtime. Night-time use provides a pathway toward delayed, shortened or disturbed sleep, while a residual direct pathway is retained for other mechanisms.*

Figure 2. Mechanisms through which night-time smartphone use may impair sleep



**Figure 2. Mechanisms through which night-time smartphone use may impair sleep.**

*Four interacting pathways through which night-time smartphone use may impair sleep are shown: time displacement, cognitive or emotional arousal, circadian effects of evening light exposure, and sleep fragmentation caused by notifications or nocturnal checking.*

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