ORIGINAL ARTICLE

# Smartphone Usage Sleep Quality and Behavioral Health in Adolescents: A Cross-sectional Study from Eastern India

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Visual Abstract

## Abstract

**Background:** Widespread smartphone use has raised concerns regarding its effects on adolescent health, particularly sleep quality and behavioral outcomes. The associations between smartphone usage patterns, sleep disturbances, and markers of obesity and vision health have yet to be systematically evaluated in India.

**Objectives:** To assess the prevalence of smartphone usage, bedtime usage patterns, and their association with sleep quality, overweight status, and visual acuity among adolescents in Eastern India.

**Methods:** A cross-sectional study was conducted among 140 adolescents aged 13–19 years attending urban and rural schools in Eastern India. Participants completed a structured questionnaire covering demographics, daily and bedtime smartphone use, and sleep quality. Sleep quality was assessed using a modified Pittsburgh Sleep Quality Index (PSQI), and smartphone addiction was estimated using behavioral proxies. Chi-square tests were employed to assess associations, and logistic regression was used to identify predictors of poor sleep quality.

**Results:** The mean age of participants was 16.8 ± 1.9 years, with 55% male participants and 70% from urban areas. Smartphone usage at bedtime was reported by 89.3% of participants, and 42.1% reported poor sleep quality. Longer bedtime smartphone use (>30 minutes) was significantly associated with poor sleep quality ($\chi^2 = 42.5$, $p < 0.001$). Daily usage exceeding 2 hours was significantly associated with overweight status ($\chi^2 = 21.9$, $p = 0.001$).

**Conclusion:** A high prevalence of bedtime smartphone use among adolescents in Eastern India is significantly associated with poor sleep quality. Excessive daily smartphone use is also linked with overweight status. Public health strategies should include digital hygiene awareness and school-based interventions.

**Keywords:** Adolescents, Digital health, Overweight, India, Sleep quality, Smartphone use.

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## Introduction

The exponential rise in smartphone penetration among Indian adolescents has reshaped their communication, entertainment, and study habits.[1] However, this technological boon has been accompanied by rising concerns over digital overexposure, particularly its impact on sleep, emotional regulation, and physical health. Sleep is an essential component of adolescent well-being, and multiple international studies have associated excessive screen exposure—especially at bedtime—with reduced sleep duration and quality.[2]

Smartphones have become an indispensable part of modern adolescence, facilitating social connectivity, academic support, gaming, and entertainment. While they enhance access to information and interpersonal relationships, they also demand constant attention, encouraging compulsive behaviors.[3] Adolescents, characterized by developmental vulnerabilities and evolving cognitive control, are particularly susceptible to behavioral dependencies such as problematic smartphone use (PSU) and smartphone addiction. These behaviors are increasingly linked to negative outcomes such as reduced academic performance, mood disorders, and physical health disturbances.[4]

The intersection of digital habits and sleep is especially critical. Adolescents need approximately 8–10 hours of sleep per night for optimal health and cognitive functioning.[5] Yet, studies from the United States, Japan, and Europe consistently report a decline in adolescent sleep duration correlated with increased electronic media use, particularly before bedtime.[6] Smartphones, unlike traditional media, are interactive, portable, and equipped with blue-light-emitting screens—factors that can delay sleep onset, reduce melatonin secretion, and impair sleep architecture. Consequently, smartphone usage close to bedtime has been linked to delayed circadian rhythms, shortened sleep duration, poorer sleep efficiency, and increased daytime dysfunction.[7]

In the Indian context, digital access has expanded across socioeconomic strata due to low-cost mobile services and government digitization efforts.[8] Consequently, Indian adolescents have experienced a similar rise in digital engagement, with increasing trends in social media consumption, mobile gaming, and digital streaming. However, empirical studies investigating how these behaviors affect physiological outcomes such as sleep, weight, and vision are still sparse. Unlike Western countries, where longitudinal data sets and national sleep surveillance systems are more robust, India lacks population-level behavioral health tracking systems for adolescents.

Moreover, cultural factors such as parental control, joint family systems, and academic pressure may differentially influence screen behaviors among Indian adolescents. Many adolescents attend tuition classes or engage in schoolwork until late in the evening, pushing leisure screen time into the night. This overlap between academic use and leisure browsing complicates the estimation of problematic use. In urban Indian households, where parental monitoring of device usage may be minimal or absent because of dual-working parents, unrestricted access to smartphones is common. This results in late-night screen exposure, further deteriorating sleep quality.[9]

While sleep is a well-established determinant of physical and mental health, it is also intricately linked to broader behavioral markers such as obesity and a sedentary lifestyle. Sleep restriction alters appetite-regulating

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hormones such as ghrelin and leptin, promotes late-night snacking, and reduces energy expenditure.[10] These physiological changes have been implicated in rising adolescent overweight and obesity. Furthermore, prolonged smartphone use often replaces outdoor physical activities, thereby promoting a sedentary lifestyle. Thus, screen addiction not only disrupts sleep but also contributes to a broader risk of noncommunicable diseases.

Visual health is another domain of concern. Prolonged near-work activities, especially under poor lighting or on small screens, may cause visual fatigue, dry eye syndrome, and refractive errors such as myopia. The increasing incidence of school-based myopia in India and other Asian countries is suspected to be partially linked to digital overuse.[11,12] However, few Indian studies have rigorously examined the relationship between screen duration and vision status in adolescents.[13]

Given the complexity and relevance of these associations, it is imperative to generate localized evidence. In India, empirical data on how bedtime smartphone use and screen exposure relate to sleep health and physical markers such as body weight and vision among adolescents are sparse. This study aims to explore these relationships in a school-based population in Eastern India.

## Methods

### Study Design and Setting

This was a school-based, observational, analytical, cross-sectional study conducted over a 3-month period from January to March 2025. The study was carried out in both urban and rural areas of Eastern India, specifically targeting secondary and higher secondary school students. Schools included a mix of government, government-aided, and private institutions to ensure heterogeneity and better generalizability of the results. The institutional ethics committee approved the study protocol, and written informed consent was obtained from parents/guardians, while assent was obtained from each adolescent participant. Anonymity was ensured using coded identifiers, and the confidentiality of all responses was maintained.

### Participants

Adolescents aged between 13 and 18 years enrolled in classes 8 through 12 were eligible to participate. The inclusion criteria were: (A) current smartphone usage for any duration, (B) ability to understand and complete the questionnaire in English or the local language, and (C) provision of written informed consent from guardians and assent from students. The exclusion criteria included: (A) known history of chronic neurological, endocrine, or sleep disorders; (B) use of sleep-modifying medications, including sedatives or stimulants; and (C) diagnosed psychiatric illness or developmental disorders.

### Sample Size and Sampling Technique

A minimum required sample size of 134 was calculated using the formula for cross-sectional studies ($Z^2pq/d^2$), assuming a 40% prevalence of poor sleep quality from prior literature,[14] a 95% confidence level, and 8% absolute precision. Accounting for potential nonresponses and incomplete data, the final target sample was set at 150, with 140 complete responses included in the final analysis. A stratified random sampling technique was employed. Schools were first stratified by location (urban/rural) and type (government/private). Within each stratum, classes were chosen randomly. From the selected classes, students were then selected using systematic sampling based on the class register. Stratification also considered academic stream (science/general) for higher secondary students to capture variability in academic demands.

### Data Collection Instruments

Data were collected using a pretested, structured, self-administered questionnaire, made available in both English and a validated vernacular translation. The questionnaire was divided into the following sections:

Sociodemographic details: Age, gender, place of residence, type of school, parental education, and monthly household income.

Smartphone usage patterns: Duration of use per day (<1 hour, 1–2 hours, >2 hours), bedtime smartphone use (yes/no), frequency of use at bedtime (1–3 times/month, weekly, daily), and types of activities (social media, study, gaming, video streaming).

Sleep quality: Evaluated using a modified version of the Pittsburgh Sleep Quality Index (PSQI), adapted for adolescent self-report.[15] A global PSQI score >5 indicated poor sleep quality.

Body weight perception: Participants self-classified into weight categories based on a reference image scale validated in adolescent health surveys (normal, overweight, obese).

Vision status: The most recent school vision screening results (6/6 or subnormal <6/6) were recorded where available or were self-reported.

The questionnaire was reviewed by two public health experts and piloted among 15 students in a nonparticipating school to ensure clarity and cultural appropriateness.

### Statistical Analysis

Data were entered and cleaned in Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0 (IBM Corp., Armonk, NY). Descriptive statistics were computed for all variables. Continuous variables (e.g., age) were summarized as means and standard deviations, whereas categorical variables (e.g., gender, residence, and smartphone usage categories) were presented as frequencies and percentages. Bivariate analyses using Chi-squared tests were performed to assess associations between sleep quality and categorical independent variables such as bedtime smartphone use, duration of use, and body weight category. Logistic regression analysis was conducted to identify predictors of poor sleep quality, with independent variables including bedtime smartphone use, daily screen time, and urban residence. A $p$-value < 0.05 was considered statistically significant.

## Results

### Participant Characteristics

A total of 140 adolescents were included in the analysis. The mean age of the participants was 16.8 years [standard deviation (SD) ± 1.9], with an age distribution ranging from 13 to 19 years. There was a slight male predominance ($n$ = 77, 55%), and the majority ($n$ = 98, 70%) resided in urban settings. Regarding parental education, 91 participants (65%) reported that either parent had completed higher secondary education or above.

Concerning socioeconomic status, the majority of families reported a monthly income between ₹30,000 and ₹40,000, with urban participants predominantly clustered in the higher income brackets. Use of hands-free devices while using smartphones was reported by only 25% of participants.

### Smartphone Usage Patterns

Among the 140 participants, 125 (89.3%) reported using their smartphones at bedtime. The frequency of bedtime smartphone use was as follows: 73.5% ($n$ = 103) used them every day, 17% ($n$ = 24) several times a week, 6.5% ($n$ = 9) once a week, and 3% ($n$ = 4) only 1–3 times per month. Regarding the duration of bedtime use, 43% of participants ($n$ = 60) reported using their smartphones for >30 minutes before sleep, including 12.5% who used them for >60 minutes (Table 1). The most commonly reported purpose of use was

**Table 1:** Smartphone usage pattern

| *Variables* | *N (%)* |
|---|---|
| Smartphone use at bedtime | 125 (89.3%) |
| Smartphone usage frequency | |
| Everyday | 103 (73.57%) |
| Several times a week | 24 (17.14%) |
| Once a week | 9 (6.42%) |
| 3 times/month | 4 (2.85%) |
| Smartphone usage duration | |
| Duration >30 minutes | 60 (42.86%) |
| Duration >60 minutes | 50 (35.71%) |
| Daily use >2 hours | 30 (21.42%) |
| Reasons for use | |
| Social networking | 113 (80.5%) |
| Watching videos | 68 (48.57%) |
| Gaming | 39 (27.85%) |
| Educational purposes | 5 (3.57%) |

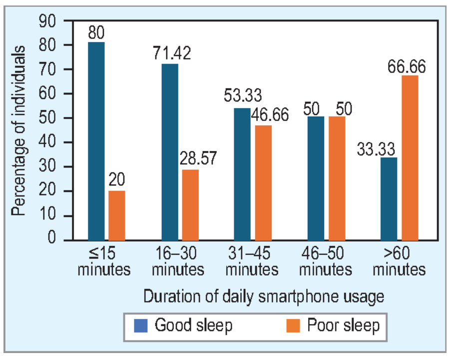


**Fig. 1:** Relationship between daily smartphone usage and sleep quality

social networking (80.5%), followed by watching videos, messaging, gaming, and educational purposes. More than 40% ($n$ = 56) reported daily smartphone use exceeding 2 hours (Table 1).

## Sleep Quality

Based on the modified PSQI scores, 59 participants (42.1%) were classified as having poor sleep quality (PSQI >5). The average reported sleep duration was approximately 6 hours per night, with a substantial proportion reporting difficulty initiating sleep or frequent awakenings. Notably, poor sleep quality was more prevalent among participants using smartphones at bedtime (47.2%) than among those who did not (10.7%), a statistically significant difference ($\chi^2 = 6.42$, $p = 0.011$).

A strong relationship was found between the time spent using smartphones at bedtime and sleep quality. Participants using smartphones for 31–45 minutes and 46–60 minutes showed significantly higher rates of poor sleep, and those using them for >60 minutes had several-fold increased odds of poor sleep ($\chi^2 = 42.5$, $p < 0.001$) (Fig. 1). Participants using smartphones for ≤15 minutes at bedtime had the lowest prevalence of poor sleep (20%).

**Table 2:** Logistic regression

| *Variable* | *Coefficeint* | *Standard error* | *z* | *p >\|z\|* | *0.025* | *0.975* |
|---|---|---|---|---|---|---|
| Constant | –1.91 | 0.95 | –2 | 0.05 | –3.78 | –0.04 |
| Gender | –0.94 | 0.82 | –1.15 | 0.25 | –2.55 | 0.66 |
| Residence | 3.76 | 1.45 | 2.59 | 0.01 | 0.92 | 6.61 |
| Daily smartphone usage | 1.27 | 0.46 | 2.78 | 0.01 | 0.37 | 2.16 |
| Bedtime usage of smartphone | –0.54 | 0.34 | –1.58 | 0.11 | –1.21 | 0.13 |

## Other Health Associations

Among the total participants, 33 (23.6%) self-identified as overweight or obese. There was a significant association between daily smartphone usage exceeding 2 hours and overweight status ($\chi^2 = 21.9$, $p = 0.001$). Of those who used smartphones for >2 hours per day, 70% were overweight, compared with 20% among those with ≤1 hour of usage.

Regarding blood pressure, only six participants were classified as hypertensive based on school health records or self-report, and no significant association was found between hypertension and smartphone usage patterns ($p > 0.05$).

Visual acuity (defined as 6/6 or subnormal) was reported to be subnormal in 18% of participants. However, no statistically significant association was found between visual status and bedtime smartphone use ($p > 0.05$), although trends suggested marginally higher rates of subnormal vision among heavy users.

Multiple logistic regression analysis revealed that both place of residence and daily smartphone use duration were significant predictors of poor sleep quality among adolescents (Table 2). Specifically, residing in urban areas was strongly associated with increased odds of poor sleep, with a regression coefficient of 3.76 ($p = 0.009$), indicating that urban adolescents were significantly more likely to experience disturbed sleep than their rural counterparts. Additionally, daily smartphone use duration showed a significant positive association with poor sleep quality ($\beta = 1.27$, $p = 0.005$), suggesting that higher screen exposure throughout the day independently contributed to adverse sleep outcomes. In contrast, gender and the frequency of bedtime smartphone use did not show statistically significant associations in the model ($p > 0.05$), implying that these factors may not independently influence sleep quality when other variables were controlled for. These findings underscore the multifactorial nature of sleep disturbances in adolescents, particularly emphasizing environmental and behavioral contributors.

# Discussion

This study comprehensively examined the relationship between smartphone usage—particularly bedtime exposure—and sleep quality among adolescents in Eastern India. It further explored the impact of daily smartphone usage patterns on indicators such as overweight status and visual acuity. The findings establish a robust association between longer durations of smartphone use at bedtime and a higher prevalence of poor sleep quality, underlining the growing concern of digital overexposure in this vulnerable age-group.

The prevalence of poor sleep quality among the study participants was found to be 42.1%, which aligns closely with several international reports. For instance, Alosaimi et al.[16] reported similar figures among Saudi university students, noting that excessive smartphone use contributed to reduced sleep duration in 43% of the cohort. A comparable pattern was also described by Exelmans and Van den Bulck, who found that frequent bedtime phone usage among Flemish adults correlated with increased insomnia symptoms and shorter sleep durations.[17] Extending this evidence to an adolescent Indian population, our study demonstrates that such associations are not geographically restricted and likely reflect universal neurobehavioral responses to screen exposure.

Our results notably confirm a gradient association between the duration of bedtime smartphone use and sleep disturbances. Adolescents who used their phones for >60 minutes before sleeping had >7.5-fold higher odds of reporting poor sleep than those who used them for <15 minutes. This reinforces the physiological hypothesis proposed by Cajochen et al.[18] that exposure to blue light from light-emitting diode (LED) screens inhibits melatonin secretion and delays the circadian phase. Similarly, Wood et al.[19] demonstrated that electromagnetic radiation from mobile phones might delay the onset of melatonin production, thereby impairing sleep onset and maintenance. The consistency of our findings with such mechanistic studies suggests that physiological processes play a critical role in the observed behavioral outcomes.

In our cohort, bedtime smartphone use was reported by 89.3% of adolescents. This high figure likely reflects the rapid digitization of Indian society, increasing access to affordable internet services, and the pervasive role of social media in adolescent life. These findings parallel the outcomes of the nationwide survey by Davey and Davey,[20] which reported that over 44% of Indian adolescents demonstrated characteristics of smartphone addiction, reinforcing the notion that digital dependency is a pressing public health concern in India.

Importantly, the observed sleep disruption appears to escalate with increased smartphone engagement. Adolescents who used their phones for >30 minutes at bedtime exhibited significantly poorer sleep quality than those with minimal usage. This response pattern is both statistically and clinically meaningful, suggesting the potential utility of digital cutoff recommendations or curfews as part of school- or family-level interventions.[21]

Additionally, 23.6% of the adolescents in our study self-identified as overweight or obese, with a clear and significant association observed between daily smartphone use exceeding 2 hours and elevated body weight. These results are in agreement with the findings of Okoli et al., who postulated that prolonged screen time contributes to weight gain by decreasing physical activity, altering appetite regulation, and negatively impacting sleep duration.[22] In our urban subgroup, the clustering of high screen use and overweight status also raises important questions about the influence of the built environment, sedentary recreation, and access to outdoor activity spaces.

Contrary to expectations, no statistically significant relationship was found between smartphone usage and visual acuity, although a nonsignificant trend toward subnormal vision among heavy users was observed. These findings echo those of Chu et al.,[23] who reported only a weak correlation between visual strain and screen time among Hong Kong adolescents. It is plausible that self-reported vision measures and the lack of objective ophthalmic testing limited our ability to detect small but meaningful visual effects. Future studies incorporating standardized clinical eye examinations would help clarify this relationship.

Similarly, no significant association was found between smartphone use and hypertension status. Only six participants reported elevated blood pressure, and the lack of statistical significance aligns with the current literature, which suggests that although screen time may indirectly affect cardiovascular health through sedentary behavior and poor sleep, direct hypertensive effects in adolescents remain unsubstantiated.

In the current analysis, we were able to build a multivariable logistic regression model that identified urban residence and daily smartphone usage (in hours) as statistically significant predictors of poor sleep quality. The significance of urban residence as an independent risk factor highlights possible environmental contributors, such as noise pollution, lower physical activity levels, or higher academic stress. Interestingly, the frequency of bedtime smartphone use and gender were not statistically significant, suggesting that overall exposure duration may outweigh these categorical variables in determining sleep quality outcomes. Although model convergence was achieved, future studies may benefit from even larger sample sizes and additional covariate adjustments to better understand these multifactorial dynamics.

This study contributes to the expanding body of evidence advocating better digital hygiene practices among adolescents. The strong associations with sleep and overweight risk markers suggest that targeted interventions—such as sleep education, restricted screen time policies, and the promotion of physical activity—could mitigate some of the negative health impacts of excessive smartphone use. Parental monitoring, school health awareness programs, and digital detox initiatives could serve as practical community-level solutions.[24]

At the policy level, these findings underscore the need to integrate digital behavior monitoring into school health programs and public health frameworks. The Rashtriya Kishor Swasthya Karyakram (RKSK) could be enhanced to include modules on sleep health, screen use guidelines, and circadian education.[25] Incorporating questions on digital usage into routine school health screenings may also help in the early identification of at-risk adolescents.

This study is not without limitations. Being cross-sectional in design, it cannot establish causal relationships. Additionally, reliance on self-reported data for sleep quality, vision, and smartphone use introduces potential recall and reporting biases. The absence of objective assessments such as actigraphy, digital use logs, or standardized body mass index (BMI) calculations limits the clinical accuracy of the health outcomes. Furthermore, despite the adequate sample size of 140 participants, broader generalizability remains constrained to similar school-going populations in Eastern India.

Future research directions include longitudinal cohort studies to establish temporal associations, incorporation of wearable technology and digital monitoring apps to capture objective screen and sleep metrics, and qualitative studies exploring adolescent perspectives on smartphone use and sleep. Randomized controlled trials evaluating the effectiveness of digital hygiene curricula or behavioral interventions would also provide policy-relevant evidence.

## Conclusion

This study highlights a strong association between bedtime smartphone usage and poor sleep quality among adolescents, with extended use beyond 30 minutes posing a greater risk. Additionally, excessive daily smartphone use correlates significantly with overweight status, reflecting its impact on both behavioral and physical health. Although associations with vision and blood pressure were not statistically significant, the observed trends warrant further evaluation. These findings emphasize the importance of integrating digital hygiene into adolescent health education and school-based interventions. Larger, longitudinal studies using objective tools are needed to establish causality and refine targeted public health strategies.

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