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# Sleep patterns in adolescents and associations with substance use

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A B S T R A C T

*Objectives:* Good sleep during adolescence is crucial for maintaining physical and psychological health; however, sleep disturbance during this period may contribute to health risks, such as substance use. This study aimed to identify the latent sleep patterns across male and female adolescents, and their association with drug use.

*Method:* A cross-sectional study was conducted involving 1391 high school students (aged 15-17; 56.4% female). Participants completed the brief Pittsburgh Sleep Quality Index alongside other sleep measures, and the Timeline Follow-Back and Drug Use History Questionnaire to measure substance use. A multiple-group latent class analysis was used to identify sleep patterns across sexes, and pairwise Logistic Regression models to compare their association with substance use.

*Results:* Four sleep patterns were identified with varying degrees of sleep difficulties: "Good Sleep" (43.3%), "Night Awakenings" (31.8%), "Poor Efficiency and Sleep Onset" (9.4%), and "Poor Sleep" (15.5%). Female adolescents were more likely to belong to Poor Sleep and Poor Efficiency and Sleep Onset patterns, and male adolescents to Good Sleep. Likewise, binge drinking and using alcohol for a longer period were associated with experiencing Poor Efficiency and Sleep Onset (OR = 1.03 and 2.3, respectively); smoking tobacco within the past month was linked to Night Awakenings (OR = 2.2); and using cannabis or illegal drugs to the Poor Sleep pattern (OR = 2.4 and 2.6, respectively).

*Conclusions:* Varied sleep difficulties exist among adolescents that significantly correlate with different aspects of drug use. Targeted interventions that address both sleep and drug prevention are recommended.



## Introduction

Sleep quality is essential for maintaining adolescents' health, as sleep regulates physiological, cognitive, and emotional processes throughout this stage of maturation.[1] However, significant developmental changes occur during adolescence that can disturb the quality of sleep and increase the risk of physical and psychological problems.[2-4] These changes encompass an increase in social interactions with less parental control, a delay in the circadian clock leading to a preference for an evening chronotype, and the initiation of using drugs.[5-7]

Social timing and social activities during adolescence may determine bedtime and wake-up times which can interfere with the circadian rhythm and lead to misalignment of sleep schedule.[8] In turn, adolescents who experience misaligned sleep, as well as trouble sleeping or later bedtimes are more likely to use tobacco, cannabis, and alcohol in emerging adulthood.[9,10] Both the tendency for evening activities and the onset of substances contribute bidirectionally to the development of night disturbances, social jetlag, and a deficit in sleep duration,[5,8,10] with up to 70% of adolescents sleeping less than the recommended 8 hours per night.[11,12]

Despite the relevance of sleep quality for adolescents' health, there is still a limited number of studies that explore the different sleep patterns among this population. Recent works have identified 3 to 4 patterns of how youth sleep, with subjective good sleep quality and short sleep as the most prevalent.[13-15] These studies concur with the identification of a specific poor sleep pattern among adolescents and children who experience problems in multiple sleep dimensions including short sleep, an evening chronotype, insomnia, and sleepiness.[13-17] Those with a poor sleep pattern seem to be at higher risk of experiencing both internalizing and externalizing problems, such as anxiety, depression, aggressive behaviors, as well as somatic problems.[13,15] Nevertheless, the identification of sleep patterns has primarily focused on sleep disorders or common sleep dimensions, as sleep duration,[13,15,16,18] disregarding other key

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indicators (e.g., sleep efficiency) relevant for the evaluation of sleep health in nonclinical populations.[19,20]

Likewise, although extensive literature supports a bidirectional association between substance use and sleep,[5,21,22] the link between sleep patterns and substance use during adolescence remains unexplored. Analyzing various dimensions of sleep may provide a better understanding of which sleep patterns are associated with different substances.[10,23] Regarding this, the psychoactive effects of particular drugs, such as alcohol and cannabis, have sleep-inducing effects reducing sleep latency and prolonging the deep sleep phase.[24,25] However, these substances can produce sleep disturbances, especially with regular or excessive use, leading to tolerance and to difficulties falling asleep and sleep fragmentation, particularly in the case of alcohol use.[21,26,27] Regarding stimulant substances such as tobacco or cocaine, their effect may contribute to sleep fragmentation, impair sleep onset, reduce total weekly sleep hours, and increase daytime dysfunction.[21] Given that polysubstance use is common in adolescence, sleep problems could be exacerbated by the concurrent or simultaneous use of substances during this period.[7,21]

Inversely, poor sleep seems to contribute to addictive behaviors through several neurocognitive and psychological pathways, including alteration of the reward system, and impulsivity traits,[2,28,29] as well as the reinforcement of using drugs to improve sleep.[30,31] In this regard, adolescents with misaligned or delayed sleep patterns may be more prone to seeking immediate rewards like the short-term consequences of using alcohol and cannabis,[28,30,32] which may also be linked to contextual and social factors. For example, the peers' influence on substance use behaviors, or activities with easier drug accessibility are predictive of consumption.[5,33] This includes engaging in evening or nighttime activities that contribute to reducing the likelihood of obtaining sufficient sleep at night while increasing access to substances.[5] Troxel et al[10] found that having later bedtimes and trouble sleeping during adolescence were prospectively associated with a higher likelihood of alcohol and cannabis use. This association continues during emerging adulthood, wherein young individuals with persistent poor sleep are more likely to use alcohol and cannabis and develop related problems.[23] Besides neurological and contextual factors, some studies indicate that the use of substances in adolescence appears to be associated with self-medication behaviors, where young people may use drugs as sleep aids (e.g., cannabis) to help them with sleep problems.[30,31] However, further research is necessary to analyze how adolescents' sleep is associated with different aspects of substance use, such as the amount, the time using the drug, or the quantity.

Likewise, gender and sex differences can also have implications for the association between sleep and substance use.[6] Young girls generally report poorer sleep quality and longer latency of sleep, and they engage in more maladaptive sleep hygiene behaviors than boys.[34] Likewise, female adolescents are more likely to experience poor sleep, and be diagnosed with insomnia, which seems related to emotional difficulties.[6] In contrast, male adolescents maintain a shorter sleep pattern in the trajectory toward adolescence.[14] Although some studies support different sleep patterns across sexes, recent findings point out that the sleep patterns during early adolescence remain similar regardless of sexes.[13] However, more studies are needed to analyze the different sleep patterns based on sex/gender and for more precise findings on adolescent sleep patterns. Similarly, literature has revealed variations in substance use among male and female adolescents, which may differ across countries. Typically, male adolescents are more inclined toward illicit drug use at an earlier age, whereas female adolescents exhibit a greater tendency for binge drinking and smoking behaviors, mainly in Mediterranean countries.[7] Therefore, it is important to examine whether sleep differences are linked to drug use in male and female adolescents.

Given the lack of studies analyzing sleep patterns among adolescents while considering sex differences and the gap regarding their association with different aspects of substance use, the aim of this study was twofold. First, to identify sleep patterns in adolescents across sexes; and second, to analyze how these sleep patterns may be associated with drug use in adolescents.

## Methods

### *Participants*

The participants of this study were high school students from 10th-12th grade of public schools in Alicante province (Spain). Inclusion criteria involved students between 15-17 years of age, with Spanish as their primary language, and with no cognitive impairment that could hinder understanding the study or the self-reported measures. We initially assessed 1569 adolescents of which 8 declined to participate, 3 were excluded because they showed difficulties in understanding, 3 because they were non-native speakers, and 57 because they were > 17 years old. This age range was excluded to specifically focus on adolescents and the goals of this study, preventing the introduction of confounding factors related to the transition into adulthood. Out of the 1498 participants, we excluded 107 due to missing values in the sleep and drug use questionnaires, with no significant differences observed between individuals with missing responses and the respondents on sociodemographic variables.

The final sample comprised 1391 adolescents with an average age of 16.2 years (SD = 0.8). The majority were female adolescents (56.4%; n = 784) and attended schools located in urban areas (78.8%; n = 1096).

### *Procedure*

This study corresponds to a cross-sectional descriptive design and is part of the preregistered PREVELANC project (Clinical Trials num.: NCT05281172). Initially, we randomly selected 30 secondary high schools using a simple computerized procedure from all public secondary schools in Alicante province. Of these selected schools, 16 agreed to participate. After receiving approval, students and their parents/guardians were informed about the study, and the confidentiality and anonymity of the provided data. All students and parents/guardians interested in participating provided their written informed consent. Once consent was given, a health psychologist attended high schools to assist adolescents in completing the survey. The evaluation took place in school classrooms in groups of 25-30 participants during the school schedule using an online survey. Adolescents completed the survey independently, and voluntarily using their mobile phones, which took approximately 50 minutes to fulfill. For those who did not have a mobile phone or permission to use it, a paper version was provided. Those who chose not to participate did not proceed with completing the survey. Data were collected between November 2021 and May 2023 and no compensation was given for participation. The Clinical Research Ethics Committee of the General University Hospital of Alicante granted approval for this study (CEIm: PI2019/112).

### *Variables and measures*

#### *Sleep characteristics*

The brief version of the Pittsburgh Sleep Quality Index (B-PSQI)[35] was used to identify sleep patterns. The 6-item B-PSQI measures sleep quality of last month and five sleep dimensions: sleep latency, sleep duration, frequency of night awakenings, sleep efficiency, and subjective sleep quality. Each dimension is scored in a range from 0 to 3 points, and the sum provides a global score from 0 to 15 with higher scores representing poorer quality of sleep. The B-PSQI has demonstrated adequate reliability ($\omega$ = 0.91) and validity in the general population. In this study, the B-PSQI internal consistency was ω = 0.71, and responses for the item of hours of sleep were coded according to the recommendations of the National Sleep Foundation.[11,36]

*Sleep functioning*

The Epworth Sleepiness Scale (ESS),[37] the Insomnia Severity Index (ISI),[38] and the Pre-Sleep Arousal Scale (PSAS)[39] were also used to assess sleep characteristics. The ESS measures daytime sleepiness in eight situations (e.g., reading) using a 4-point Likert scale, from 0 (*never)* to 3 (*high probability*). The total score ranges from 0 to 24, with higher scores indicating greater sleepiness. The ESS adolescent adaptation was used in this study which has proven adequate reliability and validity (α > 0.70) in teenagers.[40] The ESS internal consistency in this study was ω = 0.78.

The ISI measures the severity of insomnia using seven items rated on a 5-point Likert scale. The global score ranges from 0 to 28, with higher scores representing greater insomnia, and scores > 8 representing a clinical indication of insomnia in teens.[41] The ISI has demonstrated good internal consistency (α > 0.75) and structural validity in adolescent samples.[41] In this study, the ISI internal consistency was ω = 0.78.

The PSAS uses 16 items to assess two dimensions of presleep arousal: eight for cognitive and eight for physical arousal. The PSAS items responses are rated on a 5-point Likert-type scale from 1 (*not at all*) to 5 (*extremely*). The PSAS has shown concurrent validity and adequate reliability in both PSAS dimensions (α > 0.80).[42] In this study, the PSAS internal consistency was ω = 0.91.

*Substance use*

Alcohol, tobacco, cannabis, and other drugs were evaluated using the TimeLine Follow-Back (TLFB)[43] and the Drug Use History Questionnaire (DUHQ).[44] The TLFB uses a calendar to retrospectively measure drug use. We assessed standard drinking units (SDUs) and binge drinking in the last month –drinking > 3 SDUs in one occasion for female and > 4 SDUs for male adolescents–, and the number of joints smoked. The DUHQ was used to measure lifetime drug use, frequency, and years using. For this study, time using was measured in months instead of years due to the teenagers' young age. The drugs that were evaluated included alcohol, tobacco, cannabis, and other illicit drugs (cocaine, amphetamine, benzodiazepines, hallucinogens, sedatives, heroin, opioid, and inhalants). The DUHQ has demonstrated its validity in adolescents[45] and has been used in the Spanish population.[46]

*Statistical analysis*

A multiple-group latent class analysis (MGLCA) was conducted using the *glca* package for R software[47] to identify adolescents' sleep patterns and test their invariance between sexes. The MGLCA model included the 5 sleep dimensions of the B-PSQI: (1) sleep latency categorized as *< 15, 16-30, 31-60,* and *> 60 minutes*; (2) sleep hours categorized as *≥9, 9-8, 8-7, and < 7 hours;* (3) night disturbances categorized as *Not during the past month, Less than 1 a week, 1-2 a week, ≥3 times a week*; (4) sleep efficiency categorized as *≥85%, 84%-75%, 74%-65%*, and *< 64%*; and (5) subjective sleep quality categorized as *Very good, Fairly good, Fairly bad,* and *Very bad*. Based on the five sleep indicators, the sample size of this study remained sufficient (n = 1391) to achieve 80% power to detect moderate to large effects of the latent profiles.[48]

LCA was first conducted separately between female and male adolescents to estimate the adequate number of patterns in each group. Two- to six-class models were analyzed by estimating the likelihood-ratio test ($\chi^2$) and relying on Akaike information criterion (AIC) and Bayesian information criterion (BIC), with lower values representing better data fit. Entropy was also calculated, with values closer to 1 suggesting higher quality in classifying participants. After confirming an equal number of classes in both sexes, the invariance of model fit was tested by constraining item-response probabilities to be equal across groups, and compared with the variant model where item-response probabilities are not constrained. Then the prevalence of class membership was compared between groups. Differences between the latent profiles on sleep parameters we estimated with the analysis of variance (ANOVA) using the Games-Howell posthoc test.

Pairwise logistic regressions (LRs) were performed to analyze the strength of association between the sleep patterns and drug use, and the results were evaluated using Odds Ratios (ORs). Four regression models were conducted considering the distinct effects each drug may have on sleep and the sleep differences identified in prior studies.[21] Model 1: included alcohol use in the last month (*yes/no)*, number of SDUs of past month, binge drinking in the last month (*yes/no)*, and months drinking alcohol. Model 2: included tobacco use in the last month (*yes/no)*, average number of cigarettes smoked per day of use, and months smoking tobacco. Model 3: included cannabis use in the last month (*yes/no)*, number of joints in the past month, and months using. Model 4: included lifetime use of other illicit drugs (*yes/no)*. All LR models were adjusted by sex and polydrug use (≥2 substances). Likewise, interaction effects between sex and substance use were also analyzed to test if sex differences in substance use may be related to the differences observed in sleep patterns. The results were interpreted with a 95% confidence level.

## Results

*Sample characteristics in sleep and substance use*

Adolescents reported an average of 21.7 (SD = 27.5) minutes taken to fall asleep and a sleep duration of approximately 6:57 hours (SD = 1:06), with 74.3% (n = 1033) sleeping less than 8 hours per night. Notably, most participants reported good sleep quality (70.5%; n = 980) and experienced night awakenings less than once a week (60.6%; n = 843). As observed in Table 1, the B-PSQI, ESS, ISI, and PSAS scores showed moderate sleep quality. This includes 56.6% (n = 787) of good sleepers and 43.4% (n = 603) of poor sleepers according to the B-PSQI.

Half of the sample used alcohol in the past month (51.1%, n = 711), 19.2% (n = 267) used tobacco, and 8.5% (n = 118) used cannabis. For other drugs, 3.2% (n = 45) reported lifetime use, including nonmedical use of benzodiazepines (35.6%; n = 16), followed by stimulants (e.g., cocaine) (33.3%; n = 15), hallucinogens (22.2%; n = 10), and inhalants (17.8%; n = 8). Furthermore, the average duration of regular alcohol use was longer (5.3 months; SD = 8.6) compared to tobacco (3.8 months; SD = 9) or cannabis (2.4 months; SD = 5.6), with over a third of participants (35.4%, n = 492) reporting binge drinking.

*MGLCA across sexes*

*Model selection*

Two- to six-class models were estimated. According to AIC and BIC values, the model with four latent classes provided the most optimal fit for the whole sample ($\chi^2(960) = -7081.6$; AIC = 14,289.2; BIC = 14,619.2) with 72% entropy classifying participants. Consistently, the 4-class model showed better-fit statistics for female adolescents ($\chi^2(720) = -4105.6$; AIC = 8337.2; BIC = 8631.1; Entropy = 0.74). Regarding men, both 3- and 4-class models showed adequate fit with no major differences between them, therefore we continued the MGLCA using the 4-class model ($\chi^2(543) = -2907.9$; AIC = 5941.7; BIC = 6219.5; Entropy = 0.67) to analyze invariance between the two groups. MGLCA results are displayed in the Supplementary Material.

**Table 1**
Sample characteristics (N = 1391)

| | Mean (SD)/% (n) |
|---|---|
| Sleep hours | 6:57 (1:06) |
| Sleep latency (min) | 21.7 (27.5) |
| Sleep efficiency | 90.9 (11.4) |
| Night awakenings | |
| < weekly %(n) | 60.6 (843) |
| > weekly %(n) | 39.4 (548) |
| Subjective sleep quality | |
| Good %(n) | 70.5 (980) |
| Poor %(n) | 29.5 (411) |
| B-PSQI | 5.4 (2.9) |
| ISI | 7.9 (5.1) |
| PSAS | 32.2 (12.5) |
| ESS | 7.2 (4.8) |
| Alcohol use | |
| Last month use %(n) | 51.1 (711) |
| SDUs of last month | 15.7 (19.8) |
| Binge drinking %(n) | 35.4 (492) |
| Months of regular use | 5.3 (8.6) |
| Tobacco use | |
| Last month use %(n) | 19.2 (267) |
| Cigarettes | 2 (2.6) |
| Months of regular use | 3.8 (9) |
| Cannabis use | |
| Last month use %(n) | 8.5 (118) |
| Joints | 3 (9.5) |
| Months of regular use | 2.4 (5.6) |
| Other illicit drugs | |
| Lifetime use %(n) | 3.2 (45) |
| Last year use %(n) | 2.2 (31) |

Abbreviations: B-PSQI, brief Pittsburgh sleep quality index; ESS, Epworth sleepiness scale; ISI, Insomnia severity index; PSAS, prearousal sleep scale; SD, standard deviation; SDU, standard drinking units.
Other illicit drugs include cocaine, amphetamine, stimulants, benzodiazepines, hallucinogens, sedatives, heroin, opioid, and inhalants.

*Sleep patterns characteristics*

As observed in Fig. 1, the 4-class model yielded four sleep patterns in adolescents based on the response probabilities to the five sleep parameters. Pattern A was labeled “Good Sleep” and represented 43.4% of the sample (n = 603). This pattern was characterized by a low likelihood of experiencing sleep problems, with less than 20% probability of experiencing difficulties falling asleep, insufficient sleep hours, night awakenings, low efficiency, and subjective poor sleep. Pattern B (31.8%; n = 442) was named "Night Awakenings" and was characterized by a high likelihood of experiencing night awakenings during the week (56% probability), a high probability of reporting good sleep (60%), and a low probability of experiencing other sleep problems (see Fig. 1). Pattern C was named “Poor Efficiency and Sleep Onset” and represented the smallest subgroup, comprising 9.4% (n = 131) of adolescents who most likely reported < 85% of sleep efficiency (100% probability). This group was more likely to experience difficulties falling asleep after 30 minutes (34% probability) and insufficient hours of sleep (63% probability). Lastly, pattern D (15.5%; n = 215) was named “Poor Sleep” and was characterized by a pronounced likelihood of experiencing sleep problems across all sleep indicators. This included taking > 30 minutes to fall asleep (43% probability), sleeping < 7 hours (90% probability), reporting night awakenings > 3 times per week (70% probability), and reporting poor sleep (93% probability).

Consistent with MGLCA, the four sleep patterns differed in their B-PSQI scores and components, with Poor Sleep pattern showing the highest B-PSQI scores (10.1 ± 1.9) followed by Poor Efficiency and Sleep Onset pattern (7.2 ± 1.6), Night Awakenings pattern (6 ± 1.2), and Good Sleep pattern (2.9 ± 1.2). As shown in Table 2, the Poor Sleep pattern showed significantly higher scores in the ESS (9.0 ± 4.9), ISI (14.1 ± 4.6), and PSAS (44.8 ± 13.8) compared to the other classes, suggesting clinical criteria for insomnia disorder in this subgroup.

The patterns Night Awakenings and Poor Efficiency and Sleep Onset did not differ in daytime sleepiness or arousal before sleep (see Table 2), and the differences in the ISI were statistically significant ($p = .032$) but with a small effect size ($\eta^2 = 0.01$). The Poor Efficiency and Sleep Onset pattern showed a longer time to fall asleep (33.5 ± 31.4 minutes), a 35-minute difference of less sleep, and a lower percentage of sleep efficiency compared to the Night Awakenings pattern. By contrast, the Night Awakenings pattern was particularly characterized by the disruption of sleep during the night and showed worse sleep only when compared with good sleepers.

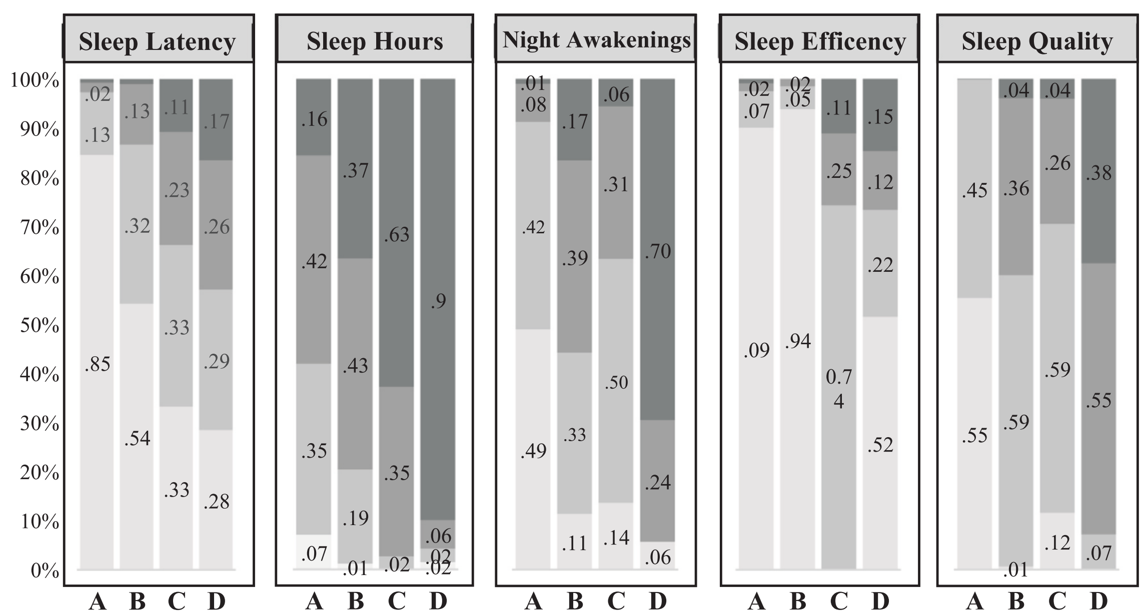


**Fig. 1.** Response probabilities to the five sleep indicators in the 4-class model. *Note.* A: “Good Sleep” pattern (n = 603); B: “Night Awakenings” pattern (n = 442); C: “Poor Efficiency and Sleep Onset” pattern (n = 131); D: “Poor Sleep” pattern (n = 215). Responses to sleep parameters are categorized into four alternatives represented from light to dark gray: Sleep latency: *< 15/16-30/31-60/ > 60 minutes*. Sleep hours: *≥9/9-8/8-7/ < 7 hours*. Night awakenings: *Not in the past month/ < 1 a week/1-2 a week/≥3 times a week*. Sleep efficiency: ≥85%/84%-75%/74%-65%/ < 64%. Subjective sleep quality: *Very good/Fairly good/Fairly bad/Very bad*

**Table 2**
Mean differences across the four latent classes (N = 1391)

| | "Good Sleep" (A) | "Night Awakenings" (B) | "Poor Efficiency and Sleep Onset" (C) | "Poor Sleep" (D) | F (*p*) | Games-Howell test | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| | *43.3% (603)* | *31.8% (442)* | *9.4% (131)* | *15.5% (215)* | | | |
| B-PSQI | 2.9 (1.2) | 6 (1.2) | 7.2 (1.6) | 10.1 (1.9) | 1626.4 (.001) | A < B < C < D | **0.78** |
| Latency | 11 (14.2) | 21.6 (20.3) | 33.5 (31.4) | 44.5 (44.2) | 108.1 (.001) | A < B < C < D | **0.19** |
| Hours | 7:31 (0:52) | 6:57 (0:51) | 6:23 (0:48) | 5:41 (1:08) | 234.9 (.001) | A > B > C > D | **0.34** |
| Awakenings | 0.6 (0.6) | 1.7 (0.8) | 1.1 (0.7) | 2.6 (0.7) | 515.9 (.001) | AC < B < D | **0.53** |
| Efficiency | 94.8 (7.9) | 94.7 (5.7) | 78.8 (11.7) | 81.5 (14.9) | 252.2 (.001) | AB > D > C | **0.35** |
| Sleep quality | 0.4 (0.5) | 1.5 (0.6) | 1.2 (0.6) | 2.3 (0.6) | 754.1 (.001) | A < C < B < D | **0.62** |
| ISI | 4.6 (3.4) | 9.2 (4) | 8.2 (4.1) | 14.1 (4.6) | 351.6 (.001) | A < C < B < D | **0.43** |
| PSAS | 26.1 (8.4) | 34.2 (11.5) | 33.2 (10.9) | 44.8 (13.8) | 170.2 (.001) | A < BC < D | **0.27** |
| ESS | 5.9 (4.5) | 8.1 (4.9) | 7.5 (4.3) | 9 (4.9) | 31.6 (.001) | A < BC < D | **0.06** |

Abbreviations: B-PSQI, Brief Pittsburgh sleep quality index; ESS, Epworth sleepiness scale; ISI, Insomnia severity index; PSAS, prearousal sleep scale; F, ANOVA F statistic; Games-Howell test, intergroup significant differences ($p < .05$); $\eta^2$, eta-squared effect size.
Bold typing indicates moderate to large effect sizes ($\eta^2 > 0.06$).

### *Model invariance across male and female adolescents*

Item-response probabilities of the 4-class model were constrained across sexes. The constrained model showed a similar fit to the variant model ($p = .14$), indicating consistent responses to the sleep parameters within each pattern regardless of sex. However, the invariant model differed statistically from the 4-class model ($p < .001$) suggesting that the pattern membership prevalence differed between male and female adolescents. Female adolescents were more likely to belong to the sleep pattern Poor Efficiency and Sleep Onset than male adolescents (11.9% female vs. 6.3% male), and to the pattern Poor sleep (19.4% female vs. 10.4% male). Consistently, male adolescents were more likely to belong to the Good Sleep pattern (35% female vs. 54% male) which indicates a substantial sex discrepancy regarding the quality of sleep. The proportion of female and male adolescents was approximately equal ($p > .05$) in the pattern Night Awakenings (33.7% female vs. 29.3% male).

### *Association between sleep patterns and substance use*

Fig. 2 displays the results of the LRs comparing the odds of using drugs across the sleep patterns, with the Good Sleep as the comparison group. While controlling the effect of sex and polysubstance use, statistically significant differences were observed between the patterns Good Sleep and Night Awakenings in tobacco use. Individuals who most likely experience night awakenings exhibited 2.2 (95% confidence interval [CI] = 1.1-4.5) times higher odds of tobacco use in the past month compared to good sleepers. This association was sustained regardless of the time smoking ($p = .125$), the average of cigarettes ($p = .461$), or the sex. No significant interaction effects were observed between tobacco use variables and sex ($p > .05$), nonetheless, female adolescents were more likely to belong to the Night Awakenings pattern than to the Good Sleep pattern (OR = 1.7; 95% CI = 1.4-2.2).

Likewise, the pattern Poor Efficiency and Sleep Onset showed significant differences compared with Good Sleep in alcohol use. Adolescents who had trouble falling asleep demonstrated more than twice the odds of engaging in binge drinking in the past month (OR = 2.4; 95% CI = 1.1-4.9) compared to good sleepers. Similarly, using alcohol for a longer period was associated with higher odds of experiencing difficulties falling asleep and lower sleep efficiency (OR = 1.03; 95% CI = 1-1.1). Regarding sex, female adolescents had 2.9 times higher odds of belonging to the Poor Efficiency and Sleep Onset pattern (95% CI = 1.9-4.5), with no significant interaction effects with any of the alcohol use variables ($p > .05$).

The pattern of Poor Sleep showed significant associations with cannabis and other illicit drugs compared to the pattern of Good Sleep. Poor sleepers were found to have twice the likelihood of using cannabis in the past month (OR = 2.4; 95%CI = 1.1-5.1) regardless of the number of joints ($p = .971$) and the time of use ($p = .673$), and a significantly higher likelihood of lifetime use of other drugs (OR = 2.6; 95% CI = 1.2-5.9). Female adolescents were three times more likely to belong to the Poor Sleep pattern (OR = 3.0; 95%CI = 2.1-4.2), and no interaction effects were observed between sex and the use of cannabis or other illicit drugs ($p > .05$).

## Discussion

This study aimed to identify sleep patterns in adolescents and their association with substance use. A high prevalence of sleep problems was observed similar to other adolescent European populations, with 43% experiencing poor sleep in the past month and about 74% sleeping less than recommended by the National Sleep Foundation.[16,18] Although most adolescents perceived their quality of sleep as good, their scores in the sleep self-reported measures were higher than those found in other healthy populations,[16] suggesting poor sleep comparable even to clinical samples.[49]

Results also provided an overview of four specific sleep patterns among adolescents whose characteristics were similar among male and female adolescents. Most adolescents experience some sort of sleep problem, with only a minority being good sleepers. This contrasts previous studies in which there is a larger percentage of good sleepers,[15] and aligns with the consistent decrease in sleep quality over time during the transition to adulthood.[23] We identified a pattern encompassing one-third of adolescents who experience more frequent Night Awakenings, another pattern associated with Poor Efficiency and Sleep Onset, and a third pattern with almost a quarter of participants, who reported overall Poor sleep. Compared to other works, we did not identify a pattern characterized solely by insufficient hours of sleep,[14,15,18] which was an aspect generalized in all the patterns found in this study. Likewise, we did observe a similar pattern of sleep related to experiencing difficulties with sleep onset among adolescents,[13,14,23] and a range of varying severity levels of sleep quality which was similar to patterns in emerging adulthood.[23] Interestingly, worse sleep patterns were also related to greater use of alcohol and cannabis.[23] This advises that interventions to prevent poor sleep and substance use should be implemented at earlier ages to mitigate long-term effects on sleep quality and overall well-being. Furthermore, the results indicate that different treatment approaches should be taken regarding adolescents' sleep patterns. For example, while adolescents with difficulties in maintaining sleep may benefit from sleep restriction and stimulus control, those with difficulties in falling asleep may benefit from cognitive distraction.

On the other hand, the prevalence of sleep patterns differed across sexes, with the patterns Poor sleep and Poor Efficiency and Sleep Onset comprising almost double the percentage of female adolescents. This is consistent with sex differences found in the literature in which female adolescents had a greater probability of

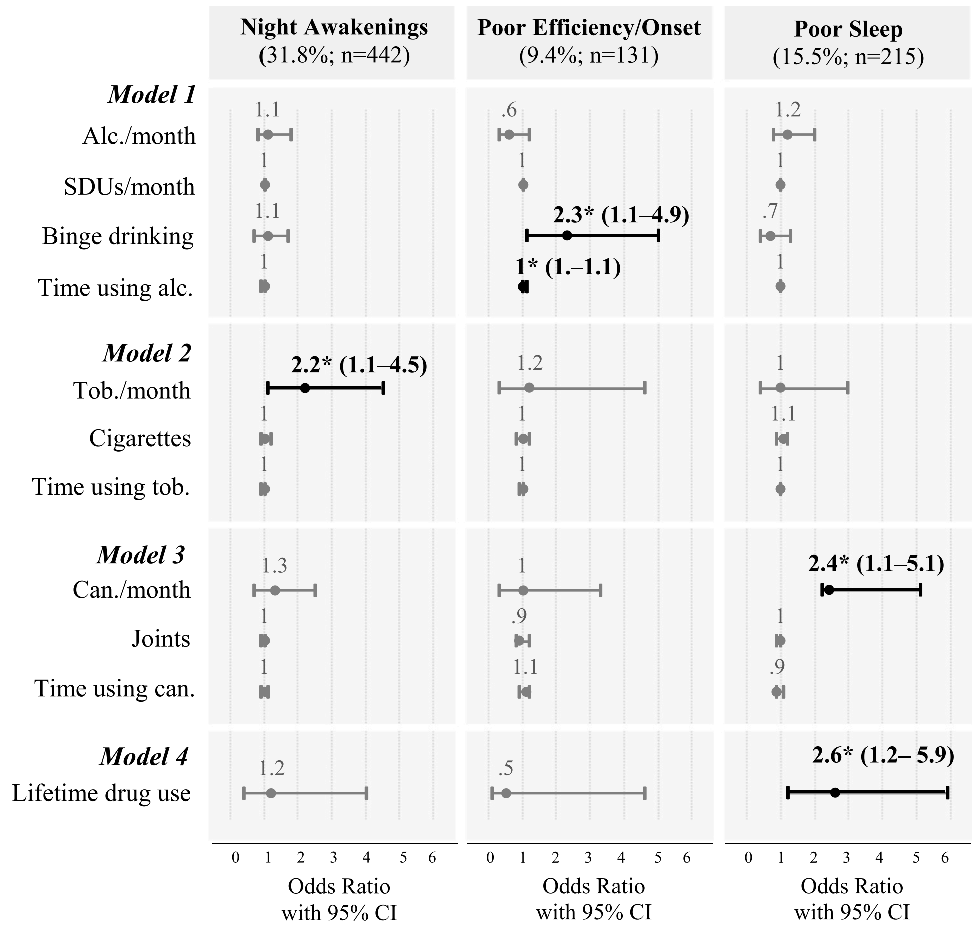


**Fig. 2.** Logistic regressions for substance use and poor sleep patterns. *Note.* "Good Sleep" group is used as the reference group (43.4%; n = 603). Model 1 includes alcohol variables, model 2 includes tobacco variables, model 3 includes cannabis variables, and model 4 includes lifetime use of other illicit drugs. All models were adjusted by sex and use of other substances. **p* < .05; ***p* < .01. Alc, alcohol use; Can, Cannabis use; SDUs, standard drinking units; Tob, tobacco use; 95% CI, 95% confidence interval

reporting disturbances in all sleep dimensions, particularly difficulties falling asleep, and worse sleep efficiency.[6] According to previous literature, this could be due not only to differences attributed to sex, but also to a higher tendency for episodic drinking among Spanish female adolescents which can disturb initiation and duration of sleep.[7,21] However, in this study, no interaction effects were observed between sex and substance use in the association with sleep patterns, indicating that both variables can independently relate to sleep disturbances.

Regarding substance use, the percentage found for alcohol use was similar to those reported in European surveys, but the prevalence of tobacco and cannabis use was slightly lower.[7,50] Half of the sample reported drinking alcohol in the last month of which 70% engaged in binge drinking. These rates are concerning given the negative consequences that binge drinking can have on health, particularly in the development of sleep disorders.[21,26] In this regard, the use of drugs was associated with poor sleep, however, the association with sleep patterns varied according to the type of substance, the quantity, and the time of regular use.

Having at least one episode of binge drinking doubled the association with the Poor Efficiency and Sleep Onset pattern, which is consistent with prospective associations found for short sleep.[9,21] According to this, both binge drinking and regular alcohol use over a longer period seem to be related to more difficulties falling asleep and spending more time awake while lying in bed. This may suggest that higher amounts of alcohol and increased tolerance can decrease the quality of sleep over time. The findings of this study support the idea that the initial perception of improved sleep could contribute to disturbed sleep.[31] Also, this suggests that an extended duration of drinking may directly impact the sleep schedule, given that drinking behaviors predominantly occur at night, emphasizing the influence of contextual factors.[5] However, the strength of the time-of-use association was small, possibly because adolescents have a relatively short history of alcohol consumption compared to adults. In this regard, it is important to address binge drinking among adolescents, as well as potential self-medication behaviors to reduce sleep onset to minimize both sleep and substance use problems, since both may contribute to each other.[5]

Additionally, adolescents who smoked tobacco in the last month seemed to have a higher likelihood of experiencing more Night Awakenings, a similar finding that has been found in previous studies, particularly when smoking occurs during night-time.[21,51] This association was significant regardless of the time smoking or the number of cigarettes, suggesting that adolescents may be more sensitive to experiencing sleep disturbances with sporadic use.[10] These findings underline the relevance of implementing preventive strategies for nicotine use at earlier stages as they can help prevent not only nicotine-related problems but also the occurrence and exacerbation of sleep fragmentation.

Besides alcohol and tobacco, using cannabis was linked to the Poor Sleep pattern. Those who used cannabis in the past month were twice as likely to experience more sleep disturbances,[9,10,21] and therefore higher levels of insomnia, sleepiness, and arousal before sleep. Again, the results of this study indicate that the use of cannabis regardless of the amount or the time using appears to be associated with worse quality of sleep in adolescents. This is noteworthy given the myths about the sleep benefits of cannabis and self-medication behaviors that can lead to low-risk perception and therefore to a higher use among adolescents.[52] In this regard, the results support informative measures and interventions that are efficient in mitigating those myths and preventing the pejorative negative effects of cannabis on the overall sleep quality of adolescents.

Also, the use of other illicit drugs was associated with experiencing sleep problems. Adolescents who used illicit drugs were 2.6 times more likely to experience worse sleep, even after controlling for polysubstance use, supporting the idea that substance use is linked to different aspects of sleep.[10] This indicates that drugs can have a significant impact on all sleep dimensions and suggests other latent factors contributing to this association. For example, psychological well-being, or even a profile of adolescents with a tendency toward immediate-reward behaviors, as previously observed.[2,13] Sleep interventions should consider addressing various aspects of sleep, and surpassing the aim of increasing sleep duration, given that all dimensions were related to substance use.

The results of this study should be interpreted considering several limitations. Firstly, self-report measures were used, which can bias the accuracy of sleep and substance use assessment. Nevertheless, the instruments used have shown adequate psychometric validity and findings concur with previous studies that use objective data. Furthermore, this is a cross-sectional study, so we cannot determine the direction of the association between variables. Future longitudinal studies would be necessary to understand how substance use may affect the sleep quality of adolescents and vice versa, and to understand the temporal dynamics between these two factors. Both longitudinal data and objective measures could help strengthen the validity and reliability of findings. In this regard, gender as a grouping variable should also be considered in future studies, so that the results can be compared with those obtained using sex. Furthermore, our study benefits from random sampling, a robust sample size, and management of nonresponse bias, however, it is worth noting that no specific data were collected from the nonparticipating schools, which could introduce bias, particularly if these schools differ from the participating ones in unmeasured aspects. Although no systematic differences in geographic location or school size were observed between participating and nonparticipating schools, these limitations should still be considered when interpreting the results and generalizing the findings to the broader adolescent population. Finally, the substance use patterns were unexplored, and although results allow a better understanding of the effects of different substances, future studies should analyze the relationship between different patterns of drug use and sleep problems, as well as explore the time of the day the drug is used.

Taking this into consideration, we conclude that identifying sleep patterns permits to gain a deeper understanding of how adolescents sleep and the implications of tailoring health programs to reduce risks associated with poor sleep. Our research fills a literature gap by exploring the connections between sleep patterns and the use of different substances, including their frequency, occurrence, and quantity of consumption. Understanding how diverse substances affect sleep quality differently enables the design of personalized interventions to mitigate the negative impacts of substance use on adolescent sleep. Regarding this, it would be advantageous to implement these interventions in early adolescence, before substance use initiation and the establishment of regular use, to minimize potential sleep problems during adolescence. Therefore, future experimental designs should explore how drug prevention efforts could alleviate the impact of poor sleep on adolescents. Additionally, findings suggest that integrating sleep improvement components into drug prevention programs could further enhance their efficacy by addressing both substance use and sleep health simultaneously. This can involve transdiagnostic sleep interventions that have already demonstrated effectiveness in improving sleep while addressing other risk behaviors.[53] A comprehensive approach that includes sleep education and substance use prevention may foster better long-term health outcomes for adolescents.

## Author contributions

CSD and JLC conceived and planned the study together. CSD and JLC participated in conceptualization, investigation, and methodology. CSD was responsible for data curation, formal analysis, and writing the original draft. JLC contributed to writing the original draft, supervision, providing resources, and project administration.

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## Declaration of conflicts of interest

None.

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None.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sleh.2024.09.002.

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