REVIEW ARTICLE

# Worldwide Prevalence of Poor Sleep Quality in Adolescents Aged 10–19 Years: A Systematic Review and Meta-Analysis

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## ABSTRACT

**Objectives:** Studies show significant variability in adolescent sleep quality prevalence, likely due to differing definitions of adolescence and the use of various assessment questionnaires. This meta-analysis aimed to determine the prevalence of poor sleep quality using the Pittsburgh Sleep Quality Index (PSQI) among adolescents aged 10 to 19 years.
**Materials & Methods:** PubMed, Scopus, and Web of Science databases were comprehensively searched until October 2, 2024. The quality of the included studies was assessed using the Joanna Briggs Institute critical appraisal tool. The random effects model was employed to compute the pooled prevalence with a 95% confidence interval. Furthermore, subgroup analyses were conducted to explore the sources of heterogeneity.
**Results:** This study analyzed 28 cross-sectional studies involving 191,408 adolescents aged 10-19 , with a male proportion of 46.23%. The quality of the records was moderate (n = 9) and good (n = 19). The pooled prevalence of poor sleep quality was 37% (95% CI: 30-45%) with significant heterogeneity between the studies ($I^2$ = 99.70%, $P_{heterogeneity}$ < 0.001). The subgroup analysis indicated that geographic location was a significant source of heterogeneity (p < 0.001), with a lower prevalence of poor sleep quality observed in Asia (30%; 95% CI = 23%–38%) when compared to other regions. No significant differences were observed in the impact of other factors, including gender, development level, sample size, survey time, PSQI cut-off, response rate, and quality score, on the overall heterogeneity of the analyzed data.
**Conclusion:** The present study is a first for providing a comprehensive overview of the problem of poor sleep quality among adolescents, with a large sample size and consistent definitions and measurements.

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## Introduction

Adolescence is a crucial phase of development playing an essential role for laying the foundation of good health (1). Sleep is an essential factor for physical and mental development during adolescence (2). Notably, getting enough sleep is crucial; however, sleep quality is vital (3). Sleep quality refers to a person's satisfaction with all aspects of their sleep (4). Sleep quality during adolescence is particularly essential due to its critical role in cognitive

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development, mood regulation, and overall health. Adolescents experience significant brain development, and quality sleep is essential for memory consolidation and learning (5, 6). Poor sleep quality among adolescents negatively affects several domains, including school performance, brain function, mood regulation, cognitive processes, and general health (7-11).

Estimating the prevalence of poor sleep quality in adolescents varies significantly among studies ranging from 2.5% in South India to 76.4% in rural areas of China (12, 13) , which may be due to different definitions of adolescence years and various questionnaires used to assess sleep quality. These factors have resulted in a lack of clear overview of the problem. Therefore, formulating policies and prevention efforts requires a comprehensive overview, with consistent definitions and measurements.

Adolescence is defined by the World Health Organization as individuals aged 10 to 19 (1). The Pittsburgh Sleep Quality Index (PSQI) is widely used to assess sleep quality in adolescents owning to its strong validity and reliability (14-17). The PSQI presents a measure of global sleep quality based on a respondent's retrospective evaluation of sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, the use of sleeping medication, and daytime dysfunction (18). The current study aims to determine the global prevalence of poor sleep quality among adolescents aged 10 to 19 years using the PSQI questionnaire and to explore the causes of heterogeneity using subgroup analyses.

## Material & Methods

This review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (19). As this meta-analysis relied solely on publicly available data, it was exempt from the requirement of ethics committee approval.

### *Data sources*

The search for published literature up until October 2, 2024, was conducted using the electronic databases of PubMed, Scopus, and Web of Science. In addition, the reference lists of the eligible studies were examined for any possible additional citations.

The Population, Exposure, Comparison, Outcomes, and Study design (PECOS) statement is used to formulate search strategies for systematic reviews (20). The PECOS in this meta-analysis was considered: (P) adolescents (E) not applicable, (C) not applicable, (O) prevalence of poor sleep quality, and (S) cross sectional studies.

The search keywords included (Adolescent OR Adolescents OR Adolescence OR Juvenile OR Juveniles OR Teen OR Teens OR Teenager OR Teenagers OR School OR Schools) AND ("Sleep Wake Disorder" OR "Sleep Wake Disorders' OR 'Sleep Disorder" OR "Sleep Disorders" OR "Sleep disturbance" OR "Sleep disturbances" OR "Sleep quality" OR 'Sleep disruption" OR "Sleep disruptions" OR "Sleep problem" OR "Sleep problems" OR "Pittsburgh Sleep Quality Index" OR "PSQI') AND ("Cross sectional" OR 'Cross section' OR Prevalence OR Prevalent OR Survey OR Frequency OR Epidemiology).

The inclusion criteria for the studies were (1) Original articles and (2) Cross-sectional studies that assessed sleep quality among adolescents using the PSQI questionnaire. The exclusion criteria were as follows: (1) Lack of access to the full text of the articles, (2) Non-English full text of the articles, (3) Outside the age range of 10 to 19 years, (4) Non-reported age, (5) Focusing on a special population, (6) Multiple articles with the same survey, and (7) Insufficient information to calculate the prevalence of poor sleep quality.

### *Study selection*

One researcher (AP, AA) searched databases. After removing duplicate studies, two researchers (SJ and FJ) independently performed the following steps to select the articles in this meta-analysis: Selecting studies based on inclusion criteria by assessing the titles and abstracts and eliminating irrelevant articles based on exclusion criteria by evaluating full-text of the articles. Third researcher (AP) resolved all disagreements between the two researchers.

### *Data extraction*

After selecting eligible articles, two researchers (AP & AA) independently extracted the following information from each study: Title, first author name, publication year, survey time, country, sampling method, sample size, response rate, total effective sample size, total event number, sample size in males and females, event number in males and females, age group (mean ± SD), and PSQI cut-off.

Joanna Briggs Institute critical appraisal tool used the 9-item to evaluate the quality of the descriptive cross-sectional study (21). If the answer to an item is "Yes", the score will be "1", and if it is "No" or "Unclear" or "Not applicable", it will be scored "0". The quality of the studies was evaluated as follows: Low quality, 0–3; Moderate quality, 4–6; and Good quality, 7–9.

The main outcome of this meta-analysis was the prevalence of poor sleep quality as measured using the PSQI Questionnaire. The PSQI is a self-report questionnaire assessing sleep quality over a 1-month

time interval. The measure consists of 19 individual items, creating seven components that produce one global score (0-21) with higher scores indicating poorer sleep quality (22). Different cut-off points were considered for poor sleep quality. The number of people whose questionnaire score was higher than the specified cut-off point was divided by the total number of people who answered the questionnaire to calculate the prevalence of poor sleep quality in each study.

Freeman-tukey double arcsine transformation was used to compute the weighted pooled estimate. To calculate the pooled prevalence with a 95% confidence interval, random effects model was utilized. A forest plot was visually provided to illustrate the points and pooled estimate. Sensitivity analysis was performed to assess the effect of each study on the final measurement. Between-study heterogeneity was evaluated using two statistics: I2 statistic and Cochrane Q statistic. The I2 statistic categorizes heterogeneity as low (25%-49%), moderate (50-74%), or high (≥75%) (23), while the Cochrane Q statistic tests for statistical significance with a P-value of less than 0.10 (24). we conducted subgroup analyses to investigate whether the average prevalence estimates of poor sleep quality among adolescents varied in relation to several factors, including gender, geographical area, level of development, sample size, survey time, PSQI cut-off, response rate, and quality score. The purpose of these subgroup analyses was to identify potential sources of heterogeneity among the included studies. Statistical analyses were carried out by Stata, version 11.0 (Stata Corp, College Station, TX).

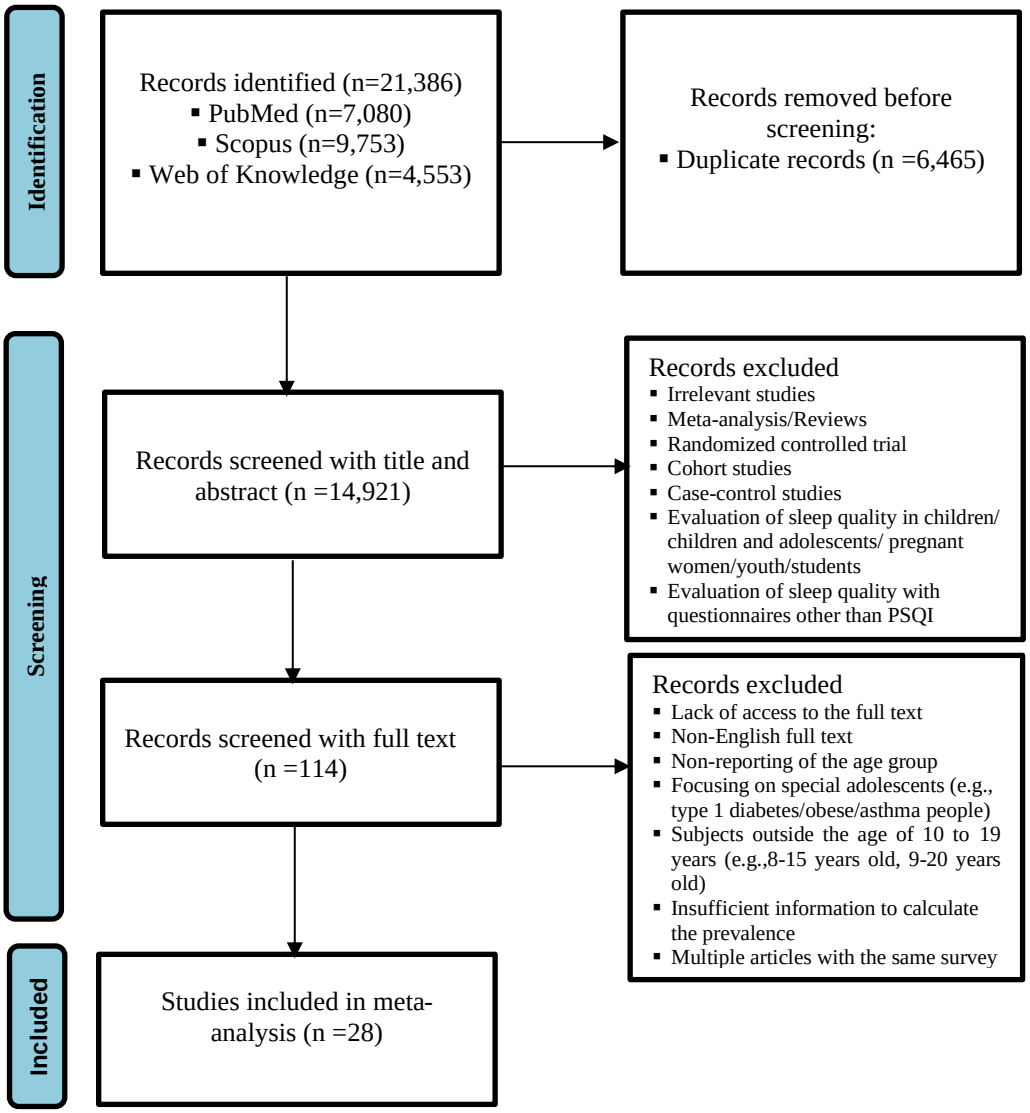


**Figure 1**. Literature search flowchart for selection of primary studies

# Results

### *Study selection*

A total of 21,386 records were identified, of which 6,465 were eliminated for duplication. After reading the titles and abstracts of 14,921 articles, 114 records were selected to evaluate the full-text. Finally, 28 records were eligible for meta-analysis, as shown in Figure 1.

### *Study characteristics*

This meta-analysis pooled data from 28 studies comprising 191,408 (46.23% male) adolescents aged 10-19. The included records were conducted in 11 countries: Brazil (7), China (5), India (3), Iran (3), Turkey (3), New Zealand (2), Ireland (1), Indonesia (1), Thailand (1), Spain/Iceland/Estonia (1), and USA (1) with the published date between 2012 and 2022. Response rates were reported by only 17 studies (60.71%), ranging from 53.4% to 99%. The PSQI cut points were reported as follows: > 5 (n = 17), = > 5 (n = 6), 5-10 (n = 2), > 7 (n = 1), > 4 (n = 1), and non-reported (n = 1). Table 1 presents the details of the selected records.

### *Quality of studies*

All records were evaluated as moderate (n = 9) and good quality (n = 19), with scores ranging from 5 to 9. The quality scores of the articles were distributed as follows: 5 (n = 2), 6 (n = 7), 7 (n = 5), 8 (n = 7), and 9 (n = 7) (Table 2).

### *Prevalence of poor sleep quality*

The prevalence of poor sleep quality among adolescents ranged from 3% in India to 69% in Thailand, while the pooled prevalence was 37% (95% CI:30–45%). Substantial heterogeneity existed between the studies (I2 = 99.70%, P heterogeneity < 0.001) (Figure 2). The results did not change significantly after removing each study sequentially.

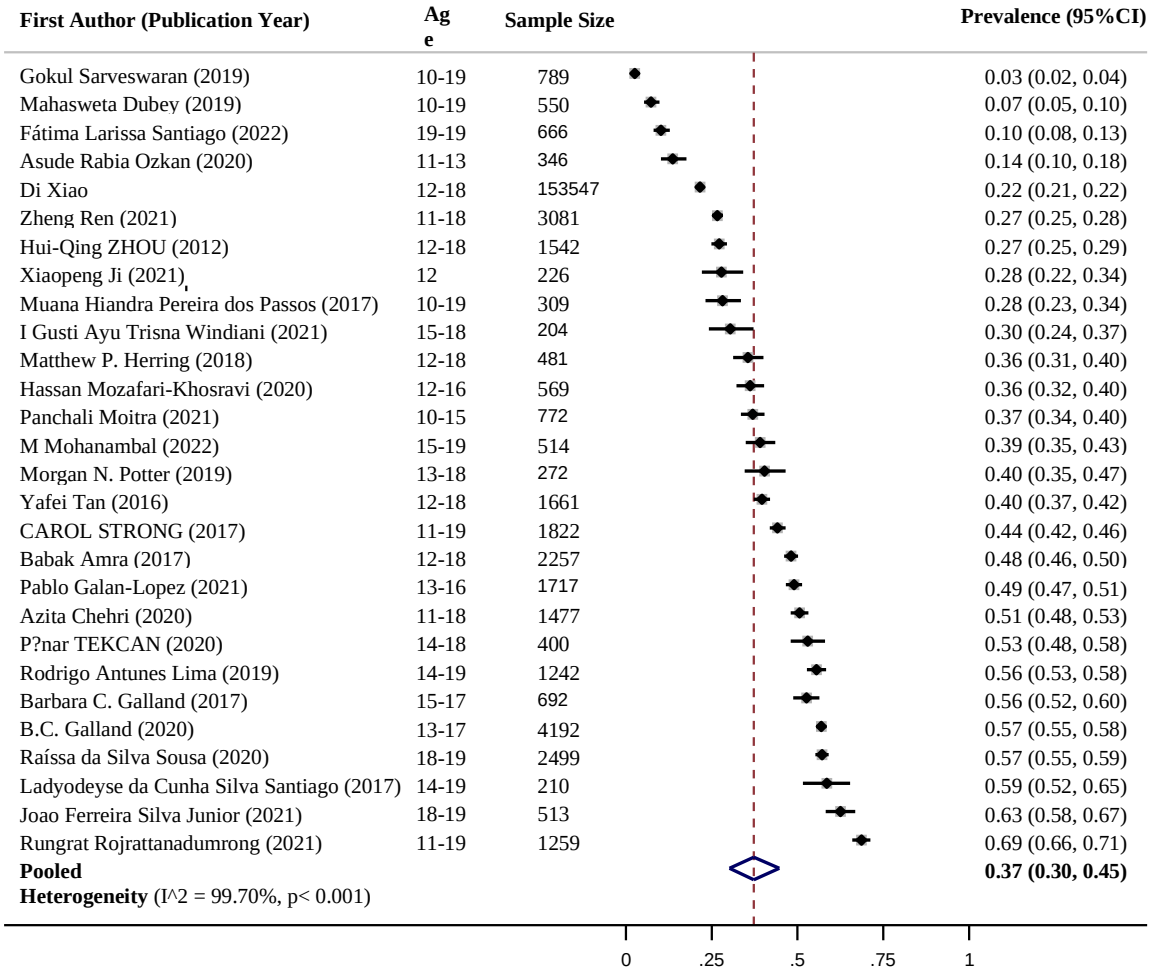


**Figure 2**: The pooled prevalence of poor sleep quality in adolescents

**Table 1.** Characteristics of studies included in this meta-analysis

| First author, Publication year | Survey time | Country | Sampling method | Age group (Mean±SD) | Response Rate (%) | Effective sample size (Male, Female) | Prevalence of poor sleep quality (%) (95% CI) | PSQI cut-off |
|---|---|---|---|---|---|---|---|---|
| M Mohanambal, 2022(49) | NR | India | SR | 15-19 (17.4 ±0.9) | NR | 514 (270,244) | 39 (35-43) | >5 |
| Fátima Larissa Santiago, 2022(50) | 2017 | Brazil | C | 14-19 | 97 | 666 (307, 347) | 10 (8-13) | >5 |
| Panchali Moitra ,2021 (51) | NR | India | NP | 10-15 (13.2 ±1.4) | NR | 772 (394, 387) | 37 (34-40 | >5 |
| Zheng Ren ,2021 (52) | 2017 | China | SR | 11-18 (13.5 ±1.1) | 97 | 3081 (1565, 1516) | 27 (25-28) | >5 |
| Rungrat Rojrattanadumrong ,2021 (53) | 2020 | Thailand | NR | 11-19 (15.66 ±1.8) | NR | 1259 (777, 482) | 69 (66-71) | >=5 |
| Xiaopeng Ji ,2021 (54) | 2013 | China | NR | 12 (12.14 ±0.55) | NR | 226 (120, 106) | 28 (22-34) | >5 |
| Pablo Galan-Lopez ,2021 (55) | NR | Spain, Iceland, Estonia | NR | 13-16 | NR | 1717 (900, 817) | 49 (47-51) | >5 |
| Joao Ferreira Silva Junior ,2021 (56) | NR | Brazil | NR | 18-19 (18 ±0.24) | NR | 513 (321, 192) | 63 (58-67) | >5 |
| I Gusti Ayu Trisna Windiani ,2021(57) | 2020 | Indonesia | NP | 15-18 | 84 | 204 (105, 99) | 30 (24-37) | >5 |
| Asude Rabia Ozkan ,2020 (58) | 2017 | Turkey | S | 11-13 (11.9 ±0.8) | NR | 346 (179, 170) | 14 (10-18) | >5 |
| B.C. Galland ,2020 (59) | NR | New Zealand | NR | 13-17 | NR | 4192 (2145, 2015) | 57 (55-58) | NR |
| Raíssa da Silva Sousa ,2020(60) | 2016 | Brazil | SYS | 18-19 | 99 | 2499 (1193, 1306) | 57 (55-59) | >4 |
| Azita Chehri ,2020(61) | NR | Iran | NR | 11-18 (15.74 ±1.82) | 96 | 1477 (690, 787) | 51 (48-53) | >=5 |
| Hassan Mozafari-Khosravi ,2020 (62) | 2019 | Iran | C | 12-16 (14.24 ±0.88) | NR | 569 (297, 272) | 36 (32-40) | >5 |
| Pınar TEKCAN ,2020 (63) | 2017 | Turkey | SR | 14-18 (15.87 ±1.16) | 80 | 400 (172, 218) | 53 (48-58) | >5 |
| Morgan N. Potter ,2019 (64) | 2018 | USA | NR | 13-18 (15.3 ±1.1) | 95 | 272 (150, 122) | 40 (35-47) | >=5 |
| Gokul Sarveswaran ,2019 (65) | 2018 | India | SR | 10-19 (14.1 ±2.4) | 96 | 789 (440, 349) | 3 (2-4) | >=5 |
| Rodrigo Antunes Lima ,2019 (66) | 2017 | Brazil | NR | 14-19 (15.07 ±0.92) | 96 | 1242 (552, 690) | 55 (53-58) | 5-10 |
| Mahasweta Dubey ,2019 (67) | NR | India | NR | 10-19 (13.8 ±2.8) | 88.7 | 550 (317, 317) | 7 (5-10) | >5 |
| Di Xiao ,2019(68) | 2015 | China | SR | 12-18 (15 ±1.8) | 96.1 | 153547 (73703, 79844) | 22 (21-22) | >7 |
| Matthew P. Herring ,2018 (69) | 2015 | Ireland | SR | 12-18 (15.1 ±1.7) | 53.4 | 481 (281, 200) | 36 (31-40) | >5 |
| Muana Hiandra Pereira dos Passos ,2017 (70) | NR | Brazil | NR | 10-19 (14.15 ±2.11) | 97 | 309 (178, 135) | 28 (23-34) | >5 |
| Babak Amra ,2017 (71) | 2015 | Iran | NR | 12-18 (15.44 ±1.55) | 90.4 | 2257 (1041, 1191) | 48 (46-50) | >=5 |
| Barbara C. Galland ,2017 (72) | 2012 | New Zealand | NR | 15-17 (16 ±0.75) | 91 | 692 (284, 408) | 56 (52-60) | >5 |
| Ladyodeyse da Cunha Silva Santiago ,2017 (73) | NR | Brazil | NR | 14-19 (15.7±1.2) | NR | 210 (113, 97) | 59 (52-65) | 5-10 |
| CAROL STRONG ,2017 (74) | 2015 | Brazil | NR | 11-19 (13.97±1.34) | 96 | 1822 (504, 1318) | 44 (42-46) | >=5 |
| Yafei Tan ,2016 (75) | 2012 | China | C | 12-18 (14.53) | 96.19 | 1661 (860, 801) | 40 (37-42) | >5 |
| Hui-Qing ZHOU ,2012 (76) | NR | China | S | 12-18 | NR | 1542 (719, 823) | 27 (25-29) | >5 |

***NR**=non-reported

***Sampling Method**: SR= Simple random sampling; S = Stratified sampling; C = Cluster sampling; SYS = Systematic sampling; NP = non-probability sampling

### *Subgroup analyses*

The findings of the subgroup analysis revealed that the geographical area is the only significant factor impacting the heterogeneity. this analysis categorized the studies into subgroups based on the geographical regions of Asia, Europe, America, and Oceania to enable comparisons of findings across different continents. The present analysis revealed significant differences between these subgroups ($p < 0.001$). Specifically, studies conducted in Asia reported a lower prevalence rate (30%; 95% CI = 23%–38%) compared to those conducted in other regions (46%, 48%, and 56% for Europe, America, and Oceania respectively). No significant differences were observed in the impact of other factors, such as gender, development level, sample size, survey time, PSQI cut-off, response rate, and quality score, on the overall heterogeneity of the analyzed data (Table3).

**Table 2.** Quality assessment of descriptive cross-sectional studies with the JBI critical appraisal tool

| First author, Publication year | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Total score |
|---|---|---|---|---|---|---|---|---|---|---|
| M Mohanambal, 2022(49) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | Unclear | 7 |
| Fátima Larissa Santiago, 2022(50) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Panchali Moitra ,2021 (51) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | 8 |
| Zheng Ren ,2021 (52) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Rungrat Rojrattanadumrong ,2021 (53) | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | 7 |
| Xiaopeng Ji ,2021 (54) | Unclear | No | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | 6 |
| Pablo Galan-Lopez ,2021 (55) | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | 6 |
| Joao Ferreira Silva Junior ,2021 (56) | Unclear | Unclear | Unclear | Yes | Yes | Yes | Yes | Yes | Unclear | 5 |
| I Gusti Ayu Trisna Windiani ,2021(57) | No | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | 7 |
| Asude Rabia Ozkan ,2020 (58) | Yes | Yes | Unclear | Yes | Yes | Yes | Yes | Yes | Unclear | 7 |
| B.C. Galland ,2020 (59) | Yes | No | Unclear | Yes | Yes | Yes | Yes | Yes | Unclear | 6 |
| Raíssa da Silva Sousa ,2020(60) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Azita Chehri ,2020(61) | Unclear | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 7 |
| Hassan Mozafari-Khosravi ,2020 (62) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | 8 |
| Pınar TEKCAN ,2020 (63) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Morgan N. Potter ,2019 (64) | Unclear | No | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | 6 |
| Gokul Sarveswaran ,2019 (65) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Rodrigo Antunes Lima ,2019 (66) | Unclear | No | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | 6 |
| Mahasweta Dubey ,2019 (67) | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Di Xiao ,2019(68) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Matthew P. Herring ,2018 (69) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Muana Hiandra Pereira dos Passos ,2017 (70) | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Babak Amra ,2017 (71) | Unclear | No | Unclear | Yes | Unclear | Yes | Yes | Yes | Yes | 5 |
| Barbara C. Galland ,2017 (72) | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Ladyodeyse da Cunha Silva Santiago ,2017 (73) | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | 6 |
| CAROL STRONG ,2017 (74) | Unclear | No | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | 6 |
| Yafei Tan ,2016 (75) | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8 |
| Hui-Qing ZHOU ,2012 (76) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | 8 |

Q1. Was the sample frame appropriate to address the target population?
Q2. Were study participants sampled in an appropriate way?
Q3. Was the sample size adequate?
Q4. Were the study subjects and the setting described in detail?
Q5. Was the data analysis conducted with sufficient coverage of the identified sample?
Q6. Were valid methods used for the identification of the condition?
Q7. Was the condition measured in a standard, reliable way for all participants?
Q8. Was there appropriate statistical analysis?
Q9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

* Each Item was scored as follows: yes = 1; no/unclear/not applicable = 0.
* The quality of the studies was evaluated as follows: low quality, 0–3; moderate quality, 4–6; good quality, 7–9.

# Discussion

This study is a first for conducting a meta-analysis of published studies to estimate the pooled prevalence of poor sleep quality among adolescents globally. The current study utilized pooled data from 28 studies, including a total sample size of 191,408 adolescents across 11 countries of four continents. The analysis yielded an estimated prevalence of poor sleep quality among adolescents is 37% (95% CI: 30%–45%). Moreover, the subgroup analyses revealed significant differences in the pooled prevalence based on geographical region.

The importance of both sleep quantity and quality for overall health has been well established. However, recent research has suggested that sleep quality may be more vital than sleep quantity when evaluating sleep health (25). Notably, while sleep quality and sleep quantity are often discussed separately, they are inherently interconnected, particularly in the context of the PSQI, including both sleep duration and subjective quality. Optimal sleep quality is considered a fundamental requirement for individuals of all ages. However, during adolescence, this need becomes critical due to the significant changes occurring in the brain regions supporting cognitive, learning, and emotional regulation, as well as physical development (26). Sleep quality plays a vital role in facilitating these processes, and its absence can lead to a range of mental

and physical issues. Several studies have indicated that poor sleep quality can impair learning capacity, which in turn can have a negative impact on academic performance (27, 28). A meta-analysis of 16 studies involving 13,631 participants has shown a significant association between sleep quality and school performance (r = 0.096) (7). The relationship between mood and sleep quality is complex and bidirectional because poor mood can exacerbate sleep quality and vice versa (29-31). Nevertheless, data support the positive impact of good quality sleep on mood and emotional regulation (32), as well as an improvement in depressive symptoms when sleep time is extended (33). Moreover, poor sleep quality has been linked to a 2.18-fold increased risk of non-suicidal self-injury in Chinese adolescents (OR = 2.18, 95% CI = 1.37–3.47) (34) . Some studies have also shown that lack of quality sleep during adolescence can adversely affect physical health, including an increased risk for obesity (35), diabetes (36), and high blood pressure (37). However, notably, the relationship between low sleep quality and these outcomes remains uncertain due to the cross-sectional of most studies and the presence of temporal bias.

**Table 3.** Subgroup analyses of studies included in this meta-analysis

| Subgroups | Number of studies | Event | Effective sample size | Pooled prevalence% (95% CI) | Between studies | | Between-group | |
|---|---|---|---|---|---|---|---|---|
| | | | | | $I^2$ | $P$ heterogeneity | $Q$ | $P$ heterogeneity |
| **Gender** | | | | | | | | |
| Male | 16 | 2966 | 8522 | 31(23-40) | 98.57 | <0.001 | 1.22 | 0.27 |
| Female | 16 | 3806 | 8923 | 39 (29-50) | 99.10 | <0.001 | | |
| **Geographical Area** | | | | | | | | |
| Asia | 17 | 39487 | 170910 | 30 (23-38) | 99.59 | <0.001 | 103.37 | <0.001* |
| Europe | 2 | 1012 | 2198 | 46 (44-48) | - | - | | |
| America | 7 | 3044 | 5817 | 48 (40-57) | 97.28 | <0.001 | | |
| Oceania | 2 | 2753 | 4884 | 56 (55-58) | - | - | | |
| **Level of development** | | | | | | | | |
| Developing countries | 17 | 6429 | 15139 | 35 (26-45) | 99.35 | <0.001 | 0.44 | 0.51 |
| Developed countries | 11 | 39891 | 168670 | 41 (29-52) | 99.78 | <0.001 | | |
| **Sample Size** | | | | | | | | |
| <500 | 8 | 857 | 2448 | 35 (25-46) | 99.49 | <0.001 | 2.78 | 0.25 |
| 500-1000 | 8 | 1505 | 5065 | 28(13-47) | 96.63 | <0.001 | | |
| >1000 | 12 | 43916 | 176296 | 37(30-45) | 99.85 | <0.001 | | |
| **Survey Time** | | | | | | | | |
| 2012-2015 | 7 | 36313 | 160686 | 38 (21-56) | 99.65 | <0.001 | 0.59 | 0.75 |
| 2016-2020 | 11 | 4529 | 11327 | 34 (20-49) | 99.59 | <0.001 | | |
| NR | 10 | 5454 | 11796 | 41 (31-51) | 99.18 | <0.001 | | |
| **PSQI Cut-Off** | | | | | | | | |
| >5 | 17 | 4891 | 14243 | 33 (26-40) | 98.74 | <0.001 | 2.18 | 0.34 |
| ≥5 | 6 | 3633 | 7876 | 40 (23-59) | 99.63 | <0.001 | | |
| Others/NR | 5 | 37796 | 161690 | 50 (28-72) | 99.91 | <0.001 | | |
| **Response Rate** | | | | | | | | |
| Yes | 17 | 40561 | 171949 | 34 (26-43) | 99.67 | <0.001 | 1.82 | 0.18 |
| NR | 11 | 5759 | 11860 | 43 (33-53) | 99.04 | <0.001 | | |
| **Quality Score** | | | | | | | | |
| Moderate quality | 9 | 4631 | 9741 | 44 (30-62) | 99.81 | <0.001 | 1.60 | 0.21 |
| Good quality | 19 | 41689 | 174068 | 34 (26-42) | 99.35 | <0.001 | | |

**NR**=non-reported
*P-value < 0.5

Poor sleep quality in adolescents is caused by a combination of biological, environmental, and social factors which together create a “perfect storm” of poor sleep (38). One of the key factors is the biological changes that occur during adolescence, including changes in the timing of melatonin secretion and an increase in the production of cortisol, which can lead to difficulty in falling asleep and staying asleep (38). Furthermore, environmental factors, such as the use of technology (smartphones and computers) before

bedtime, can negatively impact sleep quality by suppressing the production of melatonin (39). Another environmental factor that has been associated with a higher likelihood of poor sleep quality is tea or coffee consumption before bedtime (40). According to the study conducted by Raul Perez Zarate et al., social pressures and demands, such as academic obligations and extracurricular activities, which can result in increased stress and anxiety, ultimately disrupting the natural sleep-wake cycle and leading to poor sleep quality (41). These findings highlight the importance of implementing several strategies to reduce the disruption of the natural sleep-wake cycle and improve sleep quality in adolescents. These strategies include encouraging regular sleep schedules, minimizing the impact of environmental factors, and managing stress.

The subgroup analyses showed that geographical location can affect the variability of prevalence estimates of poor sleep quality across studies. Specifically, a lower prevalence of poor sleep quality was observed in Asia compared to other continents. However, based on the available literature, limited information is available to address whether poor sleep quality in adolescence differs across continents. Existing studies suggest that low socioeconomic status may be associated with a worse sleep quality (42). Furthermore, Asian adolescents tend to have later bedtimes than their peers in North America and Europe (43). A pilot study conducted in Beirut found 76.5% of surveyed teenagers were dissatisfied with their sleep quality (44). Importantly, the inclusion of the pilot study from Beirut does not fully align with the overarching theme of continental comparisons. The distinct socio-cultural context of the Middle East introduces a unique set of factors that influence sleep quality, which may not be representative of the broader sleep patterns observed in Asian countries. Consequently, this study may not serve as an appropriate exemplar for drawing comparisons with the general trends in Asia. These results are in conflict with the findings of the present study. It is uncertain whether the observed variation in prevalence across regions in this study represents genuine differences related to population characteristics, such as race and socioeconomic status or it reflects limitations in sample size in Oceania and Europe (where only two studies were conducted). The generalizability of the findings in these regions may therefore be limited. Given the limited research in this area, further investigation is warranted. Recognizing individual differences in sleep quality attributed to distinct genetic and neurobiological connections observed across diverse populations is imperative (45-48).

The study could be enhanced by exploring the practical implications of the findings for policy development or health intervention strategies. We recommend the implementation of school-based interventions, the adjustment of school start times, and the initiation of public health campaigns aimed at promoting proper sleep hygiene among adolescents.

### *Strengths*

The present study exhibits several strengths, such as a high sample size, a comprehensive search strategy, the utilization of studies with the same measurement method of quality of sleep, inclusion of studies with appropriate quality, studies from various regions of the world, and the use of subgroup analysis. These strengths enhance the reliability and generalizability of the study's findings, thereby contributing to the robustness of the evidence base and augmenting the comprehension of the global prevalence of poor sleep quality among adolescents.

### *Limitations*

The study faced several limitations, including significant heterogeneity among the included research, the inadequate reporting of sampling methods in most studies, hindering the investigation of this variable in subgroup analyses, and the notable absence of research from the African continent. These factors must be considered when interpreting the findings to ensure a more thorough understanding of the global prevalence of poor sleep quality among adolescents.

## In Conclusion

Poor sleep quality is a prevalent issue among adolescents globally. The present study provides valuable insights into the prevalence of this problem. The findings highlight the critical need for further research and interventions to address poor sleep quality in adolescents, given its significant impact on various aspects of their health and well-being.

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### *Authors' Contributions*

Review conception and design: SJ and FJ; literature review: AP and AA; draft manuscript preparation: KJ. All authors reviewed the results and approved the final version of the manuscript.

### *Conflicts of Interest*

The authors declared no conflict of interest.

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