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The Worldwide Prevalence of Sleep Problems Among Medical Students by Problem, Country, and COVID-19 Status: a Systematic Review, Meta-analysis, and Meta-regression of 109 Studies Involving 59427 Participants

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Abstract

Purpose of Review Several studies have found that medical students have a significant prevalence of sleep issues, such as poor sleep quality, excessive daytime sleepiness, and inadequate sleep duration. The purpose of this review is to carefully evaluate the current research on sleep problems among medical students and, as a result, estimate the prevalence of these disturbances. The EMBASE, PsychINFO, PubMed/MEDLINE, ScienceDirect, Scopus, and Web of Science and retrieved article reference lists were rigorously searched and rated for quality. Random effects meta-analysis was performed to compute estimates.

Recent Findings The current meta-analysis revealed an alarming estimated pooled prevalence of poor sleep quality (K = 95, *N* = 54894) of 55.64% [95%CI 51.45%; 59.74%]. A total of 33.32% [95%CI 26.52%; 40.91%] of the students (K = 28, *N* = 10122) experienced excessive sleepiness during the day. The average sleep duration for medical students (K = 35, *N* = 18052) is only 6.5 h per night [95%CI 6.24; 6.64], which suggests that at least 30% of them get less sleep than the recommended 7–9 h per night.

Summary Sleep issues are common among medical students, making them a genuine problem. Future research should focus on prevention and intervention initiatives aimed at these groups.

Keywords Excessive daytime sleepiness · COVID-19 · Sleep · Medical students · Pittsburgh sleep quality index · Insomnia · Project registration: Open Science Framework Identifier: DOI 10.17605/OSF.IO/UVH5C

Introduction

Sleep is, without question, one of the most important physiological activities for the human body to function correctly and is essential to maintaining the human body's health and well-being. Insufficient sleep has negative effects on cardiovascular diseases [1–3] neurocognitive function [4–7], psychological disorders [8–10], metabolic abnormalities [11–13] immunological response [14–16], and academic performance [17, 18].

According to both the National Sleep Foundation and the American Academy of Sleep Medicine, it is recommended that adults obtain 7–9 h of sleep every night, while the recommendation for school-aged children and teens is get up to 11 h [19–21]. Despite this, several studies have demonstrated that sleep disturbances are more frequent than we realize. For example, a 2020 research study in Australia of 836 participants revealed that 41% of females and 42% of males have sleep problems. Another study in Turkey with 5021 participants found that more than half (53%) of the individuals had sleep disturbances [22].

Because admission to medical school requires high academic and professional achievement, it is regarded as one of the most demanding professions. As a result, stress and psychological state are important factors that might impair sleep quality and quantity [10, 23], and medical students as a group are particularly stressed. It is expected that they are prone to numerous forms of sleep problems. Sleep disruption is described as a pandemic in the population of medical students compared to the general population [24], with

Extended author information available on the last page of the article particular reports of falling asleep late and having difficulty initiating sleep, as well as sleeping fewer hours [20, 24, 25]. It has also been found that using mobile phones and watching television are highly linked to sleep-related difficulties in medical students [26–28].

Due to the demanding nature of medical school and the possible consequences of poor sleep on outcomes in academics, clinical care, and mental health, sleep quality is a crucial concern for medical students. High academic demands, long study and clinical hours, and other factors that can cause sleep disturbances and sleep disorders are faced by medical students [29, 30].

Poor sleep hygiene can have an adverse effect on patient care and safety by lowering cognitive function, judgment, and clinical abilities [29, 30]. Additionally, sleep disorders and disturbances can worsen mental health conditions like depression, anxiety, and burnout as well as raise the risk of developing chronic illnesses like diabetes and cardiovascular disease [29, 30]. The importance of sleep health in medical students can enhance their performance in the classroom and in the clinic, enhance general wellbeing, and have a beneficial impact on future healthcare outcomes [29, 30].

The ongoing global COVID-19 pandemic, which the WHO proclaimed in March 2020, has had a profound impact on many facets of everyday life. Wearing masks, social distancing, travel limitations, shift to online instruction, and quarantine were all undertaken to minimize the virus' spread. In addition, students encountered a radically new daily schedule after switching to online learning, which altered their learning experience, sleep patterns, and social connections.

There are several meta-analyses being conducted on sleep difficulties in the medical student community [24, 29–31]. However, there has been limited data on the influence of COVID-19 on sleep problems among medical students. As a result, this study aims to determine the prevalence of sleep problems among medical students during the COVID-19 pandemic using data from international English language studies.

It is crucial to examine sleep issues among medical students before and after COVID-19 for a number of reasons. First, it is widely recognized that medical students are more susceptible to sleep disorders and poor sleep quality, both of which can have a detrimental effect on their academic performance, clinical abilities, and general well-being [32–34]. Second, because of adjustments in their academic and clinical training, medical students have been profoundly impacted by the COVID-19 pandemic [29, 35–37]. Online learning and virtual clinical encounters have required medical students to adjust, which may have affected their sleep habits and quality. Additionally, medical students have been involved in the care of COVID-19 patients, which might have contributed to their increased stress levels and poorer quality sleep [36]. Researchers can learn more about the possible effects of these changes on medical students' academic and clinical performance by examining how the epidemic has affected their sleep habits and sleep disorders.

Methodology

PRISMA 2020 (Preferred Reporting Items for Systematic Review and Meta-analysis) criteria were followed for this systematic review and meta-analysis [38]. The project was registered on the open science framework (OSF), identifier: DOI 10.17605/OSF.IO/UVH5C.

Information Sources and Search Strategy

From the inception to January 15, 2023, three authors (MBJ, ISA, RAA) independently conducted a systematic literature search utilizing five electronic databases (EMBASE, PsychINFO, PubMed/MEDLINE, ScienceDirect, Scopus, and Web of Science).

We broadened our search by consulting additional sources (i.e., backward, and forward citation tracking of all included articles). After removing duplicates, two authors (any two of MBJ, ISA, RAA, YSI) independently examined titles, abstracts, tables, and graphs in the first screening stage, and completed texts in the second eligibility step to determine whether publications satisfied eligibility requirements. Consensus was used to settle disagreements between any two judges.

The following keywords were used in the search strategy: 'medical student' AND 'sleep dis*' OR 'sleep issue(s)' OR 'sleep quality' OR 'sleep length**' OR 'excessive daytime sleepiness' OR 'sleep disorder' OR 'sleep habit' OR 'sleep hygiene'. The * included disruption and disturbance; and the ** included variants of the keyword length including duration, sufficient, and insufficient. Only English-language research publications were considered. However, the characteristics of the subjects were not restricted.

Data Collection Process and Eligibility Criteria

Two authors (any two of MBJ, ISA, RAA, YSI) screened the title and abstract of all studies found in the systematic search to identify studies that met our criteria for inclusion in the meta-analysis. The inclusion criteria were as follows: (1) research published in the English language, (2) date of publication from the inception of the database until the second week of January 2023, (3) medical students as the targeted population, (4) reported data on the prevalence of sleep disturbance using a validated, commonly utilized measurement tool.

Our exclusion criteria included the following: (1) case reports and case series; (2) studies that reported results for medical students with non-medical students in the same group but did not provide a subgroup analysis; (3) lack of study availability and inability to obtain the full text after contacting the authors; and (4) studies that concentrated on particular sleep disorders (e.g., sleep apnea, insomnia, etc.) among medical students.

Outcomes Measures

The population, intervention, comparison, and outcome design (PICO) [39] method dictated the following inclusion criteria: population; (1) medical students; (2)intervention/ exposure; sleep issues; (3) comparison; none;(4) outcomes; poor sleep quality, increased daytime drowsiness, and sleep duration.

The predicted results from this systematic review and meta-analysis were to conduct the prevalence of sleep disturbance among medical students during the COVID-19 pandemic. Thus, we used the following specific measure: (1) the Pittsburgh Sleep Quality Index (PSQI) [40] to determine the score and the corresponding prevalence of poor sleep quality as measured by the index, subjects with PSQI overall score greater than five are considered poor sleepers [40]; (2) the Epworth Sleepiness Scale (ESS) to determine the prevalence of excessive[41]; (3) the reported mean duration of sleep per night. Finally, (4) age, gender, country, and the COVID-19 pandemic were covariates/factors of sleep quality and excessive daytime sleepiness among medical students.

The Pittsburgh Sleep Quality Index (PSQI) [40]. The PSQI assesses sleep quality by examining seven core areas over the preceding month: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction [40]. After assessing these components, the PSQI provides a composite score on a 0 to 21-point scale to evaluate sleep quality, a score of 5 or higher indicates poor overall sleep quality [40].

The Epworth Sleepiness Scale (ESS) assesses the level of daytime sleepiness by asking patients to rate their likely sleepiness on a four-point scale in eight different situations [41]. This results in a “sleepiness score” between 0 and 24, with higher numbers indicating greater sleepiness [41]. The ESS is a sensitive tool that can provide insight into how a patient’s sleepiness is affecting their daily life, a score of 11 or higher indicating excessive daytime sleepiness (EDS) [41].

Data Extraction

Following the research selection procedure, two reviewers (any two of MBJ, ISA, RAA, YSI) retrieved data from the original studies separately. Extracted data comprised basic features such as the date of publication and the geographical location of the study. The following demographic information was extracted: age and sex (proportion of males); data on sleep quality, sleep duration, and daytime sleepiness, as well as the evaluation technique utilized. Disagreements between reviewers were solved by consulting a third reviewer (HJ).

Quality Evaluation (Risk of Bias Assessment)

The study quality was assessed using the Newcastle-Ottawa scale (NOS) [42]. Each study received a quality score based on the groups included in the study, comparability, and assessment of the result and exposure. Overall scores varied from 0 to 9, with 0–4, 5–7, and more than 8 indicating low, moderate, and high-risk of bias studies, respectively. Based on the quality ranking, no studies were omitted. Two authors (any two of MBJ, ISA, RAA, YSI) rated the risk of bias separately, and differences between the two judges were addressed by discussion with HJ.

Data Analysis

Using the meta [43] and metafor [44] packages in R, version 4.2.2, the analysis was conducted [45]. A random-effects model was used for estimating poor sleep quality, EDS, and average sleep duration pooled prevalence rates. We reported point estimates and the corresponding 95% confidence intervals (95% CI) [46]. We calculated the pooled results using the inverse variance method with DerSimonian-Laird estimator to calculate the heterogeneity variance $\tau 2$ and Jackson method for confidence intervals of $\tau 2$ and τ. The Hartung-Knapp adjustment was applied to address uncertainty in estimating the between-study variance. To facilitate the presentation of the results, we presented results visually in forest plot format using the package forester [47]. We used the sensitivity analysis termed as “one study eliminated,” which examines what impact does each included study have on the total effect estimate [48].

Egger’s test [49] for funnel plot [49] asymmetry and Begg’s rank correlation [50] were used to determine publication bias. Statistically significant publication bias was adjusted for by using the trim-and-fill method [51]. Cochran's Q [52] and I^2 [53, 54] statistics were used to test for between-study heterogeneity, with I^2 values of 25%, 50%, and 75% reflecting low, moderate, and high levels of heterogeneity, respectively [53, 54]. To further aid interpreting heterogeneity, we computer predicted intervals (PI). A prediction interval is a group of values that is likely to include the value of a single new observation given the predictors’ preset parameters. For example, we can be 95% certain that the next new (i.e., future) observation will fall inside a 95% prediction interval (95% PI) [55].

We performed subgroup analyses using random-effects models to identify possible sources of heterogeneity based on study location (i.e., country) and COVID-19 status (pre- vs. during- COVID-19) [55]. To determine whether subgroup differences can be explained solely by sampling error, Q tests were conducted. The mean age and sex (proportion of males) of each estimate were corrected using meta-regressions under random-effects models [55, 56].

Results

Descriptive Results

The electronic database search identified a total of 862 studies after removing duplicates and automated screening. The selection process described in Fig. 1 resulted in 109 qualified studies for this meta-analysis. All the studies were published after the year 2000 (i.e., 2001–2023), with a total of 59,427 participants from 31 countries. Detailed results are shown in Table 1.

The countries included Brazil (K = 7), China (K = 11), Egypt (K = 4), Ethiopia (K = 1), France (K = 1), Georgia (K = 1), Germany (K = 1), Ghana (K = 1), Greece (K = 1), India (K = 18), Indonesia (K = 1), Iran (K = 12), Israel (K = 1), Italy (K = 2), Kingdom of Saudi Arabia (KSA, K = 16), Malaysia (K = 1), Morocco (K = 1), Multiple countries (K = 1), Nepal (K = 2), Nigeria (K = 1), Pakistan (K = 8), Peru (K = 2), Poland (K = 1), Rwanda (K = 1), Sudan (K = 2), Thailand (K = 1), Tunisia (K = 1), Turkey (K = 2), UAE (K = 1), USA (K = 5), and Yemen (K = 1). K denotes the number of studies per country. The four countries providing the most studies were India (K = 18, 16.5%), KSA (K = 16, 14.67%), Iran (K = 12, 11.01%), and China (K = 11, 10.1%). Figure 2 shows the distribution of the studies worldwide.

The mean number of participants per study was 545 (range 27–6085), and their mean age was 21.6 (range 18.8–27.8 years); 44.2% of the participants were males. The Newcastle-Ottawa Scale was used to assess the quality of the assessment and the risk of bias (NOS). Eighty-five percent of the studies were of high or moderate quality. Figure 3 shows that the selection dimension, specifically the sample size and representativeness, exhibits the greatest risk bias. Supplemental Fig. 1 presents a thorough analysis of the quality rating for each study analyzed in the meta-analysis.

Fig. 1 PRISMA 2020 flow diagram for study selection

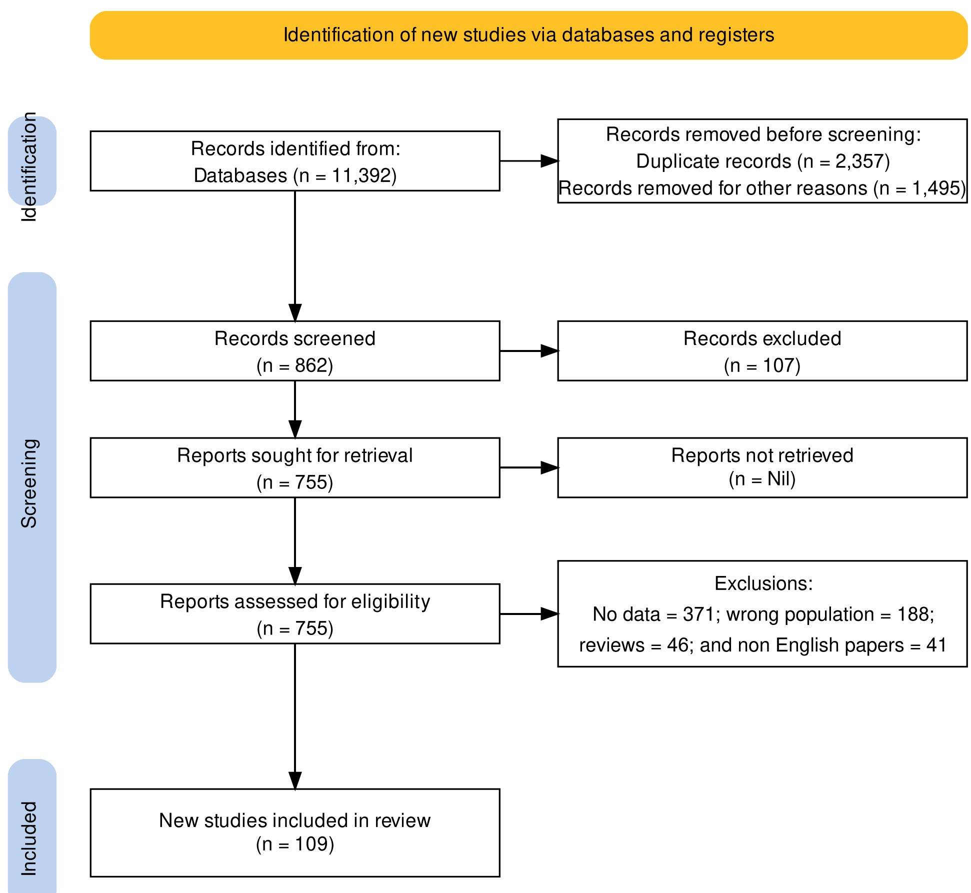

Table 1 Characteristics of the included studies

SN	Ref	Study	Country	Sample size	Sex (%Male)	Age (Years)	Sleep parameters			COVID19	Risk of bias (NOS)
1	[107]	Abdali et al., 2019	Iran	400	42.8	22.4		SQ		No	Low
2	[64]	Abdulghani et al., 2012	KSA	491	37.5	24.4	EDS			No	Low
3	[100]	Al Khani et al., 2019	KSA	200	76	20.8		SQ		No	Moderate
4	[92]	Al Otaibi et al., 2020	KSA	282	64.5	21		SQ		No	Moderate
5	[108]	Al Shammari et al., 2020	KSA	180	36	NR	EDS	SQ	SD	No	Moderate
6	[109]	Al Sulami et al., 2019	KSA	702	41.6	21.34		SQ	SD	No	Low
7	[59]	Almojali et al., 2017	KSA	263	68.8	21.9		SQ	SD	No	Moderate
8	[110]	Alnomsi et al., 2018	KSA	169	48.5	22.9		SQ	SD	No	Moderate
9	[111]	AlQahtani et al., 2017	KSA	237	61.2	22	EDS			No	Moderate
10	[60]	Alsaggaf et al., 2016	KSA	305	41.6	22	EDS	SQ	SD	No	Moderate
11	[112]	Alshahrani et al., 2019	KSA	225	NR	NR	EDS	SQ		No	Moderate
12	[27]	Amiri et al., 2020	Iran	300	55	21.94		SQ		No	Moderate
13	[113]	Asiri et al., 2018	KSA	286	63.6	22.4		SQ	SD	No	Moderate
14	[114]	Atlam et al., 2020	Egypt	899	66	21.98	EDS			No	Low
15	[115]	Attal et al., 2021	Yemen	240	41	23.3		SQ	SD	No	Moderate
16	[77]	Awasthi et al., 2020	India	221	23	20.24		SQ		No	Moderate
17	[116]	BaHammam et al., 2005	KSA	129	50	21.2	EDS		SD	No	Moderate
18	[117]	Belingheri et al., 2020	Italy	215	NR	NR	EDS			No	Moderate
19	[95]	Bogati et al., 2020	India	350	57	21.97		SQ		No	Moderate
20	[118]	Brick et al., 2010	USA	314	42.4	27.8		SQ		No	Moderate
21	[74]	Brubaker et al., 2020	USA	287	49	24.8		SQ	SD	No	Moderate
22	[119]	Carpi et al., 2022	Italy	407	16.2	24.2		SQ	SD	Yes	Low
23	[120]	Chatterjee et al., 2021	India	224	46.42	21.085		SQ		No	Moderate
24	[97]	Chen et al., 2022	China	1227	48.4	NR		SQ		Yes	Moderate
25	[121]	Christodoulou et al., 2021	France	177	36.2	NR		SQ		No	Moderate
26	[122]	Copaja-Corzo et al., 2022	Peru	3139	38.9	NR		SQ		Yes	Moderate
27	[123]	Correa et al., 2017	Brazil	372	37.1	21.3		SQ		No	Moderate
28	[124]	Dhamija et al., 2021	India	499	38	20		SQ		Yes	Low
29	[97]	Ding et al., 2022	China	1524	40.9	19.9		SQ	SD	Yes	Low
30	[125]	Dudo et al., 2022	Germany	1103	35	NR		SQ	SD	No	Moderate
31	[62]	ElArab et al., 2014	Egypt	435	48.5	21.4	EDS			No	Low
32	[126]	Eleftheriou et al., 2021	Greece	559	30.2	NR		SQ		Yes	Moderate
33	[127]	Elwasify et al., 2016	Egypt	1182	32.3	21.4		SQ		No	Low
34	[128]	Ergin et al., 2021	Turkey	127	NR	NR		SQ		No	Moderate
35	[58]	Fawzy and Hamed 2017	Egypt	700	35.4	21.22		SQ	SD	No	Low
36	[129]	Feng et al., 2022	China	450	38.7	NR		SQ		No	Moderate
37	[130]	Fernandes et al., 2022	Brazil	142	27.27	22.01		SQ		Yes	Moderate
38	[131]	Fowler et al., 2022	USA	41	24.3	23.94		SQ	SD	Yes	High
39	[78]	Giri et al., 2013	India	150	40	22.4	EDS			No	High
40	[57]	Gladius et al., 2018	India	203	40.4	21.3		SQ		No	Moderate
41	[132]	Gui et al., 2022	China	2646	44.4	20.13		SQ		No	Low
42	[81]	Guo et al., 2022	China	72	43	23.9		SQ		Yes	High
43	[133]	Gupta et al., 2020	India	222	68.5	20.73		SQ		No	Moderate
44	[134]	Ibrahim et al., 2017	KSA	576	35.8	21	EDS	SQ		No	Moderate
45	[135]	James et al., 2011	Nigeria	255	49	24.45		SQ		No	Moderate
46	[136]	Javaid et al., 2020	Pakistan	810	30.4	21.35	EDS	SQ	SD	No	Low
47	[137]	Jniene et al., 2019	Morocco	294	38.8	20.6		SQ	SD	No	Moderate
48	[138]	Johnson et al., 2017	USA	307	35.8	26.4	EDS			No	Moderate
49	[139]	Kalyani et al., 2017	Iran	278	34.9	19.88		SQ		No	Moderate

Table 1 (continued)

SN	Ref	Study	Country	Sample size	Sex (%Male)	Age (Years)	Sleep parameters			COVID19	Risk of bias (NOS)
50	[86]	Kang and Chen et al., 2009	China	160	50.6	20.3	EDS	SQ	SD	No	Moderate
51	[140]	Kawyannejad et al., 2019	Iran	321	39.9	22.03		SQ		No	Moderate
52	[141]	Khero et al., 2019	Pakistan	281	26.33	NR		SQ		No	Moderate
53	[142]	Kumar et al., 2019	India	150	41.3	NR		SQ		No	Moderate
54	[143]	Kumar et al., 2016	India	308	57.1	21.4		SQ		No	Moderate
55	[93]	Lamoria et al., 2020	India	170	NR	20.48			SD	No	Moderate
56	[28]	Lawson et al., 2019	Ghana	153	45.8	23.1		SQ	SD	No	Moderate
57	[144]	Li et al., 2022	China	364	43	20.1		SQ		No	Moderate
58	[145]	Lima et al., 2002	Brazil	27	48.1	20.2		SQ	SD	No	High
59	[146]	Mahadule et al., 2022	India	101	71	20.18	EDS	SQ		Yes	Moderate
60	[147]	Maheshwari et al., 2019	Pakistan	797	33.37	NR		SQ	SD	No	Moderate
61	[98]	Mahgoub et al., 2022	Sudan	273	NR	NR		SQ		Yes	Moderate
62	[148]	Mazar et al., 2021	Israel	87	41	25.86	EDS	SQ		No	High
63	[73]	Mazurkiewicz et al., 2012	USA	86	25.6	21.8		SQ		No	High
64	[65]	Medeiros et al., 2001	Brazil	36	58	20.7		SQ	SD	No	High
65	[25]	Meer et al., 2022	UAE	96	21.9	20		SQ	SD	No	High
66	[149]	Meo et al., 2022	KSA	410	NR	NR		SQ	SD	Yes	Moderate
67	[75]	Mirghani et al., 2015	Sudan	140	NR	NR			SD	No	Moderate
68	[150]	Mirghani et al., 2017	Sudan	140	27.9	22.8		SQ		No	Moderate
69	[151]	Mishra et al., 2022	India	284	40.5	20.6		SQ	SD	Yes	Moderate
70	[152]	Mohammadbeigi et al., 2016	Iran	363	30.3	21.8		SQ		No	Moderate
71	[76]	Mokros et al., 2017	Poland	140	50	21.3		SQ		No	Moderate
72	[79]	Nadeem et al., 2018	Pakistan	362	40	19.57		SQ		No	Moderate
73	[153]	Nsengimana et al., 2023	Rwanda	290	58.3	24		SQ		Yes	Moderate
74	[154]	Olarte-Durand et al., 2021	Peru	310	37.7	21.6		SQ		Yes	Moderate
75	[72]	Pagnin et al., 2014	Brazil	127	44.9	21.3	EDS	SQ		No	Moderate
76	[155]	Patil et al., 2019	India	463	38.2	19.55		SQ		No	Low
77	[83]	Perotta et al., 2021	Brazil	1350	47.1	22.8	EDS	SQ		No	Low
78	[156]	Prashanth et al., 2015	India	503	48.1	21.8	EDS			No	Low
79	[157]	Priya et al., 2017	India	307	76.5	20.5	EDS	SQ		No	Moderate
80	[158]	Ramamoorthy et al., 2014	India	121	53.7	21.8	EDS			No	Moderate
81	[67]	Rasekhi et al., 2016	Iran	177	46.9	20.99		SQ	SD	No	Moderate
82	[159]	Rathi et al., 2018	India	160	55.6	20.93		SQ		No	Moderate
83	[160]	Rique et al., 2013	Brazil	221	55.7	22.3	EDS	SQ		No	Moderate
84	[161]	Riskawati et al., 2022	Indonesia	444	32	21	EDS	SQ		No	Low
85	[162]	Safhi et al., 2020	KSA	326	50.6	21.86		SQ		No	Moderate
86	[163]	Saguem et al., 2021	Tunisia	251	17.5	NR		SQ		Yes	Moderate
87	[88]	Sahraian and Javadpour 2010	Iran	159	49.7	21.52		SQ		No	Moderate
88	[164]	Sarbazvatan et al., 2017	Iran	80	50	19.2		SQ	SD	No	High
89	[99]	Satti et al., 2019	Pakistan	219	43	NR		SQ		No	Moderate
90	[165]	Saygin et al., 2016	Turkey	337	42.1	21.3	EDS	SQ	SD	No	Moderate
91	[166]	Shadzi et al., 2020	Iran	402	49.7	22.4		SQ		No	Low
92	[96]	Shafique et al., 2021	Pakistan	100	49	21.13		SQ		Yes	Moderate
93	[167]	Shrestha et al., 2021	Nepal	168	64.29	21.57		SQ	SD	Yes	Moderate
94	[94]	Siddiqui et al., 2016	KSA	318	64.8	22.35		SQ	SD	No	Moderate
95	[89]	Soakin et al., 2019	Georgia	44	50	21.62	EDS			No	High
96	[168]	Sun et al., 2019	China	5497	32.7	20.2		SQ		No	Low
97	[169]	Sundas et al., 2020	Nepal	217	47.5	21.39		SQ	SD	No	Moderate
98	[170]	Surani et al., 2015	Pakistan	504	40.5	20	EDS	SQ		No	Low

Table 1 (continued)

SN	Ref	Study	Country	Sample size	Sex (%Male)	Age (Years)	Sleep parameters	COVID19	Risk of bias (NOS)
99	[171]	Tahir et al., 2021	Multiple	2749	36	NR	SQ	Yes	Moderate
100	[90]	Teimouri et al., 2021	Iran	290	40	NR	SQ	No	Moderate
101	[172]	Thaipisuttikul et al., 2022	Thailand	165	58.2	20.77	EDS SQ SD	No	Moderate
102	[173]	Wang et al., 2020	China	3738	41.52	18.8	SQ	No	Low
103	[174]	Wang et al., 2016	China	6085	27.3	21.3	SQ SD	No	Low
104	[61]	Waqas et al., 2015	Pakistan	263	43.7	21.1	SQ	No	Moderate
105	[175]	Wondie et al., 2021	Ethiopia	576	53.8	21.5	SQ	No	Low
106	[176]	Xie et al., 2020	China	1026	36.4	21.375	SQ	Yes	Low
107	[177]	Yazdi et al., 2016	Iran	285	47.4	22.8	SQ	No	Moderate
108	[178]	Yeluri et al., 2021	India	398	49.1	NR	SQ	No	Moderate
109	[84]	Zailinawati et al., 2009	Malaysia	792	41	20.8	EDS SD	No	Low

EDS, excessive daytime sleepiness measured using Epworth sleepiness scale; *NOS*, The Newcastle-Ottawa Scale for rating nonrandomized research in meta-analyses; *NR*, not reported; *SD*, sleep duration measured in hours; *SQ*, sleep quality measured using Pittsburg sleep quality index

Narrative Summary of the Literature About Sleep Problems Among Medical Students

Research has repeatedly shown that sleep issues are quite common among medical students [32, 35]. It was noted that about 50–60% of them had poor sleep, with female students more likely to have it. This rate is higher than that of the general population and other college students [29].

The high prevalence of sleep difficulties among medical students is the result of several factors. These factors include increased academic workload, shift work and unpredictable schedules, lifestyle factors, and mental health issues. According to previous research, among these factors are as follows: (1) Increased academic workload: Medical students must complete a demanding academic program that necessitates extended study sessions and clinical responsibilities [57–61]. Increased stress and anxiety can have a negative impact on sleep quality because of the pressure to perform well in school and the fear of failing [17, 62–67]. (2) Shift work and unpredictable schedules: Clinical rotations and on-call responsibilities are frequent among medical students, which might disturb their sleep cycles [68]. Their unpredictable schedules may cause circadian rhythm abnormalities and poor sleep as a result [35, 41, 69]. (3) Lifestyle factors: Medical students may develop harmful behaviors to deal with their demanding schedules, such as excessive caffeine use and inconsistent eating times [70, 71]. (4) Mental health: High levels of stress, burnout, and depression are regularly reported by medical students, which can make it difficult to fall asleep [32, 72, 73]. Poor sleep can exacerbate mental health problems and vice versa due to the bidirectional association between sleep and mental health [32, 72–74].

The effects of sleep disturbances on medical students can be severe, with a variety of potential repercussions. Academic performance can be harmed by sleep deprivation because it has been demonstrated to impede cognitive function, memory consolidation, and learning ability [17, 57, 60, 62–67, 75]. Mental health can suffer as sleep disturbances are linked to an increased risk of anxiety, depression, and burnout. This vicious cycle can make sleep issues worse by increasing the risk of these mental health issues [60, 76, 77]. Physical health can be impaired as chronic sleep loss has been linked to a number of physical health issues, including as obesity, diabetes, and heart disease [29, 78]. Finally, the ability to deliver patient care can be compromised as medical students who have sleep issues may be more likely to make mistakes with patient safety and care delivery [32, 72–74].

Prevalence of Poor Sleep Quality

A random effects meta-analysis of all the available studies evaluated sleep quality in medical students (K = 95, N = 54894). The overall pooled prevalence rate of sleep quality was 55.64% 95% CI [51.45%; 59.74%], with statistically significant evidence of between-study heterogeneity τ^2 = 0.69 [0.47; 0.93]; τ = 0.83 [0.69; 0.90]; I^2 = 98.8% [98.7%; 98.9%]; H = 9.08 [8.74; 9.45]; 95% PI [19.26%; 86.83%]. Neither age nor sex explained heterogeneity in sleep quality. Detailed results are shown in Table 2.

Using the PSQI to measure sleep quality in medical students, the raw prevalence estimates for poor sleep quality varied from 12.6 to 92%. The forest plot of the meta-analysis of sleep disturbances in all populations using PSQI is shown in Fig. 4.

According to a (leave-one-out) sensitivity analysis, no study influenced the global prevalence estimate of more than 1%. Visual inspection of the funnel plot (Supplemental

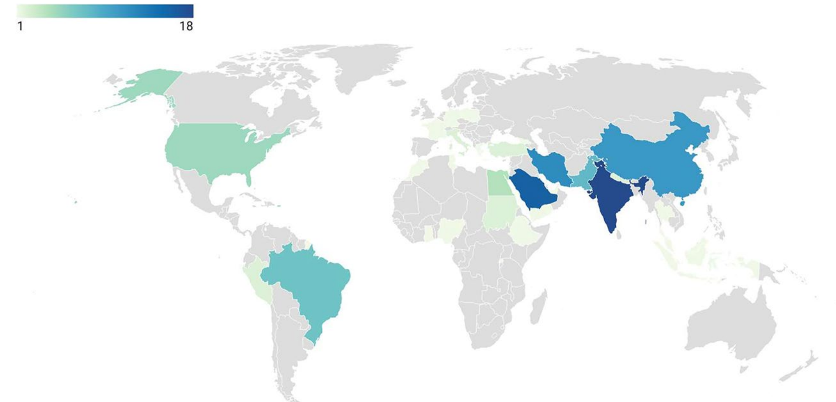

Fig. 2 Distribution of studies worldwide

Fig. 2) and radial plot (Supplemental Fig. 3) indicates a modest publication bias; however, Begg's test (z = 1.14, *p*-value = 0.26) was not significant, suggesting that there was no significant publication bias.

A subgroup analysis of the pooled prevalence of poor sleep quality by country was performed, highlighting countries with (K > 3). Results show that the highest prevalence was in the USA (K= 4) with a pooled prevalence of 61.57% [18.83%; 91.71%]; τ2 = 1.51; τ = 1.23. India, Brazil, and Pakistan followed sharing the same estimated pooled prevalence of 56% with India (K = 14) 95% CI [45.49%; 66.17%], τ2 = 0.4326, τ = 0.6578, Brazil (K = 7) 95% CI [41.77%; 70.45%], τ2 = 0.27; τ = 0.53, and Pakistan (K = 8) 95% CI [41.15%; 71.08%]; τ2 = 0.71; τ = 0.84, respectively. China (K = 11) demonstrated the lowest estimated pooled prevalence of 41.25% [31.55%; 51.68%], τ2 = 0.33, τ = 0.57. Iran (K = 11) and KSA (K = 13) fell in the middle with a pooled prevalence of 55.26% CI [47.01%; 63.23%]; τ2 = 0.21 τ = 0.45, and 54.94% [37.31%; 71.42%]; τ2 = 1.28, τ = 1.13, respectively. A statistically significant difference between countries was observed (*P*-value <0.001).

A subgroup analysis of the pooled prevalence of poor sleep quality by COVID-19 was conducted. Results before the pandemic being (K = 75) 53.83% [49.05%; 58.55%], τ2 = 0.57, τ = 0.76. In contrast, the pooled prevalence of poor sleep quality during the pandemic (K = 20) was 62.11% [53.51%; 70.01%], τ2 = 0.57, τ = 0.76, revealing an increased pooled prevalence of poor sleep quality after the pandemic; however, this difference was statistically not significant (*P*-value = 0.08), see (Supplemental Fig. 4).

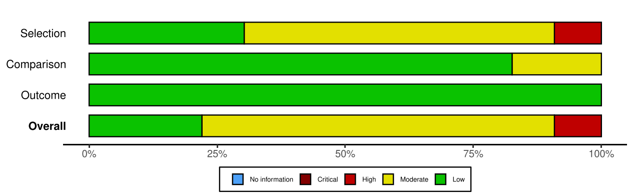

Fig. 3 Summary of the included studies

Excessive Daytime Sleepiness

The random effects meta-analytical pooling of the estimate of EDS (K = 28, *N* = 10122) yielded a crude prevalence rate of 33.32% 95% CI [26.52%; 40.91%] with statistically significant evidence of between-study heterogeneity τ^2 = 0.35 [0.30; 1.02]; τ = 0.59 [0.54; 1.01] I^2 = 96.2% [95.3%; 96.9%]; H = 5.13 [4.61; 5.70]; 95% PI [12.66%; 63.27%]. Using ESS to measure EDS, the raw prevalence estimates of EDS reported among medical students using the ESS ranged from 10.3 to 100%, as illustrated in Fig. 5. Neither age nor sex explained heterogeneity for EDS. Detailed results are shown in Table 2.

According to a (leave-one-out) sensitivity analysis, no study influenced the global EDS prevalence estimate of more than 1%. Visual inspection of the funnel plot (Supplemental Fig. 5) and radial plot (Supplemental Fig. 6) indicates no publication bias; this was supported by a non-significant Begg's test (z = -0.91, *p*-value = 0.36).

A subgroup analysis of EDS by country was conducted. Highlighting countries with (K > 3), results yielded the highest prevalence rate of EDS was in Brazil (K = 3) with 49.88% [25.54%; 74.27%]; τ2 = 0.09, τ = 0.30. India holding the lowest prevalence rate (K = 5) of 28.56% [12.16%; 53.60%]; τ2 = 0.79; τ = 0.89. KSA with 40.64% [29.91%; 52.35%]; τ2 = 0.16; τ = 0.40. A statistically significant difference between countries was observed (*P*-value <0.001).

A subgroup analysis of ESS by COVID-19 was also conducted. Results show a total of (K = 27) studies of EDS were done before the pandemic with a pooled prevalence rate of 32.62% [25.79%; 40.27%]; τ2 = 0.34; τ = 0.59. Only one study was found to measure the EDS using ESS among medical students during COVID-19 and revealed a result of 54.46% [44.7%; 63.88%], see (Supplemental Fig. 7).

Table 2 A meta-analysis of sleep problems in medical students

Analysis	K	N	Random effects model		Heterogeneity						Moderators		Publication bias	
			Pooled results [95% CI]	Forest plot	I^2	τ	$τ^2$	H	Q	Cochran's Q *P*-value[d]	Age (Years)	Sex (%Male)	Egger's test	Peter's test
PSQI														
All studies	95	54894	55.64% [51.45%; 59.74%]	Figure 4	98.8%	0.83	0.69	9.08	7757.02	0.001	-	-	NS	NS
Iran	11	3055	55.26% [47.01%; 63.23%]	Not shown	93.1%	0.45	0.2	-	145.29	0.001	-	-	NS	NS
Kingdom of Saudi Arabia	13	4242	54.94% [37.31%; 71.42%]		98.7%	1.13	1.28	-	925.43		-	-	NS	NS
India	14	3890	56.1% [45.49%; 66.17%]		96.3%	0.65	0.43	-	351.17		-	-	NS	NS
United States of America	4	728	61.57% [18.83%; 91.71%]		97.6%	1.23	1.51	-	124.2		-	-	NS	NS
China	11	22789	41.25% [31.55%; 51.68%]		99.3%	0.57	0.33	-	1335.79		-	-	NS	NS
Brazil	7	2275	56.67% [41.77%; 70.45%]		93.5%	0.52	0.27	-	92.78		-	-	NS	NS
Pakistan	8	3336	56.73% [41.15%; 71.08%]		98.4%	0.83	0.7	-	426.32		-	-	NS	NS
Pre COVID-19	75	41322	53.83% [49.05%; 58.55%]	Figure Supplemental 4	98.5%	0.75	0.57	-	4852.67	0.001	-	-	NS	NS
During COVID-19	20	13572	62.11 % [53.51%; 70.01%]		98.7%	0.76	0.57	-	1422.64		-	-	NS	NS
ESS														
All studies	28	10122	33.32% [26.52%; 40.91%]	Figure 5	96.2%	0.59	0.34	5.13	709.37	0.001	-	-	NS	NS
Kingdom of Saudi Arabia	7	2148	40.64% [29.91%; 52.35%]	Not shown	91.7%	0.4	0.16	-	72.18	0.001	-	-	NS	NS
India	5	1082	28.56% [12.16%; 53.6%]		96.3%	0.89	0.79	-	108.65		-	-	NS	NS
Pre COVID-19	27	10021	32.62% [25.79%; 40.27%]	Supplemental 7	96.3%	0.58	0.34	-	695.54	0.011	-	-	NS	NS
During COVID-19	1	101	54.46% [44.7%; 63.88%]		-	-	-	-	0.1		-	-	NS	NS
Sleep duration (SD)														
All studies	35	18052	6.44% [6.24%; 6.64%]	Figure 6	99.2%	0.59	0.35	11.07	4168.9	0.001	-	-	NS	NS
Kingdom of Saudi Arabia	9	2762	5.85% [5.6%; 6.09%]	Not Shown	95.3%	0.35	0.12	-	171.69	0.001	-	-	NS	NS
Pre COVID-19	29	15218	6.33% [6.14%; 6.52%]	Supplemental 10	98.7%	0.5	0.25	-	2104.54	0.001	-	-	NS	NS
During COVID-19	6	2834	6.97% [6.17%; 7.76%]		99.7%	0.99	0.98	-	1727.44		-	-	NS	NS

EES, Epworth sleepiness scale to measure excessive daytime sleepiness; *NS*, not significant; *PSQI*, Pittsburg sleep quality index to measure sleep quality; *SD*, sleep duration measured in hours

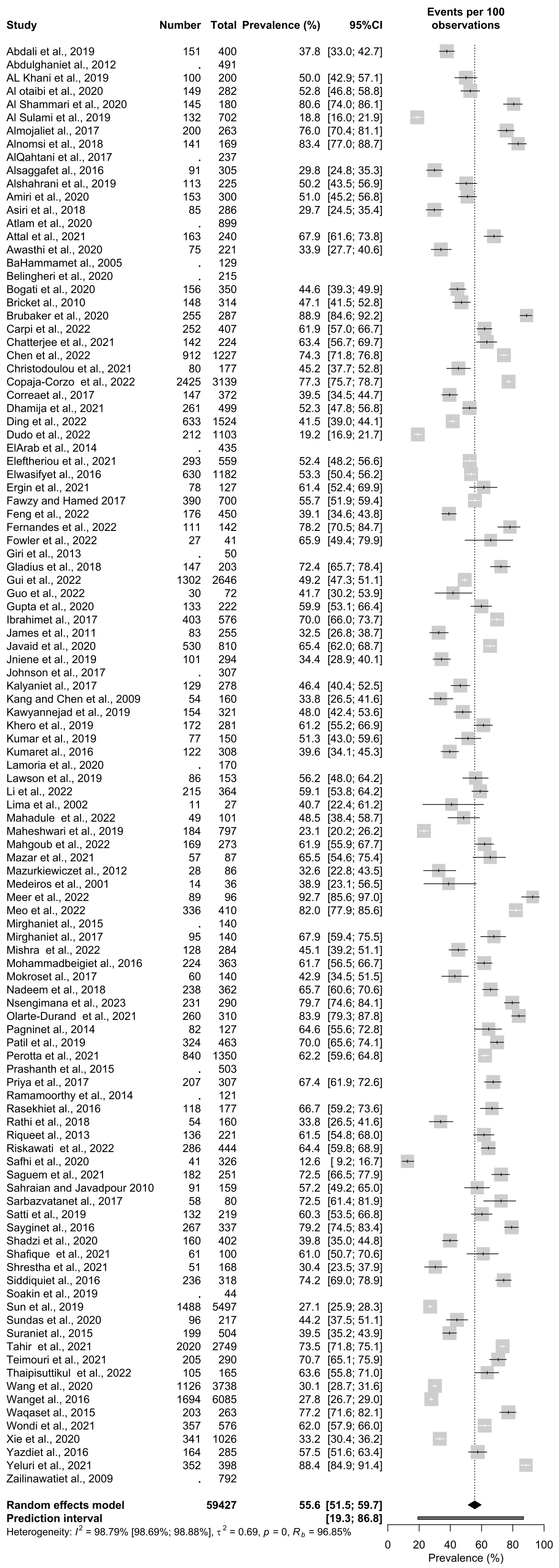

Fig. 4 Meta-analysis of the prevalence of poor sleep quality in medical students

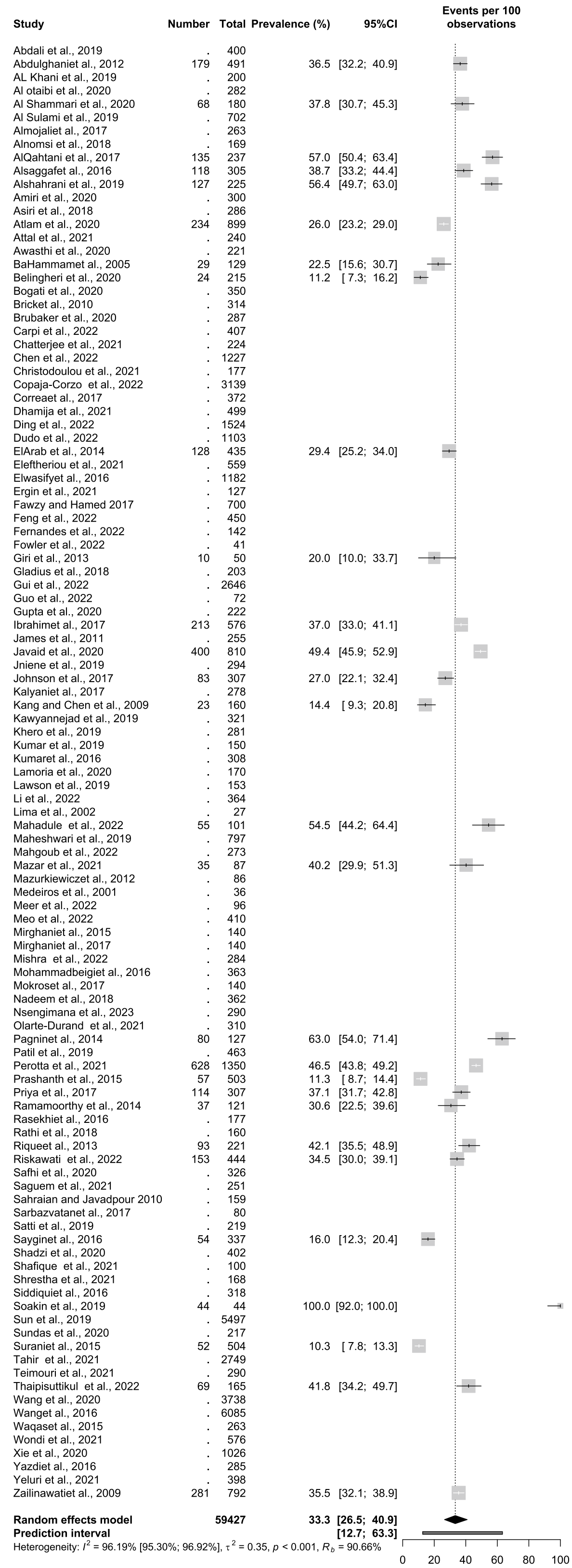

Fig. 5 Meta-analysis of the prevalence of excessive daytime sleepiness in medical students

Sleep Duration

The meta-analytic pooling of the point estimates (K = 35, $N = 18052$) of nightly sleep duration revealed that on average medical students sleep about 6.5 h per night 95% CI [6.24; 6.64], with statistically significant evidence of between-study heterogeneity $\tau^2 = 0.35$ [0.22; 0.73]; $\tau = 0.59$ [0.46; 0.85]; $I^2 = 96.2\%$ [95.3%; 96.9%]; H = 5.13 [4.61; 5.70]; 95% PI [5.21; 7.68]. The raw mean of sleep duration reported among medical students ranged from 5.3 to 7.9, as illustrated in Fig. 6. Detailed results are shown in Table 2.

A leave-one-out sensitivity analysis indicated that no study influenced the results by more than 0.25 h (i.e., 15 min) of sleep per night. Publication bias was assessed by visual inspection of the funnel plot (Supplemental Fig. 8) and radial plot (Supplemental Fig. 9), which indicated a slight publication bias; however, Begg's test (z = 0.16, p-value = 0.87) was not significant.

A subgroup analysis by country was obtained. Highlighting countries with (K >3). Results revealed the highest mean of sleep duration was in China (K = 3) with 7.00 h of sleep per night [95% CI 6.67; 7.45]; $\tau 2 = 0.11$; $\tau = 0.34$. The lowest was in KSA (K = 9), with a mean of 5.8 h of sleep per night [95% CI 5.60; 6.09]; $\tau 2 = 0.12$; $\tau = 0.35$. Iran with 6.5 h of sleep per night [95% CI 5.93; 7.11]; $\tau 2 = 0.25$; $\tau = 0.50$. There was a statistically significant difference between countries (P-value <0.001).

A subgroup analysis by COVID-19 was also conducted. Results yielded that pre-COVID-19 era (K = 29) medical students, on average, got about 6.3 h of sleep per night [95% CI 6.14; 6.52]; $\tau 2 = 0.26$; $\tau = 0.51$. In contrast, the average sleep duration during COVID-19 (K = 6) was 7.00 h of sleep per night [95% CI 6.17; 7.76]; $\tau 2 = 0.98$; $\tau = 0.99$. The difference in sleep duration was not statistically significant between pre-COVID-19 and during COVID-19 (P-value = 0.87), see (Supplemental Fig. 10).

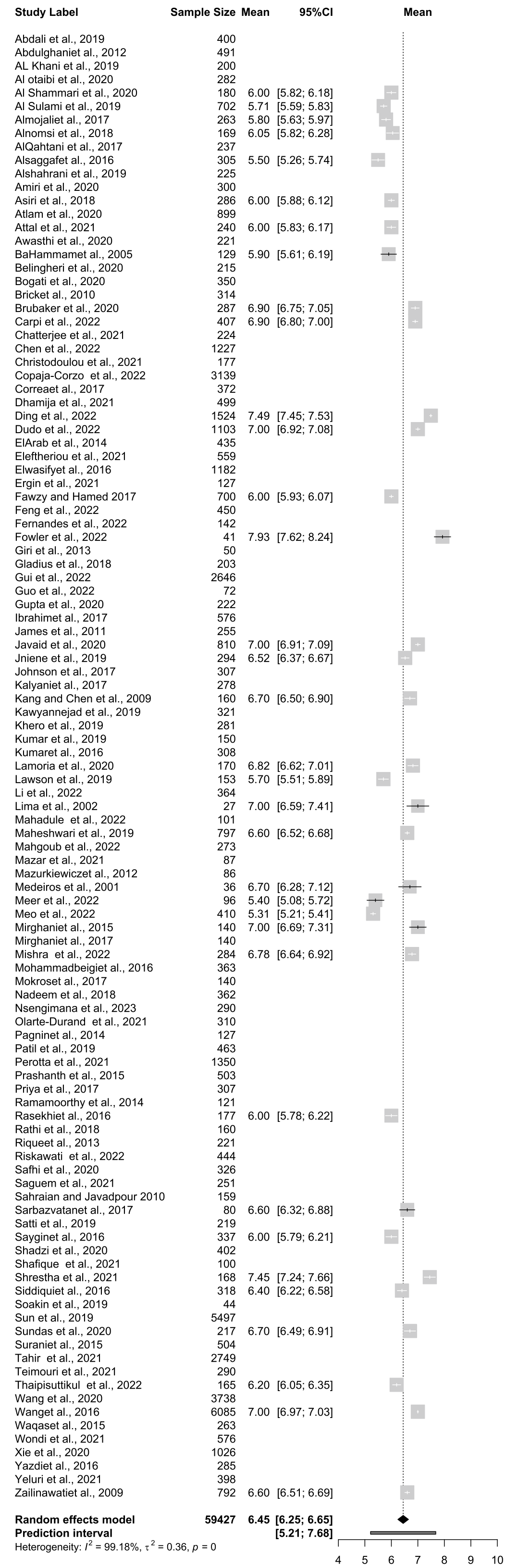

Fig. 6 Meta-analysis of the mean sleep duration in medical students

Discussion

This meta-analysis found a worldwide estimated pooled prevalence of poor sleep quality of 57% and an EDS prevalence of 33% in medical students, who also were found to be short sleepers, averaging 6.5 h per night, which suggests that at least 30% of the students were sleeping less than the recommended 7–9 h per night.

Insufficient sleep among medical students is of growing concern, with serious consequences for their health, academic performance, and career [29, 30]. Recent studies have found that medical students are more likely to experience sleep deprivation than their peers in other fields, due to the intense academic and clinical demands of medical school [61, 79]. This lack of sleep can profoundly impact medical students' physical and mental health, leading to various negative effects [80]. The most obvious consequence of insufficient sleep is decreased alertness and focus [58, 81]. Sleep is crucial for learning and consolidation of memory [82]; without adequate rest, medical students may find it difficult to concentrate in lectures and clinical rotations [81]. This can lead to poor academic performance and a greater risk of making mistakes in the clinical setting [63]. Furthermore, insufficient sleep can lead to impaired decision-making, which can have serious implications for patient care [29]. Unfortunately, it has been shown that sleep-deprived students who struggle academically are unaware of the extent to which their sleep loss can affect their capacity to perform cognitive tasks [63]. Pilcher and Walters exposed 44 college students to complete sleep deprivation for one night. They discovered that the sleep-deprived students considerably underperformed on cognitive tasks compared to the normal-sleep group [66]. However, the students who performed poorly due to lack of sleep also reported greater levels of estimated performance and incorrectly judged their performance as being higher than those who were not sleep deprived [66].

In addition to the cognitive effects of insufficient sleep, medical students may also experience physical health problems [14, 16, 83]. It can also lead to an increased risk of motor vehicle accidents, as well as an increased risk of depression and anxiety [14, 84, 85]. Finally, sleep deprivation can significantly impact medical students' professional development. Studies have found that medical students who experience insufficient sleep are more likely to experience burnout and lack motivation [29, 32]. This can lead to decreased job satisfaction and a greater risk of medical school dropout [29, 32].

Considering these potential consequences, it is essential that medical students take steps to ensure they are getting adequate rest. College students need to be taught about good sleep behaviors, which may include establishing a consistent sleep schedule, avoiding caffeine and alcohol before bed and avoiding screens before bed [18, 86, 87]. Additionally, educators and college administrators must actively consider sleep habits and disturbances in the context of students' health and academic achievement [63]. Active measures should include providing students with resources to help them manage their sleep habits, e.g., lifestyle counseling and intervention techniques [23].

University students usually have poorer sleep quality than the overall population [29, 30]. According to a recent meta-analysis, this can be explained by the challenging nature of the academic subject, the test season, side jobs, the fear of missing out, and irregular daytime schedules [60, 88, 89]. Due to their rigorous academic schedule, the competitive nature of the medical field, exposure to death and illness situations, and on-call and night shifts, medical students seem more susceptible to sleep issues than their academic peers [90].

Academic performance in medical students has been shown to be severely impacted by lower nocturnal sleep time, later bedtimes during weekdays and weekends, catching up on sleep on the weekends, and increased daytime sleepiness [63, 91]. Moreover, a recent study demonstrated a significant negative association between sleep quality and grade point average (GPA), supporting the idea that poor sleep quality is linked to subpar academic performance [18].

Poor sleep quality can be caused by a variety of factors, such as stress, long hours of studying, and lack of time management [60, 92]. In order to prevent and improve poor sleep quality, several solutions can be implemented [20, 93, 94]. One solution is to create a healthy sleep schedule and stick to it. By having a consistent bedtime and wake time, the body's internal clock will become used to the routine and help with sleep quality. Additionally, by avoiding caffeine and other stimulants close to bedtime, the body will be more relaxed and ready for sleep [70, 95].

Another solution is to reduce stress levels. Stress can be a major factor in poor sleep quality, and medical students often experience high levels of stress due to the demanding nature of their studies [29, 30]. Finding ways to reduce stress, such as exercise, relaxation techniques, yoga, or mindfulness, can be beneficial in improving sleep quality [30]. Finally, medical students should practice time management. By breaking down tasks into smaller, more manageable pieces and setting realistic goals, medical students can avoid feeling overwhelmed and reduce the amount of stress they experience [96–98]. By implementing these solutions, medical students can improve their sleep quality and, ultimately, their well-being and academic performance [67, 99, 100].

Understanding how the epidemic affects medical students' sleep could have wider effects on healthcare. It is well recognized that sleep issues are linked to a number of detrimental health effects, such as a higher chance of medical errors, burnout, and poor patient safety [32–34, 101]. Researchers can learn more about the possible long-term health effects of the COVID-19 pandemic on this high-risk demographic by examining changes in the quality and amount of sleep among medical students before and after the epidemic. Utilizing this knowledge can help create interventions that enhance medical students' sleep health, ultimately enhancing patient safety and healthcare outcomes [68, 102, 103].

When it comes to sleep issues, medical students are particularly susceptible, especially during a pandemic. It is crucial for medical students to regulate their sleep health to lessen the possible deleterious effects of interrupted sleep patterns and sleep disorders during future pandemics. Setting sleep hygiene as a priority is a crucial first step [32–34, 84]. This entails keeping a regular sleep schedule, avoiding stimulating activities right before bed, and establishing a relaxing sleeping environment. To control stress and enhance sleep, medical students may also find it helpful to practice relaxation techniques like meditation or deep breathing [32–34, 84].

Maintaining physical activity and exercise, which has been demonstrated to enhance sleep quality and lower stress, is another crucial measure. Medical students may need to come up with novel ways to exercise during a pandemic, such as working out at home or going for walks or runs in empty spaces [32–34]. It is crucial for medical students to stay socially connected and ask for help when they need it. During a pandemic, social isolation and stress are frequent, and these elements might impair sleep quality. By using technology to stay in touch with loved ones, medical students can also gain from consulting mental health professionals when needed [32–34].

Self-reported assessments and cross-sectional study designs are frequent drawbacks in many studies. The impact of the pandemic on pupils who are known to have medical or mental health issues is still another crucial factor in addition to these restrictions.

Students who already have physical or mental health issues may be more susceptible to the pandemic's effects on their sleep health. For instance, students who already struggle with anxiety or depression may become even more stressed and anxious because of the pandemic, which may have a detrimental effect on how well they sleep. Like this, students who suffer from medical conditions like sleep apnea or chronic pain may find that changes in their daily routines and elevated stress levels exacerbate their symptoms.

Future research can follow students over time and evaluate the pandemic's effects on their sleep health using more rigorous study methods, such as longitudinal studies, to address these shortcomings. Studies can also reduce the impact of self-report bias by using objective measurements of sleep quality, such as actigraphy or polysomnography. Additionally, research can examine potential interventions to lessen the pandemic's detrimental effects on students who already have medical conditions or mental health issues, as well as the impact of the pandemic on those students.

To improve the sleep health of medical students, several treatment approaches could be utilized. The incorporation of sleep education and counseling programs into medical school curricula is one potential remedy. Students could learn through these programs the value of good sleep hygiene as well as techniques for increasing both the quantity and quality of sleep [37, 104]. Programs for sleep education and counseling may be organized as group sessions or one-on-one counseling sessions, and they may be provided by qualified individuals like sleep specialists or mental health professionals [32, 105].

The inclusion of sleep hygiene in wellness programs for medical schools is another potential strategy. These programs could contain elements aimed at enhancing sleep quality, such stress-reduction strategies or exercise regimens. To help medical students monitor and enhance their sleep quality, medical institutions may also think about offering them tools like sleep aids or sleep tracking applications [32].

Medical schools could implement policies to promote sleep health among medical students, such as limiting the number of consecutive hours medical students are required to work or providing accommodations for medical students with sleep problems [35]. These policies could help to promote a culture of sleep health within the medical school system and prioritize the well-being of medical students [30].

The current review has several merits: First, we included three important sleep issues, i.e., sleep duration, sleep quality, and excessive daytime sleepiness, as outcomes facing students. Second robust statistical modeling was applied, correcting for bias, outliers, and moderators; thus, the results of the present review are anticipated to be highly generalizable.

Nevertheless, this review has a few drawbacks: First, we only incorporated research written in English. Second, epidemiological meta-analyses will inevitably have substantial heterogeneity [29, 30, 106]. In our meta-analysis, the heterogeneity remained considerable even after undertaking subgroup analyses or moderator analyses using meta-regression approaches. To deal with this, we reported 95% prediction intervals to generalize easier. Additional sources of variability, like lifestyle factors, sleep disorders (like obstructive sleep apnea), and stress, could not be investigated because of the studies' low availability of common information. Third, every study that was part of this review was a cross-sectional survey. To understand the causes linked to sleep issues in this cohort, longitudinal studies examining changes in sleep quality during medical education are required. Finally, the prevalence rates examined here were based on self-report measures. While the PSQI and the ESS are validated and widely used clinical and research instruments, the components of sleep quality and EDS they measure are limited. Future research is encouraged to look at additional aspects of sleep, such as objective sleep quality measurement, which includes polysomnography.

Conclusion

The current meta-analysis revealed that the worldwide estimated pooled prevalence of poor sleep quality is about 57% and of excessive daytime sleepiness is about 33%. The average sleep duration for medical students is only 6.5 h per night, which suggests that at least 30% of them get less sleep than the recommended 7–9 h per night. These are alarming figures as they indicate that a third to more than half of all medical students are sleeping insufficiently and are subject to all the consequences of this lack of adequate sleep. Due to the detrimental effects on their health, regular screening for poor sleep and proposed remedies are required for medical students. Sleep problems are frequent among medical students, making them a priority problem. Future studies should concentrate on preventative and intervention programs geared at these populations.

Medical students should pay careful attention to the amount of rest that they are getting and take steps to ensure that they are getting adequate amounts of sleep. This includes establishing a good sleep routine and avoiding technology for a few hours before bed. Additionally, medical students should seek help from professors and other resources on campus if they are having trouble managing their workload or are feeling overwhelmed.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40675-023-00258-5.

Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent All reported studies/experiments with human or animal subjects performed by the original authors have been previously published and complied with all applicable ethical standards (including the Helsinki Declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

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