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PSYCHIATRICS • REVIEW

Sleep quality in medical students: a comprehensive meta-analysis of observational studies

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Abstract

Purpose Poor sleep quality is common in medical students and is associated with a number of negative health outcomes. However, the prevalence estimates of poor sleep quality in medical students vary widely across studies. We thus conducted a meta-analysis of the prevalence of poor sleep quality and its mediating factors in medical students.

Methods A systematic literature search of PubMed, EMBASE, Web of Science, PsycINFO, and Medline Complete was performed. The random-effects model was used to analyze the pooled prevalence of poor sleep quality and its 95% confidence intervals (CIs).

Results A total of 57 studies with 25,735 medical students were included. The pooled prevalence of poor sleep quality was 52.7% (95% CI: 45.3% to 60.1%) using the Pittsburgh Sleep Quality Index (PSQI). The pooled mean total PSQI score across 41 studies with available data was 6.1 (95% CI: 5.6 to 6.5). Subgroup analyses found that PSQI cutoff value and study region were associated with the prevalence of poor sleep quality ($P = 0.0003$ VS. $P = 0.005$). Across the continents, poor sleep quality was most common in Europe, followed by the Americas, Africa, Asia, and Oceania. Meta-regression analyses found that smaller sample size (slope = − 0.0001, $P = 0.009$) was significantly associated with higher prevalence of poor sleep quality.

Conclusions Poor sleep quality is common among medical students, especially in Europe and the Americas continets. Due to the negative health outcomes, regular screening of poor sleep quality and effective interventions are needed for medical students.

Keywords Sleep quality · Medical student · PSQI · Meta-analysis

Wen-Wang Rao, Wen Li, Han Qi and Liu Hong contributed equally to this work.

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Introduction

Medical students are more likely to suffer from poor sleep quality [1] compared to other college students [2], which may have a negative impact on their academic performance, physical and mental health, and quality of life [3]. Poor sleep quality may be related to emotional problems (e.g., stress, depressive, and anxiety symptoms) [4, 5], clinical placements [6, 7], heavy study workload (e.g., hectic schedule, vast syllabus, various clinical training, and onerous academic load) [8–10], and significant economic pressures [11, 12],

The Pittsburgh Sleep Quality Index (PSQI) is the most widely used instrument to evaluate subjective sleep quality in the past month. It covers a broad range of indicators relevant to sleep quality [13], including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. The PSQI has been validated in numerous languages with satisfactory psychometric properties [14], and is commonly used across a wide range of clinical and research settings [15]. The PSQI has been also validated in college students [16–20] including medical students [21].

In order to develop effective interventions and lower the risk of the negative outcomes related to poor sleep, such as burnout [22], depression and anxiety [23, 24], and poor academic and work performance [25, 26], it is essential to examine patterns of poor sleep quality. To date, the findings regarding the patterns of poor sleep quality among medical students has been mixed across studies [27, 28]. No meta-analysis or systematic review has yet been conducted to examine the prevalence of poor sleep quality in this population. Thus, we conducted a comprehensive meta-analysis of the prevalence of poor sleep quality worldwide and its associated factors in medical students.

Methods

The study protocol was registered in the international prospective register of systematic reviews (PROSPERO; registration number CRD42019076413).

Data sources and search strategies

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) checklist and PRISMA study flow chart were used. Four investigators (WWR, WL, HQ, and LH) conducted literature search in PubMed, EMBASE, Web of Science, PsycINFO, and Medline Complete from their inception dates until Aug 20, 2018 using the following queries: Pittsburgh Sleep Quality Index, PSQI, medical students, health occupations students, and medical education. Titles and abstracts of relevant publications were independently screened, and then the full texts were reviewed for eligibility by the same four investigators. If the same dataset was used in more than one publication, only the one with the largest sample size was included. Any disagreement was resolved after a discussion with a senior investigator (YTX). Fig. 1 presents the literature search and selection process.

Study eligibility

Original studies were included if they fulfilled the following inclusion criteria: (1) cross-sectional or cohort studies (only the data at baseline were extracted) on medical students; (2) available data on sleep quality measured by the Pittsburgh Sleep Quality Index (PSQI); (3) those published in English. Review articles were excluded. The reference list of included studies was also reviewed for additional studies.

Data extraction

The following information from included studies was extracted and recorded by four investigators using an Excel data collection spreadsheet, such as mean age, gender, sampling method, sample size, year of publication, study site, response rate, country/region, and PSQI cut-off and total score.

Quality assessment

The methodology quality of the studies was independently assessed by the same four investigators using the quality assessment instrument for epidemiological studies [29–31], with the total score ranging from 1 (lowest quality) to 8 (highest quality) points. The eight domains were: (1) target population was clearly defined; (2) probability sampling was used or the entire population was surveyed; (3) response rate was $\geq 80\%$; (4) non-responders were clearly described; (5) sample was representative of the target population; (6) data collection methods were standardized; (7) validated criteria were used to measure the target diagnosis or symptom; and (8) prevalence estimates were given with confidence intervals and specified by subgroups. Any discrepancies in quality assessment were resolved after a discussion with the senior researcher (YTX). This quality assessment instrument has been widely used in previous studies [32, 33].

Statistical analysis

Data were analyzed by the STATA, Version 12.0 for Windows (Stata Corporation, College Station, Texas, USA) R, version 3.3.0 and R Studio, version 0.99.903. The pooled prevalence

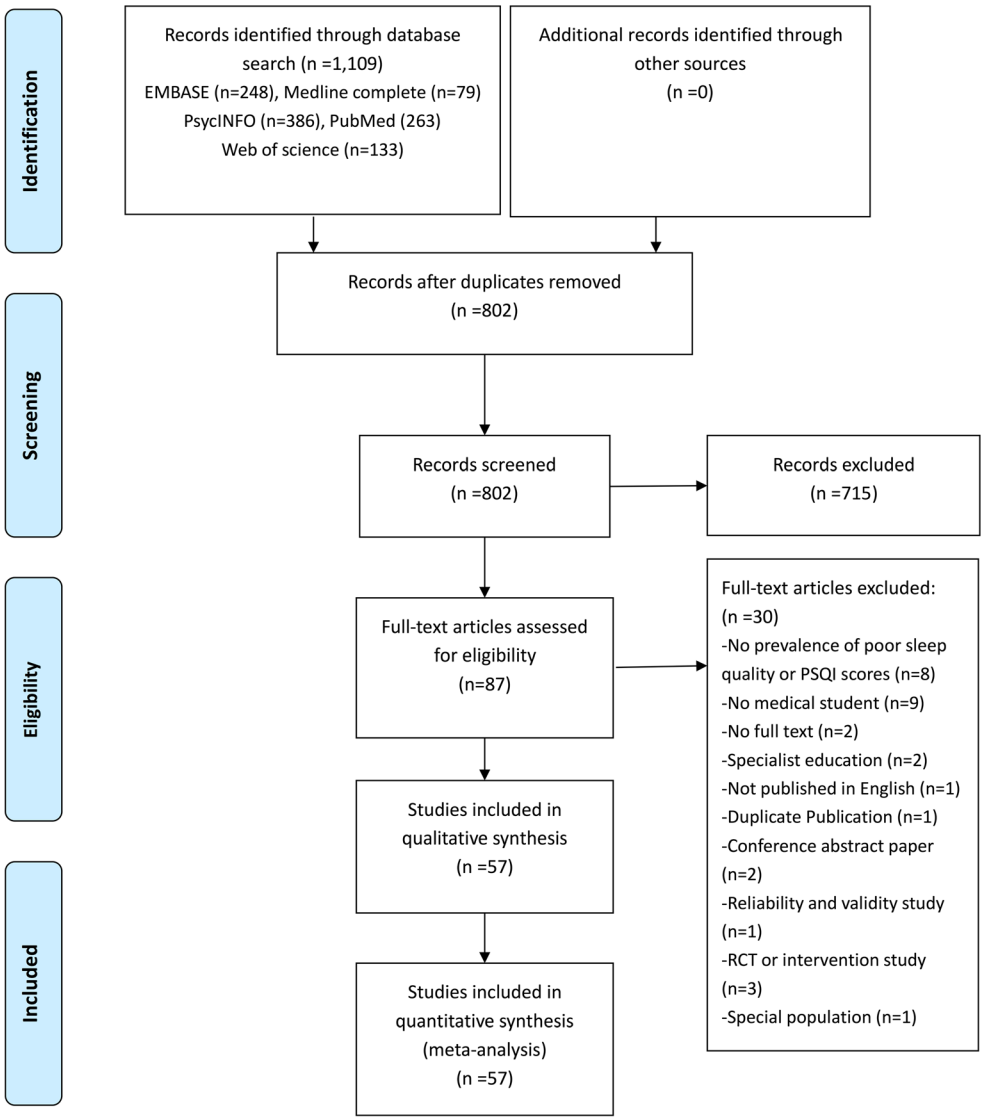

Fig. 1 Flowchart of literature selection

of poor sleep quality was calculated as effect size (ES); the estimate pooled prevalence and its 95% confidence intervals (CIs) were calculated by the "metaprop" command in Stata 12.0 using the Freeman-Tukey double arcsine transformation and DerSimonian and Laird random effects model. Heterogeneity was measured by I^2 statistics and Q-statistic, with $I^2 > 50\%$ as high heterogeneity. Subgroup analyses were performed according to the following categorical variables: sampling methods (Cluster/Random/Convenience/Others), cut-off of PSQI ($\geq 5/\geq 6/\geq 7/\geq 8$), regional classification (Africa/the Americas/Europe/Asia/Oceania continents), publication year (in and after 2016/before 2016 according to the median splitting method) and clinical medical student (Yes/No/Both). For the prevalence of poor sleep quality, meta-regression analyses were performed based on continuous variables, including publication year, sample size, response rate, quality assessment score, mean age, and sex ratio. Begg and Mazumbar's rank correlation test was used to explore publication bias. A bilateral alpha risk of 0.05 was set.

Results

Study selection

A total of 1,109 relevant articles were identified in literature search, and finally, 57 studies with 25,735 medical students were included for the analyses (Fig. 1). Of these, 50 studies had reported the prevalence of poor sleep quality and 41 had reported the PSQI total scores. One study [34] examined sleep quality in both clinical and nonclinical medical students separately; hence, this study was analyzed as two samples in subgroup analyses. Study characteristics are presented in Table 1.

Table 1 Characteristics of studies included in the meta-analysis

No.	First author	Publication year	Survey year	Sampling method	Sample size*	Response rate (%)	Mean age# (Mean ± SD)	Age range	Male (N, %)	Country	Study site	Clinical medical students	Screening of sleep quality		PSQI total score	Quality score
													PSQI Cut-off	(N, %)		
1	Adeosun S. O. et al. [49]	2008	NR	C	253	71.47	NR	NR	125 (49-.41)	Nigeria	Africa	No	⩾ 6	158 (6-2.-6)	6.15 ± 0.35	5
2	Ahrberg, K. et al. [50]	2012	NR	C	144	22.78	22.4 ± 2.48	19–31	49 (34-.03)	German	Europe	Yes	> 5	42 (2-9.-2)	4.6 ± 2.3	3
3	Al Sawah, M. et al. [51]	2015	2013	C	98	53.55	24.9 ± 2.9	NR	57 (58-.16)	US	the Americas	Yes	≥ 5	67 (6-8.-4)	7.3 ± 58.41	4
4	Almojali, A. I. et al. [4]	2017	2016	R	263	85.95	21.9 ± 1.4	NR	181 (68-.8)	Saudi Arabia	Asia	Yes	≥ 5	200 (7-6.-0)	7.11 ± 3.84	6
5	Asiri, Abdullah K. et al. [52]	2018	2015–2016	R	286	77.72	22.1 ± 1.6	NR	182 (63-.6)	Saudi Arabia	Asia	Yes	≥ 5	85 (2-9.-7)	NR	5
6	Brick, C. A. et al. [53]	2010	2008	C	291	92.7	27.8 ± 4.0	21–43	NR	US	the Americas	Yes	≥ 5	148 (5-0.-9)	6.37 ± 2.57	3
7	Cai, Z. Z. et al. [54]	2016	NR	R	380	95.0	NR	NR	165 (43-.4)	China	Asia	Yes	≥ 8	140 (3-6.-8)	NR	5
8	Cates, M. E. et al. [55]	2015	NR	C	253	67.47	NR	NR	90 (35-.9)	US	the Americas	No	> 5	140 (5-5.-3)	6.19 ± 2.93	5
9	Chen, B. F. et al. [56]	2017	2016	R	1441	92.6	19.72 ± 1.43	17–26	696 (48-.3)	China	Asia	Both	> 5	512 (3-5.-5)	NR	7
10	Chutani, A. et al. [34] &	2017	2013–2014	NR	207	92.67	18.8 ± 0.98	18–23	118 (57-.0)	India	Asia	Yes	> 5	49 (2-3.-6)	NR	5

Table 1 (continued)

No.	First author	Publication year	Survey year	Sampling method	Sample size*	Response rate (%)	Mean age# (Mean ± SD)	Age range	Male (N, %)	Country	Study site	Clinical medical students	Screening of sleep quality		PSQI total score	Quality score
													PSQI Cut-off	(N, %)		
					64				40 (62-.5)			No		7 (1-0.-9)		
11	Corrêa, C. D. C. et al. [57]	2017	NR	C	372	68.89	NR	NR	138 (37-.1)	Brazil	the Americas	Yes	≥ 5	324 (8-7.-1)	6.46 ± 2.62	5
12	Cvejic, E. et al. [1]	2018	2015	NR	59	100	20.88 ± 1.97	18–29	24 (40-.7)	Australia	Oceania	Yes	⩾ 6	18 (3-0.-5)	5.22 ± 2.62	4
13	Deepali, A. et al. [58]	2015	NR	R	100	100	19.26 ± 1.83	18–25	47 (47-.0)	India	Asia	Yes	> 5	72 (7-2.-0)	5.79 ± 2.57	4
14	Elagra, M. I. et al. [59]	2016	2014–2015	C	546	76.15	NR	NR	0 (0.0)	Saudi Arabia	Asia	Both	> 5	396 (7-2.-5)	7.6 ± 3.396	3
													≥ 8	264 (4-8.-4)		
15	Eyvazlou, M. et al. [60]	2016	2014	C	450	95.74	20.4 ± 1.6	18–28	162 (36-.0)	Iran	Asia	No	> 5	223 (4-9.-6)	6.07 ± 3.09	6
16	Fawzy, M. et al. [61]	2017	2015	R	700	100	21.22 ± 1.632	18–25	248 (35-.4)	Egypt	Africa	Yes	> 5	390 (5-5.-7)	6.13 ± 2.686	8
17	Fujii, H. et al. [62]	2009	2003	C	360	56.78	22.1 ± 2.2	NR	215 (59-.7)	Japan	Asia	Yes	⩾ 6	169 (4-6.-9)	5.5 ± 2.5	6
18	Genzel, L. et al. [63]	2013	NR	NR	31	100	23.33 ± 1.61	NR	7 (22-.58)	Germany	Europe	Yes	> 5	NR	4.28 ± 2.06	5

Table 1 (continued)

No.	First author	Publication year	Survey year	Sampling method	Sample size*	Response rate (%)	Mean age# (Mean ± SD)	Age range	Male (N, %)	Country	Study site	Clinical medical students	Screening of sleep quality		PSQI total score	Quality score
													PSQI Cut-off	(N, %)		
19	Giri, P. et al. [64]	2013	2011	Con	150	100	24.13 ± 1.93	NR	98 (65-.3)	India	Asia	Yes	NA	NR	5.97 ± 2.77	7
20	Goel, N. et al. [65]	2016	NR	NR	65	81.25	20 ± 0.8	NR	NA	India	Asia	Yes	> 5	39 (6-0.-0)	7.48 ± NA	3
21	Hasan, E. M. et al. [66]	2017	2014–2016	NR	235	100	NR	NR	122 (51-.9)	Iran	Asia	Both	NR	NR	8.26 ± 5.18	5
22	Israel, M. et al. [67]	2016	NR	R	200	100	NR	18–24	98 (49-.0)	India	Asia	Yes	> 6	106 (5-3.-0)	6.82 ± 2.42	6
23	James, B. et al. [68]	2011	2010	C	255	93.21	24.45 ± 2.32	19–40	125 (49-.02)	Nigeria	Africa	Yes	> 5	83 (3-2.-5)	NR	8
24	Kang, J. H. et al. [69]	2009	NR	R	160	81.22	20.3 ± 1.9	NR	81 (50-.6)	China	Asia	Both	> 5	54 (3-3.-8)	4.9 ± 2.4	8
25	Karaman, H. I. O. et al. [70]	2012	NR	NR	178	100	NR	NR	NR	Turkey	Europe	No	> 5	126 (7-0.-8)	NR	4
26	Kumar, A. et al. [71]	2016	2015–2016	C	308	96.25	21.5 ± 1.85	17–30	176 (57-.1)	India	Asia	Yes	> 5	122 (3-9.-6)	NR	5
27	Lei, J. et al. [72]	2015	2006	R	92	100	20.35 ± 13.81	19–21	NR	China	Asia	No	NR	NR	3.87 ± 23.98	6
28	Liu Y. et al. [73]	2014	2014	MSR	767	90.98	23.26 ± 2.88	18–27	196 (25-.6)	China	Asia	Both	> 5	182 (2-3.-7)	5.70 ± 2.73	6
29	Mansouri, A. et al. [74]	2016	NR	SR	277	100	23.4 ± 2.7	NR	119 (57-.0)	Iran	Asia	Both	⩾ 6	203 (7-3.-3)	8.57 ± 3.99	6
30		2001	NR	NR	35	97.2	20.54 ± 2	NR		Brazil	the Americas	Both	> 5		NR	4

Table 1 (continued)

No.	First author	Publication year	Survey year	Sampling method	Sample size*	Response rate (%)	Mean age# (Mean ± SD)	Age range	Male (N, %)	Country	Study site	Clinical medical students	Screening of sleep quality		PSQI total score	Quality score
													PSQI Cut-off	(N, %)		
	Medeiros, A. L. D. et al. [75]								20 (57-.1)					14 (4-0.-0)		
31	Mirghani, H. O. et al. [76]	2015	NR	C	140	84.8	22.55 ± 1.85	NR	38 (27-.14)	Sudan	Africa	Both	> 5	95 (6-7.-9)	7.55 ± 4.85	5
32	Modna, Y. et al. [77]	2017	NR	NR	77	100	24.7 ± 2.3	NR	33 (42-.86)	Saint Vincent & the Grenadin-es	the Americas	Yes	> 5	32 (4-1.-6)	NR	4
33	Mohammadbeigi, A. et al. [78]	2016	2015	SR	363	95.5	21.8 ± 3.2	NR	112 (30-.9)	Iran	Asia	Both	> 5	224 (6-1.-7)	5.30 ± 2.35	5
34	Mokros, L. et al. [79]	2017	2014–2015	Con	140	93.96	22.34 ± 1.37	20–26	NR	Poland	Europe	Yes	≥ 5	60 (4-2.-9)	4.31 ± 2.39	5
35	Majid, N. K. et al. [80]	2017	2012–2013	C	278	100	19.88 ± 1.53	NR	97 (34-.89)	Iran	Asia	Both	≥ 5	129 (4-6.-4)	4.65 ± 2.37	5
36	Pagnin, D. et al. [81]	2014	NR	NR	127	87.6	21.35 ± 2.27	NR	57 (44-.88)	Brazil	the Americas	Both	> 5	82 (6-4.-6)	6.99 ± 3.03	4
37	Peng H. et al. [82]	2004	2003	C	918	91.98	21 ± 3	16–35	389 (42-.37)	China	Asia	Both	≥ 8	159 (1-7.-3)	5.26 ± 2.40	6
38	Preisegolaviciute, E. et al. [2]	2010	NR	R	138	92.0	NR	NR	NR	Lithuania	Europe	Yes	> 5	55 (3-9.-9)	6.56 ± NR	6
39	Purim, K.S. et al. [83]	2016	2013	NR	101	94.39	NR	NR	49 (48-.51)	Brazil	the Americas	Both	NR	NR	5.90 ± 2.39	5
40		2018	2011–2013	C	101	100	24.5 ± 3.03	NR		Saudi Arabia	Asia	Yes	NR	NR	9.93 ± 4.8	5

Table 1 (continued)

No.	First author	Publication year	Survey year	Sampling method	Sample size*	Response rate (%)	Mean age# (Mean ± SD)	Age range	Male (N, %)	Country	Study site	Clinical medical students	Screening of sleep quality		PSQI total score	Quality score
													PSQI Cut-off	(N, %)		
	Qaiser, D.H. et al. [84]								101 (10-0)							
41	Randjelovic, P. et al. [85]	2018	2017	NR	21	65.63	NR	20–22	NR	Serbia	Europe	Yes	> 5	12 (5-7.-1)	5.62 ± 2.59	4
42	Rasekhi, S. et al. [86]	2016	2015	NR	177	73.75	20.99 ± 2.14	17–31	83 (46-.89)	Iran	Asia	Both	≥ 5	118 (6-6.-7)	NR	4
43	Rique, G.L.N. et al. [87]	2014	NR	S	221	86.67	22.3 ± 3.8	NR	123 (55-.7)	Brazil	the Americas	Yes	⩾ 6	136 (6-1.-5)	6.5 ± 2.6	8
44	Sahin, E.M. et al. [88]	2016	NR	NR	131	100	18.27 ± NR	NR	61 (46-.56)	Turkey	Europe	Yes	≥ 5	106 (8-2.-8)	7.9 ± 3.5	4
45	Sahraian, A. et al. [89]	2010	NR	NR	159	78.71	21.52 ± 2.67	17–28	79 (49-.7)	Iran	Asia	Both	NR	91 (5-7.-2)	NR	5
46	Saygin, M. et al. [90]	2016	2011	C	337	46.8	21.3 ± 2.1	18–30	141 (41-.8)	Turkey	Europe	Yes	> 5	268 (7-9.-6)	9.03 ± 4.21	6
47	Serra-Negra, J.M. et al. [91]	2014	2013	NR	183	82.4	21.2 ± 3.7	17–46	39 (21-.3)	Brazil	the Americas	Yes	> 5	110 (6-0.-1)	6.08 ± 2.18	5
48	Shad, R. et al. [92]	2015	NR	NR	112	NR	NR	NR	NR	India	Asia	Both	> 5	81 (7-2.-9)	NR	6
49	Siddiqui, A.F. et al. [93]	2016	2015	Con	318	84.8	22.35 ± NR	22–27	206 (64-.78)	Saudi Arabia	Asia	Both	≥ 5	236 (7-4.-2)	6.79 ± 3.06	6
50		2015	2013	Con	504	77.5	20 ± 1.4	NR		Pakistan	Asia	Yes	> 5		4.94 ± 2.32	4

Table 1 (continued)

No.	First author	Publication year	Survey year	Sampling method	Sample size*	Response rate (%)	Mean age[#] (Mean ± SD)	Age range	Male (N, %)	Country	Study site	Clinical medical students	Screening of sleep quality		PSQI total score	Quality score
													PSQI Cut-off	(N, %)		
	Surani, A.A. et al. [94]								204 (40-.5)					193 (3-9.-5)		
51	Uyar, K. et al. [28]	2016	2014	NR	290	100	23.47 ± 1.33	NR	156 (53-.8)	Turkey	Europe	Yes	NR	286 (9-8.-6)	10.56 ± 2.54	4
52	Vardar, E. et al. [95]	2008	NR	NR	141	100	19.8 ± 1.3	17–23	63 (44-.68)	Turkey	Europe	Both	> 5	NR	5.97 ± 2.79	5
53	Wang, L. et al. [96]	2016	2013	C	6085	100	NR	NR	1660 (27-.3)	China	Asia	Both	> 5	1694 (2-7.-8)	4.46 ± 2.18	7
54	Waqas, A. et al. [37]	2015	2014	RS	263	93.9	21.1 ± 1.78	NR	115 (43-.7)	Pakistan	Asia	Yes	> 5	203 (7-7.-0)	8.1 ± 3.12	6
55	Wu, X. Y. et al. [27]	2015	2013	RC	4747	98.84	19.24 ± 1.41	NR	1973 (41-.6)	China	Asia	Both	> 7	464 (9-.8)	NR	6
56	Yazdi, Z. et al. [97]	2016	2012	C	285	87.7	22.8 ± 1.74	20–27	135 (47-.4)	Iran	Asia	Both	> 5	164 (5-7.-5)	6.21 ± 1.08	6
57	Zarghami, M. et al. [98]	2015	NR	SR	358	100	25 ± 1.7	20–31	136 (38-.0)	Iran	Asia	Both	NR	52 (1-4.-5)	NR	8

*Sample size means effective sample size; [#] Mean age and SD means original mean age and SD; [&] This study included two samples: clinical medical students and non-clinical medical students

NR not reported; *SD* standard deviation; *C* cluster sampling; *M* multistage sampling; *R* random sampling; *S* stratified sampling; *Con* convenience

Quality assessment and publication bias

The scores of study quality assessment ranged from 3 to 8 with the mean of 6. No publication bias for poor sleep quality was found in funnel plot (Fig. 3) and Begg's test (z = 0.31, *P* value = 0.757).

Prevalence of poor sleep quality, subgroup analyses, and meta regression

The pooled prevalence of poor sleep quality across 50 studies with 24,884 medical students was 52.7% (95% CI: 45.3%–60.1%; $I^2 = 99.22$; $P < 0.001$; Fig. 2). Subgroup analyses found

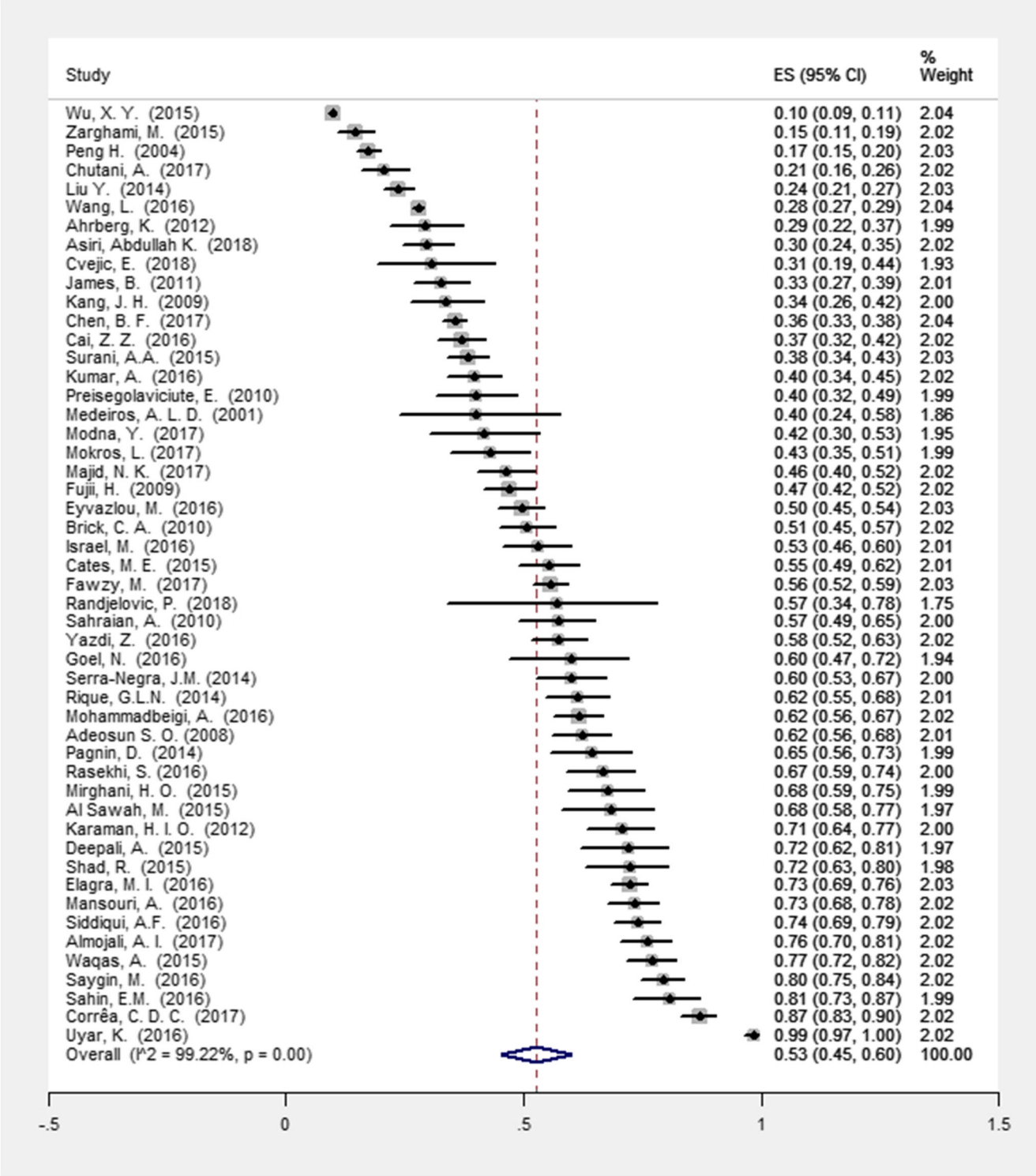

Fig. 2 Forest plot of the prevalence of poor sleep quality in medical students. The horizontal axis refers to effect size. Note: ES=Effect Size; CI=Confidence Interval

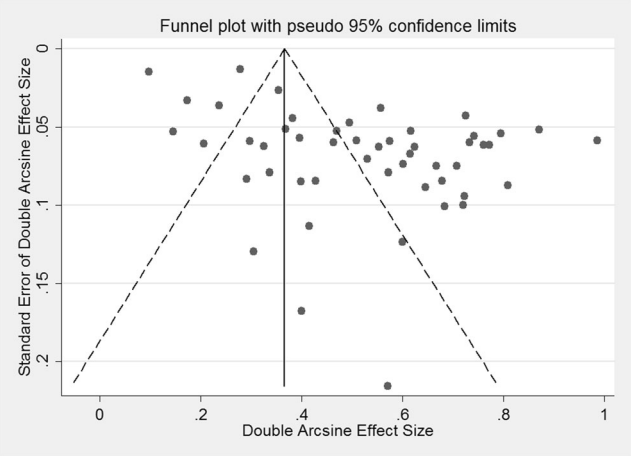

Fig. 3 Funnel plot of publication bias for studies of sleep quality (n=50)

that compared to other cutoff values (≥ 6, ≥ 7, and ≥ 8), studies using the PSQI cutoff value of ≥ 5 was associated with higher prevalence of poor sleep quality ($P = 0.0003$). Across the continents, the prevalence of poor sleep quality was highest in the studies conducted in Europe (65.13%), followed by in the Americas (59.92%), Africa (54.54%), Asia (47.44%), and Oceania (30.51%). Meta regression analyses revealed that smaller sample size (slope = − 0.0001, $P = 0.009$) was associated with higher prevalence of poor sleep quality.

PSQI total score and subscale scores

The pooled PSQI total score from 41 studies with 16,748 medical students was 6.058 (95% CI: 5.614–6.538; I^2 = 71.8; $P < 0.001$). The pooled mean score of the 7 PSQI subscales were as follows: subjective sleep quality: 1.22 (95% CI = 1.04–1.41), sleep latency: 0.99 (95% CI = 0.88–1.11), sleep duration: 1.05 (95% CI = 0.92–1.18), sleep efficiency: 0.27 (95% CI = 0.19–0.34), sleep disturbance: 1.17 (95% CI = 1.01–1.33), use of sleep medications: 0.33 (95% CI = 0.23–0.43), and daytime function: 1.32 (95% CI = 1.11–1.53) (Table S1).

Sleep habits

The data of sleep duration and sleep habits are shown in Table S2. The proportion of medical students who slept less than 7 h/day was 58.7% (95% CI = 45.3%–72.0%), while the

Table 2 Meta-regression and subgroup analyses of prevalence of poor sleep quality

Category	Variable	Tau^2	slope	se	Z	*P*	95%CI	
Meta-regression analysis	Publication year	0.072	0.014	0.011	1.277	0.202	− 0.008	0.036
	Sample size	0.051	− 0.0001	< 0.001	− 2.607	**0.009**	− 0.0001	< − 0.0001
	Response rate	0.059	− 0.002	0.002	− 0.770	0.442	− 0.006	0.003
	Quality score	0.064	− 0.045	0.027	− 1.690	0.091	− 0.098	0.007
	Mean age	0.074	0.007	0.023	0.306	0.760	− 0.038	0.053
	Sex ratio (F/M)	0.077	− 0.056	0.061	− 0.909	0.363	− 0.175	0.064
Subgroup analysis	Category	Tau^2	Sample Size	ES* (%)	95% CI		I^2	*P across subgroup*
Study site	Africa (4)	0.019	1348	54.54	40.86	67.89	95.6	0.005
	Europe (8)	0.097	1379	65.13	43.24	84.15	98.5	
	America (9)	0.028	1657	59.92	48.53	70.80	95.2	
	Asia (29)	0.053	20,441	47.44	38.87	56.08	99.3	
	Oceania (1)	–	59	30.51	19.33	42.94	–	
PSQI cutoff value	≥ 5 (10)	0.045	2354	63.10	49.82	75.45	97.7	0.0003
	≥ 6 (33)	0.037	15,478	51.90	45.13	58.64	98.3	
	≥ 8 (3)	0.021	6045	20.08	8.72	34.65	98.9	
	≥ 7 (1)	–	200	53.00	46.05	59.89	–	
Sampling methods	Cluster (17)	0.055	11,373	52.57	41.37	63.64	99.1	0.906
	Random (9)	0.024	3668	47.98	37.78	58.26	97.1	
	Others (7)	0.110	6996	44.56	21.64	68.78	99.6	
	Convenience (3)	0.048	962	52.14	27.87	75.88	98.2	
Clinical medical students	No (5)	0.007	1198	59.86	51.88	67.58	86.0	0.185
	Yes (27)	0.051	6393	56.78	48.11	65.24	97.9	
	Both (19)	0.055	17,293	47.51	36.99	58.14	99.4	
Publication year	≥ 2016 (26)	0.061	14,120	57.04	47.39	66.43	99.1	0.231
	< 2016 (24)	0.076	10,764	48.01	36.95	59.18	99.1	

*pooled effect size used by Freeman-Tukey double arcsine transformation

ES effect size; *CI* confidence interval; *se* standard error

proportion of more than and equal to 7 h/day was 41.3% (95% CI = 28.0%–54.7%).

The pooled bedtime across 6 studies with 1,332 medical students was 0:23 am (95% CI: 11:13 pm–1:33 am). The pooled mean sleep latency across 13 studies with 2,930 medical students was 21.53 min (95% CI: 18.65–24.41). The mean sleep duration across 22 studies with 4,851 medical students was 6.45 h (95% CI: 6.03–6.87) and time to get up across 5 studies with 1,393 medical students was 7:13 am (95% CI: 5:46 am–8:41 am).

Discussion

To our best knowledge, this was the first comprehensive meta-analysis of studies worldwide on the pooled prevalence of poor sleep quality in medical students using the PSQI. The main finding was that the majority of medical students had self-reported poor sleep quality (52.7%, 95% CI: 45.3%–60.1%).

In this meta-analysis, the prevalence of poor sleep quality in medical students (52.7%, 95% CI: 45.3%–60.1%) is significantly higher than the corresponding figures (23.9%, 95% CI: 20.8%–27.4%; by the PSQI) in university students [35] and in older population (38.3%; 95%CI = 32.4%–44.2%; by the PSQI) [36]. This is probably related to the high academic pressure in medical schools [4] and short sleep duration among medical students necessary to meet such academic demands [37]. Additionally, certain psychological factors, such as anxiety and depressive symptoms, and even suicidality, are relatively common in medical students [38], which is associated with higher risk of sleep problems [39–41]. On the other hand, there is an assumption that medical students may have more medical knowledge than the general population [42], and therefore may be prone to over-reporting symptoms in surveys, which could increase the prevalence of self-reported poor sleep quality.

This study found that smaller sample size was associated with higher prevalence of poor sleep quality. Due to limited statistical power, small sample size may bias the findings to an uncertain extent [43]. As expected, lower PSQI cutoff values were associated with higher prevalence of poor sleep quality, which is consistent with previous findings [35]. In addition, the use of different PSQI cutoff values may be a major source of heterogeneity between studies. Study region was significantly associated with the prevalence of poor sleep quality in medical students. The prevalence of poor sleep quality was highest in Europe (65.13%), followed by the Americas (59.92%), Africa (54.54%), Asia (47.44%), and Oceania (30.51%). Most of the high-ranking medical schools globally are located in Europe and the Americas [44]; therefore, medical students in these regions are more likely to have rigorous academic requirements and pressure compared to those in other areas, which is associated with higher risk of poor sleep quality [45]. Moreover, medical students in Western countries may also have high self-expectation to perform [46], and may therefore have a higher likelihood of poor sleep quality.

The strengths of this meta-analysis includ the large number of studies and the large pooled sample size. However, several limitations need to be addressed. First, similar to other meta-analysis [47, 48], substantial heterogeneity was inevitable in meta-analysis of epidemiological studies, although subgroup analyses alleviated this limitation to some extent. Second, some factors related to sleep quality, such as academic achievement and pressure and family support, were not recorded in most studies. Third, only studies using the PSQI were included. However, the PSQI is considered the most widely used tool to measure poor sleep quality, and in order to minimize bias caused by different measures, other instruments on sleep, such as the Epworth Sleepiness Scale (ESS) or Insomnia Severity Index (ISI), were not included.

In conclusion, poor sleep quality is common in medical students globally, particularly in Europe and the Americas. To reduce the negative health outcomes of poor sleep quality, education on the impact of poor sleep, regular monitoring of sleep and practicing sleep hygiene should be promoted in medical students. Finally, longitudinal research on the association between poor sleep quality and other demographic and clinical variables in medical students should be conducted in the future.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants performed by any of the author.

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