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Sleep health and measures

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Sleep health and measures

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Editorial: Sleep health and measures

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Editorial on the Research Topic
Sleep health and measures

In the past few decades, studies on sleep have been increasing in number, as an important crossroads of different disciplines including psychiatry, neurology, neuroscience, respiratory medicine, psychology, nursing, and public health (1, 2). Moving beyond studies of basic sleep science and sleep disorders, sleep health has emerged as a new direction that provides a more holistic framework for the main dimensions of sleep: regularity, satisfaction, alertness, timing, efficiency, and duration (1, 3). Given its growing importance, it is imperative to evaluate, consolidate, and further develop measures of sleep health so that the global sleep research community has more valid tools to deploy.

A growing body of research has revealed that poor sleep health is associated with poor health behaviors (e.g., smoking and alcohol consumption), negative psychological states (e.g., anxiety, depression, and perceived stress), chronic diseases (e.g., cardiovascular disease and diabetes), and physical injuries (e.g., road traffic injuries). Irregular sleep schedules, bedtime procrastination, and other unhealthy sleep behaviors such as widespread use of electronic devices and social media, may negatively impact sleep health in modern societies (4). As good sleep health is a critical cornerstone for overall health, routine monitoring, multi-level preventive measures, and interventions are needed to further elucidate an unmet public health problem and improve health equity (5).

To this end, our Research Topic "*Sleep health and measures*" includes original research articles, reviews, and opinion pieces that explore the current state of sleep health, its influencing factors, and key health outcomes. By identifying approaches to accurately measure, assess, and improve sleep health, the current Research Topic strives to further substantiate the significance of sleep health as a multidisciplinary field of research. In this editorial, we provide a brief overview of selected articles published on the Research Topic "*Sleep health and measures*" in the journal *Frontiers in Public Health* (https://www.frontiersin.org/research-topics/48787/sleep-health-and-measures/articles).

The study by Tesfaye et al. aimed to determine the prevalence and associated factors of poor sleep quality among healthcare professionals in Northwest Ethiopia. Using a cross-sectional design and stratified random sampling, data were collected from 418 participants using self-administered questionnaires. Results revealed a high prevalence of poor sleep quality (58.9%). Factors significantly associated with poor sleep quality included being female, shift work, a lack of regular exercise, khat chewing, and so on. The authors recommend early screening for sleep disturbances, better management of shift work schedules, and interventions targeting lifestyle behaviors and mental health support, to improve sleep quality among healthcare professionals.

Guo et al. investigated how sleep quality, perceived stress, and social support interact to influence depression in stroke patients. Conducted between January and May 2023 using cluster random sampling in five hospitals in Henan Province, China, this multicenter cross-sectional survey with 471 stroke patients revealed that poor sleep quality partially mediated the relationship between perceived stress and depression. Moreover, social support moderated this mediation effect. These findings suggest that improving sleep quality and social support may be key strategies to mitigate depression in stroke patients, providing a foundation for developing targeted intervention programs.

The study by Loke et al. reported on the development and validation of the Sleep Health And Wellness Questionnaire (SHAWQ) to identify sleep problems and potential depression risks in adolescents and university students. Using a 6-item questionnaire derived from key sleep and health predictors, the SHAWQ was tested in four studies involving 8,567 adolescents and university students. The tool demonstrated good convergent validity, test-retest reliability, and predictive validity (for academic performance), indicating that the SHAWQ is effective for screening for sleep health and mood issues in teenagers and young adults, which could guide interventions to improve sleep and mental health status in this at-risk segment of the population.

The systematic review by González-Martín et al. was an instrumental addition to this Research Topic. This meta-analysis evaluated the effectiveness of mindfulness-based programs on sleep quality in healthy, non-institutionalized older adults. Following PRISMA guidelines, the review included 10 out of 177 initially identified articles from four databases (Pubmed, Scopus, Web of Science, and CINAHL) searched in May and June 2023. Overall, older adults who underwent mindfulness-based programs indicated significant improvements in sleep quality, with moderate effect sizes across different sleep assessment tools. The findings suggest that mindfulness may be an effective treatment for insomnia symptoms and other sleep quality issues in older adults.

The breadth of measurements, measurement strategies, and related health outcomes investigated in the articles included in this Research Topic, highlights not only the excitement surrounding sleep health, but also the challenges inherent in any emerging area of investigation. We encourage scholars to be intentional in their selection of both measures and outcomes. As the accumulation of knowledge is dependent on the ability to synthesize across studies, much progress in our understanding of sleep health can be made with small advances in conceptualization and measurement.

Author contributions

RM: Conceptualization, Writing – original draft, Writing – review & editing. HM: Writing – original draft, Writing – review & editing. KS: Writing – original draft, Writing – review & editing. EYYL: Writing – original draft, Writing – review & editing. JMD: Writing – original draft, Writing – review & editing.

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Conflict of interest

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A latent profile analysis of sleep disturbance in relation to mental health among college students in China

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Aims: This study aimed to examine the subtype classification characteristics of sleep disturbance (SD) in college students and their associations with sample characteristic factors and mental health outcomes.

Methods: The sample comprised 4,302 college students (Mean age=19.92±1.42years, 58.6% females). The Youth Self-Rating Insomnia Scale, Beck Depression Inventory, 8-item Positive Subscale of the Community Assessment of Psychic Experiences, and 10-item Connor-Davidson Resilience Scale were used to assess adolescents' sleep disturbance, depressive symptoms, psychotic-like experiences (PLEs), and resilience. Latent profile analysis, logistic regression, and liner regression analysis were used to analyze the data.

Results: Three subtypes of SD in college students were identified: the high SD profile (10.6%), the mild SD profile (37.5%), and the no SD profile (51.9%). Compared with college students in the "no SD" profile, risk factors for "high SD" include being male and poor parental marital status. Sophomores were found to predict the "high SD" profile or "mild SD" profile relative to the "no SD" profile. College students in the "mild SD" profile or "high SD" profile were more likely to have a higher level of depressive symptoms and PLEs, while a lower level of resilience.

Conclusion: The findings highlighted that target intervention is urgently needed for male college students, sophomores, and those with poor parental marital status in the "mild SD" profile or "high SD" profile.

KEYWORDS

sleep disturbance, depressive symptoms, psychotic-like experience, resilience, college students

Introduction

Sleep disturbance (SD) is prevalent among adolescents and young adults, with main symptoms of insomnia, poor sleep quality, and other sleep complaints. College students, one of the most sleep deprived student groups, are particularly vulnerable to disturbed sleep. One epidemiological survey showed that more than 60% of college students were suffering from SD [on the Pittsburgh Sleep Quality Index (PSQI)] (1). Gaultney, in a sample of 1845 college students, found that 27% have clinically significant symptoms of SD (on the SLEEP-50 questionnaire) (2). Recent systematic review, involving 250 studies, estimated that global prevalence of SD among college students was 41.16% during the COVID-19 pandemic (3). Adolescents entering college is a major life transition, which means leaving home and living independently, completing demanding course and trying to earn academic degrees, facing a new social environment, and adopting new social roles (4–6). This transition contributes to increased stress levels, which, in turn, can have a profound and lasting effect on sleep (7). Moreover, studies have also shown that excessive media use by college students contributes to poor sleep hygiene and a series of sleep disturbances (8).

A growing number of research have focused on SD of college students and its symptoms, such as insomnia (difficulty initiating sleep, difficulty maintaining sleep, or early morning awakening) (9), poor subjective sleep quality (10, 11), daytime sleepiness (12), salient nightmares (13), and other general sleep problems (14). The majority of extant research on SD has relied on variable-centered analyses, which provides insight into the average relations among symptoms or diagnoses of SD within a specific group. However, the methodological approaches fail to reveal different patterns between individuals and may therefore draw over-generalized conclusions based on overall samples (15). On the contrary, the use of person-centered approaches such as latent class analysis (LCA) and latent profile analysis (LPA), to evaluate the structure of psychopathology, enables a more refined understanding of symptom presentations and is ideal for psychopathology research (16, 17).

Till now, the heterogeneity of SD for college students has only been scarcely explored. Based on the available literature, only three studies have been conducted using a person-centered methodological approach to explore the heterogeneous patterns of sleep-related impairment among college students. For instance, Carpi et al. (18) identified a five-class solution among a small sample of college students (N = 490) by using LPA, which were termed as the "severe insomnia" subtype, "moderate insomnia with medication use" subtype, "subthreshold insomnia" subtype, "subthreshold insomnia with sleep latency complaints" subtype, and "moderate insomnia with sleep duration complaints" subtype (18). Zhou et al. (19) applied LCA to discern heterogeneous patterns of sleep behaviors among 1,288 Chinese college students, and summarized four subtypes: good sleep, prolonged sleep latency, sleep disturbances–daytime dysfunction, and multiple poor sleep behavior (19). Another study in 312 at-risk college drinkers also indicted that the four profiles can clearly explain sleep and sleep-related consequences (20). Therefore, further studies with a large sample are needed to confirm heterogeneous patterns of SD among general college students.

This study intended to explore the heterogeneity of SD among the college students group with a large sample web-based survey for college students. As suggested by prior research, the risks of occurrence and persistence of SD are associated with numerous sample characteristic factors, including age (21, 22), sex (23, 24), parental marital status (25), and family economic status (26). Additionally, solid evidence showed that SD is also associated with a wide variety of adverse mental health outcomes, such as depression (27) and psychotic-like experiences (PLEs) (28), as well as inhibits the development of positive mental qualities, such as resilience (29). Collectively, there are three main aims of this study. First, the study aims to identify the heterogeneity differences in SD among college students, employing LPA. Second, it explores what sample characteristic factors (e.g., sex, age) are significant predictors of distinct profiles of SD in college students. Finally, it examines the associations among these different subtypes of SD and mental health outcomes. Based on previous research, we speculated that the college students' SD feature obvious latent profiles, and several sample characteristic factors, such as sex, parental marital status, were significant predictors of distinct profiles for SD. We also anticipated that there are robust associations between SD subtypes and depression, PLEs and resilience.

Materials and methods

Participants and procedure

A convenience sample of college students was recruited from Taiyuan city in Shanxi Province, China. The online survey was conducted during January 2021, using the "Questionnaire Star" software platform. All participants scanned the Quick Response (QR) code of the questionnaire through their mobile phones to complete the web-based survey. If respondents agree to participate in this study, they shall select the "I agree to participate" option and upload their electronic signature of informed consent on the first page of the questionnaire platform. The investigation used the principle of voluntary participation, and participants could withdraw from the survey at any time if they felt discomfort. To improve data quality, inclusion criteria for participation included: (a) upload the electronic signed version of the informed consent form; (b) response time for web-based survey was above 5 min; and (c) have no current significant physical disease or history of psychiatric illness. Finally, 4,302 responses were qualified and included in the subsequent analyses.

The current study was carried out in accordance with the Helsinki Declaration as revised in 1989 and was approved by the Ethics Committees of South China Normal University.

Measures

SD

The Chinese version of Youth Self-Rating Insomnia Scale (YSIS) was used to measure the SD in the past month (30). It consists of 8 items, clustering into two dimensions, namely daytime distress/impairment and insomnia symptoms. Each item scored from 1 to 5, and a higher total score indicate a greater level of SD. The cut-off point of 26 represents identified cases of clinically SD (30). In this study, Cronbach's α was 0.89.

Depressive symptoms

The Beck Depression Inventory (BDI) was used to assess depressive symptoms in the past week (31). It consists of 21 items, and each item was rated on a four-point Likert scale, from 0 to 3, and a higher total score suggested a greater level of depressive symptoms. A cut-off score of 14 was suggested to identify the clinically significant depression (32).The Chinese version of BDI-21 has demonstrated good internal reliability and the concurrent validity (33), and Cronbach's α was 0.91 in this sample.

PLEs

The Chinese version of 8-item positive subscale of the community assessment of psychic experiences (CAPE-P8) was used to evaluate frequency of PLEs in the past month (34, 35). CAPE-P8 originated from 42-item community assessment of psychic experiences (36, 37), which addresses the following domains, namely delusional experiences and hallucinatory experiences. Responses to items range from 1—never, 2—sometimes, 3—often, to 4—nearly always, with a higher score reflecting more frequent PLEs. Frequent PLEs were defined as having "often" or "nearly always" on one or more items (38, 39), and Cronbach's α was 0.84 in the current sample.

Resilience

The 10-item Connor-Davidson Resilience Scale (CD-RISC-10) was used to assess the level of resilience (40). Five response options are available on a scale of 0 (not true at all) to 4 (true nearly all the time). Higher score means higher level of resilience. Psychometric properties of the CD-RISC-10 have been described in the Chinese population (41, 42). In our study, Cronbach's α was rather high (α = 0.97).

Sample characteristic variables

Sample characteristic variables were collected in a self-report fashion, including sex [1 = male; 2 = female], age, grade [1 = freshman; 2 = sophomore; 3 = junior; 4 = senior], ethnicity [1 = Han (the major ethnic group in China); 2 = others], parental married status [1 = good; 2 = poor (separated, divorced, and widowed)], family income [1 = <3,000 RMB; 2 = 3,000 ~ 5,000 RMB; 3= >5,000 RMB], parents' education level [1 = junior high school or less; 2 = senior high school; 3 = college or more], and single child status [1 = yes; 2 = no].

Statistical analysis

Data analysis was performed using SPSS 24.0 and Mplus 8.30. First, the Harman's one-factor test through exploratory factor analysis (EFA) was performed to examine common method bias (43). The EFA found out that there were 5 factors with eigenvalues >1 and the first factor accounted for 11.17% of the total variance, indicating common method bias was not a serious issue in the study (44). Second, the LPA was conducted to determine whether there were heterogeneous latent classification differences in SD among college students. LPA is a form of LCA that is used when working with continuous variables. The fit of a one-class model is initially evaluated, and models with increasing number of latent profiles were estimated. To identify the optimal number of latent profiles to fit the data, we compared several fit indicates of each model, including Akaike's information criterion (AIC), the Bayesian information criterion (BIC), sample-size-adjusted Bayesian information criterion (aBIC), Entropy, Vuong-Lo–Mendell–Rubin Likelihood Ratio Test (VLMR-LRT), and bootstrapped likelihood ratio test (BLRT). Lower AIC, BIC, and aBIC values (45), higher entropy values (46), and significant VLMR-LRT and BLRT *p*-values (47) were considered as signs of a better fit. In addition, we took interpretability of the profiles into great consideration, and ensured that each profile consisted of no less than 5% of samples (48). Third, multivariate logistic regression analyses were implemented to test whether sample characteristic variables differentially predicted SD profile membership. Finally, YSIS, BDI-21, CAPE-P8, and CD-RISC-10 total scores were compared through the ANOVA test. We also treated the subtypes of SD as dummy variables and further examined the relationship between SD subtypes and depression, PLEs and resilience using linear regression. A two-tailed $p < 0.05$ was considered statistically significant.

Results

Description of the sample

In total, 4,302 participants completed questionnaires, among which 2,522 were female. The mean age of the sample was 19.92 ± 1.42 years. A majority of college students was ethnicity Han (99.4%), and reported with a good parental marital status (93.1%). Other sample characteristic variables are presented in Table 1.

TABLE 1 Sample characteristics (*N*=4,302).

Characteristics		*N*	%
Sex	Male	1780	41.4
	Female	2,522	58.6
Age [year, Mean (SD)]	19.92(1.42)		
Grade	Freshman	1876	43.6
	Sophomore	1,133	26.3
	Junior	1,044	24.3
	Senior	249	5.8
Ethnicity	Han [a]	4,277	99.4
	Others	25	0.6
Parental marital status	Good	4,005	93.1
	Poor [b]	297	6.9
Family income (monthly), RMB	<3,000	2,419	56.2
	3,000 ~ 5,000	1,153	26.8
	>5,000	730	17.0
Father's education	Junior high school or less	2,831	65.8
	Senior high school	914	21.2
	College or more	557	12.9
Mother's education	Junior high school or less	3,009	69.9
	Senior high school	846	19.7
	College or more	447	10.4
Single child status	Yes	1,107	25.7
	No	3,195	74.3
YSIS score[Mean (SD)]	14.53(5.77)		
Sleep disturbance [c]	Yes	196	4.6
BDI score [Mean (SD)]	3.45(5.76)		
Depression[d]	Yes	293	6.8
CAPE-P8 score[Mean (SD)]	9.20(2.20)		
Psychotic-like experiences[e]	Yes	209	4.9
Resilience [Mean (SD)]	30.66(7.92)		

YSIS, Youth Self-Rating Insomnia Scale; BDI, Beck Depression Inventory; CAPE-P8, 8-item Positive Subscale of the Community Assessment of Psychic Experiences; CD-RISC-10, 10-item Connor-Davidson Resilience Scale.[a]Han is the major ethnic group in China.
[b]Poor parental marital status included separated, divorced, and widowed.
[c]Sleep disturbance calculated using the YSIS, with a clinical cut-off score of 26.
[d]Depression calculated using the BDI-21, with a clinical cut-off score of 14.
[e]Psychotic-like experiences calculated using the CAPE-P8, with one or more items were selected 3-often or 4-nearly always.

Table 1 also displays 4.6% of participants ($N = 196$) reported the presence of clinically SD. 6.8% ($N = 293$) had depression, and 4.9% ($N = 209$) respondents were identified as frequents PLEs.

Model fitting

Based on the 8 items of the YSIS, a potential profile analysis was conducted, which, in turn, established four latent profile models. The results of the LPA are reported in Table 2. The VLMR-LRT and BLRT values were statistically significant for two and three-category model. Moreover, the fit of the three-category model was better than a two-category model, as indicated by the lower AIC and BIC values. Also, Entropy value for three-category model was 0.89, indicating a high accuracy of these classifications. Therefore, the three-category model was selected as the optimal model. The average probability of samples belonging to each potential category was between 92.2 and 96.8%.

Sleep disturbance profiles characterization

A latent class profile plot of the sample is shown in Figure 1. Profile 1 labeled as the "high SD" profile (N = 456, accounting for 10.6% of the total sample) was characterized by the highest level of SD, and its YSIS total score (26.12 ± 3.53) > 26 (the cut-off point). Profile 3 defined as the "no SD" profile (N = 2,234, 51.9%) was characterized by the lowest level of SD, and its YSIS total score (10.05 ± 1.95) much lower than the sample mean value (14.53 ± 5.77). Additionally, profile 2 comprised approximately 37.5% of the sample (N = 1,612) and included college students with a higher level of SD compared to the sample reported in profile 3, while lower than those belonging to profile 1. The YSIS total score of this profile (17.45 ± 2.37) slightly above the sample mean value (14.53 ± 5.77). This profile was named as "mild SD" profile.

Profile predictors and outcomes

Taking the profile of SD as the dependent variable, the "no SD" profile was used as the reference category. Sex, age, grade, ethnicity, parental married status, family income, parents' education level, and single child status were used as independent variables to carry out a multivariate logistic regression. The results (Table 3) showed that, compared with college students in the "no SD" profile, risk factors for "high SD" include being male (OR = 1.24, 95% CI = 1.01–1.53) and poor parental marital status

TABLE 2 Fit indices for latent profile analyses.

Class	BIC	aBIC	AIC	BLRT (p)	Entropy	aLMR (p)	VLMR (p)	Smallest class (%)
1	93415.61	93364.77	93313.74					
2	81361.89	81282.45	81202.71	<0.001	0.89	<0.001	<0.001	33.3
3	**77743.38**	**77635.34**	**77526.91**	**<0.001**	**0.89**	**<0.001**	**<0.001**	**10.6**
4	75615.38	75478.74	75341.61	<0.001	0.96	0.257	0.254	9.9

Bold indicates best fit. Entropy and value of p for BLRT, aLMR, and VLMR are not applicable to a one-class solution. BIC, Bayesian information criterion; aBIC, sample-size-adjusted Bayesian information criterion; AIC, Akaike information criterion; BLRT, bootstrap likelihood ratio test; aLMR, adjusted Lo–Mendell–Rubin; VLMR, Vuong-Lo–Mendell–Rubin.

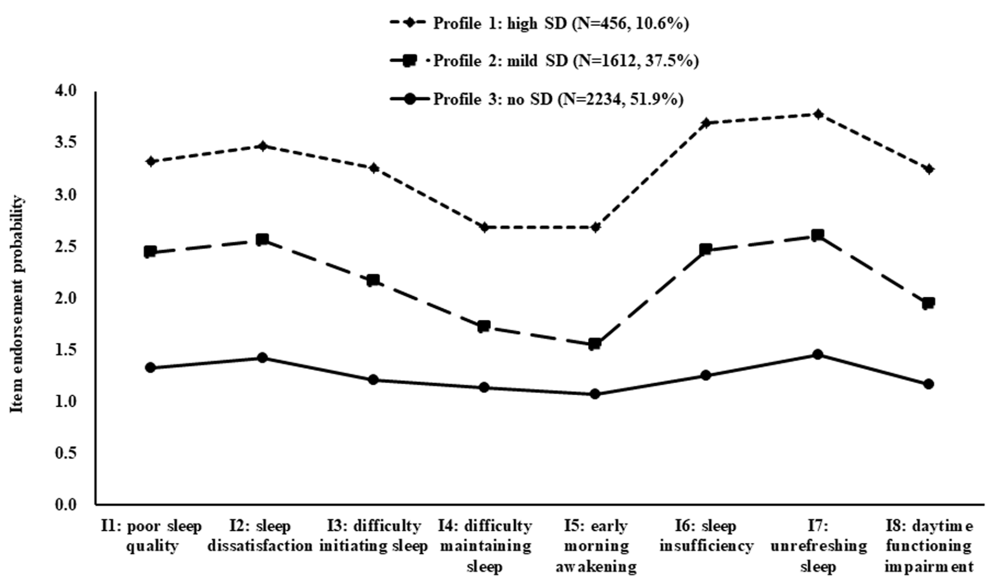

FIGURE 1
Mean sleep disturbance symptom cluster scores in the three latent profiles. SD, sleep disturbance.

TABLE 3 Predictors associated with profile membership of SD [OR(95%CI)].

Characteristics		Profile 1 high SD	Profile 2 mild SD
Sex	Female	Ref.	Ref.
	Male	**1.24 (1.01, 1.53)***	0.93(0.82, 1.06)
Age		0.95(0.86,1.06)	0.98(0.92,1.05)
Grade	Freshman	Ref.	Ref.
	Sophomore	**1.44 (1.11, 1.88)****	**1.22 (1.03, 1.45)***
	Junior	0.92(0.65,1.31)	0.95(0.77,1.18)
	Senior	0.75(0.41,1.37)	0.73(0.50,1.05)
Ethnicity	Han	Ref.	Ref.
	Others	0.67 (0.15,2.98)	0.91 (0.39,2.12)
Parental marital status	Good	Ref.	Ref.
	Poor	**1.81 (1.27, 2.59)*****	1.29 (1.00, 1.67)
Family income (monthly), RMB	<3,000	Ref.	Ref.
	3,000 ~ 5,000	0.87 (0.68,1.12)	0.82 (0.82, 1.11)
	>5,000	1.17 (0.88,1.56)	1.01 (0.84, 1.23)
Father's education	Junior high school or less	Ref.	Ref.
	Senior high school	0.99 (0.75, 1.30)	0.99 (0.83, 1.17)
	College or more	0.96 (0.66, 1.39)	0.88 (0.69, 1.13)
Mother's education	Junior high school or less	Ref.	Ref.
	Senior high school	0.96 (0.72, 1.28)	0.88 (0.73, 1.06)
	College or more	1.08 (0.72, 1.60)	0.59 (0.59, 1.01)
Single child status	Yes	Ref.	Ref.
	No	0.86 (0.68, 1.10)	0.93 (0.80, 1.09)

The reference category for the dependent variables was the "Profile 3: no SD"; SD = sleep disturbance; OR = odds ratio; CI = confidence interval; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; Bold type indicates a significant odds ratio.

(OR = 1.81, 95% CI = 1.27–2.59). Meanwhile, sophomores tended to predict the "high SD" profile (OR = 1.44, 95% CI = 1.11–1.88) or "mild SD" profile (OR = 1.22, 95% CI = 1.03–1.45) relative to the "no SD" profile.

Figure 2 compares YSIS, BDI-21, CAPE-P8, and CD-RISC-10 total scores among the three profile of SD. The "high SD" profile had higher YSIS ($F = 11119.46$, $p < 0.001$, Figure 2A), BDI-21 ($F = 541.26$, $p < 0.001$, Figure 2B), and CAPE-P8 scores ($F = 491.81$, $p < 0.001$, Figure 2C) while lower CD-RISC-10 score ($F = 123.34$, $p < 0.001$, Figure 2D) than the other two profiles. The relations among profiles and mental health outcomes are described in Table 4. In the crude model, college students in the "mild SD" profile or "high SD" profile were more likely to have a higher level of depressive symptoms and PLEs, while a lower level of resilience compared with those in the "no SD" profile. This significant effect between the mild/high SD and college students' mental health persisted after adjusting for sample characteristics variable.

Discussion

The present study adopted LPA to explore subtypes of SD and their related factors in college students. The findings are beneficial to education administrators and clinicians better understand the heterogeneous cluster classification characteristics of SD in college students to formulate more specific and targeted intervention measures.

First, three latent profiles of SD among college students were identified in this study: "high SD," "mild SD," and "no SD." The finding of the presence of three potential SD profiles is similar to previous studies in other groups (49, 50). For example, Tejada and colleagues explored the heterogeneity of SD in 1,331 chemotherapy patients using LPA, pointing out three SD profiles: "low," "high," and "very high" (50). Our data showed that approximately half of the samples (51.9%) were categorized as "no SD" profile, and only 10.6% have high SD. We compared the results with previous studies of similar university students. Zhou and colleagues used LCA to analyze the distinct classes of sleep behavior (on the Dysfunction Beliefs and Attitudes about Sleep [DBAS] and PSQI), and concluded that 6.8% of college students was in the "sleep disturbances and daytime dysfunction" subtype, while 31.8% was in the "good sleep" subtype (19). Another study (on the Insomnia Severity Index [ISI] and PSQI) adapted LPA and pointed out that 8.8% college students have severe insomnia, 66.9% reported subthreshold insomnia or subthreshold insomnia with sleep latency complaints (composed by students with relatively low insomnia severity) (18). Due to instruments and sampling, the findings differ to some extent. However, these studies have reached consistent conclusions, that is, most individuals could cope well to stressor of life events and maintain good sleep function, while only

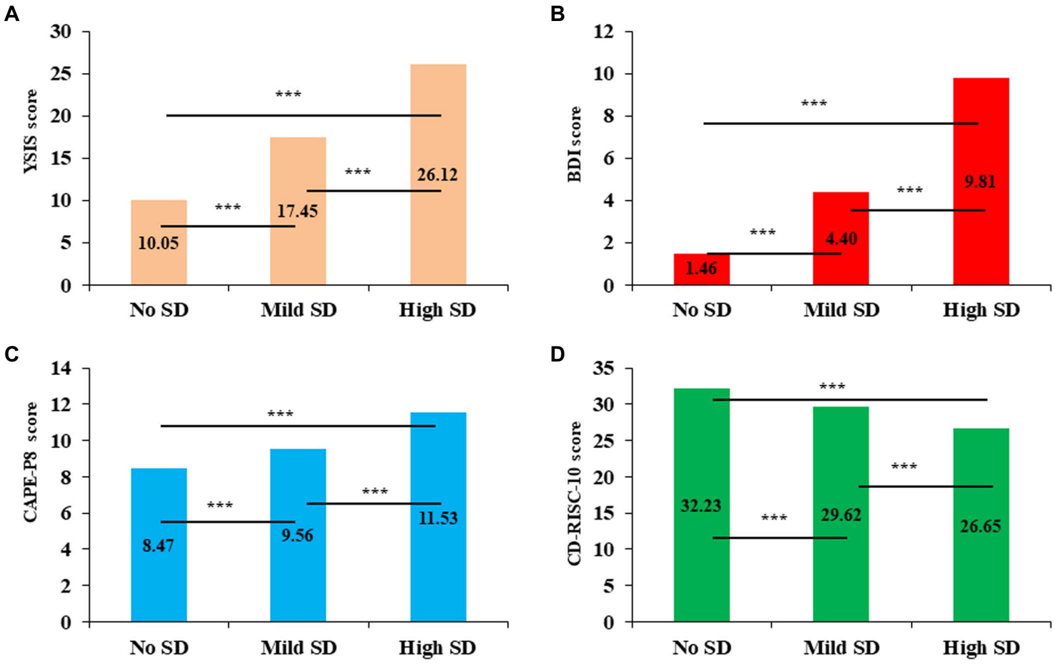

FIGURE 2
Comparison of mental health variables across different SD profiles. SD, sleep disturbance; YSIS, Youth Self-Rating Insomnia Scale; BDI, Beck Depression Inventory; CAPE-P8, 8-item Positive Subscale of the Community Assessment of Psychic Experiences; CD-RISC-10, 10-item Connor-Davidson Resilience Scale. ****p*<0.001.

TABLE 4 Sleep disturbance profiles in relation to mental health.

		Depressive symptoms			PLEs			Resilience		
	Predictor	*β*	95%CI	*p*	*β*	95%CI	*p*	*β*	95%CI	*p*
Crude model	Profile 3: no SD	Ref.			Ref.			Ref.		
	Profile 2: mild SD	0.25	1.25,1.68	<0.001	0.24	0.96,1.21	<0.001	−0.16	−3.11,-2.13	<0.001
	Profile 1: high SD	0.45	7.82,8.86	<0.001	0.43	2.86,3.26	<0.001	−0.22	−6.36,-4.81	<0.001
Adjusted model[a]	Profile 3: no SD	Ref.			Ref.			Ref.		
	Profile 2: mild SD	0.25	2.58,3.24	<0.001	0.24	0.95,1.20	<0.001	−0.16	−3.06,-2.07	<0.001
	Profile 1: high SD	0.44	7.71,8.74	<0.001	0.42	2.82,3.22	<0.001	−0.22	−6.32,-4.76	<0.001

[a]Adjusted for sample characteristics in Table 1.
CI, confidence interval; PLEs, Psychotic-like experiences; SD, sleep disturbance.

a small percentage exhibit clinical levels of SD. In addition, 37.5% of the samples were categorized as "mild SD" profile. Although the YSIS scores of these college students did not meet the criteria for clinically SD (cut-off value = 26), they had higher than average levels of SD. College students in "mild SD" profile still exhibited low frequency (the average score of the 8 YSIS item was 2.18) of SD related symptoms. Therefore, it is necessary to employ targeted interventions for those in this subtype to prevent them from sliding into sleep-related impairment and SD.

Second, multivariate logistic regression identified several risk factors associated with increased likelihood of experiencing moderate and high SD. Our data showed that male students were more likely to be found in the "high SD" profile than the female. Although previous studies have examined SD in the college students group, findings concerning the effects of sex on SD have been inconsistent. Several studies found that male students exhibiting greater SD (51–53). However, some studies suggested that SD among female students was even more severe than that of the male (23, 54, 55), while others reported no sex differences in SD (56–58). We speculated that male college students have more sleep-adverse lifestyles, such as Internet addiction, alcohol and energy drinks consumption, and cigarette smoking (59, 60). Poor parental marital status was also one of the risk factors for SD, in line with previous research (25, 61). Stressful changes in the parents' relationship lead to disruptions in family processes, which, in turn, negatively impact the individual's physiologic functioning (62, 63), and physiologic changes may interfere with sleep (64, 65). The results also indicate the possible impacts of the sophomores on the development of SD among college students. The finding is similar with previous study (66), in which sophomores had more professional course loads compared with freshmen, and these stress may have affected their sleep quality to some extent.

Third, college students in the "mild SD" and "high SD" profile report greater depressive symptoms and PLEs in comparison to those in the no SD profile. A great volume of literature has consistently asserted that SD as a risk factor for depressive symptoms and PLEs (28, 67, 68). Recent evidence has also suggested that college students with SD are prone to maladaptive emotion regulation (69) and impaired social functioning (70), resulting in the development of depressive symptoms and PLEs. Additionally, our study also found SD negatively associated with resilience. Studies in children have reported that greater SD reduced resilience (71). Another longitudinal study also found that higher sleep rhythmicity and fewer SD in early age predicted higher behavioral control in adolescence, which, in turn, predicted resilience in young adulthood (72).

Accordingly, therapeutic interventions targeting SD may benefit from a tailored approach that takes individual symptom patterns of SD into great consideration. For example, college students in profile 1 (high SD) have poor sleep quality and more adverse psychological outcomes, therefore require prompt clinical treatment to help alleviate their sleep disorders. Meanwhile, although college students in profile 1 (mild SD), who did not have particularly severe SD related symptoms, were still at higher risk for mental health problems relative to those in the no SD profile. Therefore, it is necessary to optimize the sleep habits of these students and improve their sleep quality. Several interventions can be carried out (e.g., cognitive behavioral therapy, mindfulness and hypnotherapy (73)) to improve sleep quality for college students in the mild SD and high SD profile. Also, influential factors should also be taken into consideration for effective psychosocial intervention for college students. Some students, especially those with male gender, sophomores and poor parental marital status, exhibit moderate or high SD. Thus, the need for individualized intervention with these students is indicated.

Limitations

Despite all the relevant findings, several limitations of the current study should be noted. First, measures of SD, depressive symptom, PLEs, and other psychological factors relied on self-report questionnaires, which might be influenced by reporting bias caused by recollection inaccuracy and individuals' own psychiatric states. Second, the data were collected in the Shanxi Province of China, which is uncertain whether the findings could be generalized to all college students to other regions of China. Thus, future studies would benefit from increasing the sampling range and sample size. Finally, this was a cross-sectional study, which limits the ability to make causal inference. In clinical practice, SD and mental health may do form a bidirectional relationships (74–76). Therefore, future research is necessary to design longitudinal studies to further explore the effects of different SD subtypes on mental health outcomes.

Conclusion

These findings indicate that SD in Chinese college students has obvious classification characteristics. We identified three profiles of SD in college students. Furthermore, we suggest that education or clinical workers should pay particular attention to college students classified into the mild SD and high SD profile and especially male college students, sophomores and those with poor parental marital status.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committees of South China Normal University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

DW: conceptualization. CC and DW: methodology, formal analysis, and writing—original draft. ZH, BX, and JS: data curation. BX and DW: writing–review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The influence of sleep on job satisfaction: examining a serial mediation model of psychological capital and burnout

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Introduction: This study draws on the conservation of resources theory to investigate whether the loss of sleep can trigger the loss of additional resources that are necessary for work.

Methods: Using cross-sectional design of 322 call center employees working at a government-owned public bank in South Korea, we test the study hypotheses using regression and bootstrapping indirect effects analyses.

Results: The results of analyses show that insufficient sleep increases employee burnout and that psychological capital mediates this relationship. We also find that insufficient sleep decreases job satisfaction via a serial mediation model such that insufficient sleep reduces psychological capital, which in turn increases burnout, and ultimately results in lower job satisfaction.

Discussion: The findings reinforce the previous assessment that although sleep is a non-work factor, its impact spills over to the workplace. Theoretically, this study goes beyond direct effect to uncover the underlying or mediating mechanisms that account for the impact of the sleep-burnout relationship and the sleep-job satisfaction relationship. For managers, the results highlight the significance of sleep to employees' overall health and well-being and thus underscore the need to foster a work culture that recognizes and prioritizes employee sleep needs.

KEYWORDS

sleep, psychological capital, burnout, job satisfaction, serial mediation

1. Introduction

Getting a good night's sleep is necessary for rejuvenation, performing daily activities, and general well-being. Since the dawn of civilization, scholars in the fields of art, poetry, philosophy, and mythology have been intrigued by the concept of sleep as evidenced in the early works of art, literature, and medicine (1). The 2019 Global Sleep Survey conducted by Phillips revealed that although people recognize the importance of sleep for their overall health, only 10% reported that they sleep extremely well. Another 40% of adults reported that their sleep had worsened over the previous 5 years (2). Consistent with this global trend, studies show a significant decline in the sleep duration of South Korean adults (3). In fact, sleep problems seem to be more pervasive in developed countries (4). For instance, data from a recent Gallup survey indicate that about one in three American adults do not get the recommended amount of sleep (5). In the UK, a third of Britons report getting less than 7 h of sleep per night (6). Similarly, national studies have found a prevalence of sleep problems among Japanese (7) and Swedish adults (8). The global decline in sleep has in part fueled the recent interest in sleep research by organizational scholars, which has provided insight into the effects of sleep within the workplace (9). A meta-analysis on sleep revealed that sleep impacts physical and psychological health, physiological outcomes that affect the ability to process and recognize emotional experiences, attitudinal consequences including organizational commitment and engagement, as well as performance outcomes that include safety behavior, task performance, and contextual performance such as organizational citizenship behavior (9).

Sleep does not merely denote the absence of wakefulness or suspension of the senses but rather it results from physiological processes including the activation of some neurons in certain brain areas and a passive withdrawal of sensorial stimulation from the brain (1). Several factors influence the optimal sleep requirement of each individual. For instance, some researchers have argued that women and older adults may require more sleep time (1) or have difficulty in achieving restorative sleep (10). Prior reviews (11, 12) have identified characteristics of the work environment including workload, work schedules, role conflict, role ambiguity, occupational stressors, interpersonal conflict, perceived control, and situational constraints as organizational antecedents of employees' sleep time and quality. Accordingly, subjective perceptions of meeting one's optimum sleep needs have been an important focus for researchers since this may capture the multi-faceted nature of individual sleep needs more comprehensively. This focus is reflected in empirical sleep research where sleep has often been operationalized in terms of the number of hours spent sleeping (sleep quantity) or difficulty in sleeping, staying asleep, or feeling rested after sleep (sleep quality) (9). This study focused on the subjective perceptions of having insufficient sleep time.

Given that sleep is an invaluable resource, we use the conservation of resources (COR) (13, 14), a resource-based theory to ground our research model. The basic tenet of the COR theory suggests that people are motivated to retain, build, and protect resources. Resources are defined as personal attributes, conditions, objects, or energies that are valuable to an individual or that serve as a means for obtaining these factors (15). The potential or actual loss of resources is inherently threatening and can be a source of stress for individuals. Individuals use many strategies to deal with stressful situations or possible resource loss. These include developing and investing in resource surpluses to offset future resource loss, replacing the lost resources directly, symbolically, or indirectly with other resources, or reevaluating the value of lost resources to lessen their impact. Unfortunately, these approaches for dealing with resource loss cannot be applied to sleep because sleep has no alternative. We predict that individuals with insufficient sleep can become vulnerable to additional resource loss in what COR theory describes as a "loss spiral" (13, 14). Thus, this research aimed to answer an important question: can the loss of sleep be stressful enough to trigger the depletion of additional resources? Figure 1 depicts the conceptual model.

Although the extant literature has examined the link between sleep and multiple attitudinal and performance outcomes, including burnout, job satisfaction, safety compliance, and workplace-related health (16–19) the mediating mechanisms that account for these relationships have not received equal attention. Therefore, we examined the association between insufficient sleep and employee burnout. Subsequently, we proposed psychological capital (PsyCap), a psychological resource as a possible mediating factor. PsyCap describes an individual's psychological state of development and integrates four positive psychological resources: efficacy, optimism, hope, and resiliency (20). Previous research suggests that a person's PsyCap is susceptible to change through external influence (21). We also explored the link between insufficient sleep and job satisfaction. Scott and Judge (22) found that employees who reported having a poor night's sleep also indicated low job satisfaction. Particularly, they found this relationship to be partially mediated by emotions specifically hostility, joviality, and attentiveness. While their research revealed the affective mediators in the relationship between sleep and job satisfaction, little is known about other psychological processes or mediators that may explain this link. We addressed this literature gap by using a serial mediation model to examine the relationship between sleep and job satisfaction.

In sum, this study contributes to the literature by uncovering the mediating mechanisms that explain the insufficient sleep-burnout link and the insufficient sleep-job satisfaction link. In doing so, our study responds to calls for researchers to further explore the processes underlying the sleep-work outcome relationships (23). Using survey data and a serial mediation research model, these authors concluded that although sleep is a non-work factor, it has a spill-over effect from home to work.

2. Theoretical background and hypotheses

2.1. Insufficient sleep and burnout

When employees do not get sufficient sleep, the consequences are felt in the workplace. Indeed, Ghumman and Barnes (24) found that when employees have a poor night of sleep, they lack the self-control necessary to restrict the explicit expression of their stereotypes and prejudice. Additionally, burnout is theorized an outcome of poor sleep

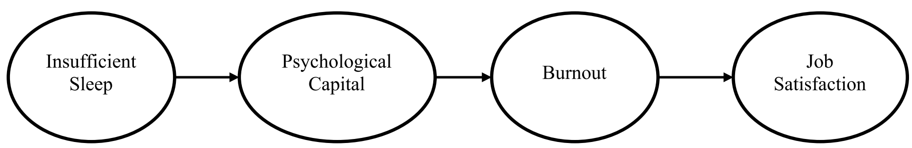

FIGURE 1
Hypothesized research model.

(19). Burnout is defined as a psychological syndrome in response to interpersonal stressors (25). It encompasses three main dimensions: emotional exhaustion, depersonalization or detachment from the job, and a reduced sense of personal accomplishment (25). Emotional exhaustion refers to fatigue resulting from the depletion of one's physical and emotional resources. Depersonalization reflects an indifferent or detached attitude toward work, while a reduced sense of personal accomplishment represents a lack of self-efficacy and achievement about social and non-social job accomplishments (26). However, it has been argued that reduced self-efficacy is not a core element of burnout but may rather be a consequence of burnout instead (27). Following this trend, our study focused on emotional exhaustion and depersonalization when referring to burnout.

Actual or even potential resource loss is powerful enough to cause psychological distress (including burnout) (28). Hobfoll (29) presented a comprehensive set of 74 resources validated in many Western contexts. They included the following: status, hope, optimism, stable employment, adequate income, and time for adequate sleep among others. The resource investment principle of the COR theory asserts that individuals must invest in resources as a buffer against the possibility of resource loss, to recover from loss, and to gain further resources (14). Unfortunately, unlike most resources, sleep is not a resource that can be replaced or compensated for with other resources. Thus, when an individual loses sleep, the potential consequences become especially significant. Similarly, Toker and Biron (30) explained that ineffective coping behavior to replenish resources may lead to further depletion of resources.

We theorize that employees with insufficient sleep are likely to experience burnout, specifically, emotional exhaustion and disengagement at work. Indeed, sleep complaints and indications of impaired sleep have been reported by individuals who experience burnout (31). Previous research suggests that poor sleep impacts emotional fatigue (22). When employees are sleepy, they are less cooperative, helpful, and courteous (towards others) because their ability to use information and discern emotions declines (12). Following previous assertions that sleep may be an indicator of employee stress levels (32), and empirical studies showing sleep as a predictor of burnout (19, 33), we posit the following:

> *H1*: insufficient sleep will be related to burnout, such that employees with insufficient sleep will experience higher burnout compared to those with sufficient sleep.

2.2. The mediating role of psychological capital

Burnout has been described as a response to stress. Thus, it is likely that PsyCap may be a mediating mechanism that explains the association between sleep and burnout. PsyCap is a higher-order construct that describes an individual's psychological state of development and integrates four positive psychological resources: (1) having the confidence to successfully tackle challenging tasks (efficacy), (2) maintaining a positive outlook about current and future success (optimism), (3) persevering towards the attainment of goals, and redirecting paths when required for success (hope), and (4) manifesting the ability to sustain and bounce back even stronger to achieve success in the face of adversity (resiliency) (20). PsyCap is a critical resource that employees use to cope with or minimize the symptoms of stress (32). PsyCap is referred to as a state-like psychological resource in that it is susceptible to external influence and development. In fact, a distinguishing characteristic of PsyCap is its malleability and ability to change over time (21). Emerging sleep literature has found that poor sleep may contribute to the depletion of a person's psychological resources. For example, Barnes and colleagues (22) asserted that because an individual's self-regulatory resources are depleted daily, and replenished during sleep, poor sleep results in ego depletion.

Extant literature suggests a relationship between sleep and the four positive psychological resources (i.e., hope, efficacy, resilience, and optimism) that make up the construct. For instance, Barnes (34) reported that sleep is necessary to be able to direct and focus attention on specific tasks. Thus, insufficient sleep may have an impact on the agency and determination to achieve goals that the motivational state of hope engenders. Additionally, prior research found a correlation between sleep and self-efficacy (35). Specifically, the researchers found that study participants with sleep problems reported lower self-efficacy than individuals without such problems. Similarly, it has been suggested that unhealthy sleep habits could hinder resilience to both current and future adversities and stressors (36). Moreover, results of a lab experiment by Haack and Mullington (37) concluded that insufficient sleep may cause a decline in psychosocial functioning and positive outlook, ultimately affecting optimism. Empirically, sleep has been linked to PsyCap (38).

Research suggests that individuals with high PsyCap possess extra resources that enable them to mentally reframe and reinterpret situations more positively (39), so that when challenged with setbacks and obstacles, they can persevere and not give up. Following the COR theory, which suggests that people employ valued resources to respond to stress and to build a reservoir for future needs, the stress literature has identified PsyCap as a mediator between stressful contexts and burnout. PsyCap has been found to be a mediator between occupational stress and burnout (40), between workaholism and burnout (41), and between workplace bullying and burnout (42). Following theoretical and empirical literature, we hypothesized that insufficient sleep would positively influence burnout through PsyCap.

> *H2*: psychological capital will mediate the relationship between insufficient sleep and burnout, such that insufficient sleep depletes psychological capital, and the decrease of psychological capital leads to higher burnout.

2.3. Insufficient sleep and job satisfaction

Locke (43) offered one definition of job satisfaction as "…a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences" (p. 1304). Saari and Judge (44) contended that perceptions of emotion and cognition are implicit in Locke's definition of job satisfaction. That is, people's thoughts and feelings factor into the overall evaluation of their jobs. Lab experiments demonstrate that sleep loss results in glucose hypometabolism (45), leading to a decrease in the deactivation of the whole brain particularly in the prefrontal cortices, causing deficits in cognitive functioning

(12). Scott and Judge (22) found that poor quality of sleep accounted for within-individual variances in multiple emotions, including hostility and joviality. Other researchers have also shown that poor quality of sleep impairs the ability to recognize and properly process emotions (46).

When individuals experience resource loss, their vulnerability to further resource loss increases (13). Ritter and colleagues (47) suggested that job satisfaction is an affective resource, which can influence a person's experience of future stressors. They argue, for instance, that "the accumulation of a resource, such as job satisfaction, may enhance one's ability to seek and perceive role clarity, such that subsequent assessments of role clarity will be higher after experiencing high levels of job satisfaction" (p. 1658). Therefore, it is quite likely that employees who report insufficient sleep will also report lower job satisfaction. Consistent with this argument, a study found a positive association between sleep and job satisfaction, and satisfaction subsequently mediated the relationship between sleep and organizational citizenship behavior directed toward both peers and the organization (16).

> *H3*: insufficient sleep will be related to job satisfaction, such that employees with insufficient sleep will experience lower job satisfaction compared to those with sufficient sleep.

2.4. Sequential mediating role of psychological capital and burnout between insufficient sleep and job satisfaction

As noted previously, individuals often try to employ other resources to offset the net loss. Losing resources is stressful. Thus, when an individual lacks the resources to offset resource loss, "loss spirals" may ensue because people become more vulnerable to additional resource loss (13, 14). This concept aligns with the resource caravan principle of the COR theory, which posits that resources do not exist in isolation but instead travel in caravans or packs (28). Hobfoll and colleagues (13) supported this by pointing to the high correlation often found among variables such as self-efficacy, self-esteem, and optimism, and explaining that these factors are likely to develop from a common supportive environment. In a similar vein, we expect that insufficient sleep would lead to the depletion of additional resources in the workplace. In a recent review (9), several studies demonstrated that poor sleep had multiple negative consequences in the workplace concerning employees' health, cognition, emotions, attitudes, and behaviors. When employees do not meet their sleep needs, they experience a depletion of their psychological resources. The diminishing of psychological resources impairs the employees' ability to effectively deal with work stress, thereby leading to burnout (48). The depletion of psychological resources along with the resultant burnout is likely to induce lower job satisfaction. Empirical evidence that supports this view includes research that found a significant relationship between sleep and PsyCap (38), between PsyCap and burnout (32), and between burnout and job satisfaction (49).

These findings together with the prior hypotheses suggest a serial mediation model or relationship. A serial mediation model describes a model with multiple mediators in which mediators causally affect each other or, more generally, the variables in the model affect each other in a causal sequence. Using a serial mediation model, prior research found that supervisors' sleep quality depleted their ego, which then induced abusive supervision and finally impacted the unit's work engagement (23). Specific to our study, we integrated all the variables in our model and predicted a serial relationship in which the relationship between sleep and job satisfaction is transmitted first through PsyCap, and subsequently, through burnout.

> *H4*: psychological capital and burnout will serially mediate the relationship between insufficient sleep and job satisfaction, such that insufficient sleep decreases psychological capital, which in turn increases burnout, and the increased burnout reduces job satisfaction.

3. Methods

3.1. Sample and procedure

To test the study hypotheses, cross-sectional survey data were collected from employees of a call center, a stressful work environment that requires high service quality and customer satisfaction without compromising response time (50). Employees in call centers are required to display prescribed emotions that are not always congruent with the emotions they are experiencing. This emotional conflict or dissonance along with the lack of control associated with the work environment, makes burnout a psychological syndrome characteristic of call centers (51). We reached out to and obtained permission from the managers of a call center for a government-owned public bank situated in Seoul, South Korea. The center is comprised of multiple teams providing varied services. Approximately 44% of the sample comprised individuals in active roles who handle outbound calls and are responsible for marketing the bank's financial products and services. 36% of them in more passive roles take care of inbound calls and provide general and professional consultation to clients. Ten percent of the sample were part of an administrative team that monitors call quality and provides training and education for employees as required. The rest is comprised of a management team that oversees the center. All employees were Korean nationals.

Although all the measures were originally developed in English, this study used the Korean language throughout the survey. Following recommendations by Brislin (52), we performed standard translation and back-translation for study variables to ensure measurement equivalence. Before data collection, management announced the research to employees. Employees were required to sign an informed consent form to participate. The survey was completed through the on-site administration of a paper-and-pencil questionnaire. Each participant was given a questionnaire package in a sealed envelope to ensure anonymity. The completed surveys were sealed and returned to a designated spot. Through cooperation with top management of the call center, 400 questionnaires were distributed to the employees, and all distributed surveys were returned to researchers directly. After data cleaning to delete the data of participants with missing values, a sample size of 322 remained. The data collection process is presented in Appendix A. The participants were predominantly female (89.75%),

TABLE 1 Demographic characteristics of sample.

Variable	Percent
Age (in years)	
20–24	2.17%
25–29	9.01%
30–34	17.08%
35–39	12.11%
40–44	16.15%
45–49	13.66%
>50	29.82%
Gender	
Female = 1	89.75%
Male = 2	10.25%
Organizational tenure (in years)	
<0.25	20.50%
1	19.25%
2–4	22.05%
5–7	13.98%
8–10	15.22%
11–13	4.35%
>14	4.65%
Position	
Employee	81.05%
Manager	18.95%

which is comparable to gender ratios in prior call center studies (53), and their ages ranged from 20 to over 50 years (please see Table 1).

3.2. Measures

This study analyzed all the variables at the individual level. Unless otherwise indicated, the study variables were measured with a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). We also assessed internal reliabilities using Cronbach's alpha values.

3.2.1. Insufficient sleep

Subjective measures of sleep correlate well with objective measures of sleep (54) and are consistent with prior sleep studies (55, 56). Additionally, it has been argued that, unlike many variables in organizational research, a single-item measure for sleep proves beneficial for measuring sleep and has been found to be substantially correlated with health, affective, and attitudinal outcomes (9). Thus, we assessed participants' sleep using a single-item: "I evaluate my sleep time as insufficient."

3.2.2. Psychological capital

Employees' PsyCap was assessed using the 12-item PsyCap Questionnaire (PCQ) (57). The PCQ-12 comprises four sub-dimensions: self-efficacy (three items), hope (four items), resilience (three items), and optimism (two items). Sample items include, "I feel confident in representing my work area in meeting with management" and "I feel confident contributing to discussions about the company's strategy" for efficacy, "If I should find myself in a jam at work, I could think of many ways to get out of it" and "At this time, I am meeting the work goals that I have set for myself" for hope, "I usually take stressful things at work in stride" and "I can get through difficult times at work because I've experienced difficulty before" for resilience and "I always look on the bright side of things regarding my job" and "I'm optimistic about what will happen to me in the future as it pertains to work" for optimism. The internal consistency reliability is 0.91.

3.2.3. Burnout

The seven items of the burnout scale from Kalliath and colleagues (58) were used to measure burnout. The scale contains two sub-dimensions: emotional exhaustion (five items) and depersonalization (two items). Sample items include, "I feel frustrated by my job," and "I feel fatigued when I get up in the morning and have to face another day on the job" for emotional exhaustion, and "I worry that this job is hardening me emotionally" and "I've become more callous towards people since I took this job" for depersonalization. The internal consistency reliability is 0.91.

3.2.4. Job satisfaction

Three items were used to measure job satisfaction (59). Sample items are "Generally speaking, I am satisfied with this job" and "I frequently think of quitting this job (Reverse-coded). The internal consistency reliability is 0.92.

3.2.5. Control variables

Research suggested that gender and age have an impact on individual sleep needs (60). Thus, following previous research (61, 62), we controlled for demographic variables including age, gender, tenure, and position to parcel out their effects on the dependent variable, job satisfaction. Age was measured in intervals and coded as 1 for 20–24 years up to 7 for more than 50. Tenure was also coded as 1 for less than three months up to 7 for more than 14 years. Gender was dummy coded as 1 for female and 2 for male with position similarly coded as 1 for employee and 2 for manager (please see Table 1 for details).

3.3. Statistical analyses

Statistical analyses were performed using STATA 14.1 (63). We first calculated Cronbach's alpha to assess the internal reliability of the measures. The mean scores of the demographic variables, sleep, PsyCap, burnout, and job satisfaction, were computed for the Pearson correlational analyses. Because of the multiple measurement items in the hypothesized model, we used item parceling (64). Generally, parceling allows for fewer parameter estimates, the reduced sampling error for better estimates, a lower indicator-to-sample size ratio, and a lower likelihood of correlated residuals and dual-factor loadings (64). Specifically, the multidimensional constructs were parceled by averaging the individual items of each dimension to create four and two parceled indicators for PsyCap and burnout, respectively. We conducted Confirmatory Factor Analysis (CFA) to assess the construct validity of our measures. The comparative fit index (CFI), root mean square error of approximation (RMSEA), and

TABLE 2 Model fit statistics for measurement models.

Measurement model	χ^2	df	CFI	TLI	RMSEA	$\Delta\chi^2$	Δdf
Baseline (hypothesized) three factor model	38.54**	20	0.99	0.98	0.05		
Alternative 1 (two factor model)[a]	148.14***	22	0.93	0.88	0.13	109.60***	2
Alternative 2 (two factor model)[b]	170.70***	22	0.91	0.86	0.14	132.16***	2
Alternative 3 (two factor model)[c]	121.20***	22	0.94	0.91	0.12	82.66***	2
Alternative 4 (one factor model)[d]	237.69***	23	0.88	0.81	0.17	199.15***	3

[a]Two-factor model with psychological capital and job satisfaction on the same factor.
[b]Two-factor model with psychological capital and burnout on the same factor.
[c]Two-factor model with burnout and job satisfaction on the same factor.
[d]One-factor model with psychological capital, burnout, and job satisfaction on the same factor. $N = 322$. ** $p < 0.01$ and *** $p < 0.001$ (two-tailed test).

TABLE 3 Descriptive statistics and inter-correlations.

	Mean	SD	1	2	3	4	5	6	7	8
1. Age	4.91	1.82	–							
2. Gender	1.10	0.30	−0.29***	–						
3. Tenure	1.72	0.49	0.23***	−0.10	–					
4. Position	2.10	0.99	−0.22***	0.15**	0.23***	–				
5. Insufficient Sleep	3.30	1.48	−0.20***	0.05	−0.12*	0.06	–			
6. Psychological Capital	4.60	0.80	−0.05	0.03	0.07	0.01	−0.20***	(0.91)		
7. Burnout	4.05	1.15	−0.16**	0.07	−0.01	0.23***	0.25***	−0.27***	(0.91)	
8. Job satisfaction	4.41	1.26	0.04	−0.07	0.16**	0.08	−0.29***	0.60***	−0.46***	(0.92)

$N = 322$. Cronbach's alpha values are reported in parentheses on the diagonals. * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$ (two-tailed).

Tucker-Lewis Index (TLI) were used to evaluate the goodness of fit of the hypothesized research model using the stringent cut-off points of 0.95, 0.05, and 0.95, respectively. We set alternative models and performed the chi-square difference test to further verify the model. The direct effect hypotheses (H1 and H3) were tested with regression analyses using robust standard errors to mitigate concerns of non-normality of the data distribution (65). We conducted bootstrapping analysis using 10,000 bootstrapped samples, to test the indirect effect of the mediation (H2) and serial mediation (H4) hypotheses. We use $p < 0.05$ as the cut-off for model and path co-efficient significance tests.

4. Results

4.1. Model validity and common method bias checks

CFA was performed to examine the factor structure of the multi-item study variables. First, we estimated the hypothesized three-factor model. As presented in Table 2, the goodness of fit indicators met the cut-off points: $\chi^2 = 38.54$; df = 20, $p < 0.01$; χ^2/df = 1.93; CFI = 0.99; TLI = 0.98; RMSEA = 0.05 (66). The factor loadings for the variables of interest were above the 0.50 cut-off value (67) ranging from 0.63 to 0.89 at a statistically significant level ($p < 0.001$). Four alternative models were also tested. In the first alternative model, where PsyCap and job satisfaction were loaded on the same factor, the model fit the data significantly worse, CFI = 0.93; TLI = 0.88; RMSEA = 0.13. The fourth alternative model with all variables loaded on one also performed significantly poorly, CFI = 0.88; TLI = 0.81; RMSEA = 0.17. In sum, the results revealed that the hypothesized model is distinct from the alternative models and presents the best-fit indicators. To check convergent validity, average variance extracted (AVE) and composite reliability (CR) were calculated for each construct, and they satisfied the standard of being above 0.50 and 0.70, respectively (67). Further, the inter-construct correlation values were lower than the square root of the AVE, satisfying the criterion for discriminant validity (67).

Due to the cross-sectional nature of the data, common method bias (CMB) may be of concern. Thus, we performed Harman's one-factor analysis to rule out the possibility that the variance in the data largely stems from one factor. The results show that no single factor accounted for more than 29% of the covariance among the variables suggesting that CMB may not be a pervasive issue (68).

4.2. Descriptive statistics

The descriptive statistics and inter-correlations results are presented in Table 3. As expected, insufficient sleep correlated negatively with psychological capital ($r = -0.20$, $p < 0.001$) and negatively with job satisfaction ($r = -0.29$, $p < 0.001$). Psychological capital correlated negatively with burnout ($r = -0.27$, $p < 0.001$) and positively with job satisfaction ($r = 0.60$, $p < 0.001$). After conducting the regression analyses, the variance inflation factors of variables in the estimations were all below 10. Thus, we determined multicollinearity would not be high (69).

TABLE 4 Results of regression analyses and bootstrapped indirect effect test.

Main effects	Psychological capital (Model 1)	Burnout (Model 2)	Job satisfaction (Model 3)
Age	−0.04 (0.03)	−0.05 (0.04)	−0.01 (0.03)
Gender	0.02 (0.15)	0.04 (0.18)	−0.29 (0.17)
Tenure	0.02 (0.03)	0.00 (0.04)	0.06* (0.03)
Job level	0.05 (0.07)	0.34*** (0.08)	0.21* (0.08)
Insufficient sleep (IS)	−0.12** (0.03)	0.13** (0.04)	−0.09** (0.03)
Psychological capital (PC)		−0.36*** (0.09)	0.76*** (0.07)
Burnout (BO)			−0.37*** (0.06)
Job satisfaction (JS)			
F	3.70**	10.96***	53.10***
R^2	0.06	0.17	0.50
ΔR^2		0.11	0.33

Indirect effects	Estimate	Lower level	Upper level
IS → PC → BO	0.04	0.02	0.08
PC → BO → JS	0.16	0.09	0.25
IS → PC → BO → JS	−0.02	−0.03	−0.01

$N = 322$. Estimates for regression were calculated using robust standard errors reported in parentheses. The indirect effects estimate was tested for significance using 95% bias-corrected bootstrapped confidence intervals (10,000 times).
*$p < 0.05$, **$p < 0.01$ and ***$p < 0.001$ (two-tailed).

4.3. Hypotheses testing

4.3.1. Hypotheses testing of the direct effects

The results of the ordinary least squares regression analyses are presented in Table 4. Hypothesis 1 posited that employees who report insufficient sleep are more likely to experience burnout compared to those with sufficient sleep. Consistent with our prediction, the regression results show a significant positive relationship between insufficient sleep and burnout ($b = 0.13$ (0.04), $p < 0.01$, Model 2). Hypothesis 3 posited that employees with insufficient sleep are more likely to experience lower job satisfaction compared to those with sufficient sleep. The results provide support for the hypothesis ($b = -0.09$ (0.03), $p < 0.01$, Model 3).

4.3.2. Hypotheses testing of the indirect effects

Hypothesis 2 posited that PsyCap will mediate the relationship between insufficient sleep and burnout. To test this simple mediation, we performed a bootstrapping analysis using 10,000 bootstrapped samples. We utilized the 95% bias-corrected confidence interval (CI) for the indirect effect. The mediation coefficient was 0.04 with a CI that did not include zero [0.02, 0.08]. The final hypothesis predicted a serial mediation wherein insufficient sleep is related to job satisfaction via PsyCap and burnout sequentially. The indirect test with 10,000 bootstrapped samples produced a coefficient of-0.02 and the 95% CI also excluded zero [−0.03, −0.01]. Altogether, these results provide support for hypotheses 2 and 4.

5. Discussion

Sleep is an important non-work factor that affects work. Using a cross-sectional design, we investigated the relationship between sleep and workplace outcomes. The results supported all the study hypotheses. The theoretical and practical implications of the study results are discussed below.

5.1. Theoretical implications

To begin with, our study focused on individual subjective beliefs about meeting one's sleep needs. This choice aligns with the literature that suggests that the optimal sleep needs of each person vary by medical, genetic, behavioral, and environmental factors (70). Particularly, operationalization of sleep (9) has often centered around the number of hours slept, staying asleep, struggling to fall asleep, the number of mid-sleep awakenings throughout the night, or whether a person feels rested after waking up. Following recommendations by Litwiller and colleagues (9) about the benefits of a single-item measure of sleep, our use of insufficient sleep, measured by individual perception of the inability to meet one's sleep needs contributes to the sleep literature.

Most research on sleep within the organizational sciences has focused on the main effects of sleep (34). In recent meta-analytic research on the relationship between sleep and work (9), the researchers noted that due to the lack of primary data, it was impossible to test the mediating processes that explain the main effects of sleep. Of the extant studies that examine the role of mediators, a large majority have focused on information processing, emotion, and affect variables (12, 22) with a few on cognitive mediators (17). This research extends the sleep literature by investigating the explanatory mechanisms of sleep from a cognitive and attitudinal perspective. We find that PsyCap and burnout are processes that underlie some of the main effects of sleep and work.

Previous studies that examine the impact of sleep on burnout have focused largely on the direct effect as well as the bi-directional relationship between these two variables (19, 33). Using a cross-sectional dataset from a South Korean bank call center, the current study corroborated research that reported a positive relationship between insufficient sleep and burnout. In addition, the study presented and found support for PsyCap as a mediating variable that explains the relationship between these variables. While we did not present a hypothesis for the direct effect of sleep on PsyCap, the regression results support this link. This finding supports early empirical work (38) linking sleep to psychological capital.

This study further deepens our understanding of how sleep impacts job satisfaction. Prior research by Scott and Judge (22) suggested that the emotions of hostility, joviality, and attentiveness mediate the relationship between sleep and job satisfaction. The resource loss and resource caravan principle of the COR theory is used to unravel other mediating mechanisms that may contribute to this relationship. We posited that insufficient sleep may trigger additional losses and adopted a serial mediation model to explain the insufficient sleep-job satisfaction link. Specifically, our findings suggest that insufficient sleep is associated with the loss of further resources leading to the depletion of PsyCap. The decreased PsyCap increases employee burnout and finally, the increased burnout reduces job satisfaction. Overall, the significant effects of sleep loss on multiple workplace outcomes underscores the spill-over effects of sleep (16).

5.2. Practical implications

The study's findings make several contributions to practice. First, our results suggest that when employees are unable to adequately meet their sleep needs, it increases the likelihood of burnout and reduces job satisfaction. These findings align with prior studies that found that poor sleep impacts employees' mental state and attitudes at work (16, 24, 37). Thus, organizations need to cultivate a healthy sleep culture among employees (71). This can be achieved through education and training campaigns that encourage employees to prioritize their sleep needs. Employees should be introduced to the scientific evidence on sleep and its effects on employee well-being, performance, and productivity. Negative notions that glorify sleep as disposable and antithetical to success need to be dispelled. Through a top-down approach, managers and supervisors must be encouraged to model healthy sleep behaviors that trickle down to employees.

For call center managers, this would require investing in optimal scheduling processes and technologies (50) that are mindful of employees' sleep needs. This ensures that agents are not overstrained by unsustainable work shifts that are detrimental to their sleep patterns but also that the agents are well-rested and in the right frame of mind to deliver quality customer service to clients. Additionally, incorporating flexible scheduling that allows agents to change shifts or self-schedule within reason would be instrumental in minimizing burnout and improving job satisfaction in an industry notorious for high employee attrition and turnover rates.

Second, the advancement of communication technology has improved connectivity, providing flexibility to work from any place without being limited by proximity (72). On the other hand, technology has blurred the boundary between working and non-working hours and an increasing number of employees are bringing work home by responding to emails, texts, and other work correspondence. This issue was compounded by the COVID-19 pandemic as the fraction of the workforce working remotely increased significantly. While remote work has reduced commute time and should translate to more time for sleep, maintaining boundaries between professional and personal lives can be difficult with employees reporting more work hours as a result (73). Thus, organizations need to have clearly delineated boundaries by instituting stricter "off hours" and limiting communication at these times (23).

Third, managers may need to pay particular attention to the sleep needs of employees in the service sector. The attitude and behavior of these employees significantly influence customer perceptions of service quality (74). Additionally, dealing with customers can be quite stressful as employees are expected to exhibit emotional intelligence and maintain a positive attitude while addressing issues in a timely manner. Thus, managers must ensure that these employees are not overtasked with extended work hours that may significantly alter their sleep (71).

Fourth, the study showed that the influence of insufficient sleep on employee burnout operates via PsyCap. PsyCap is an important psychological resource with empirical research demonstrating its importance within the work context (40). In fact, many organizations when hiring look for employees with high PsyCap while others conduct training interventions and programs to develop the PsyCap of their employees (21). While these are important, our study suggests that sleep is another factor that managers should consider because poor sleep may have a negative impact on an individual's PsyCap.

5.3. Limitations and directions for future research

Although our research possesses several theoretical and practical implications for sleep research, it also has some limitations. For one, the study uses cross-sectional dataset. When the same participant responds to both the predictor and outcome variables, self-report bias may ensue and result in inflated covariance between the variables. Although the results of the Harman's one-factor analysis show that no single factor accounted for more than 29% of the covariance among the variables, there should be cautious interpretation of the results. The use of cross-sectional data also means that causal inferences cannot be established between the study variables.

As presented, this study starts from insufficient sleep and flows towards PsyCap, burnout, and job satisfaction. However, it is important to note that organizational and occupational stressors are predictors of poor sleep (9), suggesting that the predicted directional relationships may stem from stress. The possibility of reverse causality may exist among some of the variables. For instance, PsyCap may not only be an outcome of insufficient sleep but may also predict sleep. Future studies should conduct time-lagged and longitudinal research and employ network analysis to untangle the directional relationships. Experimental designs are also useful to establish causality between variables and to alleviate problems of endogeneity in research models (75). Thus, there is a need for experiment designed to examine the relationship between sleep and other work outcomes.

The distribution of variables including gender, organizational tenure, and position did not follow a normal distribution which is the reality in the field. For one, employees in the call center industry tend to be predominantly female (53) with a high turnover rate. In addition, the age distribution is reflective of the rapidly aging workforce in South Korea where older adults (50–64 years) make up about 37.5% of the working-age population (76). While we mitigated concerns of non-normality of the data distribution by conducting the regression analysis using robust standard errors, as they are less dependent on the normality assumption (65), non-normality of the data remains a limitation of the study.

Our measurement of sleep is static and does not capture the within-person variations in sleep. However, choices are made daily in allocating time towards sleep versus other activities such as work and family (77). Research must follow the current trend that uses the daily approach such as the diary studies or experience sampling method research design (23). The sleep variable was also measured with a single-item instrument which critics say is inadequate to capture complex concepts and for which internal reliability cannot be calculated (78). However, unlike many other topics, a single-item measure of sleep has been found to be substantially correlated to workplace outcomes, and thus much of the benefit of measuring sleep can be gained from such measures (9). In fact, several sleep studies use single item measure (56). Nonetheless, multi-item and objective measures of sleep may help to address some of the inconsistencies in the relationship of the sleep-work outcome.

There is also the need to consider multilevel research designs as well as potential boundary conditions of the relationships in the study. Individual differences or work environments may serve as potential moderators. Future research could also extend the sleep literature by examining the effects on other work outcomes and paying attention to the mediating mechanisms that explain such relationships.

6. Conclusion

While sleep did not play a significant role in traditional management or human resource literature (79, 80), in recent times, organizational scholars have been paying increasing attention to sleep. This research contributes to the extant literature by investigating the effects of insufficient sleep on workplace outcomes. Insufficient sleep was associated with burnout. This link was found to have been mediated by PsyCap. Insufficient sleep was also associated with job satisfaction, and this link was serially mediated first by PsyCap, followed by burnout. Using the COR theory, our findings suggest that as an irreplaceable resource, losing sleep may trigger additional loss of resources important for work. Despite the limitations, our research contributes to advancing the sleep literature.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

MO was the principal researcher and prepared the first draft of the article under the supervision of S-WK. SC added valuable theoretical and methodological insights based on his knowledge and expertise regarding the topic of this study. S-WK supervised the study and refined the draft into a publishable article. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix A

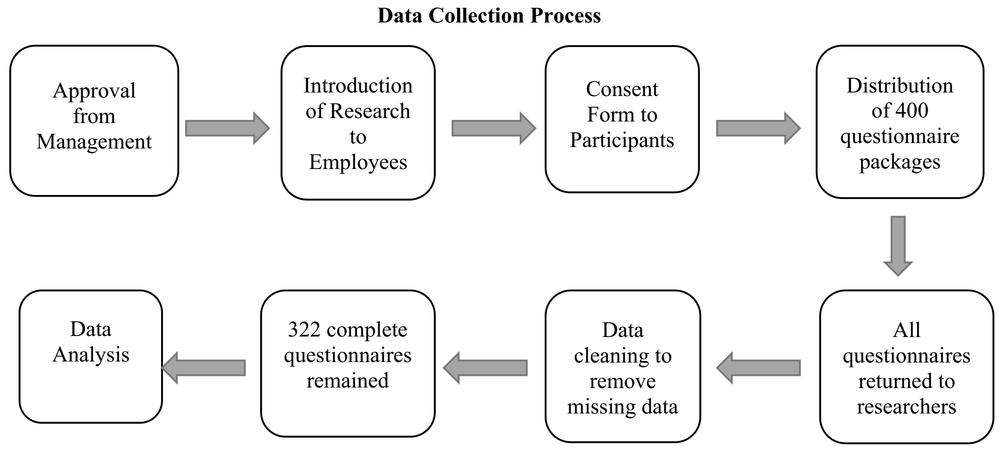

FIGURE A1
Data collection process.

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Insomnia and common mental disorder among patients with pre-existing chronic non-communicable diseases in southern Ethiopia: a survey during COVID-19 pandemic

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Background: COVID-19 has been causing significant mental health problems and other health-related issues. Despite the fact that COVID-19 has a significant impact on chronic disease patients, there is scant research on insomnia, common mental health disorders (CMD), and their associated factors among chronic disease patients.

Objective: The purpose of this study was to assess the prevalence of insomnia and common mental disorders (CMD) and their associated factors among patients with pre-existing chronic NCDs in Sidama, southern Ethiopia.

Methods: A multicenter cross-sectional study was undertaken between June 1 and September 1, 2021. The study included 633 participants. CMD and insomnia were assessed using a 20-item Self-Reported Questionnaire (SRQ-20) and a 7—item Insomnia Severity Index (ISI) scale, respectively. To describe the various variables, descriptive statistics were used. We performed multivariable logistic regression analysis to identify independent factors associated with CMD and insomnia. A value of $p < 0.05$ was considered statistically significant at a 95% confidence interval.

Results: The prevalence of insomnia and CMD was found to be 39.3% and 46.8%, respectively. Being merchant (AOR = 0.33; 95% CI = 0.13, 0.82), having a diagnosis of diabetes mellitus (AOR = 1.89; 95% CI = 1.04, 3.46), comorbid diagnosis (AOR = 3.96; 95% CI = 2.27, 6.89), low social support (poor (AOR = 3.37; 95% CI = 1.51, 7.57) and moderate (AOR = 3.13; 95% CI = 1.46, 6.69)), symptoms of insomnia (AOR = 12.08; 95% CI = 7.41, 19.72) and poor quality of life (QOL) (AOR = 1.67; 95% CI = 1.04, 2.72) were independent predictors of CMD. We also found out that, having cardiovascular disorders (CVDs) (AOR = 2.48; 95% CI = 1.18, 5.19), CMD (AOR = 12.09; 95% CI = 7.46, 19.61), and poor QOL (AOR = 2.04; 95% CI = 1.27, 3.26) were significantly associated with insomnia symptoms.

Conclusion: Our study suggests that substantially high prevalence of CMD and insomnia. Significant association between CMD and occupation, diagnosis, comorbidity, social support, insomnia, and QOL were found. We also revealed that having CVDs, CMD, and poor QOL were significantly associated with insomnia symptoms. Therefore, dealing with the mental health problems of patients with chronic NCDs is an essential component of public health intervention during the COVID-19 pandemic.

KEYWORDS

common mental disorder, insomnia, COVID-19, NCDs, Ethiopia

Introduction

Noncommunicable diseases (NCDs) are a group of chronic diseases that significantly increase morbidity and mortality in the community, including cardiovascular disease, stroke, cancer, diabetes, and mental health issues. NCDs have been exerting a significant global burden and considered as primary public health agenda for decades (1). NCDs account for three out of every 4 years lived with disability (YLD), whereas mental disorders contribute for nearly one-fourth of all YLD (2, 3). Mental illness and NCDs are commonly related by underlying individual, community, and social characteristics, and they commonly have a bidirectional relationship (4). Chronic NCDs, for instance, can lead to depression and anxiety, while mental disorders may result in decreased treatment seeking, poor adherence to treatment, and worse the outcome of NCD (5). Studies have discovered an association between chronic pain, long-term neurological conditions, or kidney illness, and depression, anxiety, and sleep problems (6–8).

COVID-19 also known as severe acute respiratory syndrome coronavirus-2 (SARS-CoV2), first appeared in the year 2020, causing a global health crisis and the collapse of several healthcare systems (9, 10). The ongoing COVID-19 outbreak overwhelmed the healthcare system, resulting in remarkable impact in the clinical management of patients with pre-existing chronic illness (11). Patients with pre-existing medical disorders such as diabetes mellitus (DM), hypertension, and cancers are considered to be among the most sensitive to COVID-19 infection, with higher severity and death (12). Patients with hypertension (6%), diabetes (7.3%) and cardiovascular disease (10.5%) had a higher case-fatality rate than the general population (2.3%) (13).

The COVID-19 pandemic is claimed to be the cause of a significant increase in the global prevalence of mental disorders such as sleep problems, anxiety and depression. In addition, WHO expressed concern regarding the influence of COVID-19 on an individual's mental health and psychosocial implications (14). Evidences showed that individuals' mental health were worsened during and after the COVID-19 pandemic, compared to before the pandemic (15, 16). Another study found that COVID-19 lockdown was linked to poor quality of sleep, sleep deprivation, and depressed symptoms (17). Moreover, a systematic review found that the COVID-19-affected population in many nations experienced somewhat high rates of insomnia, anxiety, depression, posttraumatic stress disorder, and psychological distress symptoms (18).

People may exhibit signs of depression, anxiety, and stress such loneliness, denial, insomnia, despair, boredom, and irritability, and they even face a greater chance of committing suicide (19). Isolation and loneliness, a lack of treatment options, and limited access to medical care, as well as widespread media coverage of COVID-19 infection's high infectivity, mortality, and diseases predisposing to an adverse course, all contribute to a significant psychological burden that leads to distress and sleep disturbances (20, 21).

Insomnia is described as subjective complaints about difficulty of falling asleep, nocturnal awakenings, early morning awakening, or non-refreshing sleep (22). Insomnia is one of the most common sleep related disorder, affecting 5–19% of people globally (23, 24). According to Budhiraja and colleagues, one-fourth (27.3%) of people with chronic obstructive lung disease had sleep problems (25). One of the most prevalent issues during the pandemic is sleep disturbance. According to a recent systematic review and meta-analysis (SRMA) study, patients with COVID-19 (57%) had the highest pooled prevalence of insomnia, followed by healthcare professionals (31%), and the general population (18%) (26). The pooled prevalence of insomnia in the Chinese population was 39.1%, according to a recent systematic review (27). A similar review indicated that the prevalence of insomnia in Africa during the pandemic were found to be 28.1%, with higher prevalence in North Africa than Sub-Saharan Africa (31% *Vs* 24%) (28).

A study was conducted during the initial period of COVID-19 outbreak in China, and it indicated that 8.1% had moderate to severe level of stress, 16.5% had moderate to severe symptoms of depression, and 28.8% had moderate to severe symptoms of anxiety (29). A national survey found that distress was highly prevalent in the general population, with rates of 35, 60, and 45% in China, Iran, and the United States, respectively (30).

Furthermore, sleep disturbances were associated with higher levels of mental distress (26). Sleep is essential for both mental and physical well-being, and it can even enhance immunity and resistance to infections, not to mention the different metabolic, autonomic, and inflammatory systems that are impacted by sleep deprivation (31, 32). Insomnia is becoming more often considered as a distinct and comorbid disorder that requires sleep-focused therapy, despite the fact that sleep disturbance can be an indication of psychological problems (33). In addition to resulting in distress, insomnia initiates and/or worsens other mental health problems, contributes to stress and disability when associated with mental disorders, and frequently remains after other symptoms of mental disorders have subsided. This could be because lack of sleep sensitizes the stress system even more, resulting in more stressful impressions of life events as well as diminished resilience and stress recovery (34–39).

It has been established that the COVID-19 pandemic significantly affects the development of the illness and survival of NCD patients. As a result, worries regarding the mental health of NCD patients have increased. Comorbid anxiety and depression make it difficult for patients to take their medications, which decreases therapeutic safety and efficacy and raises the risk of disability and death. Comorbid mental problems, however, are frequently ignored and sometimes not adequately treated (40). Despite the fact that COVID-19 has a significant impact on chronic disease patients, there is scant research on insomnia, CMD, and their associated factors among chronic disease patients. We hypothesized that COVID-19 has increased the risk of developing insomnia and mental disorders in patients with pre-existing chronic medical illnesses. As a result, the purpose of this study was to examine the prevalence of insomnia and CMD of patients with pre-existing common chronic medical conditions throughout the COVID-19 pandemic times, as well as the factors that contributed to them. The research will provide evidence to policymakers, program planners, and health care practitioners to help them make better decisions, as well as be valuable for evidence-based interventions in treatment of common mental health concerns during a future pandemic.

Materials and methods

Study design, area and period

We conducted a cross-sectional study at four hospitals in Sidama National Regional State, southern Ethiopia, between June 1 and September 1, 2021 [Hawassa university comprehensive specialized hospital (HUCSH), Adare general hospital (AGH), Yirgalem general hospital (YGH), and Leku Primary hospital (LPH)]. The Hawassa University comprehensive specialized hospital, with about 500 beds in southern Ethiopia, serves a population of over 18 million in the Sidama region and surrounding regions of southern Ethiopia, Oromia and Somalia. It is the only specialized hospital in the region. It was provided inpatient services for COVID-19 patients and isolation center in the region and surroundings. Yirgalem General Hospital is found in Yirgalem town and it is one of the General Hospitals in Sidama region serving about 4 million people in the region and nearby. Adare general hospital is located in Hawassa city and serves for communities from Hawassa and nearby cities. Leku primary hospital is one of the primary hospitals found in Sidama region located around 25 kilo meter away from Hawassa city.

Study participants

In this study we have included patients with chronic NCDs such as diabetes, hypertension, chronic cardiovascular diseases, respiratory diseases such as asthma, and others who had regular follow-up visit at the selected hospitals. Individuals with pre-existing chronic medical illnesses receiving follow-up care in the outpatient departments (OPDs) of the four hospitals were contacted and requested to take part in the study if they met the following criteria: (I) patients above the age of 18 with confirmed chronic NCDs; (II) patients with stable clinical condition and able to understand the objective of the survey; and (III) patients with no known serious mental or neurocognitive problems. Patients with pre-existing chronic NCDs who were admitted to the emergency or inpatient units for any reason were not included in the study. The required sample size was estimated using single population proportion formula: $(Z_{\alpha/2})^2 \times p \times (1-p)/d^2$, where n is the sample size, z is the standard normal score set at 1.96, d is the desired degree of accuracy and p is the estimated proportion of the target population. By taking $p = 50\%$ (because there were no similar study in the area and to get adequate or maximum sample size), $Z\alpha/2 = 1.96$ and $d = 5\%$, the computed sample size was 384; and by taking 10% non-response rate, the total sample size computed was 422. Using design effect 1.5, our final sample size was estimated to be 633 (we used level of hospitals as a cluster, i.e., primary, general and specialized hospital). Sample size was proportionally allocated to each hospital based on the patient flow of the hospitals.

Data collection methods

A standardized structured interviewer administered questionnaire was used to collect data. The questionnaire included items or scales that assess patients' socio-demographic characteristics, clinical characteristics, social support, common mental disorders (CMD), insomnia, and quality of life (QOL). The questionnaire was written in English before being translated into Amharic, the local language. The questionnaire was translated from English into Amharic by native speakers of the language who are fluent in English, then back-translated into English by other translators to guarantee consistency. Finally, the Amharic version of the questionnaire was used to collect data.

Data were collected by nurses who had received 2 days of training on data collection processes and assessment tools. A pretest was performed on 5% of the sample to discover potential difficulties with the data collection procedures, as well as to assess the consistency of the questionnaires and the competency of the data collectors. The investigators reviewed each questionnaire for completeness on a regular basis during data collection.

Data collection tools

Social support

Social support of patients with pre-existing chronic NCDs was measured using the three-item Oslo social support scale (OSSS). The scale has a score of minimum 3 and maximum 14. It has three categories. A score of 3–8, 9–11, and 12–14 indicates poor, moderate, and strong social support, respectively (41).

Common mental disorder

The World Health Organization developed the SRQ-20, a 20-item screening tool for common mental disorders (42). There are only binary (yes/no) questions, where "1" denotes the presence of a symptom and "0" denotes its absence. The SRQ-20 item questions categorize depression, anxiety, and psychosomatic issues as CMD (43). The SRQ-20's validity, reliability, and cut-off differ according to the population (culture, language, setting, and gender) in various circumstances (43–46). The SRQ-20 exhibited good internal reliability (= 0.78) and an ideal cut-off score of 5/6, with a sensitivity of 78.6% and a specificity of 81.5% (47). The SRQ-20 measure demonstrated good internal consistency (Cronbach's $\alpha = 0.89$) in our study.

Insomnia

The nature, intensity, and effects of insomnia are evaluated using the ISI, a seven-item self-assessment questionnaire (48). The following elements are taken into account: the severity of difficulty of falling asleep, staying asleep, and waking up early in the morning; sleep dissatisfaction; how sleep issues affect daytime functioning; how others perceive the difficulty of sleep; and the distress caused by recent difficulty of sleep. Each item is rated on a 5-point Likert scale (0 = no problem; 4 = very severe difficulty, for example), with the total score ranging from 0 to 28. The overall score is divided into four categories: no insomnia (0–7), sub-threshold insomnia (8–14), moderate insomnia (15–21), and severe insomnia (22–28). A higher score illustrates severe insomnia (48–50). In the present study, the ISI measure showed very high internal consistency (Cronbach's alpha = 0.96).

Quality of life

To analyze the impact of the COVID-19 pandemic on QOL, we used an adapted version of 12 items (51), from the WHOQOL-BREF scale (52, 53). The 12-item WHOQOL-BREF scale that was modified had a minimum score of 12 and a maximum score of 60. Due to the detrimental impacts of the COVID-19 pandemic, low scores indicate a lower QOL. In a prior study, the modified WHOQOL-BRIEF (12-items) showed acceptable internal consistency (Cronbach's alpha = 0.81) (51). The 12-item WHOQOL-BRIEF that was used in our study had good internal consistency (Cronbach's alpha = 0.82).

Data analysis

For analysis, the data collected were entered into Epi-data version 3.1 and exported to SPSS version 24 for Windows. Various variables were described using descriptive statistics such as frequency, percentage, mean, standard deviation, and median. Binary and multivariable logistic regression were used to identify independent factors of insomnia and CMD. The Hosmer-Lemeshow test was used to assess model fitness. At 95% confidence interval (CI), p-values of <0.05 were considered as statistically significant.

Results

Socio-demographic characteristics of study participants

A total of 633 patients with pre-existing chronic NCDs were involved in this study. Majority were male 357(56.4%), 410(64.8%) participants were married, 352(55.6%) were Protestant by religion and about one-fourth 175(27.6%) were illiterate. Of the total participants, about one-fifth 144(22.7%) were farmer by occupation and majority 353(55.8%) were urban residents. The mean age of the respondents was 46.49 ± 17.71 as described in Table 1.

Clinical characteristics of study participants

About half 336(53.1%) of the participants were diagnosed with diabetes mellitus followed by hypertension 111(17.5%) and nearly one-third 200(31.6%) participants had comorbid diagnosis. Majority 364(57.5%) of the participants were ill for ≤5 years, 61(9.6%) and 49(7.7%) participants were using alcohol and khat in the past three months, respectively. Among the total participants, more than one-third 224(35.4%) and about half 332(52.4%) had poor and moderate social support, respectively. Moreover, 293(46.3%) of participants were poor QOL (Table 2).

TABLE 1 Socio-demographic characteristics of study participants at Sidama National Regional State, southern Ethiopia, 2021 (n = 633).

Variable	Categories	Frequency	Percentage (%)
Age (mean ± SD)	46.49 ± 17.71		
Sex	Male	357	56.4
	Female	276	43.6
Marital status	Single	135	21.3
	Married	410	64.8
	Divorced	36	5.7
	Widowed	52	8.2
Religion	Protestant	352	55.6
	Orthodox	164	25.9
	Muslim	103	16.3
	Others	14	2.2
Educational status	Illiterate	175	27.6
	Primary	162	25.6
	Secondary	131	20.7
	College and above	165	26.1
Occupation	Gov't employee	121	19.1
	Private employee	67	10.6
	Merchant	90	14.2
	Student	68	10.7
	House wife	102	16.1
	Farmer	144	22.7
	Jobless	21	3.3
	Other	20	3.2
Place of residence	Rural	280	44.2
	Urban	353	55.8

Prevalence of insomnia and CMD

The prevalence of insomnia and CMD were found to be 39.3% (95% CI = 35.3–43.3%) and 46.8% (95% CI = 42.8–50.6%), respectively as shown in Figure 1.

Independent predictors of CMD and insomnia

In a multivariable logistic regression model, occupation, diagnosis, comorbid diagnosis, social support, insomnia, and quality of life were all significantly associated with CMD. When compared to government employees, being a merchant is 66% (AOR = 0.33; 95%

CI = 0.13, 0.82) less likely to develop CMD. Regression analyses revealed that having a diagnosis of diabetes mellitus (AOR = 1.89; 95% CI = 1.04, 3.46) and a comorbid diagnosis (AOR = 3.96; 95% CI = 2.27, 6.89) increased the likelihood of reporting CMD significantly more than having a diagnosis of hypertension and their counterparts. Poor social support (AOR = 3.37; 95% CI = 1.51, 7.57) and moderate social support (AOR = 3.13; 95% CI = 1.46, 6.69) were both associated with an increased risk of developing CMD. Individuals with symptoms of insomnia (AOR = 12.08; 95% CI = 7.41, 19.72) and poor QoL (AOR = 1.67; 95% CI = 1.04, 2.72) were more likely to report CMD as shown in Table 3. We also found out that, having CVDs (AOR = 2.48; 95% CI = 1.18, 5.19), CMD (AOR = 12.09; 95% CI = 7.46, 19.61), and poor QOL (AOR = 2.04; 95% CI = 1.27, 3.26) increased the odds of having insomnia (Table 4).

TABLE 2 Clinical characteristics of study participants at Sidama National Regional State, southern Ethiopia, 2021 (*n* = 633).

Variable	Categories	Frequency	Percentage (%)
Diagnosis	Diabetes Mellitus	336	53.1
	Hypertension	111	17.5
	Asthma	49	7.7
	CVD	82	13.0
	Others*	55	8.7
Comorbid diagnosis	Yes	200	31.6
	No	433	68.4
Duration of illness	<= 5 years	364	57.5
	6–10 years	210	33.2
	> = 11 years	59	9.3
Alcohol Use in the past 3 months	Yes	61	9.6
	No	572	90.4
Cigarette Use in the past 3 months	Yes	17	2.7
	No	616	97.3
Khat Use in the past 3 months	Yes	49	7.7
	No	584	92.3
Social support	Poor	224	35.4
	Moderate	332	52.4
	Strong	77	12.2
Quality of life	Good	340	53.7
	Poor	293	46.3

CVD, Cardio-vascular disorders, *Epilepsy, stroke, neurological, renal or hepatologic disorders.

Discussion

The COVID-19 pandemic appears to be having a severe impact on the mental health of individuals with pre-existing medical conditions. In this study, we examined the prevalence and predictors of COVID-19 pandemic related common mental disorders (CMD) and insomnia in patients with chronic medical conditions in south Ethiopia. CMD and insomnia levels were surprisingly high, according to our research. Being a merchant, having diabetes mellitus, having a longer illness duration, having comorbid diagnoses, having low social support, having comorbid insomnia, and having a poor quality of life (QoL) were significant predictors of CMD. Additionally, a significant association between a high risk of insomnia and a diagnosis of cardio-vascular disorders, concurrent CMD, and poor QoL was found. The prevalence of insomnia and CMD indicates a need for mental health and psychosocial support (MHPSS) during the COVID-19 pandemic.

CMDs such as anxiety and depression were found to be more common in pre-existing physical conditions with a higher risk of COVID-19 infection in previous studies (54, 55). Our finding suggests that nearly half (46.8%) of the participants experience CMD. Comparable findings were reported from previous studies in India (52.9%), Saudi Arabia (45.6%), and China (45%) (56–58). This shows that COVID-19 had a serious impact on the mental health of

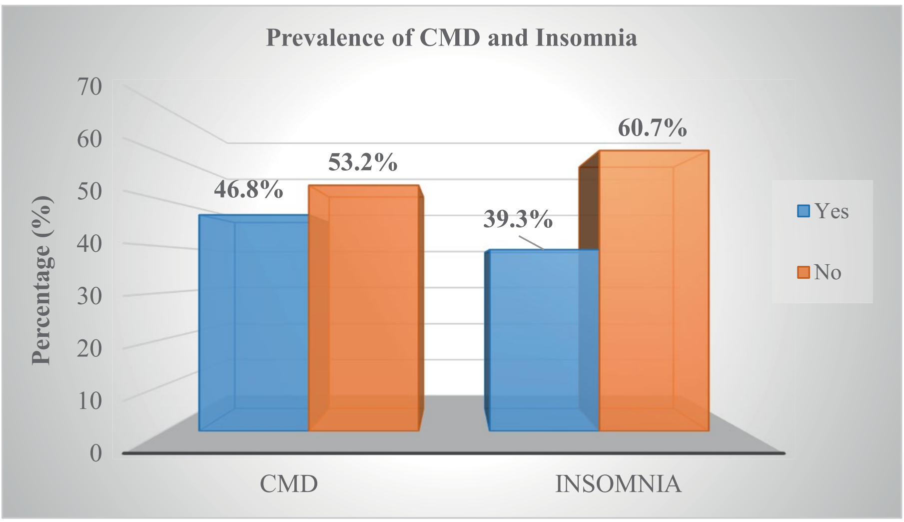

FIGURE 1
Prevalence of insomnia and CMD study participants at Sidama National Regional State, southern Ethiopia, 2021 (*n* = 633).

TABLE 3 Factors associated with CMD among patients with chronic NCDs during COVID-19 pandemic in selected hospitals of Sidama national regional state, 2021 ($n = 633$).

Variable	Category	CMD		COR (95% CI)	AOR (95% CI)
		Yes	No		
Age	≤ 30 years	22	115	1	1
	31–45 years	63	133	2.48(1.44, 4.27) *	1.19(0.47, 3.01)
	46–60 years	58	120	2.53(1.45, 4.39) *	1.41(0.52, 3.77)
	≥ 61 years	66	56	6.16(3.45, 10.99) *	1.03(0.33, 3.21)
Marital status	Single	31	104	1	1
	Married	125	285	1.47(0.94, 3.31) **	0.60(0.26, 1.37)
	Divorced	23	13	5.94(2.69, 13.07) *	1.91(0.49, 7.33)
	Widowed	30	22	4.57(2.32, 9.04) *	0.64(0.19, 2.14)
Educational status	Illiterate	57	118	0.69(0.44, 1.07) **	1.67(0.71, 3.95)
	Primary	44	118	0.53(0.33, 0.85) *	1.18(0.53, 2.64)
	Secondary	40	91	0.63(0.38, 1.02) **	1.02(0.45, 2.29)
	Tertiary	68	97	1	1
Occupation	Gov't employee	68	53	1	1
	Private employee	41	26	1.23(0.67, 2.25)	1.22(0.51, 2.95)
	Merchant	29	61	0.37(0.21, 0.65) **	0.33(0.13, 0.82)*
	Student	13	55	0.18(0.09, 0.37) ***	0.46(0.14, 1.58)
	House wife	53	49	0.84(0.49, 1.43)	0.86(0.33, 2.21)
	Farmer	71	73	0.75(0.46, 1.23)	0.63(0.25, 1.62)
	Jobless	7	14	0.39(0.14, 1.03)	0.57(0.14, 2.41)
	Other	14	6	1.82(0.65, 5.05)	1.14(0.25, 5.10)
Diagnosis	Hypertension	107	229	1	1
	Diabetes Mellitus	32	79	1.43(0.93, 2.21)	1.89(1.04, 3.46)*
	Asthma	22	27	2.13(1.07, 4.22) *	1.04(0.41, 2.66)
	CVD	40	42	1.87(1.05, 3.34) *	1.18(0.54, 2.61)
	Others	8	47	0.33(0.15, 0.71) **	0.23(0.08, 0.63)**
Duration of illness	≤ 5 years	101	263	1	1
	6–10 years	83	127	1.70(1.19, 2.44) *	1.02(0.62, 1.67)
	≥ 11 years	25	34	1.92 (1.09, 3.37) *	1.28(0.60, 2.75)
Comorbid diagnosis	Yes	119	81	5.60(3.89, 8.07) *	3.96(2.27, 6.89) ***
	No	90	343	1	1
Family History of MI	Yes	18	11	3.54(1.64, 7.64) *	2.65(0.85, 8.25)
	No	191	413	1	1
Alcohol Use in the past 3 months	Yes	38	23	3.87(2.24, 6.70) *	1.47(0.55, 3.94)
	No	171	401	1	1
Cigarette Use in the past 3 months	Yes	11	6	3.87(1.41, 10.62) *	0.80(0.13, 5.04)
	No	198	418	1	1
Khat Use in the past 3 months	Yes	29	20	3.25(1.79, 5.91) *	2.74(0.91, 8.29)
	No	180	404	1	1
Social support	Poor	64	160	1.31(0.72, 2.39)	3.37(1.51, 7.57) **
	Moderate	127	205	2.03(1.14, 3.60) *	3.13(1.46, 6.69) **
	Strong	18	59	1	1

(Continued)

TABLE 3 (Continued)

Variable	Category	CMD		COR (95% CI)	AOR (95% CI)
		Yes	No		
Insomnia	Yes	164	85	14.54(9.68, 21.83) *	12.08 (7.41, 19.72) ***
	No	45	339	1	1
Quality of life	Good	123	217	1	1
	Poor	173	120	3.11(2.23, 4.33)	1.67(1.04, 2.72) *

NB: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; CVD, Cardio-vascular disorders; CMD, Common Mental Disorder.

people with pre-existing NCDs. Mental health of the population was significantly impacted by the public health measures implemented to stop the spread of COVID-19 and the fear of getting the infection (59). The association between chronic medical problems and mental disorders is generally speculated to be bidirectional. People suffering from a significant mental illness are more likely to develop a variety of chronic physical illnesses. People with chronic medical illnesses, on the other hand, more likely to experience psychological problems than the general population (60). For instance, compliance with chronic medication use and regular use of the healthcare system may be challenging during infectious disease outbreaks, adding to psychological distress.

However, lower prevalence were reported in Ethiopia (22.8%) (61), and India (33.2%) (62). A similar study conducted in Bangladesh found a low prevalence of anxiety (35.2%) and depression (38.9%) (60). On the other hand, higher prevalence were also reported in studies conducted in Harar (62%) (60), and Mettu Karl Referral Hospital 55.7% (depression) and 61.8% (anxiety) (59). Moreover, other pre-COVID-19 researches indicated higher estimates of mental health problems in different parts of the world such as 63.3% in Ethiopia (63), 60.2% in Pakistan (64), 64.4% in Nigeria (65), and (58.7%) in Delhi, India (66). These disparities could be due to changes in sample size, inclusion criteria, screening instrument, setting, study period, and study population. Consequently, physical illnesses were associated with a higher likelihood of mental health problems, which could be explained by underlying physical disorders and a lack of medical help during an epidemic (67, 68). The findings suggested that different strategies should be designed to address mental health issues during epidemics.

This result of this study revealed that the prevalence of insomnia among chronic medical conditions was found to be 39.3%. Previous investigations and systematic review reports in different situations and populations provided almost approximate results in line with our findings (69–72). Similar results were recently observed in a variety of populations, including outpatients (39.5%), healthcare professionals (44.6%), and general population (39.8%) (73) and patients with chronic medical illness (32.6%) (74), during the COVID-19 pandemic. However, lower prevalence were also reported by Nochaiwong et al., (28%) and Liu et al., (30%) among general population and Mulyadi et al., (33%) among college students (75–77). On the other hand, higher prevalence were reported in COVID-19 patients (57%), cancer outpatients (48.6%), and depression outpatients (80.9%), individuals living with disabilities (71%) during the COVID-19 era (78–81). Therefore, variations in people's underlying medical conditions may account for variations in the prevalence rates of insomnia.

Being a governmental employee increases the likelihood to have CMD as compared to merchants. This finding is consistent with a recent study (82). The civil servants who participated in COVID-19 control were reported to have various types of psychological disorders (83). It has been noted that lack of public support, long working hours, a high degree of work related stress, work instability, and an unfavorable physical environment are risk factors for the development of symptoms of mental disorders in government employees (84–86). Furthermore, many government employees encounter emotional distress due to psychological disorders like depression and anxiety during and even after pandemics (87).

Similarly, those with inadequate (poor and moderate) social support were more likely to have CMD than those with strong social support, which is consistent with previous studies (59, 88, 89). Individuals with higher levels of social support may be more likely to believe they will obtain the necessary assistance when confronted with the stressful event of a pandemic outbreak. This idea would improve their views about dealing with adversity and difficulty in the fight against COVID19, resulting in greater levels of resilience (88). This could be associated with the fact that those who did not have social support throughout the pandemic are more vulnerable to mental illness since their social health is disrupted (61). Furthermore, a lack of social support has a detrimental effect on self-care, adherence, and the ability to react to or deal with stressful events, and it may lead to the development of depression (90). Also, perceived social support may help individuals resist and successfully cope the risk factors associated with their mental health (91). As a result, our findings highlight the importance of strong social support during pandemics, as it may have a positive impact on mental health.

This study indicated that patients diagnosed with diabetes were more prone to develop CMD as compared to hypertension. Mental health problems such as depression is more likely to occur in people with diabetes (92–94). Several studies have recently revealed that patients with diabetes mellitus had significant psychological problems during the COVID-19 pandemic (95–98). This has been linked to hypothalamic–pituitary–adrenal (HPA) dysfunction in both diabetes and depression (99). The immune system, glucose metabolism, and sleep—indicators of impaired health in both diseases—are regulated by this route, which is crucial under stress (100). Moreover, we found out that patients diagnosed with cardiovascular disorders such as heart failure were more likely to develop insomnia as compared to patients with hypertension. Previous studies suggested that patients with CVD are more prone to sleep disturbances (101, 102). Insomnia is linked to fatigue, depressed symptoms, daytime sleepiness, and decreases in self-reported and objective functional status, all of which

TABLE 4 Factors associated with Insomnia among patients with chronic NCDs during COVID-19 pandemic in selected hospitals of Sidama national regional state, 2021 ($n = 633$).

Variable	Category	Insomnia		COR (95% CI)	AOR (95% CI)
		Yes	No		
Age	≤ 30 years	30	107	1	1
	31–45 years	75	121	2.21(1.35, 3.63) *	1.06(0.43, 2.63)
	46–60 years	71	107	2.37(1.43, 3.92) *	0.93(0.35, 2.44)
	≥ 61 years	73	49	5.31(3.09, 3.15) *	1.36(0.46, 4.02)
Marital status	Single	34	101	1	1
	Married	157	253	1.84(1.19, 2.85) *	1.05(0.46, 2.37)
	Divorced	22	14	4.67(2.15, 10.13) *	1.22(0.39, 3.79)
	Widowed	36	16	6.68(3.30, 13.54) *	2.54(0.78, 8.20)
Educational status	Illiterate	74	101	0.90(0.58, 1.38)	0.94(0.41, 2.18)
	Primary	54	108	0.62(0.39, 0.96) *	0.92(0.43, 1.96)
	Secondary	47	84	0.68(0.43, 1.10)	1.16(0.54, 2.50)
	Tertiary	74	91	1	1
Occupation	Gov't employee	57	64	1	1
	Private employee	32	35	1.03(0.56, 1.86)	0.69(0.32, 1.52)
	Merchant	27	63	0.48(0.27, 0.85) *	0.75(0.31, 1.83)
	Student	10	58	0.19(0.09, 0.41) **	0.46(0.13, 1.61)
	House wife	49	53	1.04(0.61, 1.75)	1.25(0.49, 3.15)
	Farmer	58	86	0.75(0.46, 1.23)	0.71(0.28, 1.82)
	Jobless	6	15	0.45(0.16, 1.23)	0.64(0.17, 2.36)
	Other	10	10	1.12(0.44, 2.89)	0.61(0.15, 2.42)
Diagnosis	Hypertension	112	224	1	1
	Diabetes	39	72	0.92(0.58, 1.45)	0.63(0.34, 1.13)
	Asthma	27	22	2.26(1.14, 4.49) *	1.95(0.81, 4.69)
	CVD	47	35	2.47(1.38, 4.45) **	2.48(1.18, 5.19)*
	Others	24	31	1.43(0.74, 2.76)	3.38(1.45, 7.88)**
Duration of illness	≤ 5 years	128	236	1	1
	6–10 years	96	114	1.55(1.09, 2.19) *	1.21(0.74, 1.95)
	≥ 11 years	25	34	1.36(0.77, 2.37)	0.68(0.31, 1.52)
Comorbid diagnosis	Yes	109	91	2.51(1.78, 3.53) *	0.87(0.52, 1.49)
	No	140	293	1	1
Alcohol Use in the past 3 months	Yes	43	18	4.24(2.38, 7.55) *	1.82(0.80, 4.13)
	No	206	366	1	1
Cigarette Use in the past 3 months	Yes	13	4	5.23(1.68, 16.24) *	1.59(0.29, 8.65)
	No	236	380	1	1
Khat Use in the past 3 months	Yes	35	14	4.32(2.27, 8.23) *	2.43(0.93, 6.30)
	No	214	370	1	1
CMD	Yes	198	98	1	12.09(7.46, 19.61) ***
	No	51	286	11.33(7.72, 16.63) **	1
Quality of life	Good	92	248	1	1
	Poor	157	136	3.11(2.23, 4.33) **	2.04(1.27, 3.26) **

NB: *$p < 0.05$, **$p < 0.01$, ***$P < 0.001$; CVD, Cardio-vascular disorders; CMD, Common Mental Disorder.

are major issues for CVD patients (103). This could be explained by the hypothalamic–pituitary axis (HPA) dysregulation, inappropriate modulation of the autonomic nervous system, elevated sympathetic nervous system activity, and systemic inflammation that are all factors in the etiology of cardiovascular disease (102). In addition, several pandemic-specific factors, such as fear of acquiring the virus and being unable to visit loved ones, suggest that insomnia may increase during this time (104).

In this study, participants with CMD were more likely to be at risk to develop insomnia and vice versa. In general, there is evidence that mental health problems are associated to sleep disturbances and that insomnia is related to the psychological stress. That is, a bidirectional relationship between insomnia and psychological problems were clearly demonstrated (105). Furthermore, people who have a chronic medical condition may experience severe physical discomfort, which can lead to anxiety and depression and disturbed sleep (106). The conclusion could be attributed to COVID-19's direct psychosocial effects on those with chronic medical conditions, fear of contracting COVID-19, and the virus's deadly effect on chronic medical patients.

Our study also showed that participants who had poor QoL were more likely to develop CMD and insomnia. Similarly, recent studies have discovered that poor QoL is associated with insomnia and poor sleep quality (107, 108) and lower QoL scores were indicated by individuals who felt more stress, depression, and anxiety (51). Previous research has shown that there is an inverse relationship between QOL and mental health disorders such as depression and anxiety (109) and sleep disturbances (110). As a result, it is not surprising that poor QOL in individuals with chronic medical illnesses has an impact on mental health and sleep, as shown in this study.

There were certain limitations in this study. First, due to the study's cross-sectional methodology, it was unable to demonstrate causal links between the variables investigated. Second, because all of the data was self-reported and the participants' responses were not independently validated, social desirability bias and recall bias could have occurred. Third, because the study's participants were all people with chronic illnesses, the findings cannot be generalized to the general public.

Conclusion

This study highlights the prevalence of CMD and Insomnia among patients with chronic NCDs were found to be considerably high. Occupation, diagnosis, comorbid diagnosis, social support, insomnia, and quality of life were all significantly associated with CMD. We also found out that, having CVDs, CMD, and poor QOL significantly increases the likelihood of having insomnia symptoms. As a result, addressing mental health issues among patients with chronic CMD is an essential component of public health interventions during the COVID-19 pandemic.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Hawassa University, College of Medicine and Health Sciences, Institutional Review Board (IRB) with reference number IRB/076/13. The participants provided their written informed consent to participate in this study.

Author contributions

MA, BD, AG, SH, and ET participated in the conception and designed the study and involved in the data collection. MA, BD, and SD do the analysis of the study. MA and SD prepares the manuscript for publication. BD, AG, SH, SD, and ET critically reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Development and testing of the Sleep Health And Wellness Questionnaire (SHAWQ) in adolescents and university students: composite SHAWQ scores are associated with sleep problems, depression symptoms, and academic performance

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Introduction: Sleep problems frequently arise during adolescence and early adulthood and may contribute to the onset of depression. However, few sleep health instruments have been developed for use in student populations. Here, we developed a brief sleep health questionnaire for identifying adolescents and university students with sleep problems who may be at risk of depression.

Methods: In Study 1, sleep survey data in adolescents (n = 1,733) were analyzed by best-subsets regression to identify the strongest predictors of self-reported depression symptoms: sleep quality, daytime sleepiness, self-rated health, frequency of staying up until 3:00 am, school day sleep latency, and gender. A 6-item Sleep Health And Wellness Questionnaire (SHAWQ) was developed using these items. Students were categorized into good, fair, and bad sleep health groups based on their composite SHAWQ scores. In Study 2, the SHAWQ was tested in adolescents (n = 1,777) for associations with depression symptoms and excessive daytime sleepiness. In Study 3, the SHAWQ was tested in university students (n = 2,040) for convergent validity with instruments for measuring sleep quality and insomnia severity, and for associations with major depressive disorder symptoms and anxiety disorder symptoms. Test-retest reliability was determined in a subset of 407 students who re-took the SHAWQ several weeks later. In Study 4, we tested whether SHAWQ scores in university freshmen (cohort 1, n = 1,529; cohort 2, n = 1,488) were prospectively associated with grade point average (GPA) over their first year.

Results: Across studies, SHAWQ scores were associated with higher depression and anxiety scores, excessive daytime sleepiness, lower sleep quality scores, and higher insomnia severity scores, demonstrating good convergent validity. Associations of SHAWQ scores with depression symptoms were stronger compared with anxiety symptoms. SHAWQ scores showed moderate test-retest reliability. Large effect sizes were observed for bad vs. good sleep health for all sleep and mental health variables. In both cohorts of university freshmen, students with bad sleep health had lower academic performance based on their GPA and percentile rank.

Conclusion: Our findings suggest that the SHAWQ could be used to screen for students in their teens and twenties with bad sleep health who would benefit from counseling for sleep and mental health.

KEYWORDS

sleep, health, depression, anxiety, grades, academic performance

1 Introduction

Sleep is a key component of mental health and wellness. Sleep that is short, improperly timed, or low in efficiency has been linked to poorer mood and depression symptoms (Fredriksen et al., 2004; Augustinavicius et al., 2014; Lovato and Gradisar, 2014; Raniti et al., 2017; Yeo et al., 2019; Orchard et al., 2020; Short et al., 2020). Low self-reported sleep quality and high daytime sleepiness are also associated with mood disturbances and depression (Short et al., 2013; Dinis and Bragança, 2018; Tsou and Chang, 2019; Orchard et al., 2020; Boz et al., 2021; Marino et al., 2021; Shimamoto et al., 2021; Gonsalvez et al., 2022). Moreover, sleep problems are among the symptoms used for diagnosing major depressive disorder in the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) (American Psychiatric Association, 2013). There is strong overlap in symptoms associated with inadequate sleep and depression including fatigue or loss of energy, diminished ability to concentrate, and psychomotor retardation. While altered sleep may arise because of poor mental health, inadequate sleep also directly impacts mood and cognitive functioning (Short and Chee, 2019; Short et al., 2020). Hence, the relationship between sleep and mental health problems is generally viewed as bidirectional. Understanding the etiology of sleep and mood disturbances is important for developing interventions to improve health and wellness.

Sleep problems and depression symptoms often emerge during adolescence and early adulthood. Bedtimes shift later across adolescence due to a combination of biological and environmental factors (Crowley et al., 2018). A puberty-associated circadian delay and slower build-up of homeostatic sleep pressure makes it easier for adolescents to stay up late and harder to fall asleep early (Carskadon et al., 2004; Jenni et al., 2005; Taylor et al., 2005). In parallel, the increase in school workload, social commitments, and bedtime autonomy can delay and displace nocturnal sleep (Short et al., 2011; Yeo et al., 2019, 2020). Most adolescents also get up earlier than their natural wake-up time to reach school on time, resulting in chronic sleep deprivation during the school week (Minges and Redeker, 2016; Wheaton et al., 2016; Bowers and Moyer, 2017; Marx et al., 2017; Alfonsi et al., 2020). Many of these factors persist into young adulthood, when sleep opportunities during the work/school week are often restricted by late night activities and early university start times (Basner et al., 2014; Yeo et al., 2021, 2023). Sleep problems frequently coincide with mood disturbances and depression. The cumulative frequencies of insomnia and depression during adolescence are about 10% and 20%, respectively (Johnson et al., 2006; Thapar et al., 2012; Hysing et al., 2013), although estimates may vary depending on the criteria used, cultural setting, and age group. Notably, girls are about twice as likely to experience insomnia and depression compared with boys (Hyde et al., 2008; Thapar et al., 2012; Hysing et al., 2013). Depression in youth is associated with increased risk of depressive episodes and other mental disorders as an adult (Dunn and Goodyer, 2006; Fergusson et al., 2007; Rudolph and Klein, 2009). Importantly, depressive disorders contribute the most to disability-adjusted life years (a measure that accounts for premature mortality and years lived with disability) among mental disorders, with a peak that occurs in adolescence and young adulthood (Whiteford et al., 2013). It is therefore critical to identify factors that contribute to the onset of depression, including the potential role of sleep problems.

Sleep problems often precede depression. It has therefore been hypothesized that poor sleep contributes to the emergence of depression (Lovato and Gradisar, 2014; Gradisar et al., 2022). A meta-analysis of longitudinal studies in adults showed that non-depressed individuals with insomnia had a 2-fold increase in the odds of developing depression compared with individuals without sleep difficulties (Baglioni et al., 2011). Comparable findings have been reported in adolescents demonstrating that insomnia symptoms were associated with a 2-fold increase in odds of depression diagnosis within the next several years (Roane and Taylor, 2008). Epidemiologic studies have also shown that adolescents with insomnia symptoms had a 1.5-fold increase in odds of reaching survey- or interview-based thresholds for depression one year later (Luo et al., 2013; Roberts and Duong, 2014). One of the mechanisms by which poor sleep may contribute to development of depression is through its effects on mood, emotional regulation, and cognitive functioning. In healthy adolescents, exposure to insufficient sleep gives rise to reduced positive mood, increased negative mood, deficits in emotional regulation, impaired cognition, and an increase in symptoms associated with depression and anxiety (Short and Chee, 2019; Short et al., 2020). Additionally, difficulty falling asleep and nighttime awakenings provide more opportunities to worry and ruminate. Thoughts that occur prior to sleep (pre-sleep cognitions) and nighttime ruminative thinking may exacerbate sleep onset latency and amplify negative feelings and self-perceptions related to depression (Lovato and Gradisar, 2014; Orchard and Reynolds, 2018; Gradisar et al., 2022). A role for sleep problems in the development of depression is also supported by treatment studies for disordered sleep without clinical depression. Meta-analyses of cognitive-behavioral interventions (i.e., non-pharmacological interventions) in adolescents showed improvements in objective and subjective measures of sleep, as well as reduced depression and anxiety symptoms (Blake et al., 2017; Gee et al., 2019). Light therapy for adolescents with delayed sleep-wake phase disorder has also been shown to improve sleep onset difficulties and reduce repetitive negative thinking and depression symptoms (Richardson and Gradisar, 2022). Together, these studies suggest that early treatment of sleep problems may help to decrease the incidence of depressive disorders.

Multiple dimensions of sleep health are associated with depression symptoms. In broad terms, good sleep health is characterized by adequate sleep duration, appropriate sleep timing, high sleep efficiency (ease of falling and returning to sleep), sustained alertness during waking hours, and satisfaction with the quality of sleep (Buysse, 2014). While there is evidence that each of these dimensions of sleep health is associated with depression symptoms, multidimensional sleep health measures may be better at predicting mental health outcomes. This is because sleep symptoms or problems have additive effects on health (Vgontzas et al., 2009). Composite scores of sleep health reflect the combined influence of different dimensions of sleep that normally co-exist rather than treating each dimension of sleep as if it occurs in isolation. The Pittsburgh Sleep Quality Index (PSQI) is an example of an instrument that provides coverage of the primary dimensions of sleep health, even though it was conceptualized as a tool for measuring sleep problems rather than sleep health. In the original validation study (Buysse et al., 1989), PSQI global scores were much higher in patients with major depressive disorder, and subsequent studies have shown that PSQI scores are correlated with depression scores in adults and adolescents (Raniti et al., 2017; Huang and Zhu, 2020). More recently, multidimensional sleep health has been assessed using the SATED scale (satisfaction with sleep, alertness during waking hours, timing of sleep, sleep efficiency, and sleep duration) (Buysse, 2014) and its derivations including RuSATED, which considers variability in sleep timing (sleep regularity) as another dimension of sleep health. Cross-sectional studies in adults that used this framework showed that higher composite sleep health scores (i.e., better sleep health) were associated with fewer depression and anxiety symptoms (Furihata et al., 2017; Bowman et al., 2021; Appleton et al., 2022; Barham et al., 2022), lower self-reported psychological distress (DeSantis et al., 2019), and lower perceived stress (Lee and Lawson, 2021). Consistent with these findings, a prospective study of older women found that a composite measure of sleep health was associated with incidence of depression (i.e., poor sleep health preceded depression) (Furihata et al., 2017). Recent evidence suggests that the same sleep health framework can be applied to "at-risk" adolescents, in whom higher sleep health composite scores were associated with lower depression and anxiety symptoms (Dong et al., 2019). These studies show that measures of multidimensional sleep health are closely related to mental health outcomes.

The present study was performed to address the need for a short sleep health instrument that can be used to predict the co-occurrence of depression symptoms in adolescents and university students. Sleep problems are thought to contribute to the onset of major depressive disorder during adolescence and early adulthood (Gradisar et al., 2022). However, few sleep health instruments have been developed for use in student populations. Current instruments assign equal weights to the various dimensions of sleep health, even though the relative contribution of each dimension to depression and other health outcomes may vary (Buysse, 2014; Raniti et al., 2017; Dong et al., 2019). Here, we took the view that sleep health-related behaviors may be more predictive of depression if they are chosen and scored based on their strength of association with depression scores. With this view in mind, we aimed to develop and test a short questionnaire to evaluate students' sleep health and well-being. In Study 1, we developed a 6-item Sleep Health And Wellness Questionnaire (SHAWQ) by selecting for sleep survey items that were most strongly associated with depression scores in adolescents. SHAWQ scores were also used to categorize students into good, fair, and bad sleep health groups. In Study 2, we tested the SHAWQ in a different population of adolescents. We hypothesized that SHAWQ scores and categories would be associated with global depression scores and individual depression symptoms, as well as excessive daytime sleepiness. In Study 3, we tested the SHAWQ in university students. We hypothesized that the SHAWQ would exhibit convergent validity with other multidimensional instruments for assessing sleep quality and insomnia symptoms, with good test-retest reliability over several weeks. We also predicted that the SHAWQ would be more predictive of depressive disorder symptoms compared with anxiety disorder symptoms. In Study 4, we tested the SHAWQ in 2 different cohorts of university freshmen. We hypothesized that bad sleep health on the SHAWQ would be prospectively associated with lower academic performance.

2 Methods

2.1 Ethics statement

Adolescents provided written or online informed consent to participate in the research with prior permission obtained from their parent/guardian. Ethical approvals for studies in adolescents were obtained from the Institutional Review Board (IRB) at the National University of Singapore (Study 1: IRB-B-15-243) and the Nanyang Technological University (Study 2: IRB-2020-11-001-01). University students provided online informed consent to participate in the research. Ethical approvals for studies in university students were obtained from the National University of Singapore IRB (Study 3: NUS-IRB-2020-604; Study 4: NUS-IRB-L2020-06-02) and the Learning and Analytics Committee on Ethics, National University of Singapore. The research (Study 1, Study 2, Study 3, Study 4) was not pre-registered.

2.2 Study 1: analysis of sleep and depression symptoms in adolescents

2.2.1 Participant recruitment and school characteristics in Study 1

Adolescents aged 13-19 years (n = 2,364) were recruited to take part in a cross-sectional anonymous survey of their sleep habits, daily activities, and depression symptoms. As reported in our previous work (Yeo et al., 2019), the main purpose of the survey was to evaluate factors that influence sleep and well-being in adolescents. Data were extracted for the present research to analyse sleep health-related variables that were associated with depression symptoms. In short, 8 schools (out of 74) agreed to participate including 5 local schools and 3 international schools. Student recruitment was managed internally by a designated school representative (e.g., professional educator/teacher). This included distributing study information to students and obtaining written permission from parents. Students were invited to attend a one-time session during their morning assembly to complete the survey by pen and paper under supervision of the researchers. One school opted to have students complete the survey online. Surveys were administered between January 2016 and July 2017 and were scheduled to avoid major examinations.

2.2.2 Survey items and instruments in Study 1

The sleep habits survey comprised 40 questions and took about 15 min to complete. Most items were taken from the School Sleep Habits Survey used to assess adolescent sleep behavior (Wolfson and Carskadon, 1998). The survey collected information on (a) demographics and general student information, (b) sleep behavior and daily activities on school days, (c) sleep behavior and daily activities on non-school days (weekends or holidays), (d) sleep problems, sleepiness, and caffeine use, and (e) sleep preferences. The survey included a combination of free-response and multiple-choice questions. The 11-item Kutcher Adolescent Depression Scale (KADS) was used to evaluate depression severity over the past week (LeBlanc et al., 2002; Brooks et al., 2003). The global depression score was determined by summing scores across items (range=0 to 33) (Supplementary Methods).

2.2.3 Development of the sleep health and wellness questionnaire (SHAWQ)

2.2.3.1 Selection of SHAWQ survey items

We shortlisted 22 questions from the sleep habits survey that we expected to be linked to adolescents' sleep health and/or well-being (Figure 1A, Supplementary Methods). Best-subsets regression was used to identify combinations of survey items that were associated most strongly with global depression scores. This method compared all possible linear regression models that could be created based upon the identified set of predictors. With 22 survey questions shortlisted as potential predictors, there were 4,194,303 possible combinations of linear models. Free-response items were included as continuous variables, and multiple-choice questions were included as categorical variables. Among the 2,364 adolescents who participated in the survey, there were 631 individuals who were missing data for one or more of the predictor variables or the KADS. Therefore, data for 1,733 students were entered into the model (Supplementary Table 1a). The best-subsets regression model was implemented with the "olsrr" package (version 0.5.2) using R statistical software (R Core Team, 2022).

For each n-predictor model (i.e., ranging from a 1-predictor model to a 22-predictor model), we determined the set of predictors that explained the greatest amount of variance in the KADS depression score based on the R^2 value (Table 1). The full model that included all 22 predictors explained 37.6% of the variance in KADS depression scores. The first few n-predictor models accounted for most of the variance that could be explained with marginal improvement beyond several predictors. We chose the best 6-predictor model for developing our sleep health questionnaire based on theoretical and practical considerations (not based on a statistical threshold for variable selection). The 6-predictor model explained 34.5% of the variance in KADS depression scores (Table 1). The predictor variables included self-rated sleep quality, daytime sleepiness, frequency of staying up until 3:00 am or later in the past 2 weeks, and sleep onset latency on school days. There is a strong theoretical basis for including these 4 items because they overlap with previously defined dimensions of sleep health, including sleep satisfaction/quality, daytime alertness, sleep timing, and sleep efficiency (Buysse, 2014). The other 2 predictor variables were self-rated health relative to one's peers and gender, which have been shown to associate with multidimensional sleep health and depression symptoms (Dalmases et al., 2015; Appleton et al., 2022). Lastly, we opted for the 6-predictor model because it aligned with our objective to develop a short instrument that would be practical to administer and score.

2.2.3.2 Scoring of the SHAWQ

We implemented an integer-based scoring method for the SHAWQ in which scores for individual response items were based on their strength of association with the KADS depression score. We expected some questions and their individual response items would be more closely related to depression symptoms than others, and hence we did not assign equal weights. First, we determined the average KADS depression score for each response item on the SHAWQ (Figure 1B). As expected, depression scores increased with poorer sleep quality, greater severity of daytime sleepiness, higher frequency of staying up until 3:00 am or later, and longer sleep latencies. Depression scores were also higher in girls compared with boys and increased with poorer self-rated health.

Next, we rounded the average KADS depression score for each response item to the nearest integer value (Figure 1C). The rounded KADS values were then converted to scores ranging from 0 to 9 by subtracting 7 from each value (any item with an average KADS score of 7 or less was assigned a score of zero). In some cases, more than one response item from a question was assigned the same score. In these instances, we reduced the number of response items on the SHAWQ by either deleting or combining response options so that each response item for a given question had a unique value. The final version of the SHAWQ used in subsequent studies had 6 questions, with 3–5 response options for each question (Figure 2).

After assigning scores to individual SHAWQ response items, we determined the composite SHAWQ score by summing scores across the 6 questions (range = 3–35) (Figure 2). SHAWQ scores exhibited a moderately right-skewed distribution with a mode of 8 and a median score of 9 (interquartile range = 7–13) (Supplementary Figure 1). Linear regression showed that the composite SHAWQ score explained 33.0% of the variance in KADS depression score ($R^2 = 0.330$, $p<0.001$), which closely resembled results for the best-subsets regression analysis for the corresponding 6-item predictor model ($R^2 = 0.345$, $p < 0.001$). Therefore, our simplified scoring scheme for the SHAWQ

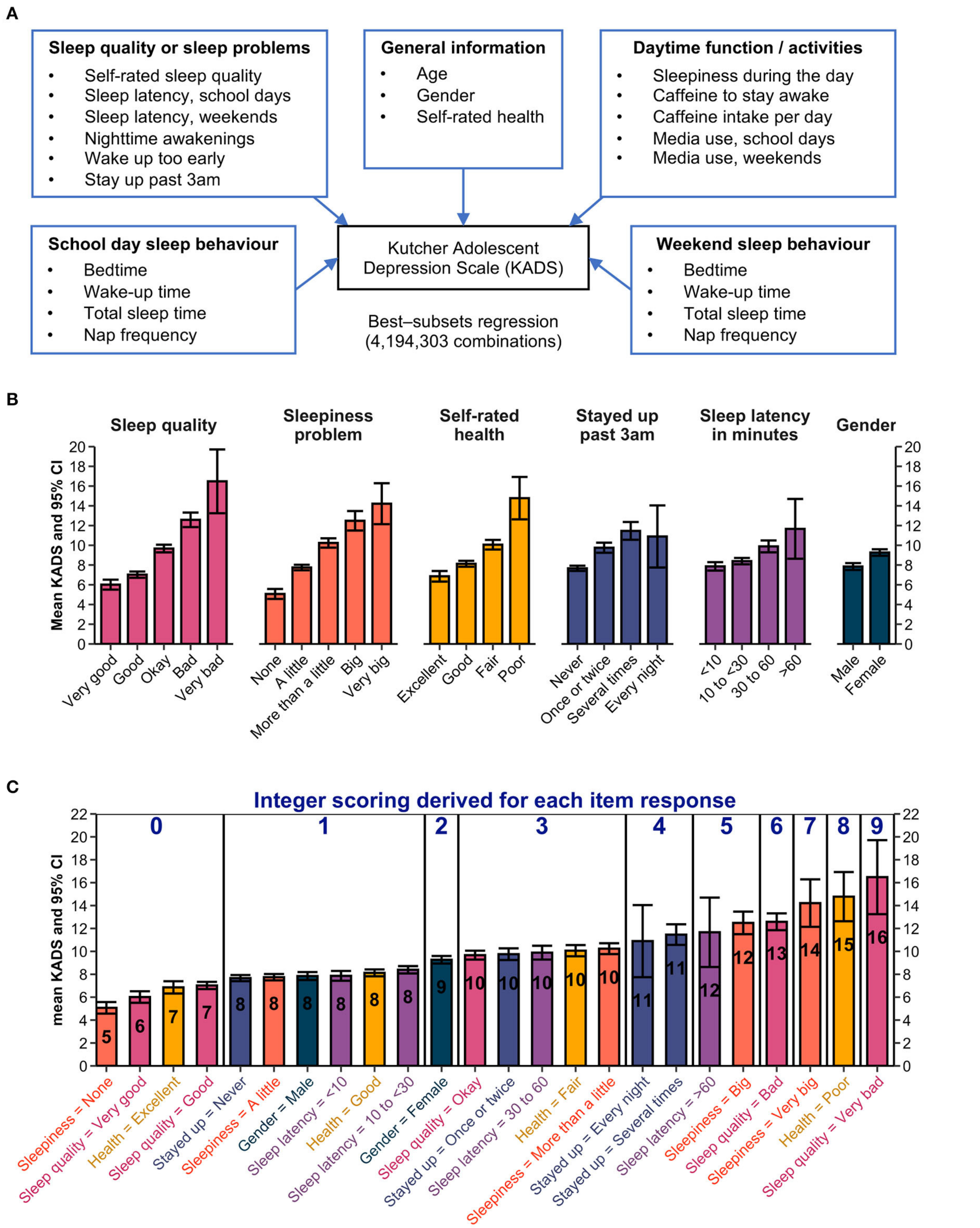

FIGURE 1
Development of the Sleep Health And Wellness Questionnaire (SHAWQ). **(A)** Best-subsets regression was used to identify combinations of sleep survey items that associated most strongly with depression scores on the Kutcher Adolescent Depression Scale (KADS). Data for 22 candidate predictors were entered in the model from 1,733 adolescents. **(B)** The best 6-predictor model included questions assessing sleep quality, daytime sleepiness, self-rated health, frequency of staying awake until 3:00 am or later in the past 2 weeks, sleep onset latency on school days, and gender. The mean and 95% CIs for KADS scores are shown for individual response items. **(C)** The integer scoring scheme is shown. Data from **(B)** were reordered by the mean KADS score. The rounded KADS score (overlaid in each bar) was converted to scores ranging from 0 to 9 by subtracting 7 for each value. Items with a rounded KADS score of 7 or less were assigned a value of zero.

TABLE 1 Results of best-subsets regression for associations of sleep survey variables with depression score (Study 1).

No.	Predictors	R^2	Adj R^2
1	Sleep quality	0.195	0.193
2	Sleepiness problem, sleep quality	0.282	0.278
3	Self-rated health, sleepiness problem, sleep quality	0.311	0.307
4	Self-rated health, sleepiness problem, stay up until 3:00am, sleep quality	0.325	0.319
5	Self-rated health, wake up during night, sleepiness problem, stay up until 3:00am, sleep quality	0.337	0.330
6	Sex, self-rated health, school day sleep latency, sleepiness problem, stay up until 3:00am, sleep quality	0.345	0.339
7	Sex, self-rated health, school day sleep latency, school day media use, sleepiness problem, stay up until 3:00am, sleep quality	0.352	0.346
8	Sex, self-rated health, school day sleep latency, school day media use, wake up during night, sleepiness problem, stay up until 3:00am, sleep quality	0.358	0.350
9	Sex, self-rated health, school day sleep latency, school day media use, wake up during night, sleepiness problem, days of caffeine use, stay up until 3:00am, sleep quality	0.363	0.353
10	Sex, self-rated health, school day bedtime, school day sleep latency, school day media use, wake up during night, sleepiness problem, days of caffeine use, stay up until 3:00am, sleep quality	0.366	0.357
11	Sex, self-rated health, school day bedtime, school day sleep latency, school day media use, wake up during night, sleepiness problem, days of caffeine use, wake up too early, stay up until 3:00am, sleep quality	0.369	0.359
12	Sex, self-rated health, school day bedtime, school day sleep latency, school day media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.372	0.360
13	Sex, age, self-rated health, school day sleep latency, school day nocturnal sleep, school day media use, wake up at night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.374	0.362
14	Sex, age, self-rated health, school day sleep latency, school day nocturnal sleep, school day media use, weekend sleep latency, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.375	0.362
15	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day media use, weekend sleep latency, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.375	0.362
16	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day media use, weekend sleep latency, weekend media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.376	0.362
17	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day media use, weekend bedtime, weekend sleep latency, weekend media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.376	0.362
18	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day naps, school day media use, weekend bedtime, weekend sleep latency, weekend media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.376	0.361
19	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day naps, school day media use, weekend bedtime, weekend sleep latency, weekend wake-up time, weekend media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.376	0.361
20	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day naps, school day media use, weekend bedtime, weekend sleep latency, weekend wake-up time, weekend naps, weekend media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.376	0.360
21	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day nocturnal sleep, school day naps, school day media use, weekend bedtime, weekend sleep latency, weekend wake-up time, weekend naps, weekend media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.376	0.360
22	Sex, age, self-rated health, school day bedtime, school day sleep latency, school day wake-up time, school day nocturnal sleep, school day naps, school day media use, weekend bedtime, weekend sleep latency, weekend wake-up time, weekend nocturnal sleep, weekend naps, weekend media use, wake up during night, sleepiness problem, days of caffeine use, caffeine drinks per day, wake up too early, stay up until 3:00am, sleep quality	0.376	0.359

did not materially alter the strength of the association with depression scores.

Students were categorized into good, fair, and bad sleep health groups based on their SHAWQ score and its association with depression symptoms (Supplementary material). The rationale was to establish threshold scores that could be used for screening students with poor sleep health who may be at risk of mental health problems. Sleep health categories were defined by the following SHAWQ score ranges: Good, 3–7; Fair, 8–16, Bad, 17–35.

1. Gender:
   - ❑ Male (1)
   - ❑ Female (2)

2. In the last two weeks, how would you rate your sleep quality?
   - ❑ Very good (0)
   - ❑ Good (0)
   - ❑ Okay (3)
   - ❑ Bad (6)
   - ❑ Very bad (9)

3. During your daily activities, how much of a problem do you have trying to stay awake?
   - ❑ No problem at all (0)
   - ❑ A little problem (1)
   - ❑ More than a little problem (3)
   - ❑ A big problem (5)
   - ❑ A very big problem (7)

4. Compared to other people your age, would you say that your health is:
   - ❑ Excellent (0)
   - ❑ Good (1)
   - ❑ Fair (3)
   - ❑ Poor (8)

5. In the last two weeks, how often have you stayed up until 3 a.m. or later?
   - ❑ Never (1)
   - ❑ Once or twice (3)
   - ❑ Several times (4)

6. On school days, after you settle in bed for sleep, about how long does it usually take you to fall asleep?
   - ❑ Less than 30 minutes (1)
   - ❑ 30 to 60 minutes (3)
   - ❑ More than 60 minutes (5)

FIGURE 2
The 6-item Sleep Health And Wellness Questionnaire (SHAWQ). The SHAWQ was developed from analysis of a prior study in adolescents (Study 1, $n = 1{,}733$), and then tested in populations of adolescents (Study 2, $n = 1{,}777$), university students (Study 3, $n = 2{,}040$), and 2 cohorts of university freshmen (Study 4, $n = 1{,}529$ and $n = 1{,}488$). The integer scoring is indicated to the right of each response item. The composite SHAWQ score was determined by summing the 6 item scores (range = 3–35). The response item "Very Good" for sleep quality was included in Study 1 but was dropped in subsequent studies. Researchers who use the SHAWQ may decide to include this response option to balance the valence of available choices.

2.3 Study 2: assessment of the SHAWQ and depression symptoms in adolescents

2.3.1 Participant recruitment and school characteristics in Study 2

Students attending secondary schools and post-secondary schools (junior college, polytechnics, vocational schools) in Singapore ($n = 2{,}382$) were recruited to take part in a cross-sectional anonymous survey of their sleep habits, lifestyle factors, and depression symptoms. The main purpose of the study was to identify factors that may negatively impact students' sleep and well-being. The SHAWQ was included in the survey as a potential predictor of depression symptoms. In Singapore, most students attend 4 years of secondary education in which their age of enrolment at the start of the school year is usually 13–16 years. Subsequently, adolescents can continue their education at post-secondary (pre-university) schools based on their preferences and national examination test scores. Students with high academic performance often enroll in junior college (functionally equivalent to the last 2 years of high school in the United States educational system) and go on to pursue a university education. Nearly half of students enroll in polytechnic schools (usually 3-year programs) that place greater emphasis on industry-oriented skills, hands-on learning, and work attachments that prepare them for employment in a particular job sector. Most of the remaining students enroll in Institutes of Technical Education (ITE), which provide technical and vocational pre-employment training.

Students were recruited from 10 schools including 3 secondary schools, 3 junior colleges, 1 polytechnic, and 3 ITEs. At each school, a teacher or educational administrator/leader managed student recruitment, including dissemination of study materials and obtaining parental permission. Students completed the survey by pen and paper under supervision of the researchers and/or teachers, or by filling out an online version of the survey. Surveys were administered between March 2021 and April 2022. Among the 2,382 students who consented to take part in the survey study, we excluded 201 students because they were not adolescents or they did not specify their age ($\geq$20 years, $n = 189$; unspecified, $n = 12$). An additional 153 students were excluded because they had missing responses on either the SHAWQ or the KADS, and 251 students were excluded because they had missing data or provided invalid responses to questions on their sleep schedules. The final dataset for our analyses therefore included 1,777 adolescents (Supplementary Table 1b).

2.3.2 Survey items and instruments in Study 2

The survey included the SHAWQ to assess sleep health parameters, as well as questions on nocturnal total sleep time and frequency of napping on school days and non-school days. The Munich Chronotype Questionnaire (MCTQ) was used to assess adolescents' bedtime and wake-up time on school days and non-school days (Roenneberg et al., 2003) (Supplementary material). The Epworth Sleepiness Scale (ESS) was used to measure excessive daytime sleepiness (Johns, 1991) (Supplementary material). An ESS global score >10 was interpreted as evidence of excessive daytime sleepiness (ESS score: 11–12, mild; 13–15, moderate; 16–24, severe). Depression symptoms were assessed using a 10-item version of the KADS (see above) in which the question on self-harm or suicide was removed.

2.4 Study 3: assessment of the SHAWQ and depression symptoms in university students

2.4.1 Participant recruitment in Study 3

Undergraduate students ($n = 2,089$, aged 18 years or older) were recruited from the National University of Singapore to participate in an online survey of sleep health and wellness. The purpose of the study was to test the associations of the SHAWQ with sleep problems and depression symptoms. Students were recruited by posting advertisements on the university's learning management system and by sending emails to participants of prior research studies who consented to be re-contacted. Upon providing consent and verifying their student status, students were directed to the online survey. Among the 2,089 students who completed the survey, we excluded 6 individuals because they were listed as graduate students based on university records. There were an additional 43 students who were excluded because they had missing data for one or more items on the SHAWQ or the depression scale. Therefore, the final sample included 2,040 undergraduate students (Supplementary Table 1c). The survey was administered from April 2021 to November 2021 during the Spring and Fall semesters when school was in session. A subset of 411 students agreed to participate in the survey a second time so that we could assess test-retest reliability of the SHAWQ. These students took the survey 6-10 weeks after their first assessment (range = 41–70 days). There were four participants with at least 1 missing response on the SHAWQ. Hence, 407 students were included in the analysis of test-retest reliability.

2.4.2 Survey items and instruments in Study 3

The sleep and wellness survey assessed different aspects of sleep health including those measured by the SHAWQ, sleep timing and duration on school days and non-school days (bedtime, wake-up time, nocturnal total sleep time), frequency of napping, and taking caffeine with the purpose of staying awake. The Pittsburgh Sleep Quality Index (PSQI; range = 0 to 21) was used to assess sleep quality over the past month (Buysse et al., 1989) (Supplementary material). A PSQI global score >5 was interpreted as evidence of poor sleep quality. The Insomnia Severity Index (ISI) was used to assess symptoms associated with insomnia (Bastien et al., 2001) (Supplementary material). An ISI score >14 was interpreted as evidence of clinical insomnia (ISI score: 0–7, no clinically significant insomnia; 8–14, subthreshold insomnia; 15–21, clinical insomnia, moderate severity; 22–28, clinical insomnia, severe).

Depression symptoms were assessed using the Center for Epidemiologic Studies Depression Scale Revised (CESDR) (Eaton et al., 2004) (Supplementary material). The CESDR is a 20-item scale that assesses depression symptoms across 9 dimensions that reflect the symptoms for diagnosis of clinical depression in the DSM-5. The CESDR is used to categorize respondents by their depression severity: (1) meeting the criteria for major depressive disorder, (2) probable major depressive disorder, (3) possible major depressive disorder, (4) subthreshold depression symptoms, and (5) no clinical significance. A subset of depression symptoms was also assessed using items from the KADS (LeBlanc et al., 2002; Brooks et al., 2003), including sadness, fatigue/low motivation, lack of focus, and anxiety. Anxiety disorder symptoms were assessed using the Center for Epidemiologic Studies Anxiety (CESA) scale (Faro and Eaton, 2020) (Supplementary material). The CESA is a 20-item scale that was developed as a diagnostic screening tool for detecting anxiety disorder symptoms based on clinical criteria in the DSM-5. A CESA score >16 with at least 1 response at level 3 (i.e., high severity) was interpreted as evidence of anxiety disorder symptomology.

2.5 Study 4: assessment of the SHAWQ and grades in university freshmen

2.5.1 Participant recruitment in Study 4

University freshmen were recruited from the National University of Singapore to participate in a survey on learning beliefs, behaviors, and strategies. The main purpose of the research was to investigate associations between learner characteristics and future academic or employment outcomes. The SHAWQ was included to test whether sleep health was related to grade point average over students' first academic year. The survey was offered to all freshmen aged 18 years or older who enrolled in the Fall semester of the 2020/2021 and 2021/2022 academic years. Students were sent an email invitation which directed them to the online consent form and survey. The email distribution list was provided by the Registrar's office.

The 2020 freshman cohort completed the survey during the late part of the first semester (between October and December), whereas the 2021 freshman cohort completed the survey at the start of the academic year (between July and August). There were 1,809 students in the 2020 cohort who took part in the survey, which represented 23.4% of the freshman class. We excluded 279 students who had missing data for at least one SHAWQ item and 1 student who was not enrolled in courses. The final sample used for analyses of the 2020 freshman cohort therefore included 1,529 students (Supplementary Table 1d). There were 2,051 students in the 2021 cohort who participated in the survey, which represented 24.4% of the freshman class. We excluded 563 students who had missing data on the SHAWQ. Hence, the final sample used for analyses of the 2021 freshman cohort included 1,488 students (Supplementary Table 1e).

2.5.2 Survey items and instruments in Study 4

Four items from the KADS were used to assess frequency of depression symptoms, including sadness, fatigue/low motivation, lack of focus, and anxiety (LeBlanc et al., 2002; Brooks et al., 2003). Two items from the World Health Organization Quality of Life Assessment were used to assess daytime energy and satisfaction with sleep over the past 2 weeks (World Health Organization, 2004). Participants were asked "Do you have enough energy for everyday life?" with the response options "Not at all" (1), "A little" (2), "Moderately" (3), "Mostly" (4), and "Completely" (5), and "How satisfied are you with your sleep?" with the response options "Very dissatisfied" (1), "Dissatisfied" (2), "Neither satisfied nor dissatisfied" (3), "Satisfied" (4), and "Very satisfied" (5).

2.5.3 Grade point average

Permission to analyse students' survey data and grades was obtained from the National University of Singapore (NUS) Institute for Applied Learning Sciences and Educational Technology (ALSET), which stores and links de-identified student data on the ALSET Data Lake. Survey data were merged with other tables on the ALSET Data Lake including demographic information (age, sex, ethnicity, country of citizenship, academic year of matriculation, and school/faculty of enrolment), course enrolment, and course grades. Student datasets were provided by the Registrar's office and identifiers were removed by the NUS department of Information Technology before being added to the ALSET Data Lake. Each student was assigned a unique tokenized identity that could be used to link data across tables. Students provided written informed consent to add their survey data to the ALSET Data Lake for research on learning-related outcomes.

Students' course grades were analyzed over their first academic year. At NUS, the grade point for a given course module is calculated by converting letter grades into numeric values ranging from 0 to 5 (A+ or A = 5.0, A- = 4.5, B+ = 4.0, B = 3.5, B- = 3.0, C+ = 2.5, C = 2.0, D+ = 1.5, D = 1.0, F = 0.0). The cumulative grade point average (GPA) represents the average grade point weighted by the number of course credits earned in each module (i.e., modules worth more credits contribute more to the GPA). Each student's cumulative GPA was calculated after he/she completed both semesters of the freshman year. Percentile rank for GPA was also calculated separately in each freshman cohort that completed the SHAWQ. In the 2020 freshman cohort, we excluded 51 students who were enrolled in the School of Medicine or Faculty of Dentistry, which have a different method of grading compared with the rest of the university, and 1 student with missing course module information. In the 2021 freshman cohort, we excluded 52 students who were enrolled in the School of Medicine or Faculty of Dentistry, and 13 students with missing course module information. Hence, the final samples used for GPA analyses were 1,477 students in the 2020 freshman cohort and 1,423 students in the 2021 freshman cohort.

2.6 Analyses and statistics

2.6.1 Correlational analyses of the SHAWQ with sleep and depression scores

The strength of the association between SHAWQ scores with depression scores on the KADS and CESDR was tested using Kendall's rank correlation coefficient (τ_b, or τ, for short). Kendall's τ was also used to test associations between SHAWQ scores with daytime sleepiness scores on the ESS, sleep quality scores on the PSQI, insomnia scores on the ISI, and anxiety scores on the CESA. Kendall's τ is a nonparametric measure of correlation strength that is based on the number of concordances and discordances in the ranks of paired observations. It is an alternative to Pearson's correlation analysis for ordinal data with many tied ranks. Kendall's τ was calculated with the "stats" package (version 0.1.0) using R statistical software. The 95% CIs for Kendall's τ were determined by performing bootstrap resampling (5,000 samples) using the "boot" package (version 1.3-28.1) in R.

Results for Kendall's τ were interpreted against effect sizes reported in psychology research. A prior study investigated effect sizes across 313 psychology research studies with between-subject designs that were not pre-registered (Schäfer and Schwarz, 2019). Based on the distribution of effect sizes (Pearson's r), thresholds for small, medium, and large effect sizes were proposed as r=0.18, r=0.34, and r=0.57. In large datasets, Kendall's τ is approximately 0.67 of the value of Spearman's rho or Pearson's correlation coefficient (for variables that have an approximately normal distribution) (Sheskin, 2000). Therefore, we used the following ranges for Kendall's τ to define the relative strength of the correlation: weak association, Kendall's τ = 0.12 to 0.23; moderate association, Kendall's τ =0.23 to 0.38; strong association, Kendall's $\tau > 0.38$.

2.6.2 Test-retest reliability of the SHAWQ and other instruments

Test-retest reliability of the SHAWQ and other instruments was assessed by calculating the intra-class correlation coefficient (ICC). The ICC reflects the strength of correlation and agreement between measurements. ICC estimates and their 95% CIs were determined with the "irr" package (version 0.84.1) in R, based on a single measurement, absolute-agreement, 2-way mixed-effects model (Koo and Li, 2016). The term "single measurement" means that in practice a person's SHAWQ score would be based on a single measurement rather than the mean of multiple measurements. The term "absolute agreement" refers to the agreement between repeated measurements. A two-way mixed-effects model was used because repeated measurements are not randomized samples. The level of reliability was interpreted using the following ICC ranges (Koo and Li, 2016): poor reliability, ICC<0.50; moderate reliability, ICC between 0.50 and 0.75; good reliability, ICC between 0.75 and 0.90; excellent reliability, ICC > 0.90.

2.6.3 Comparison of demographic, sleep, and mental health variables between SHAWQ categories

Chi-squared tests and ANOVA were used to test for differences in student characteristics across SHAWQ categories. Estimation statistics (effect sizes and their precision) were used to compare depression and sleep variables between SHAWQ categories (Ho et al., 2019). Estimates of population effect size with 95% CIs were determined for groups with fair sleep health or bad sleep health, assessed relative to the group with good sleep health that served as the reference. Cohen's d was used to compare standardized effect sizes for scores on the KADS, ESS, PSQI, ISI, CESDR, and CESA, where mean differences were expressed in terms of the pooled standard deviations of the samples. Relative effect size was interpreted using the following ranges for Cohen's d (Cohen, 1988): small, d between 0.20 and 0.50; medium, d between 0.50 and 0.80; large, d > 0.80.

Cliff's delta was used to compare ordinal data between SHAWQ categories, including item-by-item analyses of depression symptoms on the KADS and CESDR. Cliff's delta is a measure of ordinal dominance with values ranging from −1 to 1 that assesses the degree of overlap between populations. It measures the probability that a randomly selected member of one population has a higher response than a randomly selected member of a second population, minus the reverse probability. Relative effect size was interpreted using the following ranges: small, delta between 0.11 and 0.28; medium, delta between 0.28 and 0.43; large, delta>0.43. These effect size ranges are equivalent to those that we used for interpreting Cohen's d (see above) (Vargha and Delaney, 2000).

For each measure of effect size, the 95% CI was estimated by bootstrap resampling with 5,000 samples. The *p* value for a two-sided permutation *t*-test was reported for each comparison. It represents the likelihood of observing the effect size if the null hypothesis of zero difference is true. Estimation statistics were performed with the "dabest" package (version 0.3.1) using Python (Ho et al., 2019).

2.6.4 Comparisons of grades between SHAWQ categories

GPA and percentile rank were compared between SHAWQ categories using estimation statistics (Cohen's d and mean differences) and ANCOVA. The latter was performed to assess whether SHAWQ scores were significantly associated with academic performance, adjusting for covariates including age (in years), ethnicity (Chinese, Indian, Malay, Others), country of citizenship (Singapore citizen, Singapore Permanent Resident, Foreigner), and school of enrolment (Faculty of Science, School of Business, Faculty of Engineering, Faculty of Arts & Social Sciences, School of Computing, Alice Lee Center for Nursing Studies, School of Design and Environment, Faculty of Law, Yong Siew Toh Conservatory of Music, multidisciplinary degree programs, and Others which included double degree programs, students who switched programs, and undeclared majors). We did not include sex as a covariate because this variable was included in the SHAWQ. ANCOVA was performed using the "car" package (version 3.1-1) in R. Pairwise contrasts between SHAWQ categories were performed using Tukey's test using the "emmeans" package (version 1.8.3) in R.

3 Results

3.1 Study 1 in adolescents: associations of the SHAWQ with depression symptoms

In our study of adolescents whose data were used to develop the SHAWQ, we assessed the strength of the relationship between SHAWQ scores and depression scores to establish a baseline for interpreting results of subsequent studies (see below). As expected, there was a strong monotonic association between SHAWQ score and KADS depression score (Kendall's $\tau = 0.406$, 95% CI = 0.377–0.432, $p < 0.001$) (Figures 3A, B), and the distribution of depression scores differed substantially across SHAWQ categories (Figure 3C). Relative to students with good sleep health, the mean depression score on the KADS was about 1 standard deviation higher in students with fair sleep health (mean difference in KADS score = 3.81, 95% CI = 3.42–4.20; Cohen's d = 0.92, 95% CI = 0.82–1.02, $p < 0.001$), and >2 standard deviations higher in students with bad sleep health (mean difference in KADS score = 9.69, 95% CI = 8.70–10.81; Cohen's d = 2.32, 95% CI = 2.06–2.58, $p < 0.001$) (Figure 4A; Supplementary Table 2).

In item-by-item analyses by SHAWQ category, all depression symptoms on the KADS were higher in students with fair or bad sleep health relative to good sleep health (Figure 4B; Supplementary Table 3a). Fair sleep health was associated with medium effect sizes for fatigue/low motivation, lack of focus, worthlessness, and sadness (Cliff's delta, range = 0.30–0.35, $p < 0.001$ for all comparisons), and small effect sizes for anhedonia, physical signs of anxiety, anxiety, sleep difficulties, apathy, and irritability (Cliff's delta, range = 0.20–0.27, $p < 0.001$ for all comparisons). Bad sleep health was associated with large effect sizes for fatigue/low motivation, lack of focus, worthlessness, sadness, anhedonia, physical signs of anxiety, anxiety, sleep difficulties, and apathy (Cliff's delta, range = 0.46–0.72, $p<0.001$ for all comparisons), and medium effect sizes for irritability and self-harm thoughts (Cliff's delta, range = 0.34–0.42, $p < 0.001$ for all comparisons) (Figure 4B; Supplementary Table 3a).

3.2 Study 2 in adolescents: associations of the SHAWQ with depression symptoms and excessive daytime sleepiness

3.2.1 SHAWQ scores were associated with depression symptoms in adolescents

There was a strong monotonic association between SHAWQ score and depression score (Kendall's $\tau = 0.391$, 95% CI = 0.361–0.417, $p < 0.001$) (Figures 3D, E) that closely resembled results for adolescents whose data were used to develop the SHAWQ (Figures 3A, B). There was little overlap in the distribution of depression scores between students with good vs. bad sleep health (Figure 3F), hence reproducing findings from Study 1 (Figure 3C). Relative to students with good sleep health, the mean depression score was nearly 1 standard deviation higher in students with fair

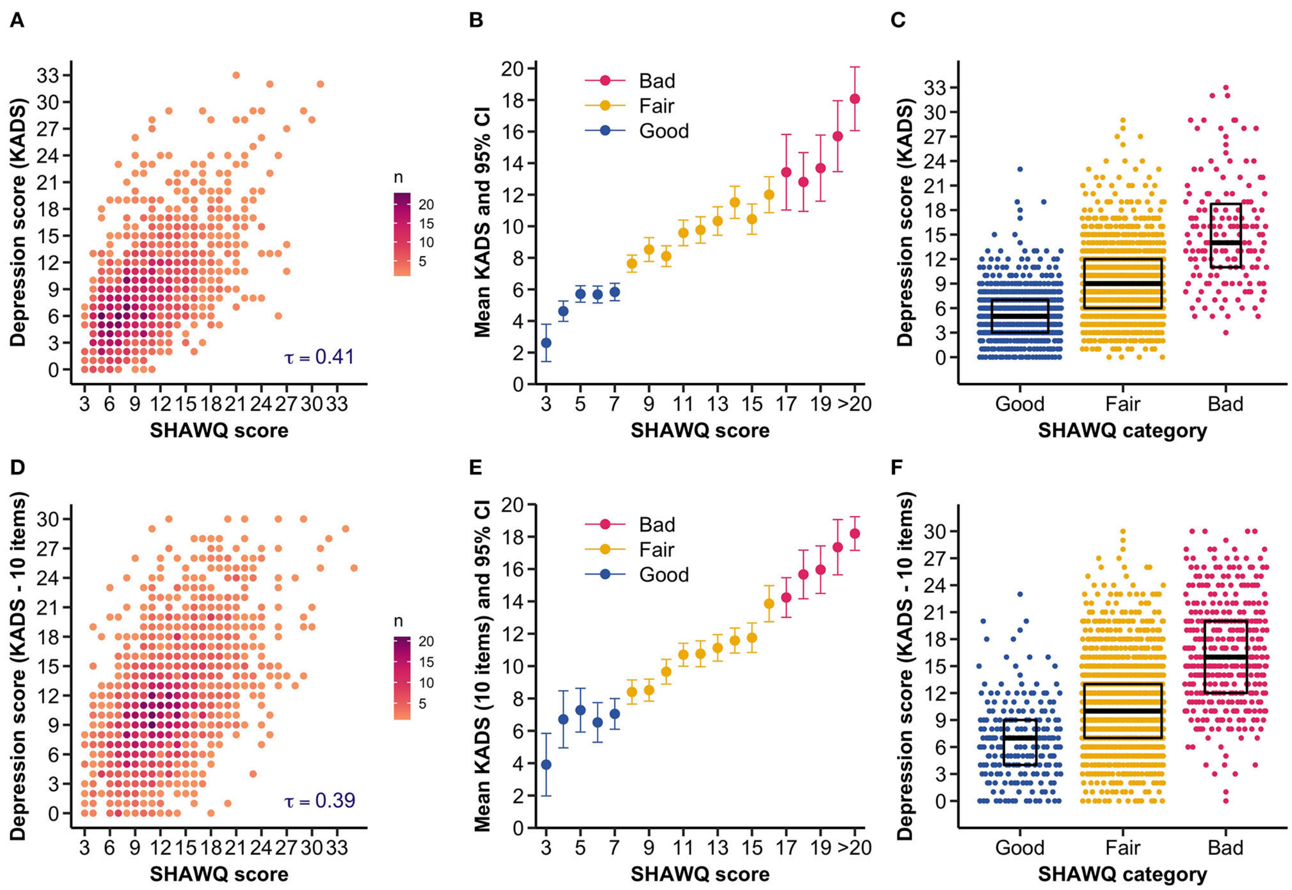

FIGURE 3
Sleep Health And Wellness Questionnaire (SHAWQ) scores were associated with depression scores in adolescents. The SHAWQ was developed from analysis of a prior study in adolescents (Study 1, $n = 1{,}733$) and tested in a different group of adolescents (Study 2, $n = 1{,}777$). In Study 1, **(A)** the scatter density plot shows that depression scores on the 11-item Kutcher Adolescent Depression Scale (KADS) increased monotonically with higher SHAWQ scores. **(B)** The average KADS score increased with the SHAWQ score. Adolescents were categorized as having as having good, fair, or bad sleep health based on the distribution of SHAWQ scores and their association with depression scores (SHAWQ score: Good = 3–7, Fair = 8–16, Bad = 17–35). **(C)** The distribution of depression scores differed across SHAWQ categories with higher scores in adolescents with bad sleep health. Box plots show the median and interquartile range. These findings were reproduced in Study 2, in which **(D)** KADS scores were positively associated with SHAWQ scores, **(E)** the average KADS score increased by SHAWQ score and category, and **(F)** the distribution of depression scores differed across SHAWQ categories. Kendall's rank correlation coefficient (τ) is shown in **(A, D)**. In Study 2, the KADS included 10 items because the question on thoughts of self-harm or suicide was removed.

sleep health (mean difference in KADS score = 3.85, 95% CI = 3.20–4.47; Cohen's d = 0.80, 95% CI = 0.66–0.93, $p < 0.001$), and nearly 2 standard deviations higher in students with bad sleep health (mean difference in KADS score = 9.77, 95% CI = 8.92–10.61; Cohen's d = 1.83, 95% CI = 1.63–2.02, $p < 0.001$) (Figure 4C, Supplementary Table 2).

All depression symptoms were experienced with greater severity in the fair and bad sleep health groups, as compared to the good sleep health group (Figure 4D; Supplementary Table 3a). Fair sleep health was associated with medium effect sizes for fatigue/low motivation, worthlessness, sadness, physical signs of anxiety, and sleep difficulties (Cliff's delta, range = 0.28–0.37, $p < 0.001$ for all comparisons), and small-to-medium effect sizes for lack of focus, anhedonia, anxiety, apathy, and irritability (Cliff's delta, range = 0.16–0.28, $p < 0.001$ for all comparisons). Bad sleep health was associated with large effect sizes for all depression symptoms (Cliff's delta, range = 0.46–0.74, $p < 0.001$ for all comparisons).

3.2.2 SHAWQ scores were associated with excessive daytime sleepiness in adolescents

There was a weak monotonic increase in daytime sleepiness on the ESS with increasing SHAWQ score (Kendall's $\tau = 0.213$, 95% CI = 0.181–0.246, $p < 0.001$) (Supplementary Figure 2). Nonetheless, there was a medium effect size of fair vs. good sleep health on ESS score (mean difference in ESS score = 2.07, 95% CI = 1.45 to 2.65; Cohen's d = 0.51, 95% CI = 0.35 to 0.66, $p<0.001$), and a large effect size of bad vs. good sleep health in which the mean sleepiness score was about 1 standard deviation higher in students with bad sleep health (mean difference in ESS score = 4.27, 95% CI = 3.51 to 4.99; Cohen's d = 0.96, 95% CI = 0.78 to 1.13, $p<0.001$). The proportion of students with an ESS score > 10 differed significantly across SHAWQ categories (Chi-squared = 96.3, $p < 0.001$), whereby the percentages of students categorized with excessive daytime sleepiness were 16.1%, 27.4% and 46.0% in the good, fair, and bad SHAWQ categories (Table 2).

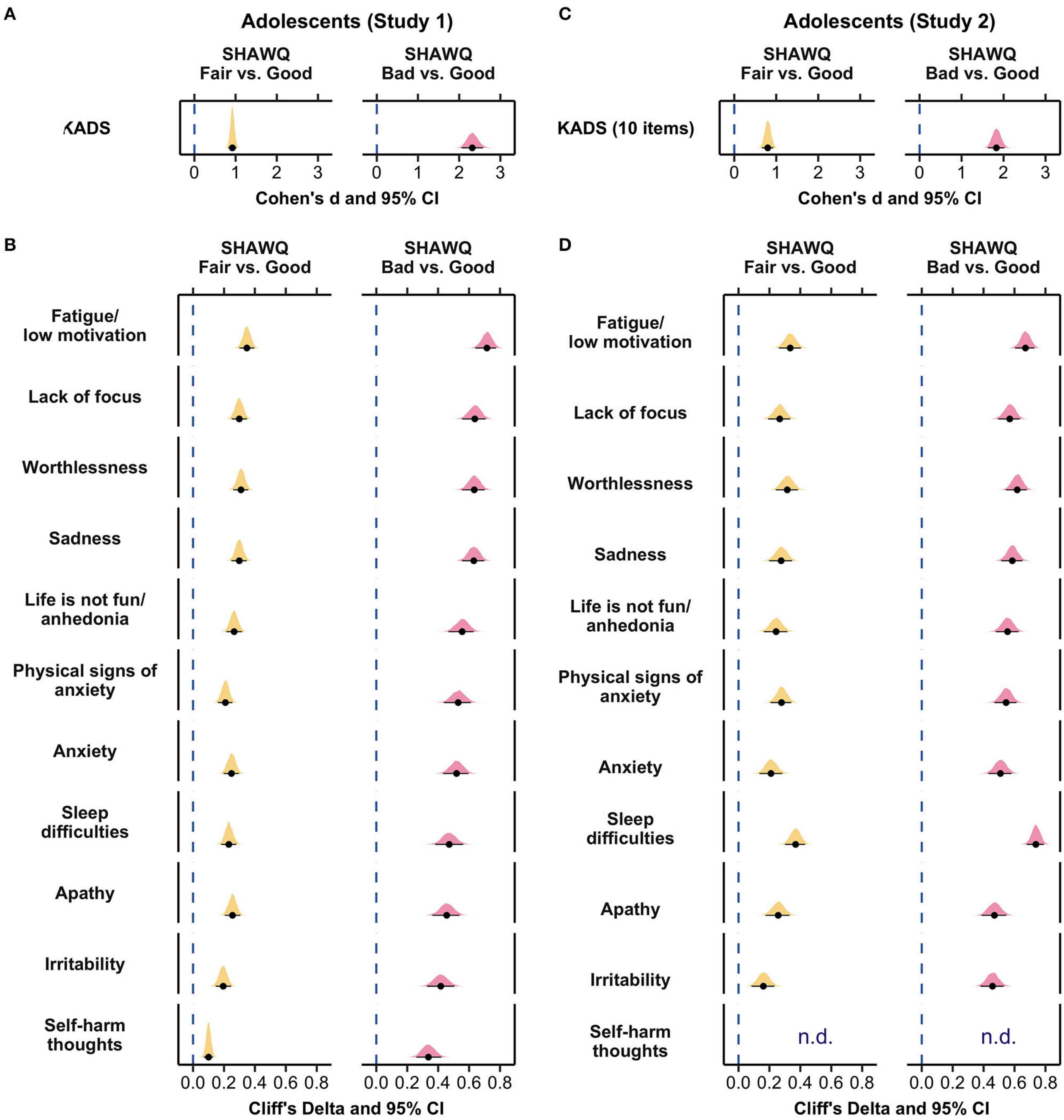

FIGURE 4
Effect size plots for associations of Sleep Health And Wellness Questionnaire (SHAWQ) categories with depression symptoms in adolescents. Adolescents were categorized as having good, fair, or bad sleep health based on their SHAWQ score. Effect sizes for fair and bad sleep health were determined relative to good sleep health. In Study 1 (retrospective study, $n = 1{,}733$), **(A)** large effect sizes (Cohen's d) were observed for associations of fair and bad sleep health with global depression score on the Kutcher Adolescent Depression Scale (KADS). **(B)** All depression symptoms were greater in the fair sleep health group with small-to-medium effect sizes, and in the bad sleep health group with medium-to-large effect sizes (Cliff's delta). These findings for effect sizes were reproduced in Study 2 ($n = 1{,}777$) for associations between SHAWQ category with **(C)** global depression scores, and **(D)** individual depression symptoms. In each plot, the population estimate of effect size is shown with 95% CIs and the bootstrap sampling distribution (5,000 samples). In Study 2, the KADS question on thoughts of self-harm or suicide was removed (n.d., not determined).

TABLE 2 Comparison of sleep and mental health diagnostic categories between SHAWQ categories in studies of adolescents and university students.

Diagnostic category	All	SHAWQ category of sleep health			X^2	p
		Good	Fair	Bad		
Study 2 in adolescents						
Sleepiness on the ESS, *n* (%)						
Normal daytime sleepiness	1,232 (70.2)	177 (83.9)	863 (72.6)	192 (54.1)	96.3	<0.001
Mild excessive daytime sleepiness	236 (13.5)	20 (9.5)	165 (13.9)	51 (14.4)		
Moderate excessive daytime sleepiness	192 (10.9)	11 (5.2)	113 (9.5)	68 (19.2)		
Severe excessive daytime sleepiness	94 (5.4)	3 (1.4)	47 (4.0)	44 (12.4)		
Study 3 in university students						
Sleep quality on the PSQI, *n* (%)						
Good sleep	1,244 (62.1)	279 (93.3)	918 (63.9)	47 (17.5)	351.9	<0.001
Poor sleep	759 (37.9)	20 (6.7)	518 (36.1)	221 (82.5)		
Insomnia severity on the ISI, *n* (%)						
No clinically significant insomnia	953 (46.9)	263 (87.4)	670 (45.9)	20 (7.4)	729.5	<0.001
Subthreshold insomnia	848 (41.7)	36 (12.0)	698 (47.8)	114 (41.9)		
Clinical insomnia (moderate severity)	212 (10.4)	2 (0.7)	92 (6.3)	118 (43.4)		
Clinical insomnia (severe)	21 (1.0)	0 (0.0)	1 (0.1)	20 (7.4)		
Depression on the CESDR, *n* (%)						
No clinical significance	1,275 (63.5)	270 (90.6)	946 (65.7)	59 (21.9)	412.4	<0.001
Subthreshold depressive symptoms	605 (30.1)	28 (9.4)	438 (30.4)	139 (51.7)		
Possible major depressive disorder	8 (0.4)	0 (0.0)	5 (0.3)	3 (1.1)		
Probable major depressive disorder	52 (2.6)	0 (0.0)	29 (2.0)	23 (8.6)		
Major depressive disorder	67 (3.3)	0 (0.0)	22 (1.5)	45 (16.7)		
Anxiety on the CESA, *n* (%)						
No anxiety disorder	1,535 (76.7)	265 (88.9)	1,128 (78.6)	142 (53.0)	112.2	<0.001
Anxiety disorder symptomology	466 (23.3)	33 (11.1)	307 (21.4)	126 (47.0)		

KADS, Kutcher Adolescent Depression Scale; ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index; CESDR, Center for Epidemiologic Studies Depression Scale Revised; CESA, Center for Epidemiologic Studies Anxiety Scale.

3.3 Study 3 in university students: associations of the SHAWQ with sleep problems and mental health

3.3.1 SHAWQ scores were associated with sleep quality and insomnia in university students

Convergent validity of sleep health scores on the SHAWQ was tested against sleep quality scores on the PSQI and insomnia severity scores on the ISI. There was a strong monotonic association between SHAWQ score and PSQI score (Kendall's $\tau = 0.498$, 95% CI = 0.473 to 0.522, $p < 0.001$) (Figures 5A, B). Secondary analyses of PSQI component scores showed moderate-to-strong associations between SHAWQ score with sleep quality (Kendall's $\tau = 0.501$, 95% CI = 0.476 to 0.527, $p < 0.001$), daytime dysfunction (Kendall's $\tau = 0.365$, 95% CI = 0.333 to 0.394, $p < 0.001$), sleep onset latency (Kendall's $\tau = 0.308$, 95% CI = 0.276 to 0.341, $p < 0.001$), and sleep duration (Kendall's $\tau = 0.253$, 95% CI = 0.219 to 0.285, $p < 0.001$), whereas weak associations were observed between SHAWQ score with sleep efficiency (Kendall's $\tau = 0.195$, 95% CI = 0.159 to 0.230, $p < 0.001$), sleep disturbances (Kendall's $\tau = 0.184$, 95% CI = 0.149 to 0.218, $p < 0.001$), and use of sleep medication (Kendall's $\tau = 0.115$, 95% CI = 0.076 to 0.151, $p < 0.001$).

Large effect sizes were observed for SHAWQ category on PSQI scores (Supplementary Table 2). Relative to students with good sleep health, the mean PSQI score was about 1 standard deviation higher in students with fair sleep health (mean difference in PSQI score = 1.99, 95% CI = 1.76 to 2.21; Cohen's d = 0.99, 95% CI = 0.87 to 1.10), and more than 2 standard deviations higher in students with bad sleep health (mean difference in PSQI score = 5.37, 95% CI = 4.98 to 5.78; Cohen's d = 2.30, 95% CI = 2.09 to 2.50) (Figure 6A). There was little overlap in the distribution of PSQI scores between students with good vs. bad sleep health (Figure 5C), and the proportion of students with poor sleep quality (PSQI score>5) differed significantly across SHAWQ categories (Chi-squared = 351.9, $p < 0.001$) (Table 2). The percentages of students with poor sleep quality on the PSQI were 6.7%, 36.1% and 82.5% in the good, fair, and bad SHAWQ categories.

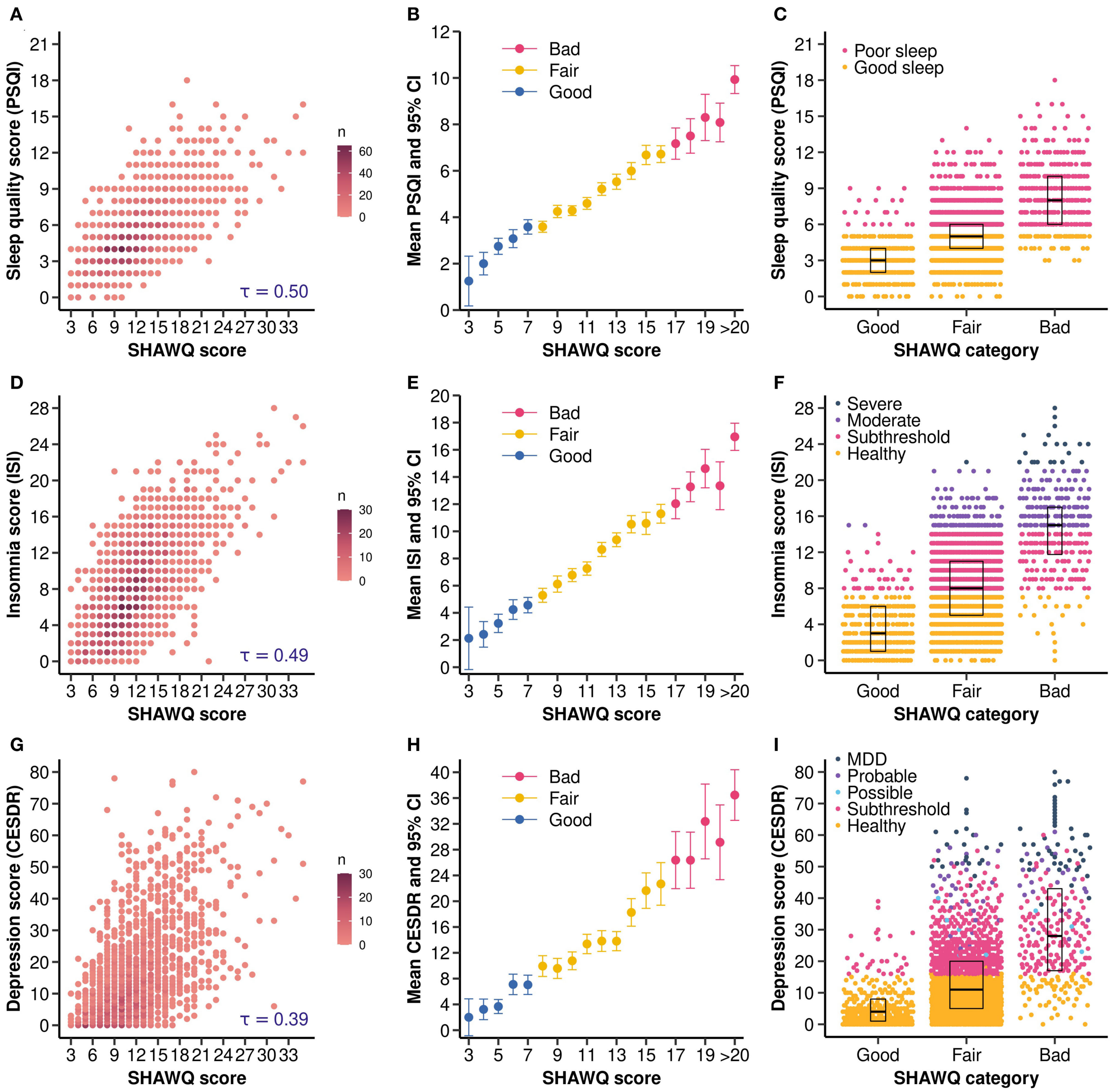

FIGURE 5
Sleep Health And Wellness Questionnaire (SHAWQ) scores were associated with sleep quality, insomnia, and depression scores in university students. University students (Study 3, $n = 2{,}040$) completed a survey that included the SHAWQ, the Pittsburgh Sleep Quality Index (PSQI), the Insomnia Severity Index (ISI), and the Center for Epidemiologic Studies Depression Scale Revised (CESDR). Students were categorized as having good, fair, or bad sleep health based on their SHAWQ score. **(A)** The scatter density plot shows that PSQI scores increased monotonically with higher SHAWQ scores, **(B)** the average PSQI score increased by SHAWQ score and category, and **(C)** the distribution of PSQI scores and sleep quality categories differed across SHAWQ categories. Similarly, **(D)** ISI scores increased monotonically with SHAWQ scores, **(E)** the average ISI score increased by SHAWQ score and category, and **(F)** the distribution of ISI scores and insomnia severity categories differed across SHAWQ categories. Comparable findings were observed for depression symptoms in which **(G)** CESDR scores increased monotonically with SHAWQ scores, **(H)** the average CESDR score increased by SHAWQ score and category, and **(I)** the distribution of CESDR scores and depression categories differed by SHAWQ category. Kendall's rank correlation coefficient (τ) is shown in **(A, D, G)**. Box plots in **(C, F, I)** show the median and interquartile range. MDD, Major Depressive Disorder.

Sleep health scores on the SHAWQ were also strongly associated with insomnia scores on the ISI (Kendall's $\tau = 0.495$, 95% CI = 0.469 to 0.517, $p < 0.001$) (Figures 5D, E). The mean ISI score was 1 standard deviation higher in students with fair vs. good sleep health (mean difference in ISI score = 4.23, 95% CI = 3.82 to 4.61; Cohen's d = 1.08, 95% CI = 0.97 to 1.18), and 2.6 standard deviations higher in students with bad vs. good sleep health (mean difference in ISI score = 10.51, 95% CI = 9.83 to 11.18; Cohen's d = 2.61, 95% CI = 2.34 to 2.88) (Figure 6A; Supplementary Table 2). The proportion of students with evidence of clinical insomnia on the ISI differed significantly across SHAWQ categories (Chi-squared = 729.5, $p < 0.001$) (Figure 5F; Table 2).

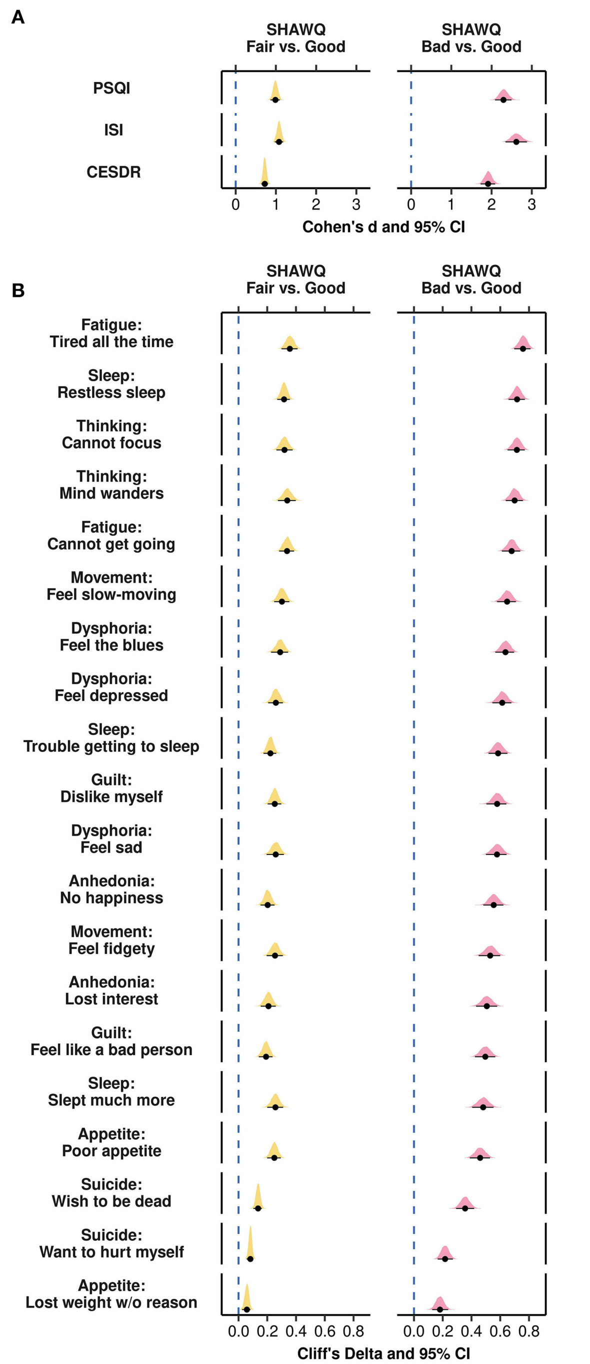

FIGURE 6
Effect size plots for associations of Sleep Health And Wellness Questionnaire (SHAWQ) categories with depression symptoms in university students. University students (Study 3, $n = 2{,}040$) were categorized as having good, fair, or bad sleep health based on their SHAWQ score. Effect sizes for fair and bad sleep health were determined relative to good sleep health. **(A)** Large effect sizes (Cohen's d) were observed for associations of fair and bad sleep health with scores on the Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), and the Center for Epidemiologic Studies Depression Scale Revised (CESDR). **(B)** All depression symptoms on the CESDR were greater in the fair sleep health group with small-to-medium effect sizes, and in the bad sleep health group with medium-to-large effect sizes (Cliff's delta). In each plot, the population estimate of effect size is shown with 95% CIs and the bootstrap sampling distribution (5,000 samples).

The percentages of students with clinical insomnia on the ISI (moderate or severe) were 0.7%, 6.4%, and 50.8% in the good, fair, and bad SHAWQ categories.

3.3.2 SHAWQ scores were associated with depression symptoms in university students

Sleep health scores on the SHAWQ were strongly associated with global depression scores on the CESDR (Kendall's $\tau = 0.393$, 95% CI = 0.366 to 0.419, $p < 0.001$) (Figures 5G, H). There was a medium effect size for fair vs. good sleep health on depression score (mean difference in CESDR score = 8.19, 95% CI = 7.18 to 9.14; Cohen's d = 0.72, 95% CI = 0.64 to 0.80, $p < 0.001$), and a large effect size for bad vs. good sleep health in which the mean CESDR score was nearly 2 standard deviations higher in students with bad sleep health (mean difference in CESDR score = 25.10, 95% CI = 22.83 to 27.36; Cohen's d = 1.91, 95% CI = 1.73 to 2.09, $p < 0.001$) (Figure 6A; Supplementary Table 2). The proportion of students with evidence of major depressive disorder differed significantly across SHAWQ categories (Chi-squared = 412.4, $p < 0.001$) (Figure 5I; Table 2). The percentages of students with either probable depressive disorder or major depressive disorder were 0.0%, 3.5%, and 25.3% in the good, fair, and bad SHAWQ categories.

All depression symptoms were experienced with greater severity in the fair and bad sleep health groups compared with the good sleep health group (Figure 6B). Medium effect sizes were observed for fair sleep health for several depression symptoms related to fatigue (tired all the time; cannot get going), sleep (restless sleep), thinking (cannot focus on important things; mind wanders), movement (feel slow-moving), and dysphoria (feel the blues) (Cliff's delta, range = 0.29 to 0.36, $p < 0.001$ for all comparisons) (Figure 6B; Supplementary Table 3b). Large effect sizes were observed for bad sleep health for most depression symptoms, including those related to fatigue (cannot get going; tired all the time), sleep (slept much more; trouble getting to sleep, restless sleep), thinking (mind wanders; cannot focus), movement (feel fidgety; feel slow-moving), dysphoria (feel sad; feel depressed, feel the blues), guilt (feel like a bad person; dislike myself), anhedonia (lost interest, no happiness), and appetite (poor appetite) (Cliff's delta, range = 0.46 to 0.76, $p < 0.001$ for all comparisons). In addition, a medium effect size of bad sleep health was observed for thoughts related to suicide (wish to be dead) (Cliff's delta = 0.36, 95% CI = 0.29 to 0.42, $p < 0.001$). SHAWQ scores in university students were also associated with frequency of depression symptoms on the KADS with medium-to-large effect sizes (Supplementary Table 3b).

3.3.3 SHAWQ scores were associated with anxiety disorder symptoms in university students

We tested the relationship between SHAWQ scores with anxiety disorder scores on the CESA. We predicted that the strength of the association with CESA scores would be weaker compared with CESDR scores because SHAWQ items were selected based on their correlation with depression symptoms (i.e., in Study 1 conducted in adolescents). Consistent with this prediction, SHAWQ scores were weakly associated with global anxiety score on the CESA (Kendall's $\tau = 0.220$, 95% CI = 0.190

to 0.251, $p < 0.001$) (Supplementary Figure 3). Nonetheless, there were substantial differences in anxiety scores between SHAWQ categories. There was a small-to-medium effect size for fair vs. good sleep health on anxiety score (mean difference in CESA score = 3.34, 95% CI = 2.61 to 3.99; Cohen's d = 0.48, 95% CI = 0.38 to 0.58, $p < 0.001$), and a large effect size of bad sleep health in which the mean CESA score was about 1 standard deviation greater relative to students with good sleep health (mean difference in CESA score = 8.87, 95% CI = 7.54 to 10.31; Cohen's d = 1.09, 95% CI = 0.93 to 1.25, $p < 0.001$) (Supplementary Table 2). The proportion of students with evidence of anxiety disorder on the CESA differed across SHAWQ categories (Chi-squared = 112.2, $p < 0.001$) (Supplementary Figure 3; Table 2). The percentages of students who were categorized as having anxiety disorder symptoms on the CESA were 11.1%, 21.4%, and 47.0% in the good, fair, and bad SHAWQ categories.

3.3.4 Test-retest reliability of SHAWQ scores in university students

Test-retest reliability of scores on the SHAWQ, PSQI, ISI, CESDR, and CESA was assessed in 407 university students who re-took the surveys 6–10 weeks later. SHAWQ scores showed moderate test-retest reliability (ICC = 0.644, 95% CI = 0.584 to 0.697, $p < 0.001$) that was comparable with PSQI and ISI scores for assessing sleep quality and insomnia severity, respectively (PSQI: ICC = 0.648, 95% CI = 0.588 to 0.702, $p < 0.001$; ISI: ICC = 0.659, 95% CI = 0.600 to 0.710, $p < 0.001$). The test-retest reliability of the SHAWQ was also comparable with CESDR and CESA scores used to assess depression and anxiety symptoms (CESDR: ICC = 0.684, 95% CI = 0.628 to 0.732, $p < 0.001$; CESA: ICC = 0.694, 95% CI = 0.637 to 0.743, $p < 0.001$).

3.4 Study 4 in university freshmen: SHAWQ scores were associated with grades

SHAWQ scores in both freshman cohorts were associated with depression symptoms on the KADS (fatigue/low motivation, sadness, lack of focus, and anxiety), as well as energy for everyday life and satisfaction with sleep on the WHO Quality of Life questionnaire (Supplementary Table 3b; Supplementary Figure 4). Bad sleep health was associated with large effect sizes for depression symptoms (Cliff's delta, range = 0.50–0.70, $p < 0.001$ for all comparisons) and quality of life measures (Cliff's delta, range = −0.88 to −0.56, $p < 0.001$ for all comparisons) (Supplementary material).

In the 2020 freshman cohort, there was no difference in grade point average (GPA) in students with fair vs. good sleep health (mean difference in GPA = −0.03, 95% CI = −0.10–0.06; Cohen's d = −0.05, 95% CI = −0.21–0.13, $p = 0.517$). However, students with bad sleep health had lower grades compared with students with good sleep health based on differences in their GPA (mean difference in GPA = −0.13, 95% CI = −0.22 to −0.04; Cohen's d = −0.25, 95% CI = −0.41 to −0.06, $p = 0.008$) and differences in their percentile rank (mean difference in percentile rank = −8.26%, 95% CI = −13.27% to −2.87%; Cohen's d = −0.29, 95% CI = −0.47 to −0.10, $p = 0.002$) (Figures 7A, B; Supplementary Table 2).

In the 2021 freshman cohort, academic performance was marginally worse in students with fair vs. good sleep health for GPA (mean difference in GPA = −0.08, 95% CI = −0.15 to −0.01; Cohen's d = −0.19, 95% CI = −0.33 to −0.03, $p = 0.028$) and percentile rank (mean difference in percentile rank = −5.26%, 95% CI = −9.67% to −0.54%; Cohen's d = −0.18, 95% CI = −0.34 to −0.02, $p = 0.029$). By comparison, students with bad sleep health performed substantially worse than their peers with good sleep health for both GPA (mean difference in GPA = −0.15, 95% CI = −0.24 to −0.07; Cohen's d = −0.33, 95% CI = −0.51 to −0.15, $p < 0.001$) and percentile rank (mean difference in percentile rank = −9.24%, 95% CI = −14.67% to −3.81%; Cohen's d = −0.32, 95% CI = −0.52 to −0.13, $p = 0.001$) (Figures 7C, D; Supplementary Table 2).

ANCOVA showed that academic performance differed significantly across SHAWQ categories, adjusting for covariates (Supplementary material). Multiple comparison tests showed that the mean percentile rank of students with bad sleep health was nearly 10 percentage points lower compared with students with good sleep health, in both the 2020 freshman cohort (estimated difference = −8.24%, 95% CI = −14.35% to −2.13%; $t = -3.16$, $p = 0.005$) and the 2021 freshman cohort (estimated difference = −9.11%, 95% CI = −15.57% to −2.64%; $t = -3.31$, $p = 0.003$). Academic performance did not differ significantly between the fair and good sleep health groups (Supplementary material).

4 Discussion

In the present study, we developed and tested a 6–item Sleep Health And Wellness Questionnaire (SHAWQ) in adolescents and university students in their teens and twenties. Items were selected based on their combined strength of association with depression symptoms and included sleep quality, daytime sleepiness, frequency of staying up until 3:00 am or later, sleep latency on school days, self–rated health, and gender. We showed that SHAWQ scores were associated with sleep and mental health outcomes using other validated instruments. Higher SHAWQ scores (poorer sleep health) were associated with excessive daytime sleepiness, poor sleep quality, insomnia, and symptoms of major depressive disorder and anxiety. We provided evidence of convergent validity of the SHAWQ with sleep quality and insomnia severity, and moderate test–retest reliability assessed over several weeks. As expected, SHAWQ scores were more closely associated with depression symptoms compared with anxiety disorder symptoms. SHAWQ scores were used to categorize students as having good, fair, or bad sleep health. Large effect sizes were observed for bad sleep health on all sleep and mental health outcomes relative to good sleep health. Additionally, we showed that higher SHAWQ scores were prospectively associated with lower academic performance in university freshmen. Together, these findings suggest that the SHAWQ may be a useful tool for identifying students in their teens and twenties with poor sleep health who are susceptible to mental health problems and academic difficulties.

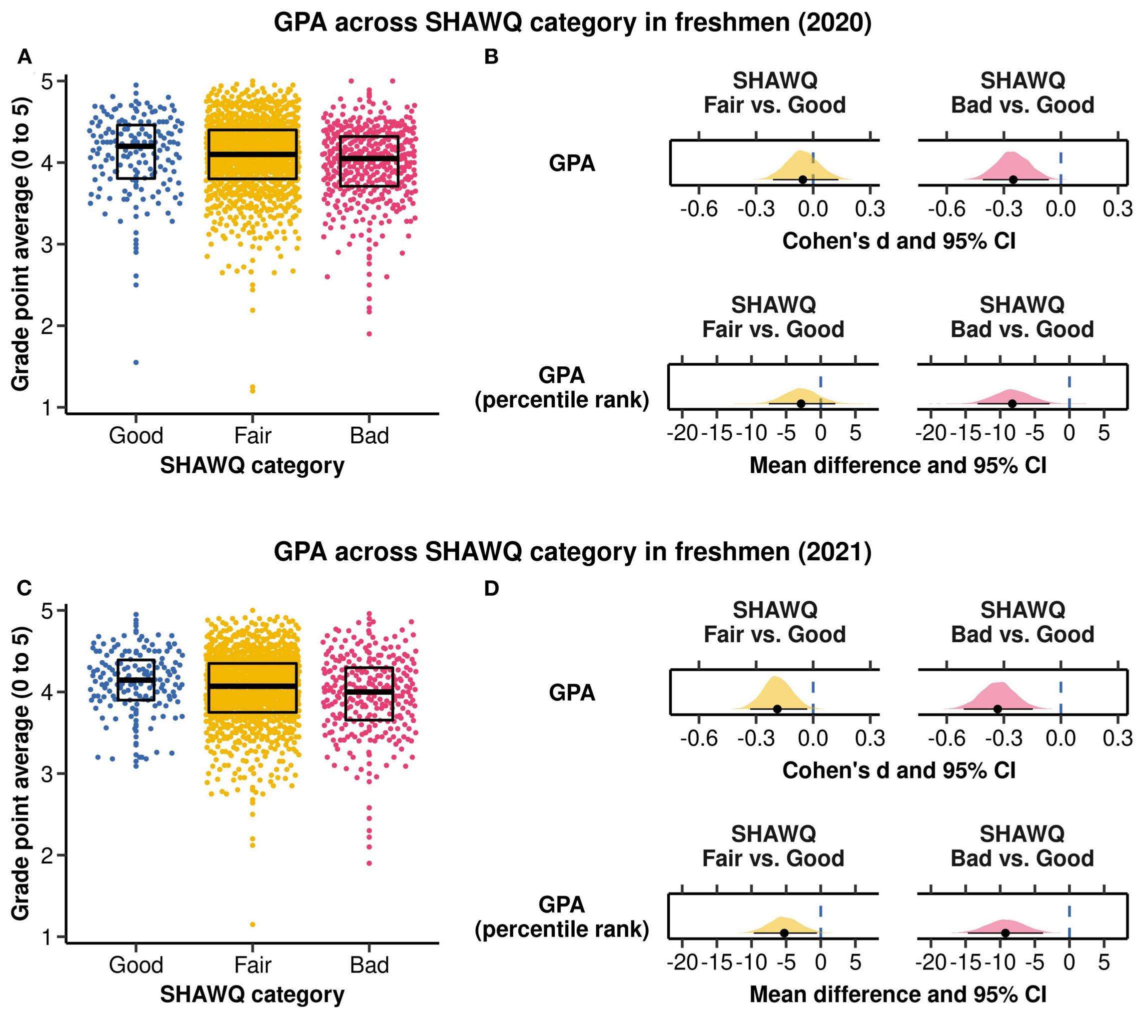

FIGURE 7
Associations of Sleep Health And Wellness Questionnaire (SHAWQ) categories with grade point average (GPA). University freshmen completed the SHAWQ near the end (2020 cohort, $n = 1{,}529$) or beginning (2021 cohort, $n = 1{,}488$) of their first semester, and their GPA was determined after the end of their first academic year spanning 2 semesters. Students were categorized as having good, fair, or bad sleep health based on their SHAWQ score. **(A)** The distribution of GPA is shown by SHAWQ category in the 2020 freshman cohort. **(B)** Effect sizes for GPA (Cohen's d) and percentile rank (mean difference) overlapped with zero in the fair sleep group, and were small-to-medium in the bad sleep health group. **(C)** The distribution of GPA is shown by SHAWQ category in the 2021 freshman cohort. **(D)** Effect sizes for GPA (Cohen's d) and percentile rank (mean difference) were small in the fair sleep health group, and were small-to-medium in the bad sleep health group. Box plots in **(A, C)** show the median and interquartile range. In **(B, D)** the population estimate of effect size is shown with 95% CIs and the bootstrap sampling distribution (5,000 samples).

4.1 SHAWQ scores were associated with sleep health-related measures

Our findings suggest that SHAWQ scores can be used as a relative indicator of sleep health. Four of the items on the SHAWQ were directly related to previously defined dimensions of sleep health (Buysse, 2014), i.e., sleep quality or satisfaction with sleep, daytime alertness/sleepiness or dysfunction, sleep efficiency (ability to fall asleep and return to sleep at night), and sleep timing. Students with high SHAWQ scores also exhibited other signs of poor sleep health, as detailed in the Supplementary material, Supplementary Table 1. In all studies, students with higher SHAWQ scores had later bedtimes and shorter nocturnal sleep on school days. Additionally, students categorized as having bad sleep health were more likely to wake up in the middle of the night, wake up earlier than desired in the morning, nap on school days and weekends, and take caffeine to help stay awake during the day. The other 2 items on the SHAWQ were gender and self-rated health (discussed in more detail below). Prior studies have demonstrated marked sex differences whereby the frequencies of sleep problems and depression were about twice as high in girls compared with boys (Hyde et al., 2008; Thapar et al., 2012; Hysing et al., 2013). Self-reported health has also been shown to associate with inadequate sleep and multidimensional sleep health scores (Steptoe et al., 2006; Dalmases et al., 2015; Yeo et al., 2019).

We observed strong monotonic associations between SHAWQ scores with sleep quality scores on the PSQI and insomnia severity scores on the ISI. Although the PSQI and ISI were constructed to assess sleep problems, both instruments cover multiple dimensions of sleep health including but not limited to self-rated sleep quality, daytime functioning, and restless or disturbed sleep. Our analyses of the ESS, PSQI and ISI by SHAWQ category provided further support that SHAWQ scores provide information on students' sleep health. Among students categorized with bad sleep health on the SHAWQ, about half reported excessive daytime sleepiness and symptoms of clinical insomnia, and more than 80% had poor sleep quality on the PSQI. Bad sleep health was associated with large effect sizes for ESS scores, PSQI scores, and ISI scores, and fair sleep health was associated with medium-to-large effect sizes. Moreover, differences in ESS scores, PSQI scores, and ISI scores between good and bad SHAWQ categories exceeded minimum clinically important difference (MCID) values proposed in prior studies (MCID: ESS >2, PSQI >3, ISI >6 (Yang et al., 2009; Buysse et al., 2011; Patel et al., 2018; Crook et al., 2019), suggesting that differences in sleep problems across SHAWQ categories are clinically meaningful.

4.2 SHAWQ scores were associated with mental health outcomes

SHAWQ scores were strongly associated with depression scores in adolescents and university students. The strength of the association was comparable across studies despite differences in student and school characteristics (e.g., demographic and socioeconomic factors, type of school) and changes in sleep or wellbeing that may have been related to the COVID-19 pandemic (Richter et al., 2023). In all studies, bad sleep health on the SHAWQ was associated with very large effect sizes whereby the average depression score on the KADS or CESDR was nearly 2 standard deviations higher compared with good sleep health. Item-by-item analyses showed that all depression symptoms (not just those related to poor sleep) were experienced more frequently in students with fair or bad sleep health. Notably, about 1 out of every 4 students with bad sleep health reached the diagnostic threshold on the CESDR for probable depressive disorder or major depressive disorder, whereas no students with good sleep health reached this threshold. SHAWQ scores were also associated with anxiety disorder symptoms. As expected, SHAWQ scores in university students were more strongly associated with depression scores on the CESDR compared with anxiety scores on the CESA. This is presumably because SHAWQ items were selected based on their association with depression symptoms rather than anxiety symptoms. Nonetheless, major depressive disorder and anxiety disorders are highly comorbid (Kalin, 2020), and they likely co-occur in many students with poor sleep health. Hence, the SHAWQ may be useful for identifying students who are at greater risk of comorbid depression and anxiety.

Our findings are consistent with previous studies in adolescents and university students demonstrating that multidimensional sleep health was associated with mental health outcomes. For example, a study of Australian adolescents showed that higher PSQI scores (i.e., more sleep health problems) were associated with higher depression scores on the CESD and higher anxiety scores on the Spence Children's Anxiety Scale (Raniti et al., 2018). Related findings were obtained in American adolescents who were screened for evening preference and late bedtimes, in whom better composite sleep health scores derived from sleep diaries (regularity, timing, efficiency and duration of sleep) and self-report (satisfaction with sleep and daytime alertness) were associated with lower depression symptoms on the Children's Depression Rating Scale-Revised and lower anxiety symptoms on the Multidimensional Anxiety Scale for Children (Dong et al., 2019). In a study of college students, scores on the National Sleep Foundation's Sleep Health Index (SHI) were inversely related with the frequency of stress-related thoughts or feelings on the Perceived Stress Scale, and intensity of stressors experienced on the Inventory of College Students' Recent Life Experiences (Benham, 2019). Stress was most strongly associated with the sleep quality sub-index of the SHI, which includes items for self-rated sleep quality, daytime sleepiness, and difficulties falling or staying asleep. Weaker associations with stress were observed for the sleep duration sub-index, which includes questions related to time in bed (relative to age-based recommendations, self-reported sleep need, and differences between weekdays and weekends), and the sleep disorder sub-index, which includes questions related to taking sleep medications, seeking help for a sleep problem, or diagnosis of a sleep disorder.

In most studies conducted in student populations and older adults (Supplementary material), the sleep health variables that were most strongly associated with mental health were self-rated sleep quality or satisfaction with sleep, daytime alertness/sleepiness, and sleep efficiency. These were also among the top variables shortlisted for the SHAWQ. Mixed findings have been reported for the associations of sleep regularity and sleep timing with depression symptoms. In our study, staying up late (3:00 am or later) was one of the top predictors of depression scores. This result could be explained by the association of later chronotype with poorer mood and depression symptoms (Bauducco et al., 2020), or by sleep deprivation that occurs when students go to bed late but must wake up early for school (Crowley et al., 2018). Previous studies found that the correlation between sleep duration and mental health was weaker compared with other dimensions of sleep health (Furihata et al., 2017; Benham, 2019; Dong et al., 2019; Bowman et al., 2021; Lee and Lawson, 2021; O'Callaghan et al., 2021; Appleton et al., 2022), despite substantial evidence that either short or long sleep duration is associated with depression symptoms (Zhai et al., 2015; Dong et al., 2022). This could explain why sleep duration was not selected in our best-subsets regression analysis, as it did not explain additional variance in depression scores beyond other sleep survey variables. The items selected for the SHAWQ and its weighted scoring scheme are therefore consistent with prior studies showing that the various dimensions of sleep health differ in their strength of association with depression scores.

4.3 SHAWQ scores were associated with lower academic performance

We found that university freshmen with bad sleep health on the SHAWQ had lower grades during their first academic year compared with their peers. In 2 freshman cohorts, the GPA percentile rank was nearly 10 percentage points lower in students with bad sleep health. Although our study does not demonstrate a causal relationship between poor sleep health and grades, SHAWQ scores may provide a relative indication of how students will perform in the future. Possible mechanisms linking SHAWQ scores with grades include effects of poor sleep health on attention and learning, mental health and wellbeing, effort and motivation, as well as psychosocial factors that influence sleep and learning habits (e.g., self-regulation, family support, socioeconomic status) (Lo et al., 2016; Cousins and Fernández, 2019; Dorrian et al., 2019; Massar et al., 2019; Short et al., 2020; Tomaso et al., 2021). Importantly, the effect sizes for the association of bad sleep health with grade point average and percentile rank were within the range considered meaningful for academic outcomes (i.e., Cohen's d >0.20, with a medium effect size defined as $d = 0.40$) (Hattie, 2015; What Works Clearinghouse, 2020). Interventions for improving sleep health could therefore have a positive impact on grades if these variables are causally related.

Our findings are consistent with previous studies in adolescents and university students demonstrating that different dimensions of sleep health were associated with academic performance (Supplementary material). Composite scores relating to sleep health have also been shown to associate with academic outcomes. In university students, sleep quality scores derived from items on sleep onset latency, nocturnal awakenings, and the quality and depth of sleep were associated with end-of-semester grades (Gomes et al., 2011). Similarly, in a study of more than 55,000 students attending 4-year colleges in the United States, composite scores of sleep problems that included items on restorative sleep, difficulties with falling and returning asleep, and feeling sleepy were associated with lower self-reported grades (Hartmann and Prichard, 2018). Poorer sleep quality scores on the PSQI and higher insomnia scores on the ISI have also been shown to associate with lower academic performance in adolescents and university students (Orzech et al., 2011; Lemma et al., 2014; Adelantado-Renau et al., 2019; Carrión-Pantoja et al., 2022; Zhang et al., 2023). Our study using the SHAWQ provides further evidence that poor sleep health is correlated with grades and might be useful for identifying students at greater academic risk.

4.4 Comparison of the SHAWQ with other instruments

The content of the SHAWQ overlaps with other questionnaires used to assess sleep problems and sleep health. This includes the PSQI and ISI which were developed as clinical tools but are widely used in non-patient populations (Buysse et al., 1989; Bastien et al., 2001). Like the SHAWQ, the PSQI and ISI include items on sleep quality (or sleep satisfaction), sleep latency (or difficulty falling asleep), and daytime sleepiness or dysfunction. However, the PSQI also has items relating to sleep duration, sleep disturbances, and use of sleep medications, and the ISI has items on sleep maintenance, how noticeable the sleep problem is to others, and the level of worry or distress about the problem. The SHAWQ also has similarities with scales for "sleep disturbances" and "sleep-related impairment" in the National Institutes of Health Patient-Reported Outcomes Measurement Information System (PROMIS) (Cella et al., 2007). These PROMIS scales provide coverage of sleep disturbances, sleep quality, daytime dysfunction, restful sleep, and difficulty falling or staying asleep. Recently, there has been a shift toward assessing (and defining) sleep health in non-clinical populations. The Sleep Health Index (SHI) was developed by a task force at the National Sleep Foundation for assessing general sleep health (Knutson et al., 2017). As described above, the SHI conceptualizes sleep health as comprising 3 domains related to sleep quality, sleep duration, and disordered sleep. The RuSATED, on the other hand, builds on the SATED framework for sleep health and comprises six dimensions of sleep health including sleep regularity, satisfaction with sleep, daytime alertness, sleep timing, sleep efficiency, and sleep duration (Buysse, 2014). Scores on the RuSATED and SATED have been shown to associate with a broad spectrum of mental and physical health outcomes and can potentially be modified for use in children and adolescents (Dong et al., 2019; Meltzer et al., 2021). All the aforementioned instruments have advanced research on sleep health but they differ in their conceptualization (theoretical basis or intended application) and their composition or form (definitions of components or domains, number and types of questions selected). The sleep health questionnaire chosen for a given study will therefore depend on the goals of the research and the study design.

There are several ways that the SHAWQ differs from prior instruments used for assessing sleep health and/or disordered sleep. The SHAWQ was developed for use in student populations whereas most prior work has focused on adults. Given that sleep problems and depression symptoms often emerge during adolescence and early adulthood, it is important to develop and implement sleep health assessment tools during this critical period of development. While sleep health instruments in adults could be adapted for use in student populations, we selected for items in the SHAWQ that were derived from prior adolescent sleep surveys. Hence, some questions on the SHAWQ may better reflect the social context of sleep in students. For example, the SHAWQ included an item for sleep latency on school days, as well as an item on the frequency of staying awake until 3:00 am or later. Difficulty falling asleep is the most common sleep problem in adolescents (i.e. more problematic than nocturnal awakenings and returning to sleep) (Gradisar et al., 2022) and may be worse on school days when students attempt to adjust their bedtime to their school schedule. Adolescents and university students are also more likely to stay up late (i.e., past 3:00 am) compared with working adults due to biological and psychosocial factors (Carskadon, 2011; Crowley et al., 2018). These sleep variables in the SHAWQ may therefore be especially relevant for sleep health in student populations in their teens and twenties.

We did not compare the SHAWQ with other sleep instruments developed for use in adolescents. As reviewed elsewhere (Lewandowski et al., 2011; Ji and Liu, 2016; Van Meter and Anderson, 2020), there are validated questionnaires in pediatric populations for assessing daytime sleepiness, sleep hygiene and bedtime routine, sleep-related attitudes or cognitions, sleep initiation and maintenance, and disordered sleep. Many of these instruments focus on a specific domain or dimension of sleep behavior, whereas some provide broader coverage of items related to sleep health or sleep quality. It is possible that scores on these sleep questionnaires may associate with depression scores with similar strength as the SHAWQ, even though items were not selected based on their relationship with depression symptoms. Future studies should test whether the SHAWQ performs as well as, or better than, other sleep questionnaires at predicting depression symptoms in adolescents (e.g., the Adolescent Sleep Wake Scale, Adolescent Sleep Hygiene Scale; Pediatric Daytime Sleepiness Scale, Chronic Sleep Reduction Questionnaire), despite having fewer items (Drake et al., 2003; LeBourgeois et al., 2005; Meijer, 2008).

Previous sleep health instruments were developed based on conceptual grounds to include items that were viewed as distinct (i.e., representing different dimensions or constructs) and relevant for overall health and wellness (Buysse, 2014; Knutson et al., 2017). Composite scores were then used to test for associations with different health outcomes. Here, we took the opposite approach and started with the health domain that we viewed as of greatest concern in adolescents and young adults (i.e., mental health), and then used best-subsets regression to select for the combination of sleep survey items most strongly associated with depression scores. We also implemented a different scoring method that reflected the strength of association for individual response items with depression scores. Additional studies are needed to assess whether our weighted scoring approach performs better at predicting mental health outcomes compared with other instruments in which each dimension of sleep health is given equal weight.

In contrast to previous work (Buysse, 2014; Knutson et al., 2017), we did not limit the SHAWQ to questions directly related to the experience of sleep. Our primary goal was to develop a questionnaire that can be used to screen for students with sleep health problems who may be at risk of depression. We think that including gender in the SHAWQ is justified because female gender is a predictor or risk factor of sleep problems and depression (Hyde et al., 2008; Thapar et al., 2012; Hysing et al., 2013). We view gender in the SHAWQ as analogous to body mass index (BMI) in the Berlin Questionnaire (Netzer et al., 1999), where BMI is not a symptom of obstructive sleep apnoea but is associated with disease risk. Self-rated health, on the other hand, is closely related to the definition of sleep health in the SATED/RuSATED framework (Buysse, 2014), i.e., "Sleep health is a multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental wellbeing". The "health" component of "sleep health" implies that a person's self-perceived health and wellbeing is integral to the concept of sleep health itself. Hence, including an item on self-rated health on the SHAWQ is consistent with how sleep health is conceptualized, even though it is not specific to how sleep is experienced.

The main caveat of including gender and self-rated health in the SHAWQ is that these variables are predictors, rather than dimensions of sleep health. We do not think that this precludes the use of the SHAWQ for estimating sleep health in student populations (e.g., categorizing students into good, fair, or bad sleep health groups) because the SHAWQ provides coverage of 4 dimensions of sleep health and the composite score was strongly associated with PSQI and ISI scores. In exploratory analyses, removing the SHAWQ items on gender and self-rated health did not alter the strength of association (Kendall's τ) between SHAWQ scores with PSQI and ISI scores (Supplementary Table 4). Additionally, the strength of association with depression scores on the KADS and CESDR was only slightly weaker if SHAWQ scores were calculated using just the 4 sleep-related items rather than all 6 items (Supplementary Table 4). Hence, the association between the 6-item SHAWQ and depression scores was largely attributable to the association between sleep health and depression, rather than being explained primarily by gender and self-rated health. Future studies could assess whether the SHAWQ can be reduced to its 4 sleep-related items (with a new categorization scheme for good, fair, and bad sleep health) without substantially altering effect sizes for associations with sleep problems and depression symptoms. At present, we recommend using all 6 items on the SHAWQ because they were selected based on their combined strength of association with depression symptoms, and our findings on convergent validity, test-retest reliability, effect sizes, and prospective associations with grades are based on the 6-item SHAWQ.

4.5 Limitations and considerations

There are several limitations associated with the development of the SHAWQ. The items considered for the SHAWQ were limited to those used in our initial sleep habits survey that was largely based on the School Sleep Habits Survey (Wolfson and Carskadon, 1998). These questions covered the main dimensions of sleep health described in prior work (except for sleep regularity), but it is possible that including other questions on sleep habits or sleep health would have explained additional variance in depression scores. We provided initial evidence of convergent validity and test-retest reliability, but more psychometric testing is needed to assess the validity and reliability of the SHAWQ. Convergent validity should be further tested by comparing the SHAWQ with instruments that were developed for assessing sleep health in non-clinical populations such as the SHI or RuSATED. Divergent validity should be tested by comparing the SHAWQ with sleep questionnaires that were designed to measure constructs other than sleep health (e.g., sleep hygiene or bedtime procrastination), as well as behaviors/disorders other than depression or anxiety (e.g., externalizing behaviors or substance abuse). Another limitation of our study is that we did not assess internal consistency (Supplementary material), and generalizability was assessed only for student populations within Singapore.

All sleep and mental health measures in our study were based on questionnaires. No clinical interviews or clinically-verified diagnostic information were collected. Additional studies are needed to test whether the SHAWQ can be used to screen for students with sleep disorders or psychiatric disorders. We did not attempt to determine optimal classification thresholds for SHAWQ scores (e.g., receiver operating characteristic (ROC) curve analyses) because there are no normative data in Singapore for interpreting results of the various sleep instruments (ESS, PSQI, and ISI) and depression/anxiety instruments (KADS, CESDR, CESA). Students were categorized into groups (e.g., excessive daytime sleepiness, poor sleep quality, insomnia, major depressive disorder, anxiety disorder) using thresholds commonly used for these instruments, but there may be cross-cultural differences in the way that sleep and mental health problems are reported and diagnosed. Notwithstanding this issue, we found that SHAWQ scores were correlated with daytime sleepiness scores, sleep quality scores, insomnia scores, depression scores, and anxiety scores, indicating that poor sleep health on the SHAWQ was associated with worse self-reported sleep and mental health.

The SHAWQ was developed with brevity in mind and is not intended to provide a comprehensive assessment of sleep health. There were sleep survey items not selected for the SHAWQ that are clearly relevant for sleep health. These include sleep duration, nocturnal awakenings, waking up too early, and napping. Previously, we showed that shorter sleep duration on school days was associated with higher depression scores in the same population of adolescents used to develop the SHAWQ (Yeo et al., 2019). In the present study, sleep duration was not included in the SHAWQ because it did not explain additional variance in depression scores beyond those items that were already selected in the best-subsets regression analysis. In any study that seeks to comprehensively assess sleep health, we strongly recommend that other questions are included to measure sleep duration and other aspects of sleep behavior. Future iterations or refinements of the SHAWQ could include questions related to sleep duration or sleep regularity, even if they do not contribute to the SHAWQ score the way that it was defined in the present study in which depression symptoms were the main health outcome. Relatedly, any study that seeks to assess depression or other mental health problems in student populations should include measures designed for this purpose, e.g., structured interviews and validated depression questionnaires. The SHAWQ was developed with the goal of identifying students with sleep health problems that are linked to depression symptoms. The SHAWQ score provides a relative indication of a student's sleep health (good, fair, bad), but it does not measure depression.

As highlighted earlier, it is possible that the SHAWQ could be reduced while still providing a useful measure of sleep health that can predict depression. Our decision to use a 6-item instrument was guided in part by theoretical considerations, including providing coverage across 4 different dimensions of sleep health. In our best-subsets regression model used to develop the SHAWQ, however, sleep quality and daytime sleepiness were the variables that accounted for the greatest proportion of variance in depression scores. Future studies could test whether these 2 items are sufficient for estimating sleep health (e.g., relative to the 6-item SHAWQ, RuSATED, and SHI) and for predicting depression symptoms in student populations.

Our approach for selecting items on the SHAWQ was sample-dependent, i.e. based on sleep survey data in one population of adolescents (Study 1). Although the SHAWQ was subsequently tested for validity and reliability in other student populations (Study 2, Study 3, Study 4), we did not test whether the 6 items in the SHAWQ represented the best items for predicting depression symptoms across samples. An alternative and rigorous statistical approach for selecting sample-independent survey items would be to use item response theory. This approach has been used as part of PROMIS to develop item banks for sleep disturbance and sleep-related impairment which have been validated in adults and adolescents (Buysse et al., 2010; Forrest et al., 2018; van Kooten et al., 2021). Similar methods could be used to develop item banks for assessing sleep health; however, additional analyses would be required to assess which items are most closely associated with depression symptoms. Another limitation of our study is that we did not evaluate the dimensionality of the SHAWQ. Factor analysis could be performed to assess the underlying structure of variables in the SHAWQ and to test whether the results are consistent with the hypothesized (theory-based) structure. As shown in prior work, however, the factor structure of commonly used sleep instruments (e.g., PSQI, ISI, RuSATED) often differs between study populations (Chen et al., 2015; Brandolim Becker et al., 2018; Manzar et al., 2018, 2021; Ravyts et al., 2021), which could be explained by sociocultural differences in sleep health and sleep-related behaviors.

4.6 Future directions and potential applications of the SHAWQ

More studies are needed to replicate and extend our work demonstrating that the SHAWQ carries information relevant for students' sleep health and mental well-being. One of the first steps is to test the generalizability of the SHAWQ in student populations outside of Singapore. Sleep behavior has been shown to differ in Asian student populations, where bedtimes are often later and nocturnal sleep is shorter compared with Western cultures (Olds et al., 2010; Gradisar et al., 2011; Ong et al., 2019). The social and environmental factors that influence sleep health and wellbeing may be context-specific. Hence, it will be important to confirm the relationship between SHAWQ scores and depression symptoms in students in other cultural settings. Future studies should also investigate whether SHAWQ scores are associated with measures of social health, defined broadly as the ability to form healthy and positive relationships with others. Poor sleep health may erode the quality of social interactions with family, friends and teachers through its effects on mood and emotional regulation (Gordon et al., 2017, 2021). Conversely, students with stronger socioemotional support from their family and community may be in a better position to cultivate and maintain healthy sleep behaviors (Hale et al., 2020). While the SHAWQ was developed with sleep and mental health outcomes in mind, future work should also assess whether SHAWQ scores are associated with lifestyle behaviors relating to dietary intake and exercise. Poor sleep health may be a contributing factor to poor food choices, increased caloric intake, and sedentary activity (Beebe et al., 2013; Stea et al., 2014; Lin et al., 2018; Van Dyk et al., 2018).

The RuSATED/SATED framework proposes that definitions of sleep health should focus on measurable characteristics of sleep. Recent studies have therefore incorporated actigraphy-based measures of sleep duration, efficiency, timing, and regularity in their assessment of sleep health and its associations with mental health (DeSantis et al., 2019; Bowman et al., 2021; Lee and Lawson, 2021). While self-reported sleep quality does not have a clear biological correlate, the other measures on the SHAWQ including daytime sleepiness, frequency of staying awake until 3:00 am or later, and sleep latency can be quantified and verified with objective data. For example, daytime alertness can be evaluated by performance testing (e.g., by computer, tablet, or smartphone) or by indirect indicators such as actigraphy-verified naps. Actigraphy monitoring can also be used to assess the frequency of late bedtimes and to estimate sleep latency. Such studies are important for establishing that students' scores on the SHAWQ reflect their objectively-determined sleep health behaviors.

There are several ways that we envisage the SHAWQ could be used by schools and researchers. The SHAWQ could be used to screen for students who are at greatest risk of sleep and mental health problems. This was the primary motivation behind developing and testing the SHAWQ in the present study. Educational institutions that have limited resources to provide students with sleep counseling and mental health care could use the SHAWQ to better direct their resources to students with bad sleep health. The SHAWQ may be especially useful in sociocultural contexts where there is stigma associated with depression and other mental health problems. Negative attitudes and misconceptions of mental illness are common among adolescents and university students (Pang et al., 2017; Goh et al., 2021), and schools may be reluctant to administer depression scales to their students due to cultural sensitivities and parental concerns. Students with depression symptoms may therefore avoid seeking help and remain undiagnosed (Vaingankar et al., 2013). By comparison, sleep problems are generally viewed as more socially acceptable if not expected in this age group. The SHAWQ could therefore be used to flag students with sleep health problems who can be followed up for mental health problems.

As a research tool, the SHAWQ could be used as a relative indicator of sleep health in population studies or observational studies. In this context, the SHAWQ could be used to identify and understand the factors that either promote or constrain sleep health in students. Our study was motivated in part by the observation that sleep problems often precede depression (Gradisar et al., 2022). However, the present study only examined the cross-sectional associations of SHAWQ scores with depression symptoms. Longitudinal studies are needed to determine whether SHAWQ scores are predictive of mental health problems. The SHAWQ could also be used as an outcome variable to assess the effects of interventions that target sleep health or mental well-being.

4.7 Conclusions

The SHAWQ is a short questionnaire whose composite score and categories (good, fair, bad) can be used as relative indicators of sleep health in adolescents and university students in their teens and twenties. Higher SHAWQ scores were strongly associated with sleep problems, insomnia symptoms, and depression symptoms. Large effect sizes were observed for associations of bad sleep health with all sleep and mental health outcomes. Bad sleep health on the SHAWQ was also prospectively associated with lower grades. These findings suggest that the SHAWQ has the potential to screen for students who would benefit from interventions for sleep and mental health problems. The SHAWQ is also one of the shortest and easiest to score among sleep-health related instruments because there are no sub-scores, sleep-based calculations, or algorithms needed for its implementation.

Data availability statement

Some datasets presented in this article are not readily available because of institutional and legal restrictions where the research was conducted. The raw data and code supporting the conclusions of Study 1 (first study in adolescents) and Study 3 (study in university students) will be made available by the authors without undue reservation. Permission to access data and code for Study 2 (second study in adolescents) should be directed to the National Institute of Education, Singapore (email contact: john.wang@nie.edu.sg). Raw data for Study 4 (university freshmen) includes university-archived data stored on the National University of Singapore (NUS) Institute for Applied Learning Sciences and Educational Technology (ALSET) Data Lake. In compliance with the Singapore Personal Data Protection Act, data on the ALSET Data Lake cannot be shared publically without student consent. Data and custom code used to analyse the data in Study 4 can be accessed on the ALSET Data Lake with approval by the NUS Learning and Analytics Committee on Ethics in accordance with NUS Data Management Policies. Researchers who wish to access the data and code should contact ALSET at NUS (email contact: alsbox1@nus.edu.sg). Requests to access the datasets should be directed to JG, joshua.gooley@duke-nus.edu.sg; JW, john.wang@nie.edu.sg; and ALSET, alsbox1@nus.edu.sg.

Ethics statement

The studies involving humans were approved by the Institutional Review Board (IRB) at the National University of Singapore and the Nanyang Technological University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YML and JG contributed to the design of the research, contributed to analyses, and wrote the article with input from all authors. PC, JW, and JG supervised the research. YML, SL, AVR, and JW collected and managed the data. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsle.2023.1188424/full#supplementary-material

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Mediating effects of depression on sleep disturbance and frailty in older adult type 2 diabetes patients in the community

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Introduction: With the progressive aging of the population, frailty is now a significant challenge in geriatrics research. A growing amount of evidence suggests that sleep disturbance and depression have independent effects on frailty, although the underlying mechanisms are not yet clear. This study aimed to investigate the mediating role of depression in the relationship between sleep disturbance and frailty in older adult patients with type 2 diabetes (T2DM) in the community.

Method: Purposive sampling was used to collect face-to-face data from 342 community-dwelling T2DM patients in Chengdu, Sichuan Province, China, between February and May 2023. The Pittsburgh Sleep Quality Index (PSQI) scale was used to evaluate sleep quality, the Simple Geriatric Depression Scale (GDS-15) was used to evaluate depressive symptoms, and the FRAIL Scale (FRAIL) was used to evaluate frailty. Linear regression equation and bootstrap self-sampling were used to verify the mediating role of depressive symptoms in sleep disturbance and frailty.

Result: The study found that sleep disturbance had a direct positive effect with frailty [$\beta = 0.040$, 95% CI: (0.013, 0.069)]. Additionally, depression had a direct positive effect on frailty [$\beta = 0.130$, 95% CI: (0.087, 0.173)], and depression was found to partially mediate the relationship between sleep disturbance and frailty.

Conclusion: Poor sleep quality and frailty are common in patients with T2DM. To reduce the frailty of older adult T2DM patients, all levels of society (government, medical institutions, and communities) must pay more attention to mental health. A variety of interventions should be considered to improve sleep quality and depression, which in turn may prevent or control frailty.

KEYWORDS

frailty, sleep disturbance, depression, type 2 diabetes, older adult

Introduction

The aging population presents a significant challenge for contemporary societies and has garnered greater global attention. It is projected that by 2050, a fifth of the population will be over the age of 65 (26.1%) (1, 2). China has the largest population of older adult citizens and is now one of the fastest aging nations globally (3). The rise in the aging population has coincided with the growing prevalence of several chronic ailments, especially diabetes (4). With the findings of the survey conducted by the International Diabetes Federation (IDF)

(5), the current global population of adults with diabetes is ∼537 million. China has been identified as the country with the largest number, with over 110 million diabetic patients (6). Type 2 diabetes mellitus (T2DM) accounts for more than 90% (7). The prevalence of T2DM is 23.9% in people aged 60–69 and 27.3% in those aged 70 and over (8). It can be seen that the situation regarding the prevalence of diabetes in the country has become even more critical.

Frailty poses a significant challenge to older adults as they age (9). Frailty is a complex concept that must account for the intricate interplay of various factors often manifesting in three dimensions: physical, psychological, and social frailty (10). In China, the older adult patient population with T2DM had 22.7% higher frailty detection rates than patients without T2DM (11, 12). Moreover, frailty may heighten the risk of falls, disability, and mortality in older adult patients with T2DM, jeopardizing the physical and mental health of older adults and causing a significant economic strain on families, society, and healthcare (13). These findings highlight the significance of prioritizing frailty management in older adult T2DM patients amidst a rapidly aging population.

Previous studies showed that sleep disturbance may associated with frailty (14), But the underlying mechanism has not yet been revealed. Sleep disturbance impacts many older people with T2DM (15). Older adult people with T2DM have a higher incidence of sleep disturbance due to obstructive sleep apnoea or nocturnal symptoms such as hypoglycemia, nocturia, or neuralgia (16, 17). Poor sleep quality can lead to impaired protein synthesis and muscle loss, and these changes are a significant cause of frailty in older people (18, 19). A previous prospective cohort study found a high risk of frailty in older adults with sleep problems (20). Older adults with sleep problems were 49.95 times more likely to be frail than those without sleep problems (21). Several studies have shown a positive association between sleep problems and frailty (21, 22). Therefore, sleep disturbance may be one of the factors affecting frailty among T2DM patients. In this study, we focused on sleep disturbance in T2DM patients and hypothesized that their sleep disturbance would be positively correlated with their frailty. In addition, sleep disturbances may associated with depression and can lead to low mood (23).

Depression is a common and complex mental illness. Globally, depression is one of the most common mental illnesses in people 65 years and older, affecting one in seven older adults (24). Studies have shown that sleep disturbance is a risk factor for depression in older patients with T2DM (25). Previous study of older adult people with T2DM, sleep disturbance was positively associated with depression. There is also evidence that sleep disturbance is strongly associated with depression, with an increasing prevalence of sleep disturbance and higher detection rates of depression in older adults (26). Additionally, Almeida et al. demonstrated that depression may be associated with frailty among older adult T2DM patients (27).

People with depression are more likely to be frailty (28, 29). A previous study found that older adult, depression people with T2DM are at high risk of frailty (30). Depression increases the risk of adverse outcomes with older adult T2DM patients in frailty. Compared with non-depressed people with diabetes, people with depression have a significantly lower quality of life in physical and mental functioning, which can lead to disability and death (31). As a result, we further predicted depression as a mediator in the relationship between sleep disturbance and frailty among community-dwelling older adult T2DM patients.

A review of previous studies found that most previous studies in this area have examined the relationship between sleep disturbance, depression, and frailty. However, the combined effects of these factors on frailty and the underlying mechanisms of these relationships were unclear. In addition, few studies have examined frailty in a specific group—older adult T2DM patients. Therefore, this study investigated the association between sleep disturbance, depression, and frailty in community older adult T2DM patients in Chengdu and the possible underlying mechanisms.

Based on previous studies, we propose 4 hypotheses: (1) Sleep disturbance has a direct positive effect on frailty; (2) Sleep disturbance has a direct positive effect on depression; (3) Depression has a direct positive effect on frailty; (4) The relationship between sleep disturbance and frailty is mediated by depression. Our findings identified the critical factors for preventing and controlling frailty in older adult T2DM patients in the community, which is essential for reducing frailty and improving the health of T2DM patients.

Materials and methods

Participants

This was a cross-sectional study conducted between February 2023 and May 2023. Approval was obtained from the Ethics Committee of Chengdu Fourth Hospital was obtained prior to this study. Our study used purposive sampling method to select two community health centers in Chengdu city, and purposive sampling was applied in the community to select respondents who met the study criteria. Respondents were asked to meet the following inclusion criteria: (1) Diagnosed by the attending physician meeting the diagnostic criteria for T2DM by the World Health Organization (WHO) in 1999 (32); (2) age ≥60 years; (3) diagnosis ≥3 months; (4) no significant (or corrected) impairment of vision, hearing or communication; and (5) voluntary participation and signing an informed consent form. Exclusion criteria were as follows: (1) diagnosed psychiatric disease; (2) presence of severe organic disease intolerant of the survey; (3) patients with severe acute complications of diabetes mellitus in combination were excluded. In the end, a total of 342 questionnaires were distributed and, after excluding invalid questionnaires, 319 valid questionnaires were finally obtained and 93% (319/342) valid responses were obtained and analyzed. In addition, we refer to the sample size estimation formula for cross-sectional studies (33): $n = \frac{Z^2 P(1-P)}{d^2}$. Where n is the sample size, Z is the statistic corresponding to the confidence level, P is the expected prevalence, and d is the precision. We assumed a confidence level of 95.0%, an expected prevalence of frailty of 19.2% based on the prevalence of frailty of T2DM in the community of Xianning City, Hubei Province, China, as reported by Linglin Kong et al. and a precision of 5.0%.Therefore, taking into account the formula, we obtained $n \approx 239$. Taking into account a questionnaire loss rate of 20%, the sample size was calculated to be at least 287 cases.

TABLE 1 Social demographic features and differences of T2DM patients frailty scores.

Variables	Mean ± SD (range) *N* (%)
Gender	
Male	153 (48.0)
Female	166 (52.0)
Age	72.54 ± 6.19
BMI (kg/m^2)	
18.5–23.9	134 (42.0)
<18.5 or >23.9	185 (58.0)
Education level	
Primary school or below	134 (42.0)
Junior school and above	185 (58.0)
Marital status	
Single	67 (21.0)
Married	252 (79.0)
Living state	
Live alone	25 (7.8)
Live with others	294 (92.2)
Monthly personal income (CNY)	
<2,000	134 (42.0)
≥2,000	185 (58.0)
Exercise	
No	62 (19.4)
Yes	257 (80.6)
Duration of diabetes	
<10 years	171 (53.6)
≥10 years	148 (46.4)
Diabetic chronic complications	
No	192 (60.2)
Yes	127 (39.8)

Measures

All measures in this study would be conducted in Chinese.

Basic sociodemographic data

A self-designed questionnaire was adopted, including gender, age, ebody fat index (BMI), education, marital status, residential status, monthly income., physical activity, disease duration, and complications. BMI is calculated by dividing weight (kg) by the square of height (m), with a value of 18.5–23.9 as normal and a value of <18.5 or >23.9 as abnormal BMI (34). Marital status is classified as married and single. Being single includes being unmarried, widowed, and divorced.

Physical Activity is exercising more than 3 times or 300 min a week (35). Types of exercise include: walking, jogging/cycling, Tai chi, swimming, apparatus sports, dance exercises (square dancing, aerobics, yoga), and ball games (36). Complications include peripheral neuropathy, retinopathy, diabetic nephropathy, diabetic foot, cerebrovascular, and cardiovascular disease (37).

Frailty

Frailty was assessed using the frailty scale (38). The scale consists of 5 questions: (1) Fatigue: Have you felt tired frequently in the past 4 weeks? (2) Low resistance: Is it difficult to climb stairs without AIDS and help from others? (3) Low walking amount: Is it difficult to walk a block of about 500 m without AIDS and help from others? (4) Weight loss: Have you lost at least 5% of your body weight in the past year? (5) Diseases: Have you had five or more diseases? The scale is scored on a scale of 0–5. If the old person answered "yes", they got a "1" and if they answered "no", they got a "0". Scores of 0, 1–2, and 3–5 represent robust, prefrail, and frail, respectively. Dong et al. (39) applied its translation to the older adult in Chinese communities and found that the frailty scale had good validity and reliability (40). It showed good validity and test–retest reliability in Chinese patients with type 2 diabetes (41).

Sleep disturbance

Sleep quality in patients with T2DM was assessed using the Pittsburgh Sleep Quality Index (PSQI) (42). The scale was compiled by Dr. Buysse in 1989. The PSQI scale included sleep quality, sleep time, sleep duration, sleep efficiency, sleep disorders, hypnotic drugs, and daytime dysfunction. Nineteen self-rated items were scored and composed of 7 components. Each component was scored on a scale of 0 3. The cumulative score of each component was the total PSQI score, with the total score ranging from 0 to 21, and PSQI score > 7 was considered as sleep disorder. Cronbach's α coefficient in this study was 0.79. The Chinese version of PSQI has been proven to be reliable and valid in the community-dwelling older population (43).

Depression

The Geriatric Depression Scale-15 (GDS-15) was developed from the Geriatric Depression Scale developed by Reisberg et al. in 1982 (44). GDS-15 consists of 15 items, each with "yes" and "no" options. The total score is 0–15 points, among which items 1, 5, 7, and 11 are scored in reverse. A score of 0–4 indicates no symptoms of depression, and a score of ≥5 indicates symptoms of depression. The Chinese version of GDS-15 is a reliable and valid screening tool for assessing geriatric depressive symptoms in the Chinese population (45). The Cronbach α coefficient of this scale in this study was 0.77.

TABLE 2 The statistical descriptions and associations among study variables.

Variables	Mean	*SD*	Sleep disturbance	Depression	Frailty
Sleep disturbance	7.81	4.42	-		
Depression	2.86	2.77	0.378**	-	
Frailty	0.85	1.11	0.319**	0.441**	-

**P < 0.01.

TABLE 3 Regression analysis among study measures.

Variables	β	*t*	*P*	LLCI	ULCI	R^2	*F*
Result variable: depression							
Predictor sleep disturbance	0.207	6.199	<0.001	0.141	0.273	0.181	7.405
Result variable: frailty							
Predictor sleep disturbance	0.040	2.981	0.003	0.014	0.067	0.259	10.259
Mediator depression	0.130	5.967	<0.001	0.087	0.173		
Result variable: frailty							
Independent variable sleep disturbance	0.067	4.999	<0.001	0.041	0.094	0.175	7.150

Controlling for gender, age, BMI, education, marital status, living state, monthly income, exercise, duration of diabetes, diabetic chronic complications.

TABLE 4 Bootstrap analysis of the chain mediating model.

Path	Effect	Boot SE	Boot LLCI	Boot ULCI	Effect ratio
Total effect	0.075***	0.014	0.040	0.094	100%
Direct effect	0.040**	0.014	0.013	0.069	59.70%
Indirect effect	0.033***	0.007	0.019	0.050	40.30%

Controlling for gender, age, BMI, education, marital status, living state, monthly income, exercise, duration of diabetes, diabetic chronic complications.
***P < 0.001.
**P < 0.01.

Procedure

To ensure consistency in survey methodology, all information was collected in face-to-face interviews by uniformly trained investigators with a medical background. All items were explained in an unbiased manner by the investigator and, after written informed consent was obtained, all participants were assured that their responses would be anonymous and confidential. The questionnaire also explained the purpose of the survey, how to complete it, and the promise of confidentiality. Finally, face-to-face data collection took place and questionnaires were returned on the spot.

Statistical analysis

The data was entered using Epidata software. Data quality was ensured by consistent coding of the questionnaires, and separate entry by two individuals. All analyses were conducted using IBM SPSS Statistics version 25.0 (Armonk, NY, United States). The significance level for the two-tailed test to $\alpha = 0.05$. We expressed continuous data as mean ± standard deviation and categorical data as (*n*) and percentage (%). We tested the correlation between variables using Pearson correlation analysis. In a similar way, McKinnon's four-step approach (46) was used in our study to analyze the mediating role with four specific criteria that had to be met: (1) There was a significant association between the independent variable (sleep disturbance) and the dependent variable (frailty); (2) There was also a significant association between the independent variable (sleep disturbance) and the mediator variable (depression); (3) There was a significant correlation between the mediator variable (depression) and the dependent variable (frailty) after adjusting for the control of the independent variable (sleep disturbance); (4) The coefficient of indirect correlation between the independent variable (sleep disturbance) and the dependent variable (frailty) through the mediator variable (depression) is significant. The first three steps were individually tested by means of a linear regression equation with $\alpha_{in} = 0.05$ and $\alpha_{out} = 0.01$. Finally, the mediation effect was analyzed using the PROCESS version 3.0 macro for SPSS (model 4), with bootstrap 5,000 self-sampling to verify the final condition. Statistical significance is indicated when 0 is excluded from the 95% confidence interval.

Results

Common method biases test

We used Harman's Single Factor Test to examine the common method bias in the study. The analysis showed that the first common factor analyzed explained only 24.45% (<40%) of the variance. This suggests that there was no significant common method bias in the study, even though we used the questionnaire.

Table 1 shows the sociodemographic characteristics of the older adult T2DM patients. Of the 319 eligible patients, 166 (52.0%) were female and 153 (48.0%) were male. The mean age of the participants was (72.54 ± 6.19) years. One hundred and thirty-four

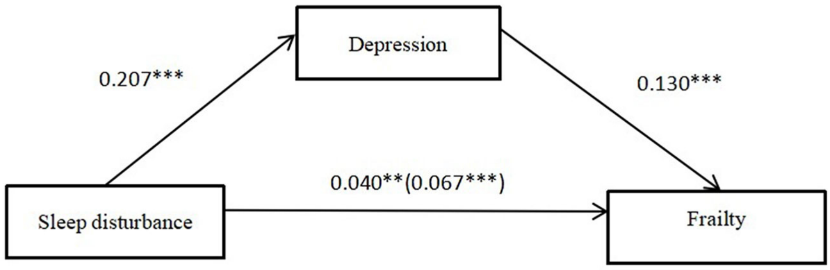

FIGURE 1
Model diagram of the effect of sleep disturbance on frailty (**$p < 0.01$, ***$p < 0.001$).

(42.0%) of the participants had a normal BMI and 185 (58.0%) had a high or low BMI. The educational background of the participants was as follows: 134 (42.0%) had a junior high school education or less, and 185 (58.0%) had a high school education or more. The participants' marital status was as follows: 67 (21.0%) were single and 252 (79.0%) were married. Of the total number of patients surveyed, 25 (7.8%) were living alone and the remaining 194 (30.7%) were not living alone. There were 134 patients (42.0%) with a monthly personal income of <\$2,000 and 185 patients (58.0%) with a monthly personal income of more than \$2,000. There were 257 (80.6%) participants who exercised regularly, while 62 (19.4%) exercised less. There were 171 (53.6%) patients with a disease duration of <10 years and 148 (46.4%) participants with a disease duration of >10 years. Finally, 127 (39.8%) patients had chronic complications of diabetes and the remaining 192 (60.2%) did not.

Correlations of the study variable

Table 2 shows Spearman's correlations for the study variables. Sleep disturbance ($r = 0.319$, $p < 0.01$) and depression ($r = 0.441$, $p < 0.01$) were significantly positively correlated with frailty. In addition, sleep disturbance was significantly positively correlated with depression ($r = 0.378$, $p < 0.01$).

The mediation effect analysis

Table 3 reports the analysis of mediating effects among the variables. After controlling for variables, there was a significant direct effect of sleep disturbances on frailty [β = 0.067, CI (0.041, 0.094)]. In addition, sleep disturbance had a significant positive effect on depression [β = 0.207, CI (0.141, 0.273)]. Depression were significantly effected frailty [β = 0.130, CI (0.087, 0.173)]. Furthermore, the effect of sleep disturbance on frailty was statistically significant even when the mediating variable was included (see Table 4; β = 0.040, CI (0.014, 0.067)]. Based on the bootstrap 95% CI (see Table 4; depression = 0.033, 95% CI = 0.019 ∼ 0.050) not containing 0, it can be concluded that depression partially mediates the relationship between sleep disturbance and frailty. Thus, hypothesis was confirmed. Note that the final mediation model is shown in Figure 1.

Discussion

This study aimed to examine the relationship between sleep disturbance, depression, and frailty in older adult T2DM patients among the community in Chengdu, China. To the best of our knowledge, this is the first study to report the mediating role of depression between sleep disturbance and frailty in older adult T2DM patients in the community. The results of this study may provide possible informations and directions for the formulation and implementation of intervention strategies and measures to improve frailty in older adult T2DM patients.

As speculated, our results suggest that sleep disturbance positively effects the frailty of older adult T2DM patients. This is consistent with existing studies (47). One possible explanation is that chronic sleep disturbance in older adult T2DM patients may lead to multisystem disease and dysfunction. Sleep disturbance often lead to daytime sleepiness and increased fatigue in older patients (14). It may also reduce social interaction or lead to a lack of social interaction in older adult T2DM patients. Over time, older adult T2DM patients may experience a significant decline in muscle strength and fitness and a lack of sensory stimulation, eventually leading to frailty (48). Therefore, providing adequate sleep security is an effective strategy to reduce frailty in older adult T2DM patients. Furthermore, lifestyle modifications, appropriate diabetes management, and increased social interaction may help to reduce frailty among older adult T2DM patients with poor sleep quality (49, 50).

After controlling for variables, depression plays a mediating role between sleep disturbance and frailty, as supported by a previous study (51). Depression is a crucial mechanism by which sleep disturbances effect frailty in T2DM, and sleep disturbances may further lead to frailty by depression in T2DM patients. Hypothesis 4 is supported. Numerous studies have demonstrated a complex biological connection between the duration of sleep and the symptoms of depression (52, 53). Sleep disturbance can cause significant variations in blood glucose levels, leading to challenges in its management (54). It also reduces insulin sensitivity, exacerbating the condition. Moreover, patients often face difficulty managing their diet in the presence of frequent fluctuations in blood glucose levels, leading to helplessness, reduced confidence in the battle against the illness, and depression (55). Older adult T2DM patients with depression have significantly elevated levels of C-reactive protein, interleukin-6 and tumor cytokines, which also contribute to frailty (56, 57). Meanwhile, older adult T2DM patients with depression are significantly less sociable and active and are more likely to have a sedentary lifestyle (58), which further contributes to muscle wasting. And muscle wasting and reduced muscle strength are important markers of frailty (59). In addition, co-morbidities with other chronic conditions can further exacerbate frailty (60). As a result, it is important to address the sleep problems of patients with type 2 diabetes mellitus to prevent the harmful impact of prolonged lack of sleep on their mental health and frailty.

Conclusion

The study suggests a significant and positive association between sleep disturbance and frailty in older adult T2DM patients living in the Chengdu community, with depression as a mediator. Thus, this study may help to elucidate the pathogenesis of frailty. A high-quality sleep may decrease the risk of depression and, consequently, frailty. Therefore, we suggest the following recommendations. To reduce frailty in T2DM patients, firstly, Government and community should provide more social opportunities for patients and actively encourage their participation in activities. Secondly, nursing managers should provide emotional regulation and management training to older adult T2DM patients in the community, which will improve their ability to cope with depression and increase their resilience. Also, patients with T2DM who need more social support from their families to improve the quality of sleep.

Limitations

This study has the following limitations: First, the sample size of this study was small. Secondly, the variables of "sleep disturbance," "depression," and "frailty" in this study were all subjectively reported by the subjects themselves, which may have information bias. Third, we tested only one mediating variable. Future studies need to further explore the influence of other potential variables, such as social support and self-efficacy, that are associated with frailty. Finally, the sample of this study comes from only two communities in Chengdu. Due to the differences in social culture, economy, and lifestyle, attention should be paid to the universality of the findings.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

XC and XP was involved in all aspects of the study and preparation of the manuscript. CH, QM, ML, and XL was involved with the design of the study and preparation of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Shift work is associated with extensively disordered sleep, especially when working nights

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Background: Shift work is generally associated with working and sleeping out of phase with the endogenous, circadian sleep–wake cycle. This exerts detrimental effects on sleep health. The present study aimed at evaluating the presence of short and long sleep as well as sleep disorders within a broad range of shift work schedules and elucidating the role of sociodemographic factors therein.

Methods: A large dataset containing information on sleep was collected through advertisement in a Belgium newspaper (De Standaard). Adult, working individuals were selected (n = 37,662) and categorized based on their work schedule (regular day, early morning, evening, night, and rotating shift). In this cross-sectional study, prevalence rates of short sleep (≤6 h), long sleep (≥9 h) and sleep disorders (screened with Holland Sleep Disorders Questionnaire), and associations between these sleep variables and sociodemographics (age, sex, education, living companion(s)) were analyzed using binominal logistic regression analyses.

Results: In the total sample all sociodemographic factors affected prevalences of short, long and disordered sleep, consistent with previous studies. Compared to day workers, shift workers more frequently reported short sleep, most prominently night workers (26 vs. 50%) ($p < 0.001$). Furthermore, all sleep disorders as well as sleep disorder comorbidity were more common in shift workers, again most pronounced in night workers (all $p < 0.05$). In night shift workers the level of education had the strongest associations with disturbed sleep with a two-fold higher prevalence of short and disordered sleep in low relative to academic educated groups (all $p < 0.02$).

Conclusion: Shift work is related not only to curtailed sleep and shift work disorder, but also to a plethora of sleep disorders, including insomnia, sleep-related breathing disorders and sleep-related movement disorders. Our findings imply that education on coping strategies may be especially important for young and/or lower educated shift workers.

KEYWORDS

work schedule, short/long sleep, sleep disorders, sleep disorder comorbidity, sociodemographic factors, education

1. Introduction

Sufficient and good quality sleep is critical to daytime functioning, physical and mental health. Lower sleep quality and/or shorter sleep duration are associated with diminished neurocognitive functions such as attention, memory and academic performance (1, 2). Both short sleep and poor sleep quality pose a risk for physical conditions like obesity, cardiovascular diseases and type 2 diabetes (3, 4). Though less often studied, long sleep duration is also associated with negative health outcomes, such as infectious and incident cardiovascular diseases (5, 6) and poorer cognitive functioning (7). With respect to mental health, disturbed sleep increases the risk for mood-, anxiety- and substance abuse-disorders, worsen daytime symptoms and impede remission of these mental diseases (8–11). In view of its overall importance, good sleep health is thus a major public health concern.

To assess sleep health, Buysse (12) proposed five quantifiable aspects of sleep, each clearly related to neurobehavioral, physical and mental well-being: sleep duration (total amount of sleep per 24 h), sleep efficiency (ease of falling and returning to sleep), sleep timing (sleep placement within the 24 h day), satisfaction with sleep (subjective sleep quality) and alertness (ability to maintain attentive wakefulness). A societal factor consistently interfering with sleep health is shift work, a situation where the behavioral sleep–wake schedule is out of phase with the endogenous, circadian sleep–wake rhythm and where additionally light exposure and feeding occur at non-optimal times of the day (13). A wealth of studies demonstrated that being forced to sleep in the biological day, during which the circadian system increasingly promotes wakefulness, is associated with problems falling and maintaining sleep and curtailed sleep (14–16). Concomitantly, having to work in the biological night, during which the circadian wake-promoting signal rapidly dissipates, is associated with higher levels of fatigue, sleepiness, performance impairments and accident-proneness (15, 17, 18). In about 27% of shift workers the sleep problems evolve into a shift work disorder (SWD) (19), a circadian rhythm sleep–wake disorder characterized by symptoms of insomnia, excessive sleepiness or both with a broad range of severe health consequences (20, 21). The significance of the disruptive effects of shift work is stressed by the fact that a considerable and rising number of people are working in shifts. For instance in 2010, 17% of all workers in the European Union were engaged in shift work and in 2015 the proportion had increased to 21% (22). Although underlying mechanisms have not been fully elucidated, the impact of shift work varies greatly between persons. This may be due to individual characteristics. For example, early chronotypes, so-called morning-types, appear sleepier during night shift hours than non-early chronotypes (23). Another example is the finding that tolerance to shift work differs between persons as a function of sleep quality (24). Variations in the impact of shiftwork may also be associated with work-related factors, such as permanent night shift workers sleeping consistently shorter than those in other shift types (25, 26). In spite of the large amount of studies on the effects of shift work on sleep quantity and quality, relatively little is known about the relation between work schedule and the presence of sleep disorders. A recent study found that a group of shift workers, compared to day workers, not only had a higher prevalence of SWD symptoms, but also of other, often comorbid, sleep disorders like insomnia, hypersomnia and sleep-related movement disorder, which was particularly strong for younger and single shift workers (27). Thus, shift work seems to provoke substantial sleep–wake disturbances.

The present study aimed to investigate the relation between a broad range of different shift work types (day, early morning, evening, night and rotating shift), the estimated presence of (co-occurring) sleep disorders and the influence of sociodemographic factors thereon. This study made use of a large dataset obtained from Belgian readers of a national newspaper who completed a screener for sleep disorders, the Holland Sleep Disorders Questionnaire (HSDQ), and provided sociodemographic information. Specifically, the estimated presence of short sleep duration (≤6 h), long sleep duration (≥9 h) and the six main groups of ICSD-defined sleep disorders (International Classification of Sleep Disorders, (28)) was assessed in the working population subdivided by sex, age, education level, living companions, and work schedule.

2. Methods

2.1. Procedure and study population

Participants were recruited via an advertisement on February 17th 2016 in a national Belgian newspaper, "De Standaard" (29). This newspaper is written in the Dutch language. The advertisement included a link to the online informed consent form and the questionnaires. The questionnaires consisted of demographic questions, the HSDQ, and some questions about sleep habits (bedtime, sleep duration). For the present study, respondents (n = 50,064) were only included if they were adult (≥18 years of age) and had a job working "regular day shift," "regular early morning shift," "regular evening shift," "regular night shift" or "rotating shifts" (see Figure 1). The final sample consists of 37,662 participants and there were no missing data. This cross-sectional study presents point prevalence of short sleep duration, long sleep duration and six types of sleep disorders in the total sample and in subgroups based on demographic-factors. Additional analyses within the specific shift work groups into associations of the demographic variables were performed for three outcome variables known to be strongly affected by shift work, namely short sleep duration, presence of a sleep disorder and the presence of a circadian rhythm sleep wake disorder.

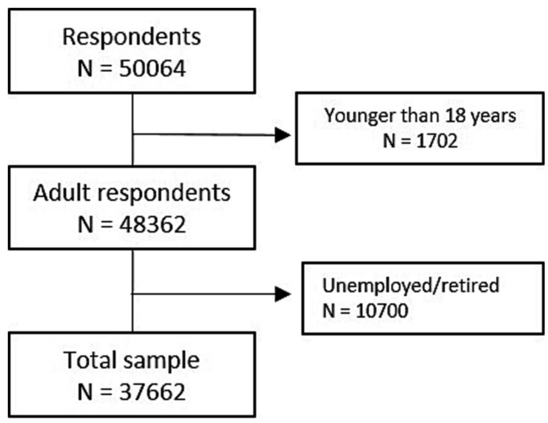

FIGURE 1
Flow chart representing the inclusion of participants in the study.

2.2. Demographic characteristics

Participants were asked to report their sex (male or female) and age. The age of the participants was categorized as younger than 30 years, between 30 and 50 years and older than 50 years. For the level of education participants could choose between elementary school, secondary school at lower level, secondary school at higher level, vocational training, university of applied sciences, and university. In the analyses, secondary school at low and higher level were grouped together as secondary education, and university of applied sciences and university as academic education. Participants were subdivided according to their work schedule (either regular day-, early morning-, evening-, night- or rotating-shifts). Concerning living companions, participants were asked to indicate whether they lived alone, with a partner, with children under the age of three, with children over three years old, with parents, with friend(s) and/or roommate(s). In the analyses, the living companions were grouped together in the following five categories: alone, with partner, alone with children, with partner and children, and with other(s).

2.3. Measurements

The Holland Sleep Disorders Questionnaire (HSDQ) is a 32-item questionnaire aimed at screening for the six main categories of the ICSD -defined (30) sleep disorders: insomnia, sleep-related breathing disorders (SBD), hypersomnia, parasomnia, circadian rhythm sleep–wake disorders (CRSWD), and sleep-related movement disorders (SRMD). Table 1 provides a brief description of these groups of sleep disorders. The HSDQ has been validated in a sample of the Dutch general population and has good psychometric properties (31). Items are scored on a 5-point Likert-scale (1 "never" to 5 "almost always"), whereby participants indicated to what extent an item applied to them in the last 3 months. For each participant the mean item score per sleep disorder subscale was calculated and compared to previously determined cut-off scores (insomnia: 3.68, SBD: 2.87, hypersomnia: 2.90, parasomnia: 2.42, CRSWD: 3.41, SRMD: 2.70). In addition, the total number of subscales scored above cut-off was used to calculate the suspected number of (comorbid) sleep disorders.

Participants were asked to estimate the average duration they slept per 24 h. A binary variable, short sleep, was made differentiating those that slept six or less hours. A second binary variable was computed for long sleep, differentiating individuals sleeping nine of more hours.

2.4. Statistical analysis

Means and standard deviations for age and total sleep time were calculated. Statistical analyses were performed using SPSS software (IBM SPSS statistics 26). Distribution (% of the total population) of demographic and sleep parameters (presence of short, or long sleep duration and/or sleep disorders) were determined across the study sample. The prevalence with 95% confidence interval ($CI = p \pm 1.96^* \sqrt{((p^*(1-p))/n)}$, where p = point prevalence, and n = sample size) of sleep disorders as indicated by the HSDQ were assessed using cross-tables. Differences in the prevalence rates of sleep disorders between the different demographic categories were determined with chi-square tests. A Bonferroni correction was applied to the reported p-values to correct for multiple testing, and a value <0.05 was considered statistically significant. To express the size of the effects, prevalence ratio's (PRs) (sample prevalence rate/referent prevalent rate) were provided. Five subsamples were formed to compare and analyze the associations of sleep parameters and demographic factors within those working day ($n = 32{,}468$), early morning ($n = 434$), evening ($n = 507$), night ($n = 186$), and rotating ($n = 4{,}067$) shifts, respectively. In all subsamples, three binominal logistic regression analyses were performed with the presence of short sleep duration, a sleep disorder, and/or CRSWD as dependent variable, and sex, age, education, and living condition as independent variables. The male sex, an age below 30, an academic education and living alone were used as the indicator (referent) variables in these regression analyses. Alpha <0.05 was used to indicate statistical significance. PRs with 95% confidence intervals were calculated ($e^{LN(PR)} \pm 1.96 * \sqrt{(1/a + 1/b + 1/c + 1/d)}$, where PR = prevalence ratio, and a,b,c,d represent the cells of the cross-table) for each comparison.

3. Results

3.1. Study population

The average age of the final sample was 40.1 ± 12.0 years. The majority of the study population was female (59.4%), between 30 and 50 years old (49.0%), received an academic education (58.7%), performed daytime work (86.2%) and was living with partner and children (39.5%). On average the participants slept 6.97 ± 1.02 h per 24 h.

TABLE 1 Description of sleep disorder categories according to the ICSD-3.

Sleep disorder group	Brief description
Insomnia disorder	Persistent (≥3 months) and frequent (≥3 nights a week) difficulty initiating and/or maintaining sleep, resulting in daytime impairment.
Sleep breathing disorders (SBD)	Frequent (obstructive) respiratory events during sleep, associated with clinically relevant symptoms and/or diseases.
Hypersomnia	Excessive daytime sleepiness not explained by other sleep disorders.
Parasomnia	Undesirable behaviors or experiences during non-rapid eye movement (non-REM) sleep, REM sleep, or while transitioning between sleep and wake.
Circadian rhythm sleep–wake disorders (CRSWD)	Symptoms of insomnia and daytime impairment due to a misalignment between one's endogenous sleep–wake rhythm and the external light–dark cycle.
Sleep-related movement disorders (SRMD)	Restless legs syndrome (RLS): unpleasant sensations in the legs paired with a strong urge to move the legs. Symptoms are worse at rest and during the evening/night and cause sleep disturbances and/or daytime impairments. Periodic Limb Movements during sleep (PLMD): involves sleep disruptive repetitive movements of the limbs.

3.2. Prevalence of sleep disorders

About a quarter of the population reported short (≤6h) sleep duration (Table 2; Supplementary Table S1.1) and about 5 percent long (≥9h) sleep duration. The average sleep time for those with normal sleep duration was 7.46±0.63h, for those with short sleep duration 5.66±0.63, and for those with a long sleep duration 9.00± 0.00h. Approximately one third of the total sample scored positive on at least one sleep disorder subscale of the HSDQ, most frequently insomnia, closely followed by SRMD and CRSWD. Comorbid sleep disorders were also common; 12.6% screened positive for two or more sleep disorders.

A significantly larger proportion of males than females reported short sleep duration ($p < 0.01$), and a smaller proportion long sleep duration ($p < 0.01$). All sleep disorders were more common in females (insomnia $p < 0.01$; hypersomnia $p < 0.01$; parasomnia $p < 0.01$; CRSWD $p < 0.05$; SRMD $p < 0.05$), with the marked exception of SBD ($p < 0.01$). Comorbidity of sleep disorders was slightly higher in females (≥2 sleep disorders $p < 0.01$). With increasing age the prevalence of short sleep duration ($p < 0.01$) and SBD ($p < 0.01$) clearly increased. In contrast, long sleep duration ($p < 0.01$), insomnia ($p < 0.05$), hypersomnia ($p < 0.01$), parasomnia ($p < 0.01$) and CRSWD ($p < 0.01$), as well as sleep disorder comorbidity ($p < 0.01$) occurred most frequently in the youngest age group. Looking at education level, having a lower education (elementary or secondary) was associated with a significantly higher prevalence of both short ($p < 0.01$) and long ($p < 0.05$) sleep duration, all sleep disorder categories (insomnia $p < 0.01$; SBD $p < 0.01$; hypersomnia $p < 0.01$; parasomnia $p < 0.05$; CRSWD $p < 0.01$; SRMD $p < 0.01$) and comorbidity thereof (≥2 sleep disorders $p < 0.01$). Concerning living companions, living alone, living alone with children and/or with other(s) were generally related a higher occurrence of short sleep ($p < 0.01$) and all sleep disorders, except for parasomnia and SBD (insomnia $p < 0.01$; SBD $p < 0.05$; hypersomnia $p < 0.01$; parasomnia $p < 0.01$; CRSWD $p < 0.01$; SRMD $p < 0.05$). Also the proportion of people exhibiting comorbid sleep disorders (≥2 sleep disorders $p < 0.01$) was highest in these groups. In contrast, the prevalence of long sleep duration was highest in those living without children ($p < 0.01$). Regarding work schedules, about a quarter of the regular day and evening workers reported short sleep duration, yet the proportion was significantly higher (up to 49.5%) in those working early morning, night or rotating shifts ($p < 0.01$). Long sleep duration was more prevalent in those working evening shifts than in all other groups ($p < 0.01$). In day workers the most common sleep disorders were insomnia and SRMD, both occurred in about 12% of the population. All sleep disorders were more prevalent in those working on other work schedules, most strikingly insomnia, hypersomnia and CRSWD (insomnia $p < 0.05$; SBD $p < 0.05$; hypersomnia $p < 0.01$; parasomnia $p < 0.05$; CRSWD $p < 0.01$; SRMD $p < 0.05$). Of note, in the early morning shift CRSWD was only marginally increased, while all sleep disorders and sleep disorder comorbidity (≥2 sleep disorders $p < 0.01$) were most prevalent in the night shift workers; 51.1% of this group reported at least one sleep disorder and 26.3% at least two.

3.3. Short sleep duration within different work schedules

Independent of the type of work schedule, a larger percentage of men reported short sleep duration than women (Table 3; Supplementary Table S2.1). Although PRs were comparable, this effect only reached statistical significance in day, early morning and rotating shifts (day $p < 0.05$; early $p < 0.05$; evening $p = 0.341$; night $p = 0.172$; rotating $p < 0.001$). In general, increasing age was associated with a higher prevalence of short sleep (day $p < 0.05$; early $p < 0.05$; evening $p < 0.05$; night $p = 0.168$; rotating $p < 0.001$). The effect was slightly less pronounced in the early morning and night shifts (PR 1.26–1.31 vs. 1.7–1.9 in the other groups). For education, short sleep duration was more commonly reported by those with a lower education level in all work schedules (day $p < 0.001$; early $p < 0.001$; evening $p < 0.05$; night $p < 0.05$; rotating $p < 0.001$). In particular, those with only primary or secondary school significantly more often reported short sleep duration, with the PR being highest in early morning and night shifts. The influence of living companions is relatively small. Only in the day and rotation shift workers a significant association was found, with those living alone (with or without children) more frequently reporting short sleep than those living with a partner (day $p < 0.001$; early $p = 0.494$; evening $p = 0.355$; night $p < 0.05$; rotating $p < 0.001$).

3.4. Prevalence of any sleep disorder within different work schedules

The proportion of females having a sleep disorder generally exceeded that of men, with the exception of the early morning and evening shift (Table 4; Supplementary Table S2.2) (day $p < 0.001$; early $p = 0.633$; evening $p = 0.785$; night $p = 0.065$; rotating $p < 0.05$). Although prevalence rates were comparable in the day and night shift group, it did not reach statistical significance in the latter. Concerning age, in all work schedules those younger than 30 more frequently had a sleep disorder than the older age groups, with statistical significance in the day, evening and rotating shift workers (day $p < 0.001$; early $p = 0.681$; evening $p < 0.05$; night $p = 0.715$; rotating $p < 0.05$). In nearly all work schedules the rate of sleep disorders increased with lower education levels (significant in day, early, evening and rotating shifts) (day $p < 0.001$; early $p < 0.05$; evening $p < 0.05$; night $p = 0.696$; rotating $p < 0.001$). Merely in the night workers the prevalence of a sleep disorder was comparably high, independent of educational level. Finally, living alone or with other(s) generally tended to be associated with the highest occurrence of sleep disorders, although statistical significance was seldom reached (day $p < 0.001$; early $p = 0.785$; evening $p = 0.155$; night $p = 0.656$; rotating $p < 0.01$). More than half of the evening-, night- and rotating shift workers living alone or with others were estimated to suffer from disordered sleep.

3.5. Prevalence of a circadian rhythm sleep–wake disorder within different work schedules

Females more frequently scored on CRSWD than males in the regular day, early morning and night shift, with statistical significance being reached in the day shift (Table 5; Supplementary Table S2.3) (day $p < 0.001$; early $p = 0.259$; evening $p = 0.296$; night $p = 0.210$; rotating $p = 0.587$). In the rotating shift workers no sex difference was implied by the PRs. Rather independent of work schedule, CRSWD was most prevalent in the youngest age group (day $p < 0.001$; early $p = 0.083$; evening $p < 0.05$; night $p = 0.227$; rotating $p < 0.01$). Surprisingly, in the night workers no difference was observed between the youngest and oldest age groups. In the day workers, there was a strong effect of

TABLE 2 Percentage (95% CI) of the total sample with short sleep duration, long sleep duration and sleep disorders, differentiated by sex, age, education, living companion(s) and work schedule.

	≤6 h of sleep	≥9 h of sleep	≥1 sleep disorders	≥2 sleep disorders	Insomnia	SBD	Hypersomnia	Parasomnia	CRSWD	SRMD
Total population (n = 37,662)	27.5 (27.0–28.0)	5.3 (5.1–5.5)	33.3 (32.8–33.8)	12.6 (12.3–12.9)	12.8 (12.5–13.1)	5.9 (5.7–6.1)	6.4 (6.2–6.6)	5.1 (4.9–5.3)	9.4 (9.1–9.7)	12.6 (12.3–12.9)
Sex										
Males (n = 15,279)	30.9 (30.2–31.6)	4.0 (3.7–4.3)	30.4 (29.7–31.1)	11.0 (10.5–11.5)	10.1 (9.6–10.6)	8.3 (7.9–8.7)	4.8 (4.5–5.1)	3.4 (3.1–3.7)	8.7 (8.3–9.1)	11.5 (11.0–12.0)
Females (n = 22,383)	25.1 (24.5–25.7)	6.3 (6.0–6.6)	35.3 (34.7–35.9)	13.8 (13.3–14.3)	14.6 (14.1–15.1)	4.3 (4.0–4.6)	7.4 (7.1–7.7)	6.3 (6.0–6.6)	9.8 (9.4–10.2)	13.4 (13.0–13.8)
Age										
< 30 years (n = 9,146)	20.1 (19.3–20.9)	7.8 (7.3–8.3)	38.8 (37.8–39.8)	16.8 (16.0–17.6)	15.1 (14.4–15.8)	3.3 (2.9–3.7)	9.0 (8.4–9.6)	9.1 (8.5–9.7)	14.4 (13.7–15.1)	13.4 (12.7–14.1)
30–50 years (n = 18,450)	26.5 (25.9–27.1)	4.7 (4.4–5.0)	31.1 (30.4–31.8)	10.7 (10.3–11.1)	12.4 (11.9–12.9)	5.5 (5.2–5.8)	5.4 (5.1–5.7)	4.5 (4.2–4.8)	7.6 (7.2–8.0)	11.6 (11.1–12.1)
> 50 years (n = 10,066)	36.0 (35.1–36.9)	4.2 (3.8–4.6)	32.2 (31.3–33.1)	12.5 (11.9–13.1)	11.4 (10.8–12.0)	9.1 (8.5–9.7)	5.7 (5.2–6.2)	2.8 (2.5–3.1)	8.0 (7.5–8.5)	14.0 (13.3–14.7)
Education										
Academic (n = 22,119)	23.7 (23.1–24.3)	5.3 (4.9–5.5)	29.7 (29.1–30.3)	10.2 (9.8–10.6)	11.2 (10.8–11.6)	4.8 (4.5–5.1)	5.1 (4.8–5.4)	4.8 (4.5–5.1)	7.8 (7.4–8.2)	10.8 (10.4–11.2)
Vocational (n = 9,000)	29.6 (28.7–30.5)	5.1 (4.6–5.6)	34.7 (33.7–35.7)	13.4 (12.7–14.1)	13.8 (13.1–14.5)	6.5 (6.0–7.0)	6.8 (6.3–7.3)	4.9 (4.5–5.3)	9.3 (8.7–9.9)	13.3 (12.6–14.0)
Secondary (n = 6,401)	36.9 (35.7–38.1)	6.0 (5.4–6.6)	43.2 (42.0–44.4)	19.8 (18.8–20.8)	17.0 (16.1–17.9)	8.8 (8.1–9.5)	10.1 (9.4–10.8)	6.8 (6.2–7.4)	14.6 (13.7–15.5)	17.8 (16.9–18.7)
Elementary (n = 142)	46.5 (38.3–54.7)	7.0 (2.8–11.2)	52.8 (44.6–61.0)	22.5 (15.6–29.4)	18.3 (11.9–24.7)	15.5 (9.5–21.5)	10.6 (5.5–15.7)	8.5 (3.9–13.1)	18.3 (11.9–24.7)	22.5 (15.6–29.4)
Living companion(s)										
Alone (n = 4,705)	32.9 (31.6–34.2)	6.0 (5.3–6.7)	35.9 (34.5–37.3)	15.5 (14.5–16.5)	15.1 (14.1–16.1)	6.3 (5.6–7.0)	7.0 (6.3–7.7)	5.9 (5.2–6.6)	13.5 (12.5–14.5)	12.3 (11.4–13.2)
With partner (n = 10,663)	23.7 (22.9–24.5)	5.9 (5.5–6.3)	34.3 (33.4–35.2)	12.5 (11.9–13.1)	11.8 (11.2–12.4)	6.4 (5.9–6.9)	5.6 (5.2–6.0)	6.0 (5.5–6.5)	8.9 (8.4–9.4)	14.1 (13.4–14.8)
Alone with kid(s) (n = 2041)	35.3 (33.2–37.4)	4.1 (3.2–5.0)	33.7 (31.6–35.8)	12.2 (10.8–13.6)	13.4 (11.9–14.9)	6.9 (5.8–8.0)	7.3 (6.2–8.4)	4.3 (3.4–5.2)	8.0 (6.8–9.2)	12.1 (10.7–13.5)
With partner and kid(s) (n = 14,895)	28.1 (27.4–28.8)	3.9 (3.6–4.2)	29.2 (28.5–29.9)	9.8 (9.3–10.3)	11.3 (10.8–11.8)	6.0 (5.6–6.4)	5.5 (5.1–5.9)	3.2 (2.9–3.5)	6.0 (5.6–6.4)	11.5 (11.0–12.0)

(Continued)

TABLE 2 (Continued)

	≤6 h of sleep	≥9 h of sleep	≥1 sleep disorders	≥2 sleep disorders	Insomnia	SBD	Hypersomnia	Parasomnia	CRSWD	SRMD
Other(s) (*n* = 5,280)	25.2 (24.0–26.4)	8.1 (7.4–8.8)	40.3 (39.0–41.6)	18.5 (17.5–19.5)	16.8 (15.8–17.8)	4.1 (3.6–4.6)	9.5 (8.7–10.3)	8.5 (7.7–9.3)	16.5 (15.5–17.5)	13.7 (12.8–14.6)
Work schedule										
Day (*n* = 32,468)	26.3 (25.8–26.8)	5.0 (4.8–5.2)	31.5 (31.0–32.0)	11.4 (11.1–11.7)	12.3 (11.9–12.7)	5.6 (5.3–5.7)	5.5 (5.3–5.7)	4.9 (4.7–5.1)	7.8 (7.5–8.1)	12.1 (11.7–12.5)
Early (*n* = 434)	45.2 (40.5–49.9)	5.3 (3.2–7.4)	41.2 (36.6–45.8)	18.9 (15.2–22.6)	16.6 (13.1–20.1)	9.9 (7.1–12.7)	11.1 (8.1–14.1)	7.4 (4.9–9.9)	11.1 (8.1–14.1)	14.7 (11.4–18.0)
Evening (*n* = 507)	25.0 (21.2–28.8)	12.0 (9.2–14.8)	42.8 (38.5–47.1)	19.7 (16.2–23.2)	17.4 (14.1–20.7)	6.7 (4.5–8.9)	9.5 (6.9–12.1)	7.3 (5.0–9.6)	20.1 (16.6–23.6)	14.6 (11.5–17.7)
Night (*n* = 186)	49.5 (42.3–56.7)	7.0 (3.3–10.7)	51.1 (43.9–58.3)	26.4 (20.1–32.7)	19.9 (14.2–25.6)	10.2 (5.9–14.5)	15.6 (10.4–20.8)	8.1 (4.2–12.0)	24.7 (18.5–30.9)	22.6 (16.6–28.6)
Rotating (*n* = 4,067)	34.0 (32.5–35.5)	7.3 (6.5–8.1)	44.5 (43.0–46.0)	20.6 (19.4–21.8)	15.4 (14.3–16.5)	7.5 (6.7–8.3)	12.1 (11.1–13.1)	6.9 (6.1–7.7)	19.4 (18.2–20.6)	15.8 (14.7–16.9)

CRSWD = circadian rhythm sleep–wake disorder, SBD = sleep breathing disorder, SRMD = sleep-related movement disorder. Prevalence rates are provided in Supplementary Table S1.1.

education level, with a lower education being associated with higher prevalence of CRSWD. The early, evening and rotating shift workers demonstrated a similar pattern, yet only significant in the rotating shift (day $p < 0.001$; early $p = 0.180$; evening $p = 0.131$; night $p = 0.806$; rotating $p < 0.01$). Within the night shift sample no effects of education were observed, with relatively high prevalence rates at all education levels. With the exception of the early morning shift, those living alone and with other(s) had the highest occurrence of CRSWD. These effects reached significance in the day, early, evening and rotating shifts (day $p < 0.001$; early $p < 0.05$; evening $p < 0.05$; night $p = 0.084$; rotating $p < 0.001$).

4. Discussion

This study in a large sample of Belgian newspaper readers, confirmed previous findings (32) that there is a significant association between shift work and sleep problems. In the present study, this is expressed in both curtailed sleep duration and a high prevalence of estimated sleep disorders as well as sleep disorder comorbidity in all types of alternative work schedules, including early morning and evening shifts. The results implicate that regular night shift is by far the most debilitating condition at least concerning sleep; approximately half of the night workers reported short sleep (≤6 h), 51% scored positive on at least one sleep disorder, and 26% on two or more sleep disorders. An exception was long sleep duration, which was most prevalent in evening shift workers (12%). Several of the investigated sociodemographic factors influenced shift work-induced disordered sleep. The most prominent associations were found for the level of education; prevalence ratios of short sleep and one or more sleep disorders all increased about two-fold between the highest (academic) and lowest (elementary) education level.

4.1. Regular day shift

The influence of sociodemographic factors on sleep disturbances in the day workers followed similar patterns to those previously described in general populations. In both the current and earlier studies, being female was related to a higher risk of having a sleep disorder (except for SBD), while women less often reported short sleep duration (33–36). As is typically reported, short sleep becomes more common with increasing age (33–36). Yet consistent with previous findings, the prevalence of disordered sleep reduced with age, which was most prominently seen in the category of CRSWD (33, 36). Both sex and age were associated with short sleep duration and sleep disorders, but in opposite directions (being female and older is associated with lower short sleep, but higher sleep disorder occurrence). This underlines the notion that total sleep duration is one, but not the only aspect of healthy sleep (12).

Also consistent with previous findings, the level of education had a major impact on sleep, with both short sleep and sleep disorders being more common in lower educated individuals (37). The association with living-companionship was less straight forward across sleep measures, however, a general trend was that living alone (without partner and/or children) had negative consequences for sleep health. It is possible that those living alone receive less social pressure to maintain strict circadian patterns of behavior, which may impair their sleep hygiene practices. Alternatively, this group may receive less social (familial) support, which has been shown to reduce sleep health (38).

TABLE 3 Prevalence and prevalence ratios of short (≤6 h) sleep duration in day, early morning, evening, night and rotating shift subsamples differentiated by sex, age, education and living companion (s).

	Day shift		Early shift		Evening shift		Night shift		Rotating shift	
	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)
Sex										
Male	29.5	1	51.2	1	27.0	1	57.1	1	38.7	1
Female	24.2	0.82 (0.77–0.87)**	39.6	0.77 (0.39–1.15)*	23.8	0.88 (0.47–1.29)	45.5	0.80 (0.18–1.41)	30.5	0.79 (0.66–0.92)**
Age										
< 30 years	18.7	1	41.3	1	20.1	1	39.1	1	26.3	1
30–50 years	25.4	1.36 (1.29–1.43)**	41.6	1.01 (0.52–1.49)	21.6	1.07 (0.56–1.59)	50.6	1.29 (0.36–2.23)	34.4	1.31 (1.15–1.47)**
> 50 years	34.7	1.86 (1.78–1.93)**	52.0	1.26 (0.76–1.76)	35.2	1.75 (1.23–2.28)*	51.4	1.31 (0.36–2.27)	43.3	1.65 (1.47–1.82)**
Education										
Academic	23.2	1	31.3	1	23.9	1	36.4	1	29.2	1
Vocational	28.7	1.24 (1.18–1.30)**	38.0	1.21 (0.65–1.78)	20.2	0.85 (0.26–1.43)	46.1	1.27 (0.50–2.03)	34.7	1.19 (1.02–1.35)*
Secondary	35.1	1.51 (1.45–1.58)**	56.6	1.81 (1.34–2.27)**	29.3	1.23 (0.75–1.71)*	62.9	1.73 (0.93–2.53)**	40.0	1.37 (1.22–1.52)**
Elementary $	43.4	1.87 (1.47–2.27)**							48.0	1.64 (0.85–2.44)
Living companion(s)										
Alone	31.7	1	44.9	1	24.7	1	50.0	1	40.8	1
With partner	23.0	0.73 (0.64–0.81)**	40.3	0.89 (0.30–1.50)	22.6	0.91 (0.29–1.54)	42.9	0.86 (−0.10–1.81)	27.1	0.66 (0.45–0.88)
Alone with kid(s)$	33.9	1.07 (0.95–1.19)	52.2	1.16 (0.22–2.11)	40.7	1.65 (0.74–2.55)			44.8	1.10 (0.76–1.43)
With partner and kid(s)	26.9	0.85 (0.77–0.93)*	45.5	1.01 (0.44–1.59)	27.8	1.13 (0.53–1.72)	52.1	1.04 (0.15–1.94)	37.6	0.92 (0.72–1.12)
Other(s)	23.7	0.75 (0.65–0.84)**	50.0	1.11 (0.46–1.76)	20.4	0.83 (0.15–1.51)	47.8	0.96 (−0.17–2.08)	30.7	0.75 (0.53–0.97)

$Low number of cases in the category of the early, evening and/or night shift subgroups ($n < 20$). *$p < 0.05$, ** $p < 0.01$. PR = prevalence ratio (calculated against indicator). Binominal logistic regression results in Supplementary Table S2.1.

4.2. Regular night shift

The sample included a considerable group of fixed night shift workers ($n = 186$). A strikingly large proportion of this group reported short sleep duration (50%), and scored positive on the sleep disorders insomnia (20%), CRSWD (25%) and/or SRMD (23%). Compared to other types of shift work, night shift is associated with the largest change in sleep–wake timing. It is well-known that the circadian system resists the shift from a day- to a night-schedule and requires long lasting, consistent exposure to the altered sleep–wake and a matching light–dark schedule (21). It is estimated that merely 25% of the people adapt to night work (39). This is among others related to the fact that most night workers live in a day-oriented society (not in an isolated environment facilitating circadian adaptation), have domestic responsibilities, also during working days, and return to a relatively normal sleep–wake pattern on days off. Thus, particularly in fixed night workers there is an enduring, large misalignment between their endogenous and work-related sleep–wake schedule, negatively affecting sleep and many other health-related processes (21). The high prevalence of curtailed sleep and the different sleep disorders are in line with previous findings in shift workers [e.g., (25–27, 40)]. With regards to the prevalence of short sleep, insomnia and CRSWD, they are likely interrelated and might, at least partially, reflect the presence of SWD. That shift work-induced disordered sleep can be very persistent appears from a recent study demonstrating that night shift work is strongly associated with insomnia and daytime sleepiness even in the years after cessation of night work (41). The finding that also SRMD is rather common in night workers is in line with the literature [e.g., (27, 40)]. Underlying mechanisms are still unknown. There are implications that the SRMD restless legs syndrome (RLS) is associated with SWD. For instance, Waage and colleagues found in a sample of nurses that the prevalence of RLS was comparable in different shift work schedules, but was significantly higher in the nurses having SWD than in those without (42). The authors suggest that having one shift work-associated sleep disorder might increase the vulnerability to experience other sleep problems related to their work schedule.

TABLE 4 Prevalence and prevalence ratios of at least one sleep disorder in day, early, evening, night and rotating shift subsamples differentiated by sex, age, education and living companion (s).

	Day shift		Early shift		Evening shift		Night shift		Rotating shift	
	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)
Sex										
Male	28.4	1	42.5	1	42.9	1	46.0	1	42.3	1
Female	33.7	1.19 (1.14–1.23)**	40.1	0.94 (0.56–1.33)	42.8	1.00 (0.64–1.36)	53.7	1.17 (0.56–1.78)	46.0	1.09 (0.96–1.21)*
Age										
< 30 years	36.4	1	45.0	1	51.7	1	56.5	1	49.9	1
30–50 years	29.7	0.82 (0.76–0.87)**	41.0	0.91 (0.43–1.40)	42.7	0.83 (0.41–1.25)	47.2	0.84 (−0.09–1.76)	41.3	0.83 (0.68–0.97)*
> 50 years	30.7	0.84 (0.78–0.91)**	38.8	0.86 (0.36–1.36)	33.8	0.65 (0.18–1.12)*	54.1	0.96 (0.01–1.90)	42.6	0.85 (0.69–1.02)
Education										
Academic	28.5	1	36.7	1	37.0	1	50.0	1	40.5	1
Vocational	33	1.16 (1.10–1.21)**	32.6	0.89 (0.32–1.45)	50.6	1.37 (0.89–1.85)*	51.3	1.03 (0.28–1.77)	45.2	1.12 (0.96–1.27)
Secondary	41.3	1.45 (1.38–1.51)**	46.8	1.28 (0.82–1.73)	50.9	1.38 (0.94–1.81)*	48.4	0.97 (0.20–1.74)	49.3	1.22 (1.07–1.36)**
Elementary [$]	48.5	1.70 (1.31–2.10)**							56.0	1.38 (0.59–2.18)**
Living companion(s)										
Alone	33.3	1	36.2	1	50.6	1	61.5	1	50.3	1
With partner	32.9	0.99 (0.91–1.07)	43.7	1.21 (0.60–1.82)	43.1	0.85 (0.32–1.39)	51.0	0.83 (−0.14–1.80)	42.6	0.85 (0.65–1.05)**
Alone with kid(s)[$]	32.5	0.98 (0.86–1.09)	39.1	1.08 (0.11–2.05)	44.4	0.88 (0.01–1.74)			42.5	0.84 (0.51–1.18)
With partner and kid(s)	27.9	0.84 (0.76–0.91)**	40.0	1.10 (0.51–1.70)	31.8	0.63 (0.09–1.17)*	47.9	0.78 (−0.13–1.69)	39.5	0.79 (0.59–0.98)**
Other(s)	37.7	1.13 (1.04–1.22)*	44.9	1.24 (0.58–1.90)	51.5	1.02 (0.45–1.59)	60.9	0.99 (−0.16–2.14)	50.8	1.01 (0.80–1.22)

[$]Low number of cases in the category in the early, evening and/or night shift subgroups ($n < 20$). *$p < 0.05$, **$p < 0.01$. PR = prevalence ratio (calculated against indicator). Binominal logistic regression results in Supplementary Table S2.2.

Alternatively, shift work is a risk factor for adverse mental health consequences, particularly depressive symptoms. Meta-analyses demonstrated a 33% increase for depressive symptoms among shift workers (43) and a 42% increase for depression in night workers (44). Various antidepressants trigger and aggravate SRMD (45). Yet, studies on the use of psychiatric medication in shift workers are inconclusive (46, 47).

In contrast to earlier studies (27, 40), we found a significant doubling of estimated SBD in the night compared to day workers. At this point, an explanation for this discrepancy remains elusive. Yet, a polysomnographic study in shift workers with obstructive sleep apnea syndrome found that the apnea-hypopnea index (AHI) is significantly higher during sleep scheduled in the day time than during night time (48). The increase in obstructive sleep apnea severity may be related to the high occurrence of respiratory events during rapid eye movement (REM) sleep, a sleep state that occurs most during the biological morning, a time of day during which night shift workers are typically sleeping (49).

Within night workers, sex, age and living companions had a relatively minor association with the already very prevalent short sleep duration. Especially the absence of differences between the age groups might be considered unexpected, as several studies report more sleep problems in older night shift workers compared to younger workers [e.g., (50–52)]. However, consistent with our data a recent meta-analysis on sleep quality revealed a moderating effect of age in those working rotation shifts, but an absence hereof in the night shift workers (53). In contrast, the level of education had a significant impact with a PR of 1.7. This might be related to differences in the type of profession between those with a high and a low education level (e.g., factory work vs. working as a physician). Furthermore, education level is often used as a proxy for socioeconomic status, and thus may be tied to the living conditions, for example living in a small, noisy apartment versus independent housing. The ability to adapt to the challenging circumstances may also hamper sleep. Concerning the presence of any sleep disorders, none of the sociodemographic factors was a significantly associated with this outcome parameter. Considering the

TABLE 5 Prevalence and prevalence ratios of a circadian rhythm sleep–wake disorder in day, early, evening, night and rotating shift subsamples differentiated by sex, age, education and living companion (s).

	Day shift		Early shift		Evening shift		Night shift		Rotating shift	
	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)	%	PR (95% CI)
Sex										
Male	7.0	1	9.7	1	23.0	1	22.2	1	19.8	1
Female	8.4	1.20 (1.12–1.28)**	12.3	1.27 (0.66–1.88)	18.3	0.80 (0.36–1.24)	26.0	1.17 (0.45–1.89)	19.1	0.96 (0.81–1.12)
Age										
< 30 years	12.0	1	18.3	1	30.2	1	30.4	1	25.3	1
30–50 years	6.5	0.54 (0.45–0.64)**	5.2	0.28 (−0.54–1.11)	18.8	0.62 (0.13–1.11)	19.1	0.63 (−0.41–1.66)	16.3	0.64 (0.47–0.82)**
> 50 years	6.7	0.56 (0.45–0.67)**	12.5	0.68 (0.00–1.37)	11.7	0.39 (−0.23–1.00)**	29.7	0.98 (−0.04–2.00)	16.7	0.66 (0.46–0.86)**
Education										
Academic	6.8	1	8.6	1	16.8	1	27.3	1	16.9	1
Vocational	7.6	1.12 (1.02–1.22)**	4.3	0.50 (−0.68–1.68)	21.3	1.27 (0.68–1.86)	23.7	0.87 (0.02–1.72)	20.1	1.19 (0.99–1.39)**
Secondary	12.2	1.79 (1.69–1.90)**	15.1	1.76 (1.03–2.48)	26.7	1.59 (1.08–2.10)	22.6	0.83 (−0.06–1.72)	22.4	1.33 (1.14–1.51)**
Elementary	15.2	2.24 (1.68–2.79)**							20.0	1.18 (0.20–2.17)
Living companion(s)										
Alone	11.3	1	7.2	1	29.2	1	30.8	1	26.1	1
With partner	7.6	0.67 (0.55–0.80)**	8.4	1.17 (0.05–2.29)	18.2	0.62 (−0.01–2.25)*	20.4	0.66 (−0.42–1.75)	18.3	0.70 (0.46–0.94)**
Alone with kid(s)$	7.3	0.65 (0.44–0.85)**	8.7	1.21 (−0.51–2.92)	18.6	0.64 (−0.43–1.71)			13.3	0.51 (0.04–0.98)**
With partner and kid(s)	5.1	0.45 (0.33–0.58)**	6.9	0.96 (−0.16–2.07)	9.9	0.34 (−0.36–1.04)**	23.3	0.76 (−0.24–1.75)	13.6	0.52 (0.28–0.77)**
Other(s)	13.9	1.23 (1.10–1.36)	26.9	3.74 (2.70–4.78)*	30.1	1.03 (0.41–1.65)	39.1	1.27 (0.09–2.45)	26.3	1.01 (0.77–1.25)

$Low number of cases in the category in the early, evening and/or night shift subgroups ($n < 20$). *$p < 0.05$, **$p < 0.01$. PR = prevalence ratio (calculated against indicator). Binominal logistic regression results in Supplementary Table S2.3.

overall high prevalence of sleep disorders in regular night workers, this may be explained by a ceiling effect. This notion is strengthened by the fact that prevalence rates were higher in evening and rotating shifts to the level, but not beyond, of night workers as a function of sociodemographic factors.

4.3. Early morning work

Rather independent of sociodemographic factors, working early mornings had little effect on the occurrence of sleep disorders, including CRSWD. However, it was associated with a high prevalence of short sleep duration. This higher prevalence of curtailed sleep may be explained by 1) going to bed earlier, experiencing problems initiating sleep (21), and 2) keeping normal bedtimes, while rising earlier on work days. The contradiction between an association with short sleep and the absence thereof with most sleep disorders may be due to early workers maintaining relatively normal night and day rhythms, which may protect them from circadian misalignment and sleep disorders. The only sleep disorder that was clearly more prevalent in early morning workers was hypersomnia, with a 2-fold PR compared to day workers. Restricted sleep has been shown to induce accumulating levels of sleepiness during the day in both naturalistic and experimental settings (54, 55). Thus, the higher risk to hypersomnia might result from the repeated shortened sleep duration in early morning workers. Of note, the relationship of an early morning shift with short sleep seems weaker in females than in males. This difference is possibly explained by women more often being early birds (56), thus requiring less adaptation to an early morning shift. In the early morning workers, the prevalence of CRSWD was strikingly higher (3.7 fold) in the “others” living companion group. Within the ‘others’ group CRSWD estimates were high in those living with their parents (27% with CRSWD), whereas those living with friends (11% with CRSWD) displayed prevalences more similar to early morning workers living alone, with partner and/or children. In our sample, individuals living with their parents had lower education levels than those living with friends (80% vs. 33% with only primary or secondary education), which may partially explain the heightened prevalence of CRSWD in this group.

4.4. Evening and rotating shifts

Overall the associations within evening and rotating shifts on sleep are less pronounced, but comparable to those of night shift workers. Furthermore, the relationships of sociodemographic factors with sleep parameters followed similar patterns as in day shifts, with younger, lower educated individuals, living without partner and kid(s), being at highest risk for disordered sleep. Shift work is indicated to be associated with a slight increase in the prevalence of long sleep duration (6). In the present study, this association was only significant for the evening shift. It is conceivable that evening workers tend to go to bed soon after work, at a biological time of high sleep propensity, and sleep in as they do not need to get up early for work.

Unfortunately, in the current study we were not able to differentiate between different orders of shifts within the rotating shift group. Previous studies have shown that those working in a backward rotating shift schedule tend to have more sleep problems than those working in a forward schedule (57, 58). Given the known effects of the order of shifts, future studies should take this into account.

4.5. Limitations

There are some limitations to this study, the first concerning the study sample. Due to the recruitment of participants through a newspaper advertisement, a selection bias is likely. For example, compared to the general Belgian population (59), the current sample was clearly higher educated (14.6% with academic education in general population in 2016 versus 59% in current sample). Furthermore, individuals with sleep problems might be more inclined to participate in a study focused on sleep than good sleepers, and thus persons with sleep disturbances may be overrepresented in our sample. This may be evidenced by the presently observed slightly higher prevalence of sleep disturbances in comparison with a study in a representative sample of the Dutch population (33). However, differences between the countries may play a role here as well, with previous reports of more self-reported sleep problems in Belgium than in the Netherlands (60). Nevertheless, although absolute prevalence rates might be overestimated in our study, we believe it unlikely that the associations with the investigated sociodemographic factors are strongly affected by such a selection bias.

A second limitation is the use of a screenings-questionnaire to assess the prevalence of sleep disorders. Though the used HSDQ has good clinical validity (31), a questionnaire can only provide an estimate. Especially those sleep disorders that require polysomnography for diagnosis, like SBD, are less accurately assessed using a questionnaire.

Finally, using a naturalistic study design has led to large differences in the sample sizes of the work shift subgroups. This complicated direct comparisons between subsamples as similar prevalence ratios reached statistical significance in the larger subsamples, yet failed to do so in the smaller subsamples.

4.6. Implications and perspectives

Compared to regular day work, all shift work schedules seem associated with adverse sleep effects; night shifts most strongly. As societies cannot do without night work and adaptation to it is hard and often undesirable, rotational shifts are generally advised, particularly fast-forward rotating work schedules, with the period of night work as short as possible and plenty of resting days in between to recover from the accumulated sleep deficit (61, 62). To prevent sleep curtailment and sleep disorders, employers/occupational health practitioners should encourage good sleep health and give tools to deal with shift work as well as possible, both promoting optimal sleep during the resting period and wakefulness during working hours. It would, for instance, be useful to educate shift workers, and ideally their family members and/or other supporting living companions, on homeostatic and circadian regulation of sleep, good sleep hygiene (avoiding alcohol and caffeine close to bedtime), and optimization of the sleep environment (dark, cool and quiet bedroom), and reduction of sleepiness during the working period by for instance powernaps, caffeine and bright light. Such information could be particularly helpful for young and low educated shift workers, as these groups appear to experience most sleep problems and may benefit most from information on coping strategies. Furthermore, regular assessment of sleep quality and quantity and screening for disordered sleep in those working shifts might be crucial to timely treat sleep disorders such as SWD and insomnia, and thereby preventing persistent sleep disturbances and their adverse effects on physical and mental health and work performance.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because The study involved a questionnaire published in a newspaper. Participants could freely choose whether to complete the questionnaire or not. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

PV and GK were involved in data collection. GB, TM, and ML were involved in data analysis. GB and ML were responsible for conceptualization and the first draft of the manuscript. All authors reviewed and provided feedback on the final manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Sleep quality and subjective well-being in healthcare students: examining the role of anxiety and depression

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Objective: Sleep issues, negative emotions, and health conditions are commonly co-occurring, whereas their associations among healthcare students have yet to be elucidated. This study aimed to examine whether anxiety and depression mediate the relationship between sleep quality and subjective well-being in healthcare students.

Methods: A cross-sectional survey was conducted among Chinese healthcare students ($N = 348$). A battery of paper-and-pencil questionnaires—the Sleep Quality Questionnaire (SQQ), World Health Organization-Five Well-Being Index (WHO-5), and Patient Health Questionnaire-4 (PHQ-4) were applied. Descriptive analysis with means (standard deviations) and counts (proportions), Spearman correlation analysis between the SQQ, WHO-5, and PHQ-4, and mediation analysis via structural equation models were performed.

Results: Correlation analysis revealed statistically significant associations between sleep quality, anxiety and depression, and well-being among healthcare students. Mediation analysis identified that poor sleep quality produced relatively low levels of self-reported well-being, which were entirely attributable to anxiety and depression.

Conclusion: Sleep quality was associated with subjective well-being, and this interrelationship was fully mediated by anxiety and depression. Interventions aimed at promoting sleep quality of healthcare students may contribute to promoting their well-being by reducing anxiety and depression.

KEYWORDS

sleep quality, well-being, anxiety and depression, mediation, healthcare students

1 Introduction

Sleep health is an essential component of daily functioning (1). Adequate sleep quality (i.e., regularity, satisfaction, alertness, timing, efficiency, and duration) is considered integral to both physical and psychological well-being (2). Poor sleep frequently occurs in the general population due to numerous influencing factors such as high-intensity work, domestic and social responsibilities, and harmful lifestyle and behavior (3). Sleep disorders disrupt healthy homeostasis, triggering reactions in the body systems, often producing adverse health consequences (4–7). Impaired sleep is widespread in the general population (8, 9), and is associated with numerous diseases, e.g., multiple chronic conditions (10), cardiovascular disease (7, 11), impaired cognitive function (12, 13), and cancer mortality risk (14, 15). Chronic sleep issues have the potential to increase susceptibility to a variety of physical and mental illnesses, ultimately leading to a decline in overall well-being (16). Conversely, improving the qualities of sleep-onset latency, sleep dissatisfaction, and daytime sleepiness are potential avenues for enhancing physical and mental wellness (17–19). Nevertheless, the mechanism between sleep quality and well-being has yet to be comprehensively elucidated.

The burden of mental disorders is widespread across the world. Poor sleep quality and excessive daytime sleepiness can increase negative emotions, further resulting in anxiety and depressive symptoms. Sleep difficulty is a significant predictor of anxiety and depression (20). Sleep difficulty has been shown to reduce the quality of life among patients with cardiovascular diseases (21), Parkinson's disease (22), multiple sclerosis (23), and chronic anorectal disorder (24). A meta-analysis revealed that the prevalence of depression was higher in people complaining of sleep difficulties than in the general population. Meanwhile, in people without sleep disturbances, the prevalence of depression was much lower (25). Sleep and negative emotions are interrelated, namely, dysfunction of sleep-awakening regulatory neural circuits may lead to altered emotional responses (26). Unsatisfying sleep has a known impact on raising the occurrence of psychological disturbances (27, 28); and unsurprisingly, higher levels of anxiety and depression possibly lead to a reduction in well-being (29). A previous study confirmed that anxiety and depression can negatively influence multiple elements of subjective well-being (e.g., physical well-being) (29). A longitudinal study found that anxiety disorders help predict optimal well-being over the next 10 years (30).

Poor sleep and consequent decline in well-being are common among university students, particularly those studying in healthcare professions (31–33). Data consistently reveal that healthcare students worldwide report symptoms of poor-quality sleep, and their sleep problems are more intense than non-healthcare students (34). Healthcare students' attitudes, behaviors and lifestyles, academic pressure, and internet addiction can potentially contribute to sleep disturbances, while some variables are probably interrelated (34). Consequently, inadequate sleep has a detrimental effect on daytime functioning with prolonged drowsiness throughout the day, lowering academic performance, escalating unpleasant emotions, and risk of suicidal behavior (35, 36). Nearly one-third of healthcare students are exposed to persistent and severe anxiety or depression during the academic years due to the intensive curriculum schedule and transition from school to society (35–39). It is crucial to identify the health outcomes and underlying mechanisms between poor sleep health and negative well-being (39). Despite prior studies that have indicated the role of anxiety and depression on the sleep and well-being association, no existing evidence directly addresses the pathways underlying sleep quality and well-being in healthcare students.

A better understanding of the pathways through which sleep quality links to well-being may help to formulate tailor-made psychotherapeutic behavioral interventions. Considering the possible relationship between sleep quality, anxiety and depression, and well-being, we hypothesized significant associations among the three. Simultaneously, we constructed a mediation model and hypothesized that: (i) better sleep would be positively associated with better well-being among Chinese healthcare students; and (ii) anxiety and depression would mediate the relationship between sleep quality and well-being.

2 Methods

2.1 Study design and procedure

A cross-sectional study using anonymous and self-administered questionnaires was conducted in a healthcare student cohort. All data collection occurred in the last quarter of 2022. The study was approved by the Institutional Review Board of the School of Public Health, Hangzhou Normal University (Reference No. 20190076). The STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines were followed (40).

Participants were enrolled via a stratified random sampling method. Students were not retained if they were unwilling to participate, unable to understand Chinese, or not attending school on the day. As the minimum required sample size is 15 participants for each variable, a total of at least 285 subjects were needed for this study. The final sample size of 348 exceeds this requirement. The study purpose and privacy instructions were conveyed by trained researchers prior to the survey. Each respondent acknowledged their rights and was entitled to withdraw at any point. Subsequently, a battery of paper-and-pencil surveys were administered to assess information on sleep quality, well-being, anxiety and depression, and basic socio-demographic characteristics.

2.2 Measures

2.2.1 Sleep Quality Questionnaire (Chinese version)

The Sleep Quality Questionnaire (SQQ) is a 10-item self-report scale covering daytime sleepiness and sleep difficulty, which are two dimensions of sleep quality (41). Participants respond on a five-point Likert scale ranging from 0 (strongly disagree) to 4 (strongly agree) referring to the past month's sleep. The total score is calculated by summing item scores with a higher score indicating poorer sleep quality. The adequate reliability, validity, and measurement invariance were well-documented by prior multi-site studies (41–45). In this study, Cronbach's α of the SQQ was 0.811.

2.2.2 World Health Organization-five well-being index (Chinese version)

The World Health Organization-Five Well-Being Index (WHO-5) is a widely used short and generic global rating scale to estimate subjective psychological well-being during the last two weeks (46). A six-point Likert scale was used, ranging from 0 to 5 (never, sometimes, less than half the time, more than half the time, most of the time, and all the time), with lower scores indicating poorer subjective physical and mental health. The questionnaire has been in existence for nearly 30 years, has been translated into over 30 languages, and has demonstrated stable psychometric properties in worldwide applications (47, 48). In this study, Cronbach's α of the WHO-5 was 0.908.

2.2.3 Patient Health Questionnaire-4 (Chinese version)

The Patient Health Questionnaire-4 (PHQ-4)[1] is a brief and freely available instrument rated on a four-point Likert scale ranging from 0 (not at all) to 3 (nearly every day), with a higher score means more serious depressive and anxiety symptoms. The scale has a stable two-factor structure—anxiety and depression—and good psychometric properties (49, 50). In this study, Cronbach's α of the PHQ-4 was 0.821.

2.2.4 Sociodemographic

Participants completed a series of demographic questions: gender, age, home location, single-child status, family income, part-time status, leisure time sports involvement, and engagement in hobbies.

2.3 Statistical analysis

EpiData (version 3.1) and R (version 4.1.2) were used for data organization and data analysis. Given that researchers quickly checked the questionnaires at the time of collection and requested respondents to fill in missed questions, there were no missing values in this dataset. The "*MVN* v.5.9" package was used for multivariate normality (51). The "*dplyr* v.1.0.10" package was used for descriptive analysis: means and standard deviations (SD) were used to summarize the continuous variables while counts and proportions were used to summarize the categorical variables in descriptive statistics (52). Since the scale scores were ordinal categorical variables and the data was not normally distributed, the "*Hmisc* v.5.1–0" package was used for Spearman correlation to investigate the relationship among sleep quality, well-being, anxiety and depression (53).

The "*lavaan* v.0.6–9" (54) and "*semTools* v.0.5–5" (55) packages were used for structural equation modeling (SEM) to further explore whether anxiety and depression may explain any observed associations between sleep quality and well-being. If the direct effects of sleep quality on well-being were significant, the mediating variables were added to further calculate the indirect effects and total effects. A 1000 bias-corrected bootstrap procedure with the percentile method was evaluated for the significance of the mediation effect. The goodness-of-fit indices contain goodness-of-fit index (GFI), Tucker–Lewis index (TLI), comparative fit index (CFI), adjusted goodness-of-fit index (AGFI), parsimony normed fit index (PNFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) were reported, in which GFI, TLI, CFI, and AGFI greater than 0.90 or 0.95, RMSEA and SRMR lower than 0.08 or 0.05 for a reasonable and close fit, respectively. PNFI greater than or equal to 0.50 is considered acceptable (53, 56, 57).

3 Results

3.1 Characteristics of participants

Among the 348 valid participants (Clinical Medicine: 154; Preventive Medicine: 194), 130 (37.36%) were males (Table 1). There were slightly fewer participants younger than 20 years old ($N = 155$, 44.54%) than those greater than or equal to 20 years old ($N = 193$, 55.46%). Those who were involved in sports ($N = 260$, 74.71%) and those who had hobbies ($N = 88$, 25.28%) accounted for about three quarters and one quarter, respectively. The Kolmogorov–Smirnov test showed that the p-value for the SQQ was 0.026, and the PHQ-4 and WHO-5 were all less than 0.001. The t-test and analysis of variance (ANOVA) results were as follows: (i) worse sleep quality in the older subgroup ($p = 0.035$); (ii) more severe anxiety and depression and lower well-being were found in the group who did not participate in sports ($p_{PHQ\text{-}4} = 0.007$; $p_{WHO\text{-}5} = 0.012$) and who did not engage in hobbies ($p_{PHQ\text{-}4} = 0.026$; $p_{WHO\text{-}5} = 0.007$); (iii) healthcare students who ignored problems as the preferred coping strategies exhibited poorer sleep quality ($p = 0.022$), well-being ($p < 0.001$), anxiety and depression ($p < 0.001$) status.

3.2 Correlations among sleep quality, well-being, and anxiety and depression

The Spearman correlation was performed among the subscale scores and total scores of the SQQ, PHQ-4, and WHO-5. As shown in Table 2, there were statistically significant correlations ($p < 0.001$) between all scores, ranging from 0.339 to 0.924. Due to the WHO-5 scoring, it correlated negatively with other scores clustered around −0.409 and −0.696. The association between the total scores of the SQQ and PHQ-4 was 0.514, while the total score of the WHO-5 was significantly, and negatively, related to the SQQ ($r = -0.526$). Similarly, the total score of the WHO-5 was negatively correlated with the PHQ-4 ($r = -0.696$).

3.3 The mediating role of anxiety and depression

The total effect ($c = -0.723$, $p < 0.001$, standard error [SE] = 0.059) of sleep quality on well-being was first estimated (Figure 1A), which revealed a significant association and resulted in the conditions necessary for the mediator model construction. Subsequently, anxiety and depression were integrated into the model as a mediator. The standardized regression coefficients from sleep quality to anxiety and depression ($a = 0.769$, $p < 0.001$, SE = 0.068) and from anxiety and depression to well-being ($b = -0.519$, $p < 0.010$, SE = 0.190) were both

1 Retrieved from: https://www.phqscreeners.com; accessed on 29 August 2019.

TABLE 1 Characteristics of participants ($N = 348$).

Variable	N (%)	SQQ		PHQ-4		WHO-5	
		Mean (SD)	t/F	Mean (SD)	t/F	Mean (SD)	t/F
Gender			0.107		0.928		0.253
Male	130 (37.356)	18.862 (6.218)		3.477 (2.062)		14.508 (4.325)	
Female	218 (62.644)	18.725 (6.647)		3.729 (2.269)		14.234 (4.477)	
Age			4.049*		2.189		2.476
< 20	155 (44.540)	17.961 (6.224)		3.432 (2.165)		14.819 (4.345)	
≥ 20	193 (55.460)	19.430 (6.624)		3.798 (2.209)		13.948 (4.446)	
Home location			0.040		0.272		0.536
Urban	159 (45.690)	18.899 (6.770)		3.616 (2.308)		14.635 (4.505)	
Rural	102 (29.310)	18.608 (6.323)		3.735 (2.277)		14.147 (4.615)	
Suburban	87 (25.000)	18.747 (6.186)		3.552 (1.879)		14.011 (4.010)	
Single-child status			0.121		0.187		0.001
Single-child	129 (37.069)	18.915 (6.578)		3.581 (2.068)		14.271 (4.200)	
Non-single-child	219 (62.931)	18.694 (6.438)		3.667 (2.269)		14.374 (4.548)	
Family income			0.848		0.508		0.632
< 10,000 CNY	145 (41.667)	18.924 (6.429)		3.779 (2.367)		13.959 (4.649)	
≥ 10,000 CNY	203 (58.333)	18.670 (6.532)		3.532 (2.062)		14.606 (4.234)	
Part-time status			1.932		0.420		0.065
Do part-time job	33 (9.483)	20.303 (6.664)		3.879 (1.883)		14.091 (4.340)	
No part-time job	315 (90.517)	18.616 (6.452)		3.610 (2.225)		14.362 (4.430)	
Leisure time sports involvement			0.032		7.502*		7.991**
Yes	260 (74.713)	18.708 (6.658)		3.450 (2.087)		14.681 (4.366)	
No	88 (25.287)	18.977 (5.962)		4.182 (2.414)		13.318 (4.432)	
Engagement in hobbies			0.586		4.864*		6.506*
Yes	249 (71.552)	18.594 (6.637)		3.470 (2.203)		14.735 (4.478)	
No	99 (28.448)	19.232 (6.081)		4.051 (2.126)		13.333 (4.111)	
Preferred coping strategies			3.847*		10.224***		7.326***
Active copies	191 (54.885)	18.738 (5.981)		3.634 (2.075)		14.639 (4.024)	
Push through	124 (35.632)	18.089 (6.835)		3.242 (2.050)		14.613 (4.702)	
Ignore problems	33 (9.483)	21.576 (7.323)		5.121 (2.759)		11.545 (4.637)	

Bold fonts stand for different variables. The unit of the Monthly household income is CNY (1 CNY ≈ 0.140 US dollars). SQQ, Sleep Quality Questionnaire; PHQ-4, Patient Health Questionnaire-4; WHO-5, World Health Organization-Five Well-Being Index; SD, standard deviation; *$p < 0.050$; **$p < 0.010$; ***$p < 0.001$.

TABLE 2 Correlations of the primary variables in the study for participants ($N = 348$).

Measures	SDS	DSS	SQQ	Anxiety	Depression	PHQ-4
DSS	0.381					
SQQ	0.686	0.924				
Anxiety	0.339	0.422	0.464			
Depression	0.362	0.409	0.462	0.622		
PHQ-4	0.383	0.461	0.514	0.891	0.897	
WHO-5	−0.409	−0.468	−0.526	−0.604	−0.655	−0.696

Color gradient represents correlation level. Red represents a positive correlation. Blue represents a negative correlation. SDS, Sleep Difficulty Subscale; DSS, Daytime Sleepiness Subscale; SQQ, Sleep Quality Questionnaire; PHQ-4, Patient Health Questionnaire-4; WHO-5, World Health Organization-Five Well-Being Index.

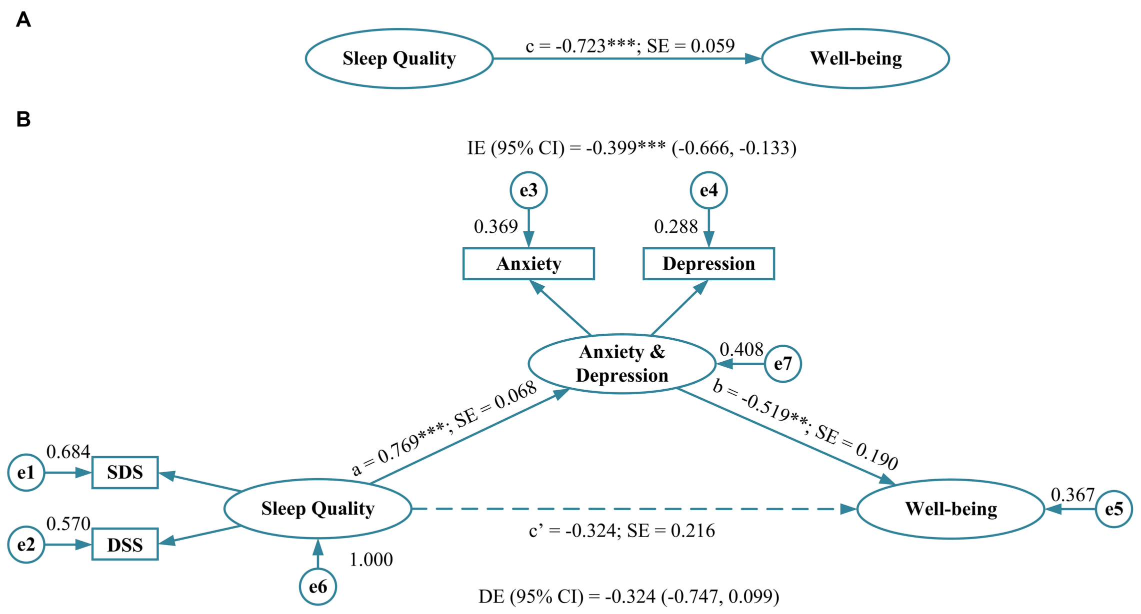

FIGURE 1
Path coefficients for simple mediation analysis on sleep quality. **(A)** The direct effect of sleep quality on well-being and **(B)** the effect of sleep quality on well-being when anxiety and depression is included as a mediator. a, b, c, and c': standardized regression coefficients; dotted line represents the effect of sleep quality on health condition when anxiety and depression is included as a mediator. SDS, Sleep Difficulty Subscale; DSS, Daytime Sleepiness Subscale; SE, standard error; IE, indirect effect; DE, direct effect; $^{**}p < 0.010$; $^{***}p < 0.001$.

TABLE 3 Evaluation of the goodness-of-fit of the mediation model ($N = 348$).

GOF index	Index	Threshold
Absolute measures		
RMSEA (90% CI)	0.000 (0.000, 0.082)	≤ 0.080
SRMR	0.010	≤ 0.080
GFI	0.997	≥ 0.900
χ^2/df	0.777	2–3
Incremental fit measures		
TLI	1.004	≥ 0.900
CFI	1.000	≥ 0.900
Parsimony measures		
AGFI	0.987	≥ 0.900
PNFI	0.299	≥ 0.500

GOF index, goodness-of-fit index; RMSEA, root mean square error of approximation; SRMR, standardized root mean residual; GFI, goodness-of-fit index; χ^2, Chi-square; df, degree of freedom; TLI, Tucker-Lewis index; CFI, comparative fit index; AGFI, adjusted goodness-of-fit index; PNFI, parsimony normed fit index; CI, confidence interval.

significant, while the direct effect ($r = 0.324$, $p > 0.050$, 95% CI: −0.747, 0.099) from sleep quality to well-being was not significant. Simultaneously, the indirect effect ($r = -0.399$, $p < 0.001$, 95% CI: −0.666, −0.133) of sleep quality on well-being through anxiety and depression was statistically significant, implying that anxiety and depression function as full mediators between sleep quality and well-being. The model showed excellent goodness-of-fit indices (RMSEA = 0.000, SRMR = 0.010, GFI = 0.997, TLI = 1.004, CFI = 1.000, and AGFI = 0.987), except for the PNFI of 0.299 which was slightly below the threshold (Table 3).

4 Discussion

The current study provided empirical support for the relationship between sleep quality and well-being among healthcare students, while examining an important potential mechanism—depression and anxiety. Our findings confirmed that sleep quality was directly related to well-being, but such a link was fully mediated by depression and anxiety. Consequently, healthcare students who had high-quality sleep might have lower levels of anxiety and depression, which was associated with better well-being. This study expanded on previous research to highlight the relationship between sleep quality and well-being in healthcare students, including important variables related to negative emotions (34, 39, 58).

Correlation analysis demonstrated that sleep quality, including sleep difficulty and daytime sleepiness, was correlated with anxiety and depression. The relationships between these variables were shown in previous studies; sleep disturbance, psychological distress, and health impairment seem to be commonly intertwined (59–61). Our findings were also congruent with the phenomenon of unsatisfactory or poor sleep being relevant to the onset of mental disorders, as well as social, interpersonal, and self-health impairment (60). Previous prospective analyses have shown insomnia to be strongly predictive of impending anxiety and depression (62). Anxiety and depression have also been found to be predictor variables of sleep-related symptoms and to serve as mechanisms underlying future insomnia in the general population (62, 63). Previous studies have proposed that people with insomnia do not have higher levels of daytime sleepiness than individuals without insomnia, but this is only on an individual basis and is based on assessing physiological indicators only (64–66). A large body of literature has suggested other mechanisms at play in insomnia. Although this study assessed sleep quality primarily through sleep difficulty and daytime sleepiness, a formal diagnosis of sleep disorders was not conducted. Previous research has found that comorbid anxiety and depression are strongly associated with somatic health problems and subjective well-being (67–69). A study based on the Chinese population reported that improving sleep quality and alleviating anxiety would be attributed to decreasing somatic symptoms (60). These findings suggest that the interrelationship between sleep quality and self-perceived health is not directional, but instead, a complicated two-way process, where sleep quality influences well-being, and vice versa.

Given the extensive adverse outcomes on individual health, we should pay more attention to depressive and anxiety problems for healthcare students who are potentially at high risk. Mediation analysis supported our hypothesis, i.e., the sleep quality and well-being connection was fully mediated by anxiety and depression. Respondents with poor sleep quality were more likely to experience anxiety and depression, which in turn influenced well-being. Our findings align with results in the literature that highlight the protective role of alleviating anxiety and depression on sleep quality and a series of health events (70–72). A three-wave longitudinal study, for instance, indicated that anxiety and depression mediate the relationship between self-reported adaptability and insomnia in university students (72). The association between exposure to adverse childhood experiences and increased somatic symptoms in adolescents could be explained through anxiety and depression symptoms (69). In perimenopausal and postmenopausal women, the reduction of anxiety and depression was found to be helpful in improving sleep quality for those who were plagued by hot flashes (70). In terms of psychological health, a cross-sectional study demonstrated that anxiety fully mediated the connection between sleep disturbance and recent suicide attempts, and that relief from anxiety might reduce the risk of suicide attempts in individuals with sleep disorders (71). These findings suggest that anxiety and depression could represent one pathway through how sleep quality connects to well-being. A deepened understanding of the association between, on one hand, sleep quality and self-reported well-being, and on the other hand, remission of anxiety and depression might provide avenues for continued efforts to promote well-being.

Enhancing the well-being of healthcare students can begin with the model's starting point, sleep quality, and its full mediators, anxiety and depression. Although sleep is a necessity, it is underappreciated. Comprehensive education can help to increase the recognition of sleep and the potential harm of poor sleep quality among healthcare students (64, 73). A critical step regarding anxiety and depression is to raise the recognition of psychiatric disorders and reduce the stigma about seeking psychological help (37, 65). Prolonged exposure to such negative emotions without seeking help may have a negative impact on academic performance, professionalism, empathy, and so on (66, 74, 75). Developing positive thinking practice courses, stress management training, and adjusting medical education programs may be possible solutions (76–78).

4.1 Strengths and limitations

Previous research has chiefly concentrated on one-way or two-way interactions between sleep quality, psychologies, and well-being, but few studies have focused on the potential mediating influence of anxiety and depression among healthcare students. The current study allowed for a holistic understanding of how exposure to poor or adequate sleep quality affects outcomes for healthcare students. The association between sleep quality and well-being was found to be entirely mediated by anxiety and depression. The high risk of exposure to poor sleep in this group might result in severe anxiety and depression and therefore reduced self-perceived well-being.

There are several study limitations. Respondents were recruited from a single-center sample and might not be generalized to the general population of healthcare students across China or other countries. This study did not include students from other majors as a comparison. Another limitation was that self-report questionnaires were conducted to measure sleep quality, negative emotions, and psychosomatic well-being, which might introduce potential reporter bias. Moreover, the cross-sectional design limited the ability to determine how sleep quality changed subjective well-being through anxiety and depression. A longitudinal study, relatively, would be more appropriate for examining the variation of well-being via sleep quality and emotions. Lastly, prior psychological conditions and use of medications were not assessed, which could have potentially influenced the results.

4.2 Future directions

Research on large, multi-center samples is needed to provide more comprehensive evidence for capturing sleep quality in different cohorts. Longitudinal examinations should be collected to elucidate causality, while considering potential confounders that might affect sleep quality, such as seasonal effects and course changes. Simultaneously, the influence of factors such as sleeping medication, antidepressants, cigarettes, and alcohol in this model can be further explored. Best approaches to apply the findings of the study to influence public policy or conduct educational activities is an area for further exploration.

5 Conclusion

The present cross-sectional study makes initial advances to clarify the mechanism underlying the connection between sleep quality and subjective well-being. Poor sleep quality may result in decreased well-being in healthcare students through anxiety and depression. Conducting regular screening of sleep quality and psychological conditions, providing health education to enhance the awareness of physical and mental health, and adopting targeted interventions such as sleep health education, positive thinking training, psychological counseling, and group exercise for some high-risk groups may help to promote the well-being in healthcare students.

Data availability statement

The data generated or analyzed during this study are not publicly available due to restrictions imposed by the ethics committee. The dataset supporting the conclusions is available upon reasonable request to the corresponding author.

Ethics statement

The studies involving humans were approved by the Institutional Review Board of School of Public Health, Hangzhou Normal

University, China. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YZ: Validation, Writing – original draft, Writing – review & editing. RM: Validation, Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision. CJ: Formal analysis, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. NY: Validation, Writing – original draft, Writing – review & editing. MH: Validation, Writing – review & editing. XW: Writing – review & editing. WZ: Writing – review & editing. CL: Writing – review & editing. RX: Writing – review & editing. JL: Writing – review & editing. JX: Writing – review & editing. UJ-C: Validation, Writing – review & editing. HM: Resources, Validation, Writing – review & editing. KS: Methodology, Validation, Writing – review & editing. JD: Methodology, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Effects of mindfulness-based cognitive therapy on older adults with sleep disorders: a systematic review and meta-analysis

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Objective: This systematic review and meta-analysis was conducted to analyze the effectiveness of a mindfulness-based program on sleep quality in healthy non-institutionalized older people.

Methods: This study was conducted following the PRISMA (Preferred Reporting Items For Systematic Reviews And Meta-Analyses) guidelines. The search was conducted during May and June 2023 using four databases: Pubmed, Scopus, Web of Science, and CINAHL. Different keywords combined with Boolean operators were used. Only 10 articles of the initial 177 were included. In the study, the standardized mean difference (SMD) was used along with a 95% confidence interval to measure the effect. Heterogeneity among the studies, assessed using Cochran's *Q*-test and the I^2 statistic was found to be low, leading to the use of a fixed-effects model in the analysis. The effect size was expressed as Hedge'g. Furthermore, a subgroup analysis was conducted, taking into account the various tools used to assess sleep conditions.

Results: Mindfulness was found to reduce poor sleep quality in people with both long-term and short-term sleep disorders. Weighting effect model Hedge'g = −0.344 with a 95% confidence interval ranging from −0.425 to −0.263. In all cases, statistically significant results were observed, as well as moderate and negative effect sizes according to the Hedge's g index: −0.326 for Insomnia Severity Index (ISI), −0.343 for Pittsburgh Sleep Quality Index (PSQI), and −0.28 for Sleep Onset Latency (SOL).

Conclusion: This systematic review and meta-analysis found that mindfulness can be used to remedy poor sleep quality in older people, so it could be a viable treatment option for insomnia or other problems related to poor sleep quality in this population.

KEYWORDS

mindfulness, sleep disorders, older adults, systematic review, meta-analysis

1 Introduction

Sleep disorders are a widespread public health problem affecting between 20% and 30% of adults (1). They have numerous adverse consequences on individual quality of life and place a significant economic burden on society. Poor sleep quality is more common among adults over the age of 60 because this age group has a higher prevalence of sleep problems than younger age groups when measured through biological assessments or self-reports (2). This poor sleep quality is related to multiple factors such as nighttime worry and chronic stress, which subsequently affect health outcomes, including increased morbidity and mortality, as well as reduced quality of life (3–5). In numerous studies, about half of older adults have reported sleep problems, including difficulty falling asleep, sleep disruption, and general dissatisfaction with sleep quality and quantity (6, 7).

Generally, specialists argue that the reduction in sleep quality is not a direct consequence of normal aging but a consequence of different aging-related factors or processes that lead to difficulty sleeping (4, 8). Currently, insomnia treatment procedures incorporate pharmacological and behavioral treatments (9), but each has a series of limitations that impair their impact. Although hypnotic medications can decrease sleep latency and increase total nighttime sleep (10, 11), significant concerns have been raised related to drug tolerance and dependence, as well as potential side effects such as acute memory disturbances, impaired balance and gait, and residual daytime sleepiness. Therefore, most patients prefer non-pharmacological strategies or treatments (12, 13), of which psychotherapy is one option to consider, but this requires a time contribution from health professionals (14).

Psychobehavioral therapies are also recognized as non-pharmacological treatments for sleep disorders (9). A universally known behavioral program is sleep hygiene education, characterized primarily by changing the environmental factors and everyday behaviors that negatively affect sleep deprivation (15). Within standard clinical treatments, cognitive behavioral therapy focuses on modulating sleep needs and modifying attitudes, expectations, and beliefs about sleep (16). These non-pharmacological treatments have several advantages over pharmacotherapy due to their effectiveness in improving both long- and short-term sleep while showing no serious contraindications (17). However, interventions like cognitive behavioral therapy are intensive, aimed at patients with sleep problems, and require the intervention of therapists with high levels of knowledge (18).

The limitations of recent treatments for sleep problems highlight the need for affordable treatments for sleep improvement among older adults with moderate sleep disorders (19). Of these treatments, mindfulness-based interventions (MBI) have the potential capacity to meet these needs as they are characterized as evidence-based programs for stress-related ailments (20) that train the person in the systematic practice of paying attention to experiences, emotions, and thoughts (21). Evidence from previous studies (22, 23) indicates preliminary but mixed support for the use of MBIs for sleep disorders in adults, and a systematic review of the effectiveness of MBIs for sleep problems highlighted a range of gaps in the existing research (24). Sleep has been mainly evaluated as a secondary outcome of a primary pathological state that can disrupt sleep (25, 26), so the findings may be confused due to changes in the primary ailment. Overall, the existing MBI studies need to be updated to determine the optimal intervention protocols in non-institutionalized older people.

Therefore, the objective of this systematic review and meta-analysis was to analyze the effectiveness of a mindfulness-based program on sleep quality in healthy non-institutionalized older people.

Abbreviations: PRISMA, Preferred Reporting Items For Systematic Reviews And Meta-Analyses; PEDro, Physiotherapy Evidence Database; MBI, Mindfulness-based interventions; RCTs, Randomized controlled clinical trials; SMD, Standardized Mean Difference; CI, Confidence Interval; RR, Risk Ratio; Q, Cochran's *Q*-Test; I^2, *I*-squared Statistic; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index; SOL, Sleep Onset Latency.

2 Materials and methods

A systematic review with meta-analysis was conducted to determine the effects of mindfulness-based cognitive therapy in older adults with sleep disorders. The review was conducted following the PRISMA (Preferred Reporting Items For Systematic Reviews And Meta-Analyses) 2020 guidelines and the Cochrane Handbook for the Elaboration of Systematic Reviews of Interventions, as proposed by Higgins et al. (27). The review protocol was pre-specified in PROSPERO and registered under the code CRD42023424438.

2.1 Sources of information

A bibliographic search was carried out using the Pubmed, Scopus, Web of Science, and CINAHL databases during May and June 2023.

2.2 Search strategy

("Mindfulness-based cognitive therapy" OR "MBCT" OR "mindfulness based therapy" OR "Mindfulness based intervention" OR "MINDFULNESS SLEEP THERAPY") AND ("Older adults" OR "ELDERLY" OR "Aged") AND ("sleep quality" OR "Sleep disorders" OR "SLEEP HYGIENE").

2.3 Inclusion criteria

Included articles had to meet the following criteria: (i) Randomized controlled clinical trials (RCTs) using objective measures to assess insomnia, sleep quality, or hypersomnia in older adults; (ii) Types of intervention: mindfulness-based cognitive therapy or mindfulness-based therapy as a treatment; (iii) Languages of the study: English or Spanish; (iv) Published from January 2010 to June 2023.

Additionally, the researchers imposed a rigorous time frame for the inclusion of publications. This time interval encompassed a 12-year period, ranging from January 2010 to June 2023.

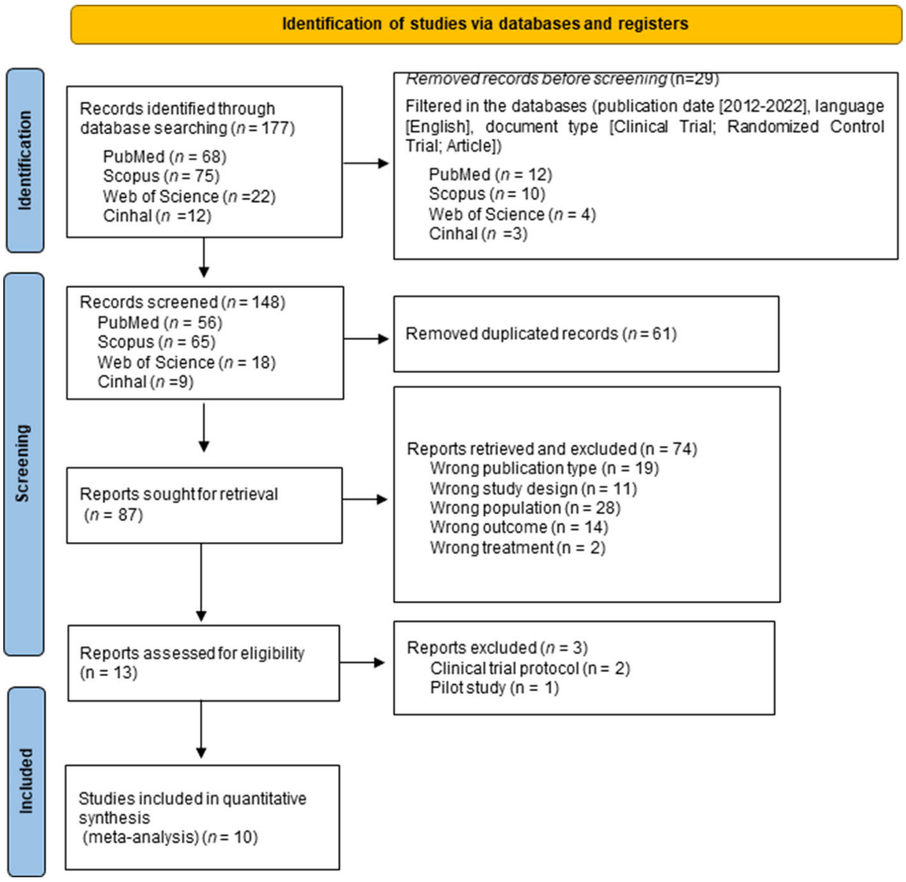

FIGURE 1
Flow diagram of the study selection process.

The rationale behind this choice was based on the belief that evaluating the effects of mindfulness application within their field of study required a substantial amount of time to gain wide recognition and adoption within the academic and scientific community. Establishing this 12-year window enabled them to comprehensively capture the most up-to-date literature related to their research topic while ensuring that the selected publications were aligned with the most recent developments in the field.

2.4 Exclusion criteria

They discarded studies that did not meet an acceptable level of internal validity (i.e., those with a score below six on the PEDro scale) and external validity. Additionally, publications such as books or articles, meta-analyses, reviews, systematic reviews, protocols, clinical trial registries, and articles that had not undergone peer review were excluded from consideration. Furthermore, studies that focused on ethnic minorities, individuals with limited mobility, acute infections, and hormonal disorders were also excluded. These exclusion criteria were implemented to ensure the integrity and validity of the information used in their work, with a priority placed on the inclusion of research supported by rigorous peer review and a solid scientific foundation.

2.5 Study selection process

The search results were processed using the Rayyan QCRI (https://rayyan.qcri.org/welcome) application. Duplications were eliminated. Two authors reviewed the titles and abstracts of the articles and excluded those that failed to meet the inclusion criteria. This task was performed blindly. Two authors independently and blindly verified compliance with the inclusion criteria and read the full articles. Differences arising during this process were resolved by reaching a consensus with a third author.

2.6 Data extraction

The main variables used in the review focus on the measurement of outcomes of sleep disorders. Each article was classified according to the type of disorder evaluated, year of publication, country, author/s, characteristics of the participants (age, inclusion and exclusion criteria, sample size, and group distribution), details of the intervention (duration, frequency), types of variables, tests used, and follow-up time.

2.7 Evaluation of methodological quality

The methodological quality of the selected articles was evaluated using the Physiotherapy Evidence Database (PEDro) scale, one of the most common scales for assessing this feature. This tool is specially designed to assess the methodological quality of randomized controlled trials; it consists of 11 items that address various aspects of the study methodology, such as random allocation, allocation concealment, blinding of participants and assessors, patient follow-up, among others. Each item is scored dichotomously (1 if the criterion is met, 0 if it is not), and the total score is used to determine the methodological quality of the study (28). Scores were sought on the PEDro website whenever they were available, the maximum being 10 points (29). When these were unavailable, two authors assessed the methodological quality of the articles, with a third author resolving any discrepancies that arose.

2.8 Analytical decisions for meta-analysis

Statistical estimators were employed to synthesize the findings, specifically the mean difference (SMD) and a 95% confidence interval (CI), or the risk ratio (RR) along with a 95% CI, as applicable. Heterogeneity was assessed through Cochran's *Q*-test, indicating significant heterogeneity when present, and the I^2 statistic, which quantified the proportion of total variability.

Subsequently, a subgroup analysis was conducted, taking into consideration the specific tool used to evaluate sleep conditions. This analysis aimed to explore whether variations in results were associated with these distinct assessment methods. Furthermore, to evaluate potential publication bias, a funnel plot was employed.

In the results analysis phase, a sensitivity analysis was undertaken to examine the impact of individual studies or key variables on the overall outcomes. This analysis was performed through subgroup analyses that considered the sleep condition assessment tool, investigating whether the results exhibited variations based on these specific criteria. Additionally, publication bias was assessed using a funnel plot.

The research employed Comprehensive Meta-Analysis (CMA) software version 3.0, developed by Biostat, Inc. in the United States. This software is widely acknowledged and utilized for conducting meta-analyses across various research disciplines.

3 Results

3.1 Selection of the studies

Complete searches were performed in the different databases, resulting in a total of 177 articles; the number was reduced to 148 when applying the automation filters. Subsequently, 61 duplicate articles were eliminated, leaving a total of 87 articles to be evaluated. Once the evaluation was completed, the articles were analyzed for eligibility, with only 10 articles (30–39) meeting the inclusion criteria (Figure 1).

3.2 Methodological quality

The PEDro scale was used to assess methodological quality. The scores for two studies (32, 33) were obtained from the PEDro website, while the others (30, 31, 34–39) were evaluated manually. Of all the articles included, seven were classified as having "good" (30, 32–35, 37, 39) methodological quality, while three obtained an "excellent" (31, 36, 38) classification.

3.3 Characteristics of the studies

The articles selected in this systematic review corresponded to randomized controlled clinical trials published in English (30–39) from 2012 to 2022, as well as in 2012 (33), 2014 (38), 2015 (36, 37), 2017 (32), 2018 (35), and 2022 (30, 31, 34, 39). They originated from different countries: Spain (30), Singapore (31, 33), China (32, 34, 36, 39), and the USA (35, 37, 38). Four articles focused primarily on insomnia (30, 32, 33, 38) while the other six addressed overall sleep disorders (31, 34–37, 39). A total of 1,218 people participated in the selected studies, of which 605 belonged to experimental groups. The sample sizes used in the 10 articles included in this systematic review ranged from 47 (30) to 209 individuals (34).

In terms of duration, the mindfulness-based cognitive therapy interventions generally lasted 8 weeks (30–36, 39). Two investigations were extended with follow-up to 2 months (32, 35), one was extended to 4 months (34), and the longest had a follow-up at 16 months (38). Table 1 contains the full details of the articles selected in this review.

3.4 Study results

All ten articles (30–39) evaluating the effects of mindfulness-based cognitive therapy on older adults with sleep disorders) obtained statistically significant results after the intervention. This was evidenced by changes in the Insomnia Severity Index (ISI), Pittsburgh Sleep Quality Index (PSQI), and SOL (Sleep Onset Latency), evaluated by polysomnography (PSG).

After 8 weeks of treatment, Camino et al. (30) achieved a significant decrease in ISI values [$F_{(10.41)}$; $p = 0.002$] in older adults with insomnia. With the same intervention time, Perini et al. (33) found that the time interaction × group [$F_{(125.1)} = 6.89$, $p = 0.010$] showed a significantly greater reduction in insomnia severity than the control group; while Wong et al. (32) demonstrated significant changes in ISI, $p = 0.023$, but with a small effect size (−0.360

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TABLE 1 **Characteristics of the included studies.**

Country	References	Population	Sample CG/IG	Control group	Intervention group				Results	Values post treatment
					Age	Intervention type	Measuring instrument	Assessments		
Spain	Camino et al. (30)	Older adults with subclinical and moderate insomnia	CG = 24 EG = 23	Eight-week film-forum activity (coinciding with the intervention weeks) on active aging. After the activity ended, participants were also invited to a group session to conduct the post-intervention assessment.	72.9 (6.6)	Treatment that combines mindfulness and cognitive therapy is effective for treating insomnia in older adults.	Pittsburgh Sleep Quality Index	T0 = Baseline T1 = 8 weeks	Results were obtained on both scales, with a reduction in insomnia symptoms in the subclinical and moderate intervention groups. The intervention group obtained significantly decreasing effects on subjective sleep quality, $F_{(1,\,45)} = 15.25$, $p = 0.027$, $\eta^2 = 0.105$. The control group showed no significant effects on subjective sleep quality, $F_{(1,\,45)} = 0.66$, $p = 0.419$, $\eta^2 = 0.015$	$p < 0.001$
							Insomnia Severity Index (ISI)		ISI: simple effects tests showed a significantly decreasing effect in the intervention group, $F_{(1,\,45)} = 10.41$, $p = 0.002$, $\eta^2 = 0.188$, whereas the effect was not significant in the control group, $F_{(1,\,45)} = 0.95$, $p = 0.334$, $\eta^2 = 0.021$.	$p = 0.01$

(Continued)

TABLE 1 (Continued)

Country	References	Population	Sample CG/IG	Control group	Intervention group				Results	Values post treatment
					Age	Intervention type	Measuring instrument	Assessments		
Singapore	Shaif et al. (31)	Older adults with sleep disorders	CG = 55 EG = 58	Eight weekly sessions of 2 h. Each session introduced a concept related to sleep and sleep hygiene. Participants received a manual describing the concept and how they intended to apply it in their daily lives.		Eight 2-h sessions covering various mindfulness techniques (e.g., mindfulness of breathing, body and movement, senses and informal practice, and empathy and compassion) pertaining to people with sleep problems and insomnia. Participants received brochures with the information covered during the talks and discussions.	Sleep discrepancies at sleep onset latency (SOL) and awakening after sleep onset (WASO). The SOL discrepancy was measured by polysomnography/ ISI.	T0 = Baseline T1 = 8 weeks	The sleep onset latency discrepancy, measured by polysomnography and actigraphy, decreased significantly after MBTI and SHEEP interventions. In contrast, no significant changes in wakefulness occurred after the discrepancy in sleep onset in either group.	SOL Dif = 18.24 p = 0.036/ISI Mean difference: 5.02 t-value: 8.499 $p < 0.001$ Cohen's $d = 1.135$
China	Wong et al. (32)	Older adults with insomnia	CG = 95 EG = 101	Eight weeks of sleep psycho-education with exercise control (PEEC)	58 (9.1)	Eight weeks of mindfulness-based cognitive therapy for insomnia (MBCT-I)	Insomnia Severity Index (ISI), Insomnia Severity Index; FFMQ, the Five Facet Mindfulness Questionnaire; SOL, sleep onset latency; WASO, wake time after sleep onset; TST, total sleep time	T0 = baseline T1 = 2 months (post-intervention) T2 = 5 months (3-month follow-up), and T3 = 8 months (6-month follow-up)	The ISI score significantly decreased in the MBCT-I group compared to the PEEC group at 2 months (i.e., post-intervention) (p = 0.023, effect size [95% CI] −0.360 [−0.675, −0.046]) but not at 5 or 8 months.	ISI t0 = 18.2 (3.8) t1=-4.0 (3.7) t3= −5.2 (4.1)

(Continued)

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TABLE 1 (Continued)

Country	References	Population	Sample CG/IG	Control group	Intervention group				Results	Values post treatment
					Age	Intervention type	Measuring instrument	Assessments		
Singapore	Perini et al. (33)	Older adults with insomnia	CG = 62 EG = 65	Sleep hygiene, education, and exercise (SHEEP) program on sleep biology and self-monitoring sleep behavior showed changes in habits and environment that could improve sleep quality.	60.9 (6.4)	Eight weekly sessions of 2 h each of MBTI mindfulness-based therapy for insomnia.	Insomnia Severity Index (ISI)	T0 = Baseline T1 = 4 weeks T2 = 8 weeks	Significant interaction of time × group [$F_{(125.1)} = 6.89$, $p = 0.010$], with MBTI showing a significantly greater reduction in insomnia severity than SHEEP. Estimation analysis confirmed that both groups improved from baseline [MBTI: $d = -1.27$, 95% confidence interval (CI) −1.61 to −0.89; SHEEP: $d = -0.69$, 95% CI −0.96 to −0.43].	IG T0 = 14.89 (3.89) T2 = 9.95 (3.88) CG T0 = 14.21 (4.13) T2 = 11.23 (4.54) $p = 0.34$
							Pittsburgh Sleep Quality Index (PSQI)	T0 = Baseline T1 = 4 weeks T2 = 8 weeks	Both groups reported better sleep quality scores over time without significant time interactions × group on the PSQI.	T0 = 10.98 (3.10) T1 = 9.14 (2.74) T2 = 7.34 (3.01)
China	Lee et al. (34)	Older adults	CG = 104 EG = 105	Control group (received the mindfulness program 8 weeks later; i.e., immediately after participants in the intervention group received the mindfulness program).	CG = 71.8 (8.2) EG = 71.3 (7.0)	Eight-week modified mindfulness-based stress reduction (mMBSR). Participants were asked to do mindful home practices six times per week.	Pittsburgh Sleep Quality Index (PSQI)	T0 = Baseline T1 = 5 months T2 = 4 months	There was a change in the PSQI at 2 months: 8.3–6.7, $p <$ 0.001. The change was maintained at 4 months.	EG) T0 = 8.3 (4.9) T1 = 6.7 (4.5) <0.001 T2 = 6.6 (4.9) $p <$ 0.001 CG T0 = 6.5 (4.3) T1 = 5.5 (4.2) $p = 0.002$

(Continued)

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TABLE 1 (Continued)

Country	References	Population	Sample CG/IG	Control group	Intervention group				Results	Values post treatment
					Age	Intervention type	Measuring instrument	Assessments		
USA	Gallegos et al. (35)	Older adults with sleep disorders	CG = 100 EG = 100	Wait-list control group (WLC)	CG = 73 (6.59) EG = 72 (6.82)	Eight-week mindfulness-based stress reduction (MBSR) program	Pittsburgh Sleep Quality Index (PSQI)	T0 = Baseline T1 = 8 weeks T2 = 2 months	A significant medium-sized effect was found for MBSR participants with baseline PSQI scores $\geq$ 10, $F_{(2, 28)} = 3.13$, $p = 0.04$. These findings indicated that better sleep quality for older adults with higher levels of sleep disorders may be associated with participation in MBSR.	EG T0 = 6.22 (3.73) T1 = 5.23 (3.36) T2 = 5.44 (3.32) CG T0 = 5.29 (3.58) T1 = 5.19 (3.66) T2 = 5.10 (3.60) $F = 3.68$, $p = 0.03$. Effect size = 0.02
China	Zhang et al. (36)	Older adults with sleep disorders	CG = 30 EG = 30	Wait-list control group (WLC)	CG = 77.63 (3.01) EG = 78.57 (2.94)	Eight-week MBSR group with 2-h classes and a 0.5-day retreat	Pittsburgh Sleep Quality Index (PSQI)	T0 = Baseline T1 = 8 weeks	MBSR group showed a decrease in the overall PSQI score (Cohen's $D = 1.12$), while the control group did not (Cohen's $D = -0.06$). This showed that the MBSR program could be a beneficial treatment for chronic insomnia in adults over 75.	EG T0 = 11.50 (3.28) T1 = 8.17 (2.61) Cohens's $d = 1.12$ CG T0 = 1.27 (3.62) T1 = 11.47 (3.58) COHENSD = −0.06. $F = 8.121$ $p = 0.006$

(Continued)

TABLE 1 (Continued)

Country	References	Population	Sample CG/IG	Control group	Intervention group				Results	Values post treatment
					Age	Intervention type	Measuring instrument	Assessments		
USA	Black et al. (37)	Older adults with sleep disorders	CG = 24 EG = 25	Sleep hygiene education (SHE) intervention of 6 weeks (2 h per week)	66.3 (3)	Standardized mindfulness practices intervention of 6 weeks (2 h per week)	Pittsburgh Sleep Quality Index (PSQI)	T0 = Baseline T1 = 6 weeks	The MAP group showed significant improvement compared to the EHS group in terms of the secondary health outcomes of insomnia symptoms, depression symptoms, fatigue interference, and fatigue severity ($p < 0.05$ for all).	MAP, media T0 = 10.2 (1.7) T1 =7.4 (1.9) With SHE intervention, T0 = 10.2 (1.8), T1 = 9.1 (2.0). Mean difference between the groups of 1.8 (IC 95 %, 0.6–2.9) with an effect size of 0.89.
USA	Irwin et al. (38)	Older adults with chronic and primary insomnia	CG = 48 TCC/25SS EG = 50	Tai chi or sleep seminar education control (SS) for 2-h group sessions weekly over 4 months with follow-up at seven and 16 months.	66.3 (7.4)	CBT, traditional therapies, or SS for 2-h group sessions weekly over 4 months with follow-up at seven and 16 months.	Insomnia diagnosis according to DSM-IV-TR criteria using a structured interview and checklist, performed by the study psychiatrist (MRI)/Pittsburgh Sleep Quality Index (PSQI)/Athens Insomnia Scale, AIS	T0 = baseline T1 = 2 months T2 = 3 months T3 = 4 months T4 = 7 months T5 =16 months	CBT performed better than traditional therapies and SS in terms of the remission of clinical insomnia as determined by a physician ($P < 0.01$). CBT also showed greater and more sustained improvement in sleep quality and sleep parameters than TCC and SS (all $P < 0.01$).	CBT resulted in a nearly two-fold greater rate of remission than TCC and SS ($\chi^2 = 9.34$, $P < 0.01$) T0 = 10.4 (2.9) T1 = 7.1 (2.8) T2 = 6.6 (2.8) T3= 6.4 (2.6) T4 = 5.5 (2.5) T5 = 5.6 (3.0). CBT resulted in greater improvements in global sleep quality than TCC (t531.3 = 2.64; $P < 0.01$; estimated $d = 0.27$) and SS (t522.7 = 2.70; $P < 0.01$; estimated $d = 0.44$) from baseline to 16 months

(Continued)

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TABLE 1 (Continued)

Country	References	Population	Sample CG/IG	Control group	Intervention group				Results	Values post treatment
					Age	Intervention type	Measuring instrument	Assessments		
China	Wong et al. (39)	Older adults with sleep disorders	CG = 46 EG = 48	Sleep hygiene education and exercise program (SHEEP)	72 (5.3)	Mindfulness-based therapy for insomnia (MBT) I8 weekly 2-h group sessions, plus daily practice.	Macroarchitecture (N2, N3, and REM), and microarchitecture (sleep fragmentation, slow wave activity, spectral band power) measured by ambulatory polysomnography (PSG).	T0 = Baseline T1 = 8 weeks	The MBTI (Myers-Briggs Type Indicator) test and sleep hygiene education had different effects on sleep macro- and microarchitecture, suggesting that the underlying mechanisms of mindfulness training to improve sleep quality may differ from traditional interventions. In short, the way mindfulness affects sleep quality may be different from other traditional techniques used to improve sleep.	SOL 2.05 $P < 0.001$ SOL pre 22.46 (17.63) post 20.40 (20.52)

IG, Intervention group; CG, Control group; T, Type; D, Duration; F, Frequency; SD; Standard deviation; CBCT, Computer-based cognitive training; TCT, Traditional cognitive training; CT, Cognitive training; CSDD, Cornell Scale for Depression in Dementia; GDS, Geriatric Depression Scale; CDR, Clinical dementia rating; IADL, Instrumental Activity of Daily Living; ICS, individual cognitive stimulation; MMSE, Mini-mental state examination; MoCA, Montreal Cognitive Assessment; TAU, Treatment-as-usual group; CST, Cognitive stimulation therapy; BDI, Beck Depression Inventory; NE, Neuroeducation; MADRS, Montgomery-Åsberg Depression Rating Scale; CBT, Cognitive behavioral therapy.

Study name	Subgroup within study	Statistics for each study						
		Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Camino, M	ISI	-0,505	0,215	0,046	-0,926	-0,084	-2,353	0,019
Shaif et al	SOL Y	-0,288	0,132	0,018	-0,548	-0,029	-2,180	0,029
Wong et al	ISI	-0,228	0,100	0,010	-0,424	-0,032	-2,279	0,023
Perini et al	ISI	-0,423	0,128	0,016	-0,674	-0,172	-3,301	0,001
Lee et al	PSQI	-0,328	0,099	0,010	-0,523	-0,133	-3,298	0,001
Gallegos et	PSQI	-0,207	0,100	0,010	-0,403	-0,010	-2,059	0,039
Zhang et al	PSQI	-0,527	0,190	0,036	-0,900	-0,154	-2,769	0,006
Black et al	PSQI	-0,483	0,205	0,042	-0,885	-0,080	-2,350	0,019
Irwin et al	PSQI	-0,487	0,148	0,022	-0,777	-0,198	-3,304	0,001
Wong et al	SOL Y	-0,498	0,151	0,023	-0,794	-0,203	-3,304	0,001
		-0,344	0,041	0,002	-0,425	-0,263	-8,293	0,000

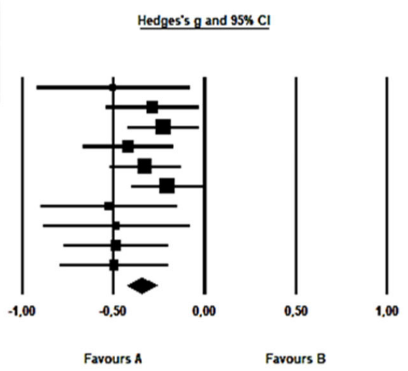

FIGURE 2
Forest plot effect of mindfulness-based cognitive therapy on older adults with sleep disorders. The black box represents the point estimate for each respective study, while the box size represents the population size and the horizontal line is the 95% CI. The diamond-shaped figure represents the estimated point of the mean difference.

Group by Subgroup	Study name	Subgroup within study	Statistics for each study						
			Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
ISI	Camino, M	ISI	-0,505	0,215	0,046	-0,926	-0,084	-2,353	0,019
ISI	Wong et al	ISI	-0,228	0,100	0,010	-0,424	-0,032	-2,279	0,023
ISI	Perini et al	ISI	-0,423	0,128	0,016	-0,674	-0,172	-3,301	0,001
ISI			-0,326	0,074	0,005	-0,471	-0,181	-4,405	0,000
PSQI	Lee et al	PSQI	-0,328	0,099	0,010	-0,523	-0,133	-3,298	0,001
PSQI	Gallegos et	PSQI	-0,207	0,100	0,010	-0,403	-0,010	-2,059	0,039
PSQI	Zhang et al	PSQI	-0,527	0,190	0,036	-0,900	-0,154	-2,769	0,006
PSQI	Black et al	PSQI	-0,483	0,205	0,042	-0,885	-0,080	-2,350	0,019
PSQI	Irwin et al	PSQI	-0,487	0,148	0,022	-0,777	-0,198	-3,304	0,001
PSQI			-0,343	0,058	0,003	-0,456	-0,229	-5,915	0,000
SOL Y	Shaif et al	SOL Y	-0,288	0,132	0,018	-0,548	-0,029	-2,180	0,029
SOL Y	Wong et al	SOL Y	-0,498	0,151	0,023	-0,794	-0,203	-3,304	0,001
SOL Y			-0,380	0,099	0,010	-0,575	-0,185	-3,817	0,000
Overall			-0,344	0,041	0,002	-0,425	-0,263	-8,293	0,000

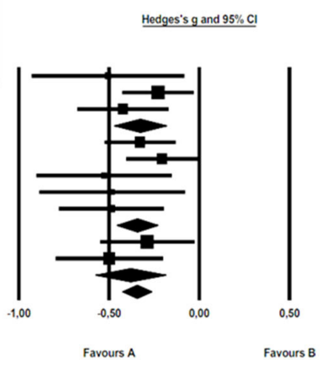

FIGURE 3
Subgroup analysis to assess the effect of MBCT on the Insomnia Severity Index (ISI), Pittsburgh Sleep Quality Index (PSQI), and SOL (Sleep Onset Latency).

CI 95: −0.675, −0.046). On the other hand, Shaif et al. (31) highlighted that the discrepancy in sleep onset latency, measured by polysomnography and actigraphy, decreased significantly (SOL Dif = 18.24 $p = 0.036$). Similarly, Wong et al. (39) reported SOL differences: pre 22.46 (17.63) and post 20.40 (20.52) $p < 0.001$ (10).

At 8 weeks post-intervention, Zhang et al. (36) identified a decrease in the global score of the PSQI (Cohen's D = 1.12). Gallegos et al. (35) found a significant medium-sized effect for a change in PSQI, $F = 3.13$, $p = 0.04$; while in the research developed by Lee et al. (34), changes were evidenced (PSQI: 8.3–6.7, $p < 0.001$) that were maintained at 2 months and 4 months post-intervention. Irwin et al. (38) employed a 4-month intervention that showed changes in PSQI values ($\chi^2 = 9.34$, dif means 2.64; $P < 0.01$; estimated $d = 0.27$), while Black et al. (37) demonstrated mean between-group differences for the same variable (1.8 95% CI, 0.6–2.9), with an effect size of 0.89 after only 6 weeks of treatment (Table 1).

3.5 Meta-analysis

All 10 articles could be integrated into the meta-analysis to synthesize the findings. The heterogeneity analysis showed that the value of Q was 7.740 with nine degrees of freedom. The I-squared statistic, which quantifies the percentage of variability in observed effects attributed to real effects rather than sampling error, was set at 0%. Furthermore, we calculated Tau-squared and Tau, which provided insights into the variance and standard deviation of true effect sizes in d units, respectively. Both Tau-squared and Tau were computed as 0.000, suggesting that all studies shared a common effect size without any dispersion of true effects. Lastly, with regard to the prediction interval, it was not reported because our analysis estimated Tau-squared as zero, reinforcing the notion that all studies exhibited consistent effect sizes without any variability in true effects. This comprehensive analysis, incorporating these statistical measures, provides valuable insights into the results and the homogeneity observed in effects among the selected studies. Since the heterogeneity

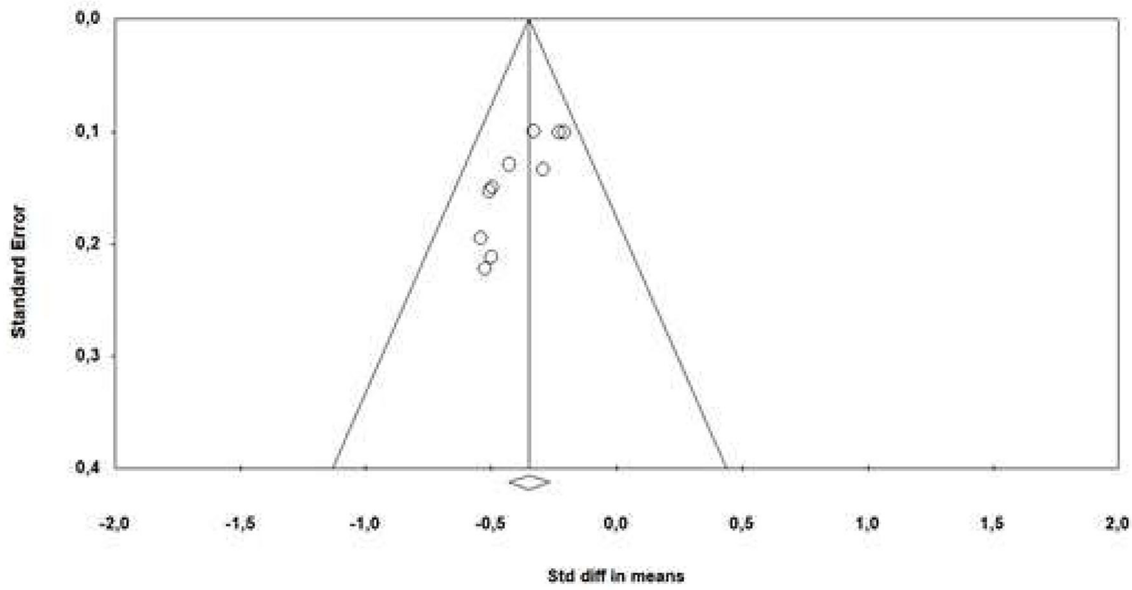

FIGURE 4
Funnel plot of standard error by standard differences in medias.

indexes I-squared, tau-squared, and tau are minimal, the fixed-effect model was used for the analysis. The effect size index used was the standardized difference between the means (g), −0.344, with a 95% confidence interval of −0.425 to −0.263 (Figure 2).

3.6 Subgroup analysis

Subgroup analysis was conducted using the three sleep-disturbance measurement tools, the outcomes revealed notable statistical significance, underpinned by moderate and inversely negative Hedge's g effect sizes; Specifically, the results indicated an effect size of −0.326 for the ISI, −0.343 for the PSQI, and −0.28 for the SOL, showcasing the substantial impact of these respective measurement tools on the observed outcomes. Subgroup analyses based on the assessment tool demonstrated consistent effect sizes in all cases. This consistency in our results suggests that the choice of the assessment tool had a minimal impact on the observed treatment effects.

Independent *Q*-tests were conducted for each of the subgroups. In the ISI Subgroup, no evidence of significant heterogeneity was found, as the *Q*-value was 5.2 with 3 degrees of freedom (df) and a *p*-value of 0.16. Similarly, in the PSQI Subgroup, the *Q*-value was 4.5 with 2 df and a *p*-value of 0.11, also indicating the absence of significant heterogeneity. In contrast, the SOL Subgroup exhibited significant heterogeneity, with a *Q*-value of 10.8 and 4 df, along with a *p*-value of 0.03. These results suggest that the variability in treatment effects is more pronounced in the group of patients assessed with the SOL instrument compared to the other two groups, where heterogeneity is insignificant (Figure 3).

3.7 Publication bias

The publication bias analysis was performed using a funnel plot (Figure 4) that included all the articles in the meta-analysis. An expected publication bias was revealed as various articles showed different mean difference results. However, when a subgroup analysis was performed based on the assessment instrument used, heterogeneity was observed to decreased, thus producing a more symmetrical distribution of results.

3.8 Quality of evidence

For each review outcome, quality of evidence was assessed (Table 2) using the Grading of Recommendations Assessment Development and Evaluation (GRADE) framework (40–42). An a priori ranking of "high" was assigned given that all studies included were randomized controlled trials. Evidence quality was downgraded a level if one single study presented a high risk-of-bias (failure to achieve "low risk" in two or more criteria included in the risk-of-bias assessment presented in Table 3, or the majority of studies suffered from the same risk of bias. Evidence quality was also downgraded if inconsistent findings imprecision, indirectness, and publication bias were reported. The quality of evidence was rated as high, moderate, low or very low.

4 Discussion

This systematic review and meta-analysis aimed to analyze the effectiveness of a mindfulness-based program on sleep quality in healthy non-institutionalized older people. The review included a total of 10 articles that met the eligibility criteria and utilized

TABLE 2 Quality of evidence.

Outcomes	Number of participants (studies)	Quality of evidence (GRADE)
Insomnia severity	221 (3 studies)	⊕⊕⊕◯ Moderate[b]
Sleep quality	790 (5 studies)	⊕⊕⊕⊕ High
Sleep onset latency	207 (2 studies)	⊕⊕⊕◯ Moderate[a,c]

[a]High risk of bias, downgraded with one level.
[b]Inconsistent findings, downgraded with one level.
[c]Imprecision due to the small number of participants, downgraded with one level.

mindfulness as the main treatment for improving sleep quality (30–39). The results indicated that a mindfulness program improved sleep quality in older adults with sleep disorders.

Poor sleep quality is a common problem associated with several adverse effects on the physical, mental, and social wellbeing of older adults (43). Moreover, sleep problems have been shown to increase considerably with aging (41). In this systematic review, although most studies used the Pittsburgh Sleep Quality Index as the instrument for assessing sleep quality (30, 33–38), others used the Insomnia Severity Index (30–33), and two used polysomnography (31, 39). Therefore, a meta-analysis could be performed in which a subgroup analysis was performed. This analysis was carried out using the three tools for measuring sleep disturbances presented in the selected articles and the findings showed notable statistical significance supported by moderate and inversely negative Hedge's g effect sizes, being consistent in all cases.

Various pharmacological interventions have been undertaken to improve sleep problems; however, in addition to the well-known risks of sleep medications, no lasting improvements in sleep outcomes have been demonstrated after discontinuation (8). The results of this review suggest that non-pharmacological intervention approaches to address sleep quality problems are more effective, safer, and preferable compared to sleep medications. Some therapies, such as cognitive behavioral therapy, are not widely available since they must be administered by a trained and licensed specialist (3). In addition, healthcare providers have no established practice guidelines or standards for the combined use of individual therapies, so they may opt for sleep medications (44). Another non-pharmacological strategy carried out in all the studies selected for this systematic review and meta-analysis to address sleep quality problems was the mindfulness-based intervention, which has demonstrated beneficial effects in older adults (45, 46). First used as an intervention approach for treating chronic stress, anxiety, depression, and even pain, mindfulness has also proven effective in preventing falls (47), reducing systemic inflammation (48), and reversing metabolic disease (49) in older people. A qualitative study (50) found that older adults lose work-related activity and stress after retirement, so mindfulness can become an opportunity to increase physical activity, decrease inflammatory factors, reduce anxiety, and, therefore, improve sleep quality. A previous meta-analysis has also shown that in cancer patients, although mindfulness had a lesser effect than aerobic exercise, both interventions significantly improved sleep problems (51). Similarly, the current study adds to the highly comprehensive evidence indicating the effect of MBI on sleep quality.

Likewise, the analysis showed that mindfulness for 16 months (38) or, alternatively, 2 months (32, 35) of intervention, had similar effects on sleep that were maintained even at 2 and 4 months after the intervention (34). Thus, its effectiveness was not only short-term but also long-term. It must also be highlighted that three of the articles selected (31, 36, 38) for this review had excellent quality and the remaining seven (30, 32–35, 37, 39) were rated as good, so the relatively high quality of the included RCTs makes our conclusions comparatively reliable. Together with the high rate of adherence in the participation of these studies, it can be argued that the treatment and evaluation protocol is feasible in this population. Similarly, these types of interventions provide feedback to patients, motivating them to fully accept their new experiences. Therefore, these interventions must be incorporated due to the better quality of life and acceptance they bring to people at an age when a series of changes occur that negatively affect their health. However, therapists have yet to incorporate these approaches consistently into their recommendations, despite the evidence of their effectiveness and safety.

Meanwhile, several sleep improvement interventions focused on physical exercise therapy have been carried out but with mixed results. Some researchers have suggested that mild to moderate exercise may improve self-perceived sleep quality and alleviate symptoms of sleep deprivation in older people after an intervention (52–56). In addition, the main advantages of exercise programs include their low cost, accessibility, and lack of adverse effects (57). However, only limited evidence is available of the lasting benefits of exercise for improving long-term sleep problems (3, 58, 59). Similarly, light exposure therapy has been conducted for sleep improvement, but this has produced insufficient evidence of consistent improvements in long-term sleep quality, even compared to a control group that followed no treatment (3, 59). Conversely, mindfulness interventions, computer-based cognitive training, or other multidimensional approaches that integrate certain underlying causes of poor sleep quality, primarily chronic stress have shown promise for improving sleep later in life (8, 44, 58). In addition, these approaches avoid potential adverse effects and safety issues, do not need to be delivered by highly trained professionals with specific certifications, and are more accessible. Some even use low-cost online sessions as a delivery method (37, 60). Mindfulness has also produced results in a shorter period and it can be practiced anytime and anywhere (61). Therefore, for several reasons, multidimensional non-pharmacological intervention approaches have several distinct advantages that could make them ideal for older adults experiencing poor sleep quality.

The current study has certain limitations. First, four databases were used to search for studies published in English, which may limit the generalizability of the results to some extent. Ongoing database updates and replenishment will be considered in the future. Second, only a limited number of studies and a relatively small overall sample size provided the physiological measures of sleep duration. Although significant effects on subjective sleep outcomes were observed, no improved sleep quality could be detected through physiological parameters. More research on subjective and physiological sleep is needed in future studies.

TABLE 3 Methodological quality of the articles included.

References	1	2	3	4	5	6	7	8	9	10	11	Total
Camino et al. (30)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Shaif et al. (31)	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	9
Wong et al. (32)	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	6
Perini et al. (33)	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Lee et al. (34)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Gallegos et al. (35)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Zhang et al. (36)	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	9
Black et al. (37)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Irwin et al. (38)	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	9
Wong et al. (39)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7

Items: 1 = eligibility criteria; 2 = random allocation; 3 = concealed allocation; 4 = baseline comparability; 5 = blind subjects; 6 = blind therapists; 7 = blind assessors; 8 = adequate follow-up; 9 = intention-to-treat analysis; 10 = between-group comparisons; 11 = point estimates and variability. Y, Yes; N, No.

Third, most studies were conducted in Asia and the Americas, so a geographic bias is identifiable, making it impossible to generalize the results to populations in other regions. Finally, gender differences were not considered in the meta-analysis of this review because the selected studies only included older adult participants with no gender distinctions.

5 Conclusion

Following this systematic review with meta-analysis of published data to assess the effects of mindfulness on sleep quality in older people, it is suggested that mindfulness could be introduced to remedy poor sleep quality in older people in both the short and long term. Therefore, it could be a viable treatment option for insomnia or other problems related to poor sleep quality in this population. In addition, the available evidence regarding this therapy remains limited and the methodological quality of the evidence must be more rigorous. Considering that mindfulness programs can be easily offered in many communities, outreach efforts would not be a barrier in this case. Therefore, older adults would generally have immediate access to these programs, which are offered at low cost. It must be emphasized that further research with more structured quality randomized controlled trials, as well as standardized and comparable protocols, is needed to determine the relative position of meditation-based therapies among treatment options. More studies are also needed to determine whether mindfulness is a better, worse, or equivalent strategy to other types of meditation training.

Author contributions

AG-M and AM-G: conceptualization. AA-A and YC-C: methodology. YR-C: formal analysis. AA-A and AM-G: writing—original draft preparation. AG-M and YC-C: writing—review and editing. YR-C and AA-A: supervision. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Is sleep quality a moderated mediator between perceived stress and depression among stroke patients?

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Background: Sleep quality can offer new insights into addressing depression among stroke patients. However, the current understanding of the mechanism by which sleep quality reduces depression is not clear in existing research.

Objectives: This study aimed to identify the relationships and mechanisms among perceived stress, sleep quality, social support, and depression in stroke patients.

Methods: A multicenter cross-sectional study was conducted from January to May 2023. Cluster random sampling was used to recruit 500 stroke patients from five hospitals in Henan Province, China. The Chinese Perceived Stress Scale (CPSS), Pittsburgh Sleep Quality Index (PSQI), Social Support Rating Scale (SSRS), and Hamilton Depression Scale (HAMD-24) were employed to assess perceived stress, sleep quality, social support, and depression, respectively. Data were analyzed using descriptive analysis, *Pearson's* correlation analysis, and moderated mediation analysis. The study adhered to the STROBE checklist for reporting.

Results: Out of 500 participants, 471 completed the survey (94.2%). After controlling for sex and age, mediation analysis revealed that poor sleep quality partially mediated the relationship between perceived stress and depression (β = 0.184, 95% CI: 0.110, 0.359). Additionally, social support played a moderating role in the mediation model.

Conclusion: This study explained the moderated mediation of sleep quality and social support between perceived stress and depression. It provided a theoretical basis for the development of a sleep quality intervention program for reducing depression among stroke patients.

KEYWORDS

stroke, sleep quality, perceived stress, depression, social support, mediating effect, moderating effect

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Introduction

Stroke is the second-leading cause of death worldwide, with its prevalence, morbidity, and overall impact steadily increasing each year (1). The estimated worldwide prevalence of stroke is 1,240 per 100,000 individuals (2). According to the Global Burden of Disease study (GBD), there were 101 million reported cases of stroke worldwide in 2019 (3, 4). Furthermore, stroke accounted for 143 million disability-adjusted life years (DALYs), constituting 5.7% of the total burden of diseases (5, 6). The incidence of stroke cases in China has consistently risen over time (7). Numerous studies have indicated that over 70% of individuals who have experienced a stroke continue to manifest significant levels of impairment or disability. This results in limited self-care function and increased susceptibility to acute disorders, followed by a range of psychological problems. Among these, perceived stress and depression are the most prevalent.

Perceived stress refers to the extent of stress an individual experiences from an external event that surpasses self-absorption (8). Population-based epidemiological studies have indicated that stroke patients are prone to experiencing perceived stress, and it may serve as a reliable predictor of depressive symptoms (9–12). Depression is a common complication following a stroke attack (13). Post-stroke depression (PSD) refers to a syndrome that emerges after a stroke event, encompassing a range of depressive symptoms and associated somatic manifestations (14). Approximately one-third of stroke patients develop depression at varying intervals following an early stroke, with a cumulative incidence ranging from 39 to 52% over 5 years. In the United States, 20–65% of stroke patients experience depression (15). Depression significantly impairs their ability to perform daily activities and exacerbates cognitive dysfunction in stroke patients (16, 17). The mortality rate among stroke patients with depression is 3.4 times higher than that of those without depression, a phenomenon known as the double burden of stroke (18).

It is noteworthy that sleep quality can play a pivotal role in reducing perceived stress, depression, and overall recovery following a stroke event (19, 20). Nevertheless, research indicates a high prevalence of poor sleep quality in stroke patients, reaching up to 30.1% (21). Furthermore, persistent poor sleep quality has detrimental effects on neurological function recovery, overall quality of life, and physical and mental wellbeing. Most concerning is its association with an increased risk of mortality and stroke recurrence. Empirical evidence has established poor sleep quality as a distinct risk factor for depression, with more than 90% of individuals with depression experiencing sleep problems (22). Individuals who achieve good sleep quality exhibit a 10–30% lower risk of cardiovascular disease than those with poor sleep quality (23). Results from a randomized controlled experiment indicated that intervening in sleep quality could reduce 87% of depressive symptoms (24). Despite this, there is a notable lack of emphasis on the importance of sleep quality among stroke patients.

Moreover, the provision of social support has been shown to positively impact perceived stress and depression. Social support, encompassing understanding, recognition, and assistance from familial, friendly, and other communal networks, plays a crucial role in individuals' wellbeing (25). There exists a significant positive relationship between perceived stress and depression, and effective social support has the potential to alleviate these conditions among stroke patients (26). Moreover, social support may contribute to the improvement of sleep quality by reducing perceived stress and, consequently, lowering the incidence of depression among stroke patients.

American psychologist Lazarus' stress and coping theory points out that stress is a product of the interaction between humans and the environment (27). When internal and external environmental stimuli exceed one's own coping ability and resources, stress will be generated. If the intensity of the stressors is high or persistent, and the stress cannot be successfully relieved, corresponding emotional or behavioral reactions will occur. The confirmed relationship between sleep quality and depression among students, with sleep quality acting as a mediator and social support as a moderator, has been documented (28). However, there is limited knowledge regarding these dynamics among stroke patients. The established theory not only provides a robust foundation for elucidating the antecedents of depression but also furnishes a comprehensive theoretical framework. The deleterious impact of stress on depression may be mediated and moderated through various mechanisms. One such avenue for explaining these mechanisms is the interplay between sleep quality and social support. Consequently, this study aimed to delve into these mechanisms based on the observed correlation, enlightening the relationships between sleep quality, social support, and depression.

Based on this theory, the following research hypotheses are proposed: Hypothesis 1, there is a relationship between perceived stress, sleep quality, depression, and social support. Hypothesis 2, sleep quality has a mediating effect between perceived stress and depression; Hypothesis 3, social support has a moderating effect between perceived stress, sleep quality, and depression. The theoretical framework is presented in Figure 1.

Therefore, the purpose of this study was to explore the moderated mediating mechanism of sleep quality and social support among stroke patients and to provide theoretical guidance for subsequent intervention studies. This will aid in understanding psychological phenomena related to sleep and guide healthcare professionals in improving sleep quality in post-stroke patients.

Methods

Participants and procedure

Patients were eligible for inclusion in the study if they met the following criteria: (1) had a physician-diagnosed stroke; (2) were at least 18 years old; (3) demonstrated effective communication skills; and (4) exhibited normal cognitive function, with a score of 24 or higher on the Mini-Mental State Examination (29). Individuals were excluded from the study if they: (1) had previously participated in other research studies; or (2) suffered from severe organ dysfunctions or physical illnesses not suitable for investigation.

A total of 500 participants were selected for this study from five tertiary grade A hospital in Henan Province, China. Following recommended guidelines for cross-sectional surveys, the sample size ideally should be 10–20 times the total number of variables, with a provision for a 20% allowance for invalid questionnaires. Given the inclusion of 24 independent variables in the study, the calculated sample size ranged from 300 to 600 participants. Ultimately, the survey was completed by 471 stroke survivors, resulting in an effective response rate of 94.2%.

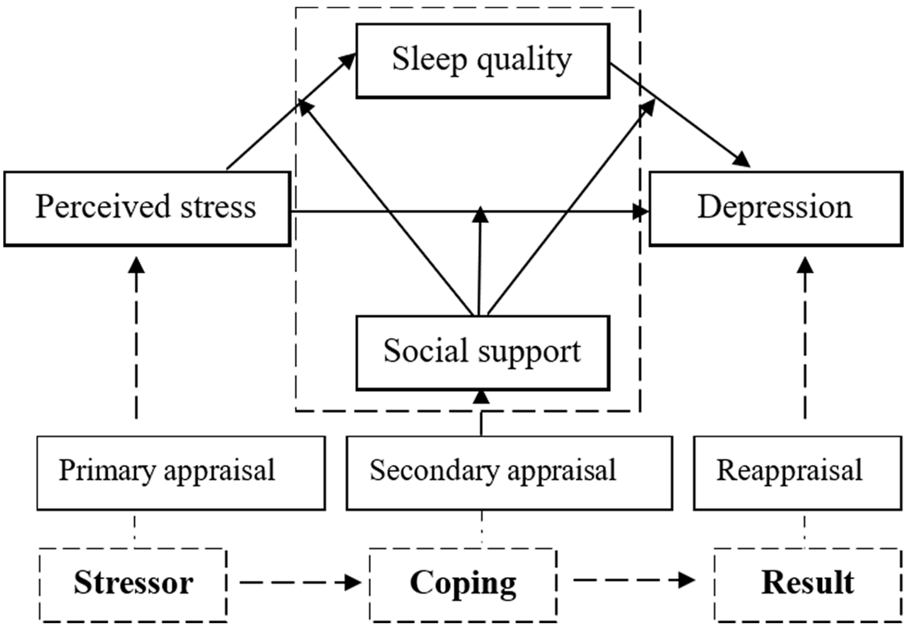

FIGURE 1
Hypothesis theoretical model of moderated mediation.

Moreover, it is crucial to emphasize that this study strictly adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement checklist. This checklist is designed to establish essential criteria that enhance the transparency and quality of reporting in observational studies, ensuring the completeness and reliability of the research findings.

Ethical considerations

Ethical approval for this study was obtained from the Ethics Committee of the First Affiliated Hospital of Zhengzhou University (2022-KY-1168-001). Prior to participation, each participant provided written informed consent, signifying their voluntary involvement and understanding of the study's procedures, potential risks, benefits, and the confidentiality of their data.

Data collection

The cluster-random sampling approach was utilized to collect data from January 2023 to May 2023. Henan Province was initially divided into five distinct regions: eastern, southern, western, northern, and central. Within each region, tertiary grade A hospitals were numbered. To ensure randomness, we employed an online random number generator[1] to select one hospital from each region for participation in the survey. Consequently, five tertiary grade A hospitals were recruited for the study.

Approval and consent were obtained from the respective hospital managers. To ensure standardized data collection procedures, nurses involved in the survey received comprehensive training. This training covered the use of each measurement scale and the application of consistent instructions and language during the investigations. Before conducting the survey, nurses provided detailed explanations to the patients, outlining the purpose, significance, and methodology of completing the questionnaire. Throughout the survey process, investigators promptly addressed any concerns or queries raised by the patients. In instances where questionnaires had missing or empty items, they were completed on the spot. For cases in which patients faced difficulty completing the questionnaire independently, whether due to factors such as educational level or visual impairment, the investigator filled in the questionnaire based on the patient's responses. After the survey, the collected questionnaires were carefully examined on-site to enhance data accuracy and completeness. This quality control process aimed to ensure the reliability of the collected information.

Measurements

The researchers designed a social-demographic information questionnaire, which included inquiries about age, sex, body mass index (BMI), education, work status, residence, residential status, medical insurance type, marital status, monthly income, number of children, and history of smoking and alcohol consumption. Disease-related characteristics, such as the history of stroke, TOAST classification, times of stroke attacks, thrombolysis status, duration after the first stroke, and the Charlson Comorbidity Index (CCI), were extracted from the medical records. Additionally, stroke severity information was obtained from the same records using two widely recognized assessment scales: The National Institute of Health Stroke Scale (NIHSS) and the modified Rankin Scale (mRS).

1 https://www.random-online.com/

The evaluation of perceived stress symptoms was conducted using the Chinese version of the Perceived Stress Scale (CPSS), originally developed by Cohen (30). This scale comprises 14 items organized into two dimensions: a sense of being out of control and a feeling of tension. All items were rated on a 5-point Likert scale ranging from 0 to 4, with a maximum score of 56. A higher score indicated a higher level of perceived stress (31).

Sleep quality over the last month was assessed using the widely employed Pittsburgh Sleep Quality Index (PSQI) (32), known for its good reliability and validity (33). The 18-item PSQI includes seven dimensions: sleep quality, sleep disturbance, habitual sleep efficiency, sleep latency, sleep disturbances, hypnotic medication use, and daytime dysfunction. Each item had a score range from 0 to 3, with a higher score indicating poorer sleep quality. Cronbach's alpha for reliability in this study was 0.863.

Social support was evaluated using the Social Support Rating Scale (SSRS), developed by Chinese researcher Xiao (34). This scale, comprising 10 items and three dimensions (subjective support, objective support, and utilization of social support), had a total possible score ranging from 12 to 66. A higher score indicated greater social support (35), with a threshold of 23 or less considered as low social support. Cronbach's alpha for reliability in this study was 0.819.

The severity of depressive symptoms was assessed using the 24-item Hamilton Depression Scale (HAMD-24) (36). The HAMD-24 comprises seven dimensions: anxiety/somatization, weight, cognitive disturbance, diurnal variation, retardation, sleep disturbance, and hopelessness. Most items use a 5-point scale ranging from 0 to 4, with a few items using a 3-point scale ranging from 0 to 2. The total score ranges from 0 to 76, with a higher score indicating more severe depression (37). Cronbach's alpha for reliability in this study was 0.823.

The statistical analysis was conducted using SPSS 21.0 (IBM Corporation, Armonk, NY, USA). Continuous variables were presented as means and standard deviations, while categorical variables were described with frequencies and percentages. The Pearson correlation coefficient was used to assess the relationships between stress, depression, sleep quality, and social support. Hierarchical regression analysis, specifically Model 59 of the SPSS-PROCESS procedure (38, 39) was employed to investigate mediation, moderation, and moderated mediation among stress, sleep quality, social support, and depression. Age and sex were considered as covariates, and the analysis used 5,000 bootstrap samples for replications. A significance level of $p < 0.05$ was applied to determine statistical significance.

Results

Descriptive characteristics

The age of the 471 stroke survivors in this study ranged from 23 to 88 years, with a mean age of 58.28 years (SD = 15.49). The BMI had a mean value of 24.56 (SD = 2.50). The mean scores for the SSRS, CPSS, and HAMD-24 were 39.11 (SD = 6.53), 24.46 (SD = 6.99), and 12.61 (SD = 3.41), respectively. Importantly, the mean value of the PSQI was 7.42 (SD = 4.22), indicating that 70.90% of the patients experienced sleep problems. Additional characteristics of the participants are presented in Table 1.

Correlation analysis

Pearson correlation analyses revealed that perceived stress was positively correlated with poor sleep quality ($r = 0.572$, $p < 0.01$) and depressive symptoms ($r = 0.648$, $p < 0.01$). Poor sleep quality also showed a positive association with depression ($r = 0.486$, $p < 0.01$). Conversely, social support exhibited a significantly negative correlation with perceived stress ($r = -0.421$, $p < 0.01$), poor sleep quality ($r = -0.328$, $p < 0.01$), and depression ($r = -0.354$, $p < 0.01$). To address the issue of multiple testing, *R* (version 4.2.0; 40) was used for false discovery rate (FDR) correction (Table 2).

Mediation analysis

As shown in Tables 3, 4, with sex and age as controlled variables, the results of the mediation analysis revealed that perceived stress positively and indirectly predicted depression through poor sleep quality ($\beta = 0.184$, $p < 0.001$). The 95% bias-corrected bootstrap confidence interval was 0.110–0.359, signifying that the indirect effect of perceived stress on depressive symptoms was statistically significant. Furthermore, the direct effect of perceived stress on depressive symptoms ($\beta = 0.338$, $p < 0.001$) was also significant, indicating that poor sleep quality partially mediated the relationship between perceived stress and depression.

Moderated mediation analysis

The moderating effect of social support indicated that the interaction between perceived stress and social support contributed to poor sleep quality ($\beta = -0.028$, 95% CI: −0.054, −0.003), and the interaction between poor sleep quality and social support contributed to depression ($\beta = 0.019$, 95% CI: 0.004, 0.034). However, the results of the moderated mediation analysis revealed that social support did not play a moderating role in the direct effect between perceived stress and depression ($\beta = -0.018$, 95% CI: −0.046, 0.011). Detailed information is given in Table 5, and the final moderated mediation model is displayed in Figure 2.

To further validate the moderating effect of social support, we categorized it into three groups: low (mean minus one SD), moderate (mean), and high (mean plus one SD). As presented in Table 6, poor sleep quality significantly mediated the association between perceived stress and depression at both moderate ($\beta = 0.217$, 95% CI: 0.032, 0.459) and high levels of social support ($\beta = 0.280$, 95% CI: 0.038, 0.788). Tables 5, 6, along with Figure 2, illustrate that at moderate and higher levels of social support, an increase in social support was associated with a weaker relationship between perceived stress and sleep, while the connection between poor sleep quality and depression became stronger.

Discussion

This study represents the first exploration of the relationship between perceived stress, sleep quality, social support, and depression using mediating and moderating effects analyses among stroke patients in a multicenter survey in China. The application of the

TABLE 1 Characteristics of the sample (n = 471).

Variables	*n* (%)	Variables	*n* (%)
Sex		Smoking	
Male	328 (69.6)	Non-smoker	254 (53.9)
Female	143 (30.4)	Current smoker	146 (31.0)
Education		Former smoker	71 (15.1)
Elementary school or below	193 (41.0)	Drinking	
Junior school	137 (29.1)	Non-drinker	275 (58.4)
High school	81 (17.2)	Current drinker	142 (30.1)
Undergraduate and above	60 (12.7)	Former drinker	54 (11.5)
Monthly income (RMB)		Employment status	
<3,000	265 (56.3)	Unemployed	148 (31.4)
3,000–5,000	140 (29.7)	Employed	227 (48.2)
>5,000	66 (14.0)	Retired	96 (20.4)
Spouse		Duration after first stroke	
Have	390 (82.8)	≤ 3 months	198 (42.0)
No	81 (17.2)	≤ 1 year	149 (31.6)
Residence		≤ 3 years	56 (11.9)
Rural	335 (71.1)	>3 years	68 (14.4)
Urban	136 (28.9)	mRs	
Residential status		≤2	286 (60.7)
Live alone	27 (5.7)	>2	185 (39.3)
Live with spouse	200 (42.5)	CCI	
Live with children	37 (7.9)	≤2	268 (56.9)
Live with spouse and children	207 (43.9)	>2	203 (43.1)
Health insurance type		Thrombolysis	
Urban residents basic health insurance	102 (21.7)	Yes	413 (87.7)
Rural residents basic health insurance	198 (42.0)	No	58 (12.3)
Employee basic health insurance	46 (9.8)	TOAST	
Retired cadres health insurance	73 (15.5)	Large-artery atherosclerosis	204 (43.3)
Commercial insurance	32 (6.8)	Cardioembolism	38 (8.1)
Other	20 (4.2)	Small-artery occlusion	108 (22.9)
Number of children		Other/unknown	121 (25.7)
0	45 (9.6)	Occurrence of stroke attack	
1	58 (12.3)	First time	277 (58.8)
2	236 (50.1)	Second times	144 (30.6)
≥3	132 (28.0)	≥3 time	50 (10.6)
Family history of stroke		NIHSS	
Yes	126 (26.8)	≤4	301 (63.9)
No	345 (73.2)	>4	170 (36.1)

moderated mediation analysis method offers valuable methodological guidance for future nursing research. The identification of relationships and mechanisms among these four variables provides a theoretical framework for future clinical nursing interventions.

The correlations observed among perceived stress, sleep quality, social support, and depression in stroke patients support Hypothesis 1. Specifically, a higher presence of perceived stress symptoms was associated with an increased risk of depression, while better sleep quality and stronger social support were linked to a reduced risk of depressive symptoms. This finding aligns with a previous study conducted among older stroke patients (41), which similarly found a significant and positive correlation between perceived stress and depression. Additionally, a longitudinal study based on 18,776 participants, followed for 11.8 years from the UK Biobank database,

TABLE 2 Correlation of main variables ($n = 471$).

Variables	Perceived stress	Poor sleep quality	Social support	Depression
Perceived stress	1			
Poor sleep quality	0.572**#	1		
Social support	−0.0421**#	−0.0328**#	1	
Depression	0.648**#	0.486**#	−0.354**#	1

**$p < 0.01$; #FDR (false discovery rate) < 0.01.

TABLE 3 Results of poor sleep quality as a mediator ($n = 471$).

Model	Outcome variable	Independent variables	β	p
Model 1	Poor sleep quality	Constant	−4.671	0.000
		Perceived stress	0.482	0.000
		Sex	0.238	0.426
		Age	0.003	0.773
		R^2	0.659***	
		F	125.974	
Model 2	Depression	Constant	−8.44	0.000
		Perceived stress	0.522	0.000
		Sex	0.078	0.879
		Age	−0.020	0.333
		R^2	0.436***	
		F	50.511	
Model 3	Depression	Constant	−6.659	0.001
		Perceived stress	0.338	0.000
		Poor sleep quality	0.381	0.002
		Sex	−0.013	0.979
		Age	−0.021	0.291
		R^2	0.436***	
		F	50.511	

***$p < 0.001$.

TABLE 4 The total, direct, and indirect effects of the mediation model ($n = 471$).

	β	SE	t	p	LL95%CI	UL95%CI
Total effect	0.522	0.043	12.251	0.001	0.438	0.606
Direct effect	0.338	0.071	4.75	0.001	0.198	0.479
Indirect effect	0.184	0.063	/	/	0.110	0.359

LL95%CI, low limit of 95% confidence interval; UL95%CI, under limit of 95% confidence interval.

revealed that good sleep quality was significantly associated with a 55% lower risk of anxiety and depression (42). Coincidentally, a research team conducting both quantitative and qualitative studies highlighted the crucial role of social support in overcoming anxiety and depression (43, 44). However, it is interesting to note that a study on stroke patients also affirmed the correlation between sleep quality, stress, depression, and social participation. Yet, the path analysis in that article indicated that depression serves as a risk factor for sleep quality, presenting a different conclusion from our study (45). This suggests the presence of a complex, potentially bidirectional interaction between sleep quality and stress.

The results from PROCESS analysis validated the theoretical hypothesis regarding the moderated mediating mechanism of sleep quality and social support among stroke patients. Sleep quality acted as a mediating variable between stress and depression, with poor sleep quality exacerbating the impact of perceived stress on depression and better sleep quality mitigating the impact of stress on depression. This finding aligns with Hypothesis 2, suggesting that when individuals experience stress, the generation of pressure depends on cognitive evaluation and coping, and the quality of sleep reflects the effectiveness and appropriateness of these processes. This is consistent with a study among older people by Liu and colleagues (46), which also supported this conclusion. At moderate and high levels of social support, it has been confirmed that social support moderates the relationship between perceived stress and sleep quality, as well as between poor sleep quality and depression. As expected, higher social support weakened the connection between perceived stress and poor sleep quality among stroke patients. This may be because patients with greater social support are less likely to experience perceived stress and depression in response to the same stressors. This protective role of social support has also been observed in breast cancer patients, where social support played a protective role in anxiety, depression, and sleep quality (47). Most notably, even at higher levels of social support, stroke patients with poor sleep quality were found to be more sensitive to experiencing depressive symptoms. This is likely due to the fact that poor sleep quality can lead to physiological disorders and emotional anxiety, further aggravating depressive symptoms. This result is in line with previous research (48, 49) and provides additional support for the validity of Hypothesis 3.

Therefore, this study offers the following insights: First, attention should be directed toward alleviating the perceived stress of stroke patients. This can be achieved by reducing stressors to lower their perceived stress, involving collaboration between the government and family members to enhance the support system and improve the patient's quality of life. Second, it is essential to address and improve sleep quality. Enhancing sleep quality can help alleviate stress and reduce the occurrence of depression. Medical staff should focus on alleviating physical discomfort, providing psychological counseling, improving sleep environments, and judiciously administering sleep medications. Finally, there should be a regular assessment of the dynamic psychological state. Healthcare professionals should conduct real-time psychological assessments, and screening, and provide timely interventions for stroke patients, both within and outside the hospital.

TABLE 5 The moderated mediation analysis ($n = 471$).

Outcome variable	Independent variables	*β*	*p*	LL95%CI	UL95%CI
Poor sleep quality	Constant	−0.360	0.814	−3.378	2.657
	Perceived stress	1.017	0.000	0.054	0.782
	Social support	−0.018	0.000	−0.131	0.095
	Interaction 1	−0.028	0.030	−0.054	−0.003
	Age	0.019	0.423	−0.028	0.066
	Sex	−0.798	0.187	−1.986	0.390
	R^2	0.518 ***			
	F	41.766			
Depression	Constant	6.974	0.000	4.686	9.262
	Perceived stress	0.471	0.000	0.262	0.680
	Poor sleep quality	0.214	0.000	0.106	0.321
	Social support	−0.201	0.000	−0.287	−0.115
	Interaction 1	−0.018	0.223	−0.046	0.011
	Interaction 2	0.019	0.012	0.004	0.034
	Age	−0.008	0.652	−0.04	0.028
	Sex	0.027	0.953	−0.880	0.934
	R^2	0.568***			
	F	36.078			

***$p < 0.001$; Interaction 1, perceived stress× social support; Interaction 2, poor sleep quality ×social support; LL95%CI, low limit of 95% confidence interval; UL95%CI, under limit of 95% confidence interval.

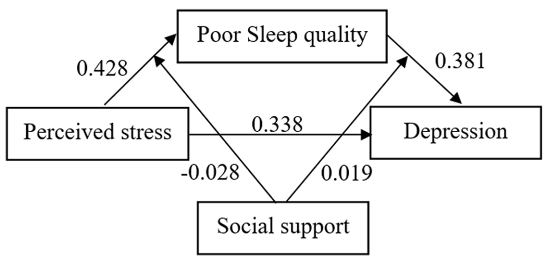

FIGURE 2
Moderated mediation model.

TABLE 6 Conditional indirect effects of perceived stress on depression at different values of social support ($n = 471$).

Path	Moderator (Social support)	*β*	SE	LL95%CI	UL95%CI
Perceived stress→ Poor sleep quality → Depression	Low	0.111	0.132	−0.097	0.434
	Medium	0.217	0.106	0.032	0.459
	High	0.280	0.193	0.038	0.788

Limitation

While this study has generated valuable results, there are certain limitations. First, the geographical representation of the sample is restricted as participants were sourced from five hospitals in five cities within Henan Province. This limitation hinders the generalizability of the research results to a nationwide context, highlighting the need for future research based on more diverse national data. Second, being a cross-sectional survey, this study cannot establish causal relationships between perceived stress, sleep quality, social support, and depression. This limitation restricts the exploration of dynamic changes in trajectories between these variables. Therefore, future studies should consider adopting a longitudinal research design. Finally, this study identified sleep quality as a partial mediator variable and social support as a moderating variable. This suggests the presence of other variables influencing the relationship between stress and depression. Future research should delve into exploring additional variables affecting this relationship, and consider practical implications for implementation.

Conclusion

This study identified the moderated mediation of sleep quality and social support between perceived stress and depression, supporting and validating the theoretical framework and hypotheses. The mediating effect of sleep quality and the moderating effect of social support offer a positive perspective for addressing post-stroke depression. Additionally, this study provides a theoretical basis for developing sleep quality intervention programs aimed at improving depression among stroke patients.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by Ethical approval was obtained from the Ethics Committee of the First Affiliated Hospital of Zhengzhou University (2022-KY-1168-001) prior to this study. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

LG: Funding acquisition, Writing – original draft, Writing – review & editing. MW: Data curation, Writing – review & editing. GN: Writing – review & editing. MZ: Data curation, Writing – review & editing. YX: Data curation, Writing – review & editing. RM: Conceptualization, Writing – review & editing. YG: Methodology, Project administration, Writing – review & editing. YL: Funding acquisition, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Shift schedules and circadian preferences: the association with sleep and mood

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Object: We explored the circadian preferences of non-shift workers (non-SWs) and various types of shift workers (SWs), and the associations of these preferences with sleep and mood.

Methods: In total, 4,561 SWs (2,419 women and 2,142 men aged 37.00 ± 9.80 years) and 2,093 non-SWs (1,094 women and 999 men aged 37.80 ± 9.73 years) completed an online survey. Of all SWs, 2,415 (1,079 women and 1,336 men aged 37.77 ± 9.96 years) reported regularly rotating or fixed schedules ("regular SWs"), and 2,146 (1,340 women and 806 men aged 36.12 ± 9.64 years) had irregular schedules ("irregular SWs"). Of the regular SWs, 2,040 had regularly rotating schedules, 212 had fixed evening schedules, and 163 had fixed night schedules. All participants completed the Morningness-Eveningness Questionnaire (MEQ) exploring circadian preferences, the short form of the Center for Epidemiological Studies-Depression Scale (CES-D) evaluating depression, the Insomnia Severity Index (ISI), and the Epworth Sleepiness Scale (ESS).

Results: Compared to non-SWs, SWs had lower MEQ scores, i.e., more eveningness, after controlling for age, gender, income, occupation, and weekly work hours ($F = 87.97$, $p < 0.001$). Irregular SWs had lower MEQ scores than regular SWs ($F = 50.89$, $p < 0.001$). Among regular SWs, the MEQ scores of fixed evening and fixed night SWs were lower than those of regularly rotating SWs ($F = 22.42$, $p < 0.001$). An association between the MEQ and ESS scores was apparent in non-SWs (r = −0.85, $p < 0.001$) but not in SWs (r = 0.001, $p = 0.92$).

Conclusion: SWs exhibited more eveningness than non-SWs; eveningness was particularly prominent in SWs with irregular or fixed evening/night shifts. Eveningness was associated with sleepiness only in non-SWs, but not in SWs.

KEYWORDS
shift work (MeSH), circadian preference, insomnia, depression, sleepiness

Introduction

Shift work is essential in modern industrialized societies. More than 25% of the global workforce engages in shift work (1). However, shift work compromises health and wellbeing (2). The work schedules of shift workers (SWs) are not aligned with the normal circadian rhythm (3, 4). Circadian rhythms are endogenous rhythms that repeat over a 24 h cycle and are regulated by exposure to light and dark conditions. Adaptation to shift work requires the modification of the circadian preference (the chronotype) (5), i.e., the preferred sleep and activity times; these synchronize biological events with the circadian rhythm (6). The circadian preference modulates the effects of shift work on sleep (7). However, it remains unclear whether an eveningness or morningness preference aids adaptation to shift work. Morningness indicates a preference for going to bed early and waking up early, whereas eveningness indicates a tendency to sleep at later times, often accompanied by difficulty waking up in the morning (8). Previous studies suggested that eveningness might facilitate night shift work more than morningness, and it might also be associated with higher sleep efficiency (9–11). As eveningness has been associated with mood and sleep problems in the general population, the association between circadian preference and sleep/mood may differ between SWs and non-shift workers (non-SWs). However, other studies suggested that eveningness was not necessarily associated with better adaptation to shift work (11, 12). SWs with high morningness working during both the night and day had better sleep quality (11, 13) and less insomnia (11) than eveningness SWs. Therefore, the associations of the circadian preferences of SWs with sleep and mood require attention; both sleep and mood greatly affect shift work adaptation.

In the real world, shift work patterns are diverse and complex. SW sleep and mood vary according to the work schedule (13). A study of 1,253 Hispanic SWs found that those with irregular or nighttime schedules reported later sleep midpoints and greater sleep variability (14). Furthermore, irregular or nighttime SWs exhibited disturbed or delayed circadian rhythms, perhaps reflecting their circadian preferences, especially eveningness (15). However, the cited study had the limitation of including a relatively small number of SWs ($N = 447$). Additionally, it did not compare groups according to the regularity of shift work. It is thus necessary to investigate the circadian preferences of SWs in larger studies that consider various work schedules, including irregular and nighttime shift schedules.

This study aimed to investigate the associations of circadian preferences with sleep and mood in non-SWs and SWs with regular rotating, irregular rotating, and fixed evening/night schedules. We formulated four hypotheses. First, SWs would show more eveningness than non-SWs. Second, irregular shift schedules would be associated with eveningness. Third, night or evening shift schedules would also be associated with eveningness. Finally, the associations of circadian preferences with sleep and mood would differ by shift schedule.

Methods

Participants

Participants were recruited via online advertisements and an online survey company (Macromill Embrain Co. Ltd., Seoul, South Korea). Initially, 1,254 participants (32.58 ± 7.93 years of age; 448 men and 806 women, 961 SWs, and 293 non-SWs) were recruited online and via a hospital bulletin board. A consent form and the questionnaires were sent electronically to all eligible participants. As a bias toward young women was apparent, Macromill Embrain recruited 5,400 additional participants (aged 38.33 ± 9.89 years; 2,693 men and 2,707 women, 3,600 SWs, and 1,800 non-SWs) with biases toward men, middle-aged workers, and non-SWs. The company has enrolled >1 million people in various panels, and invitations were sent by e-mail or text messages to members of panels who had agreed to receive such communications. Those who had not agreed to personal contact could apply via a website. The inclusion criteria were an age of ≥18 years and employment in a full- or part-time job. The exclusion criterion was an inability to complete the online questionnaires. Eleven participants whose work schedules were difficult to classify were excluded. Finally, data for 6,654 participants (aged 37.80 ± 9.73 years; 3,413 women and 3,141 men; 4,561 SWs and 2,093 non-SWs) were analyzed. All procedures adhered to the ethical standards of national and institutional committees on human experimentation and the Declaration of Helsinki 1964 (as revised in 2013). The study protocol was approved by the Institutional Review Board of Samsung Medical Center (Approval no. 2019-04-095), and all participants provided written informed consent.

Shift work patterns

As the effects of SW circadian preferences would be expected to vary by both work time (night or evening) and work regularity, SW patterns were operationally defined as follows: Individuals who worked only during the daytime (7 a.m.–6 p.m.) were classified as non-SWs ($n = 2,093$; 1,094 women and 999 men aged 37.80 ± 9.73 years). SWs ($n = 4,561$; 2,419 women and 2,142 men aged 37.00 ± 9.80 years) were those whose working schedules rotated or whose typical working hours included times before 7 a.m. or after 6 p.m. SWs were classified as regular or irregular according to the presence or absence, respectively, of rules governing work schedules (13, 16). If a consistent predetermined rule was in effect, the workers were classified as regular SWs ($n = 2,415$; 1,079 women and 1,336 men aged 37.77 ± 9.96 years). On the other hand, if there was no fixed rule or the schedules were unpredictable and inconsistent, the workers were classified as irregular SWs ($n = 2,146$; 1,340 women and 806 men aged 36.12 ± 9.64 years). To compare SWs with rotating and fixed schedules, regular SWs were classified as regularly rotating SWs, fixed evening SWs, or fixed night SWs. Regularly rotating SWs ($n = 2,040$; 886 women and 1,154 men aged 37.55 ± 9.80 years) had schedules that regularly changed over time. Fixed evening SWs ($n = 212$; 135 women and 77 men aged 38.63 ± 10.24 years) worked fixed hours (typically from 6 p.m. to 11 p.m.). Fixed night SWs ($n = 163$; 58 women and 105 men aged 39.44 ± 11.33 years) typically worked from 11 p.m. to 7 a.m. Each participant was asked to choose the category that most closely matched his/her work schedule.

Instruments

All questionnaires were completed online. Participants could not proceed to the next question if they did not provide an appropriate answer to the current question. Information on demographic variables (e.g., age, income, gender, type of occupation, and weekly work hours) was collected from all participants. The participants were requested to indicate whether they had any medical or physical illnesses. The question about daily coffee consumption was scored as follows: 1, less than one cup; 2, one or two cups, 3: three or four cups; and 4, at least five cups. The income range was divided into two categories based on a cutoff of 3 million won, which is considered to be a middle-class

TABLE 1 Circadian preferences, depression, and sleep disturbances among non-shift and shift workers.

	Non-shift workers (n = 2,093)	Shift workers (n = 4,561)	F	p-value
Age (years) *(mean ± SD)*	37.80 ± 9.73	36.99 ± 9.84	t = 3.101	0.002
Gender (male) *[n (%)]*	999 (47.7%)	2,142 (47.0%)	χ^2 = 0.34	0.56
Personal income [*n* (%)]				
<3 million KRW/month	1,339 (64%)	2,819 (61.8%)	χ^2 = 2.88	0.09
≥3 million KRW/month	754 (36%)	1,742 (38.2%)		
MEQ+ *(mean ± SD)*	47.15 ± 7.87	44.96 ± 8.09	87.97	<0.001
CES-D+ *(mean ± SD)*	7.11 ± 5.84	8.75 ± 6.30	72.59	<0.001
ISI+ *(mean ± SD)*	7.98 ± 5.82	10.15 ± 6.17	129.98	<0.001
ESS+ *(mean ± SD)*	7.83 ± 3.88	8.36 ± 3.97	18.45	<0.001
PSQI *(mean ± SD)*	6.25 ± 3.23	7.42 ± 3.59	121.62	<0.001

ANCOVA controlling for age, gender, income, occupation, and weekly work hours.
MEQ, Morningness-Eveningness Questionnaire; CES-D, Center for Epidemiological Studies-Depression scale; ISI, Insomnia Severity Index; ESS, Epworth Sleepiness Score.

income in South Korea (17). Occupations were divided into categories A (managers, professionals, and clerks), B (service and sales workers), and C (skilled agricultural forestry and fishery workers, craft and related trade workers, and elementary workers) based on the Korean Standard Classification of Occupations (KSCO) (17).

The Korean version of the Horne and d'Östberg Morningness-Eveningness Questionnaire (MEQ-K) (18) was used to measure circadian preferences. The MEQ-K has 19 items, with total scores ranging from 16 to 86. Higher scores indicate greater morningness. The Korean version of the Insomnia Severity Index (ISI) (19, 20) was also administered. The ISI comprises seven questions that assess insomnia severity, and scores range from 0 to 28; higher scores are associated with more severe insomnia. The Korean version of the Epworth Sleepiness Scale (ESS) assesses daytime sleepiness (21, 22). The eight items comprising the ESS evaluate the likelihood of falling asleep or dozing off in different situations and during various activities, including sitting and reading, watching television, and sitting in a car (as a passenger). Scores range from 0 to 24; higher scores indicate greater daytime sleepiness. The Korean version of the Pittsburgh Sleep Quality Index (PSQI) was used to measure sleep quality (23). The PSQI consists of 19 items across seven domains: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. Higher scores indicate worse sleep quality. The short form of the Center for Epidemiological Studies-Depression Scale (CES-D; Korean version) was used to measure depressive symptoms (24, 25). The CES-D has 11 items, with total scores ranging from 0 to 33; higher scores indicate more severe symptoms.

Statistical analysis

Independent t-tests and analysis of covariance (ANCOVA; covariates = age, gender, income, type of occupation, and weekly work hours) were used to compare dimensional variables (sex and occupation) among the groups. Chi-squared tests were performed to compare categorical variables among groups. Skewness and kurtosis were evaluated when examining data normality (26). The Bonferroni correction was applied in a *post-hoc* analysis of group differences revealed using ANCOVA. Partial correlations between the MEQ and other variables were derived after controlling for age, gender, income, occupation, and weekly work hours. All analyses were performed using SPSS software (ver. 21.0; IBM Corp., Armonk, NY, United States). A p-value of 0.05 was taken to indicate statistical significance.

Results

Comparisons between non-SWs and SWs

SWs were significantly younger than non-SWs (t = 3.10, $p < 0.01$). Gender distribution and income did not differ between non-SWs and SWs. SWs had higher coffee consumption compared with non-SWs (χ^2 = 8.07, $p < 0.05$). The MEQ score was significantly higher in non-SWs than SWs after controlling for age, gender, income, occupation, and weekly work hours (F = 87.97, $p < 0.001$) (Table 1; Figure 1). The CES-D, ISI, and ESS scores were significantly higher in SWs than in non-SWs (CES-D, F = 72.59, $p < 0.001$; ISI, F = 129.98, $p < 0.001$; ESS, F = 18.45, $p < 0.001$). SWs had significantly higher PSQI scores compared with non-SWs (t = −13.25, $p < 0.001$).

Comparisons among non-SWs, regular SWs, and irregular SWs

Age differed significantly among the groups (F = 21.07, $p < 0.01$) (Table 2). Irregular SWs were significantly younger than non-SWs and regular SWs (all $p < 0.001$). Gender distribution differed significantly among the groups (χ^2 = 144.19, $p < 0.001$). Regular SWs were more likely to be men than non-SWs ($p < 0.001$). Non-SWs were more likely to be men than irregular SWs ($p < 0.001$). Incomes differed significantly among the groups (F = 11.58, $p < 0.001$). Irregular SWs earned more than non-SWs ($p < 0.05$) and regular SWs ($p < 0.001$).

The MEQ scores differed significantly among the groups after controlling for age, gender, income, occupation, and weekly work hours (F = 50.89, $p < 0.001$). Non-SWs exhibited higher MEQ scores than regular SWs and irregular SWs (all $p < 0.001$). Regular SWs had

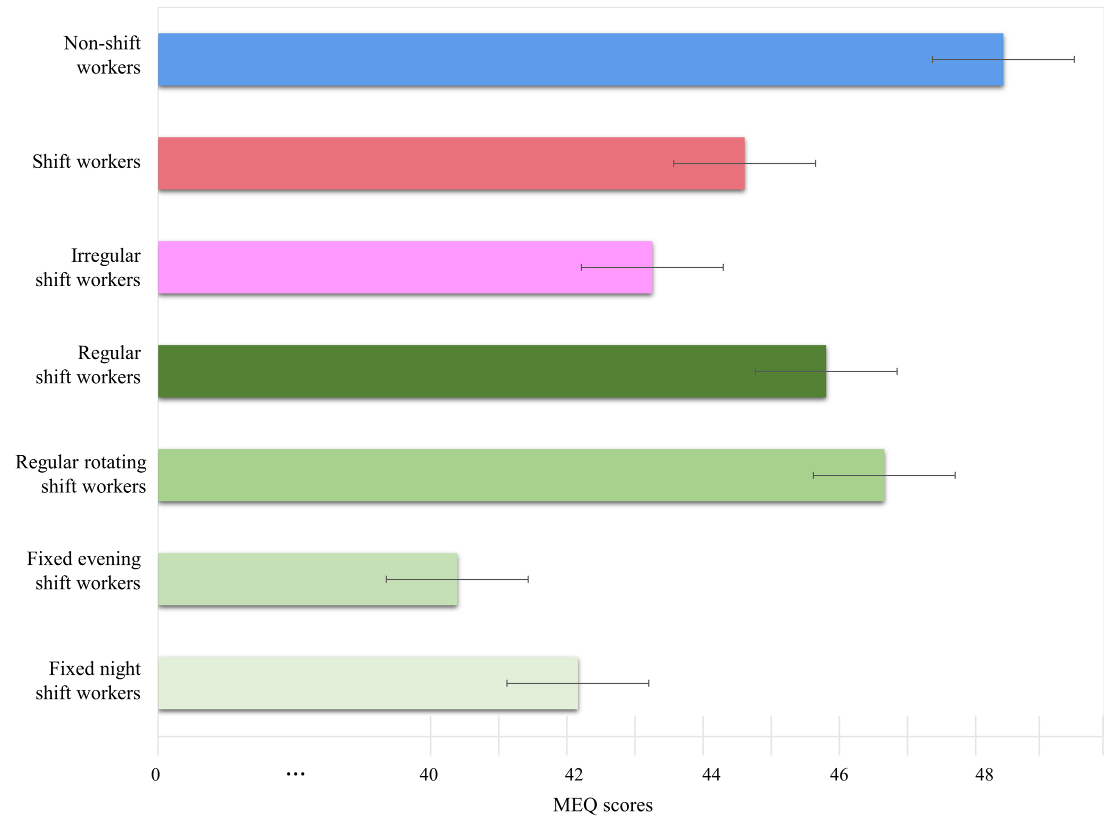

FIGURE 1
Circadian preferences by shift work type. The Morningness-Eveningness Questionnaire (MEQ) scores of shift workers (SWs) with different work schedules. The bars indicate mean MEQ scores, while the whiskers indicate standard deviations. MEQ scores of non-SWs (blue bars), SWs (red bars), irregular SWs (pink bars), regular SWs (dark green bars), regularly rotating SWs (green bars), fixed evening SWs (light green bars), and fixed night SWs (bright green bars) are shown.

higher MEQ scores than irregular SWs ($p < 0.01$). The ISI scores differed significantly among the groups after controlling for age, gender, income, occupation, and weekly work hours ($F = 73.49$, $p < 0.001$). Irregular SWs had higher ISI scores than regular SWs and non-SWs (all $p < 0.01$). The ESS scores differed significantly among the groups after controlling for age, gender, income, type of occupation, and weekly work hours ($F = 10.41$, $p < 0.001$). Regular and irregular SWs had higher ESS scores than non-SWs ($p < 0.01$ and $p < 0.001$, respectively). The PSQI scores differed significantly among the groups after controlling for age, gender, income, types of occupation, and weekly work hours ($F = 76.03$, $p < 0.001$). Irregular SWs exhibited higher PSQI scores compared with non-SWs and regular SWs (all $p < 0.001$). Regular SWs had higher PSQI scores compared with non-SWs ($p < 0.001$). The CES-D scores differed significantly among the groups after controlling for age, gender, income, occupation, and weekly work hours ($F = 41.14$, $p < 0.001$). Regular and irregular SWs had higher CES-D scores than non-SWs (all $p < 0.001$). Irregular SWs had higher CES-D scores than regular SWs ($p < 0.05$) (Table 3).

Comparisons among regular SWs

Age did not differ between fixed night and regularly rotating SWs. Gender distribution differed significantly among the groups ($\chi 2 = 14.67$, $p < 0.001$). Fixed night SWs were more likely to be men (64.4%) than regularly rotating SWs and fixed evening SWs (all $p < 0.001$). Regularly rotating SWs were more likely to be men than fixed evening SWs ($p < 0.01$). Incomes differed significantly among the groups ($F = 24.08$, $p < 0.001$). Regularly rotating SWs earned more than fixed evening SWs ($p < 0.01$) and fixed night SWs ($p < 0.01$).

The MEQ scores differed among regularly rotating SWs, fixed evening SWs, and fixed night SWs after controlling for age, gender, income, occupation, and weekly work hours ($F = 22.42$, $p < 0.001$). Regularly rotating SWs had higher MEQ scores than fixed evening and fixed night SWs (all $p < 0.001$). There was no significant difference in MEQ scores between fixed evening and fixed night SWs. The CES-D scores differed among regularly rotating SWs, fixed evening SWs, and fixed night SWs after controlling for gender, income, occupation, and weekly work hours ($F = 3.79$, $p < 0.05$). Fixed night SWs had higher CES-D scores than regularly rotating SWs ($p < 0.05$). The ISI, ESS, and PSQI scores did not differ among regularly rotating SWs, fixed evening SWs, and fixed night SWs after controlling for gender, income, occupation, and weekly work hours.

Relationships of circadian preference with depression and sleep

The MEQ scores were significantly associated with the CES-D scores in all types of SWs (all participants, $r = -0.13$, $p < 0.001$;

TABLE 2 Circadian preferences, depression, and sleep disturbances among non-shift workers, regular shift workers, and irregular shift workers.

	Non-shift workers (*n* = 2,093)	Regular shift workers (*n* = 2,415)	Irregular shift workers (*n* = 2,146)	*F*	*p*-value	
Age (years) *(mean ± SD)*	37.80 ± 9.73	37.77 ± 9.96	36.12 ± 9.64	21.07	0.001	Non-SWs > irregular SWs*** Regular SWs > irregular SWs***
Gender (male) *[n (%)]*	999 (47.7%)	1,336 (55.3%)	806 (37.6%)	χ^2 = 144.19	<0.001	Regular SWs > non-SWs > irregular SWs***
Personal income [*n* (%)]						
<3 million/KRW month	1,339 (64%)	1,566 (64.8%)	1,253 (58.4%)	11.58	<0.001	Irregular SWs > non-SWs* Irregular SWs > regular SWs***
≥3 million KRW / month	754 (36%)	849 (35.2%)	893 (41.6%)			
MEQ+ *(mean ± SD)*	47.15±7.87	45.65±7.97	44.18±8.15	50.89	<0.001	Non-SWs > regular SWs***. Non-SWs > irregular SWs***. Regular SWs > irregular SWs**.
CES-D+ *(mean ± SD)*	7.11±5.84	8.49±6.28	9.03±6.31	41.14	<0.001	Regular SWs > non-SWs***. Irregular SWs > non-SWs***. Irregular SWs > regular SWs*.
ISI+ *(mean ± SD)*	7.98±5.82	9.87±6.11	10.48 ±6.23	73.49	<0.001	Regular SWs > non-SWs***. Irregular SWs > non-SWs***. Irregular SWs > regular SWs**.
ESS+ *(mean ± SD)*	7.83±3.88	8.26±3.97	8.48±3.96	10.41	<0.001	Regular SWs > non-SWs** Irregular SWs > non-SWs***
PSQI+ *(mean ± SD)*	6.25±3.23	7.2±3.57	7.66±3.61	69.59	<0.001	Regular SWs > non-SWs*** Irregular SWs > non-SWs*** Irregular SWs > regular SWs***

[b]Bonferroni correction: *$p < 0.05$; **$p < 0.01$, ***$p < 0.001$.
+ANCOVA controlling for age, gender, income, occupation, and weekly work hours. Bonferroni corrections were applied during *post-hoc* analyses.
MEQ, Morningness-Eveningness Questionnaire; CES-D, Center for Epidemiological Studies-Depression scale; ISI, Insomnia Severity Index; ESS, Epworth Sleepiness Score, non-SWs, non-shift workers; regular SWs, regular shift workers; irregular SWs, irregular shift workers.

non-SWs, r = −0.13, $p < 0.001$; all SWs, r = −0.12, $p < 0.001$; irregular SWs, r = −0.09, $p < 0.001$; all regular SWs, r = −0.13, $p < 0.001$; regularly rotating SWs, r = −0.12, $p < 0.001$; fixed evening SWs, r = −0.18, $p < 0.05$; fixed night SWs, r = −0.17, $p = 0.03$) (Table 4). The MEQ scores were significantly associated with the ISI scores in all types of SWs (all participants, r = −0.20, $p < 0.001$; non-SWs, r = −0.16, $p < 0.001$; all SWs, r = −0.20, $p < 0.001$; irregular SWs, r = −0.17, $p < 0.001$; all regular SWs, r = −0.22, $p < 0.001$; regularly rotating SWs, r = −0.20, $p < 0.001$; fixed evening SWs, r = −0.25, $p < 0.001$; fixed night SWs, r = −0.27, $p < 0.01$) (Table 4). The PSQI scores were significantly associated with the MEQ scores (all participants, r = −0.21, $p < 0.001$; non-SWs, r = −0.21, $p < 0.001$; all SWs, r = −0.20, $p < 0.001$; irregular SWs, r = −0.19, $p < 0.001$; all regular SWs, r = −0.21, $p < 0.001$; regular rotating SWs, r = −0.20, $p < 0.001$; fixed evening SWs, r = −0.29, $p < 0.001$; fixed night SWs, r = −0.20, $p < 0.05$) after controlling for age, gender, income, occupation, and weekly work hours. The ESS and MEQ scores were significantly associated in non-SWs (r = −0.85, $p < 0.0001$) but not in any type of SW (Table 4; Figure 2). Coffee consumption was significantly negatively associated with the MEQ scores after controlling for age, gender, income, occupation, and weekly work hours in non-SWs (r = −0.08, $p < 0.001$), SWs (r = −0.04, $p < 0.001$), regular SWs (r = −0.05, $p < 0.001$), regular rotating SWs (r = −0.05, $p < 0.01$), and fixed evening SWs (r = −0.12, $p < 0.05$). The ESS scores were correlated with the MEQ scores in non-SWs (r = −0.09, $p < 0.001$) but not in any type of SW, after controlling for age, gender, income, occupation, weekly work hours, illness, and coffee consumption. The ESS scores were correlated with the MEQ scores in non-SWs (r = −0.05, $p < 0.05$) and regular rotating SWs (r = −0.05, $p < 0.05$), but not in irregular SWs, fixed evening SWs, or fixed night SWs, after additionally controlling for PSQI scores. The ESS and MEQ scores were significantly correlated with each other after additionally controlling for ISI scores in non-SWs (r = −0.57, $p < 0.01$) and regular rotating SWs (r = 0.06, $p < 0.01$) but not in irregular SWs, fixed evening SWs, or fixed night SWs.

Discussion

We found that SWs exhibited more eveningness than non-SWs, particularly those with irregular or fixed evening/night shifts. An association between eveningness and daytime sleepiness was apparent in non-SWs but not in SWs. The greater eveningness of SWs is consistent with our first hypothesis. There are two possible explanations for this result. First, eveningness SWs may be more likely to choose night shift work than morningness SWs. Previous studies demonstrated that morningness individuals found it difficult to adjust to shift work and were less likely than eveningness individuals to engage in such work (27). People with morningness exhibited slower

TABLE 3 Circadian preferences, depression, and sleep disturbance scores of fixed evening shift workers, fixed night shift workers, and regularly rotating shift workers.

	Regularly rotating shift workers (*n* = 2,040)	Fixed evening shift workers (*n* = 212)	Fixed night shift workers (*n* = 163)	*F*	*p*-value	
Age (years) *(Mean ± SD)*	37.55±9.80	38.63±10.24	39.44±11.33	6.57	0.03	
Gender (men) [*n (%)*]	1,154 (56.6%)	77 (36.3%)	105 (64.4%)	$\chi^2 = 14.67$	<0.001	Regularly rotating SWs > fixed evening SWs***; Fixed night SWs > fixed evening SWs***
Personal Income [*n* (%)]						Regularly rotating SWs > fixed evening SWs**; Regularly rotating SWs > fixed night SWs**
<3 million/month (KRW)	1,278 (62.6%)	163 (76.9%)	125 (76.7%)	24.08	<0.001	
≥3 million/month (KRW)	762 (37.4%)	49 (23.1%)	38 (23.3%)			
MEQ+ *(mean ± SD)*	46.14±7.72	42.53±8.82	43.55±8.69	22.42	<0.001	Regularly rotating SWs > fixed evening SWs***; Regularly rotating SWs > fixed night SWs***
CES-D+ *(mean ± SD)*	8.36±6.23	8.76±6.35	9.84±6.69	3.79	0.01	Fixed night SWs > regularly rotating SWs*
ISI+ *(mean ± SD)*	9.82±6.02	9.53±6.39	10.88±6.71	4.00	0.007	–
ESS+ *(mean ± SD)*	8.33±3.98	7.84±4.06	8.01±3.78	0.83	0.48	–
PSQI+ *(mean ± SD)*	7.18±3.53	6.97±3.67	7.72±3.87	2.36	0.07	

[b]Bonferroni correction, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
+ANCOVA controlling for age, gender, income, occupation, and weekly hours worked.
Bonferroni corrections were applied during *post-hoc* analyses. MEQ, Morningness-Eveningness Questionnaire; CES-D, Center for Epidemiological Studies-Depression scale; ISI, Insomnia Severity Index; ESS, Epworth Sleepiness Score; regularly rotating SWs, regularly rotating shift workers; fixed evening SWs, evening shift workers; fixed night SWs, night shift workers.

TABLE 4 Relationships among circadian preference, depression, and sleep disturbance scores according to shift work type.

	All subjects	Non-shift workers	Shift workers					
			All shift workers	Irregular shift workers	Regular shift workers			
					All regular shift workers	Regularly rotating shift workers	Fixed evening shift workers	Fixed night shift workers
CES-D	r = −0.13 *p* < 0.001	r = −0.13 *p* < 0.001	r = −0.12 *p* < 0.001	r = −0.09 *p* < 0.001	r = −0.13 *p* < 0.001	r = −0.12 *p* < 0.001	r = −0.18 *p* = 0.01	r = −0.17 *p* = 0.03
ISI	r = −0.20 *p* < 0.001	r = −0.16 *p* < 0.001	r = −0.20 *p* < 0.001	r = −0.17 *p* < 0.001	r = −0.22 *p* < 0.001	r = −0.20 *p* < 0.001	r = −0.25 *p* < 0.001	r = −0.27 *p* = 0.001
ESS	r = −0.31 *p* = 0.11	r = −0.85 *p* < 0.001	r = 0.00 *p* = 0.92	r = −0.01 *p* = 0.70	r = 0.01 *p* = 0.50	r = 0.00 *p* = 0.99	r = 0.02 *p* = 0.75	r = 0.05 *p* = 0.56
PSQI	r = − 0.21 *p* < 0.001	r = − 0.21 *p* < 0.001	r = − 0.20 *p* < 0.001	r = −0.19 *p* < 0.001	r = −0.21 *p* < 0.001	r = −0.20 *p* < 0.001	r = −0.29 *p* < 0.001	r = −0.20 *p* < 0.05

r: correlation coefficients; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Partial correlation analyses controlled for age, gender, income, occupation, and weekly hours worked.
MEQ, Morningness-Eveningness Questionnaire; CES-D, Center for Epidemiological Studies-Depression scale; ISI, Insomnia Severity Index; ESS, Epworth Sleepiness Score.

circadian adjustment to night work than those with eveningness (28); moreover, they experienced more sleep deprivation and greater fatigue (29) and were sleepier during night work (9). Taken together, such findings suggest that eveningness individuals choose shift work more often than morningness individuals because they experience less difficulty adapting to it.

Another possibility is that the circadian preferences of SWs may change after beginning shift work. As shift work differs from work during normal hours, circadian rhythm readjustment may be required. Repeated readjustments necessitated by shift work may change the circadian preference. During adaptation to night work, sleepiness during work decreased, and bedtime was gradually delayed (30). A

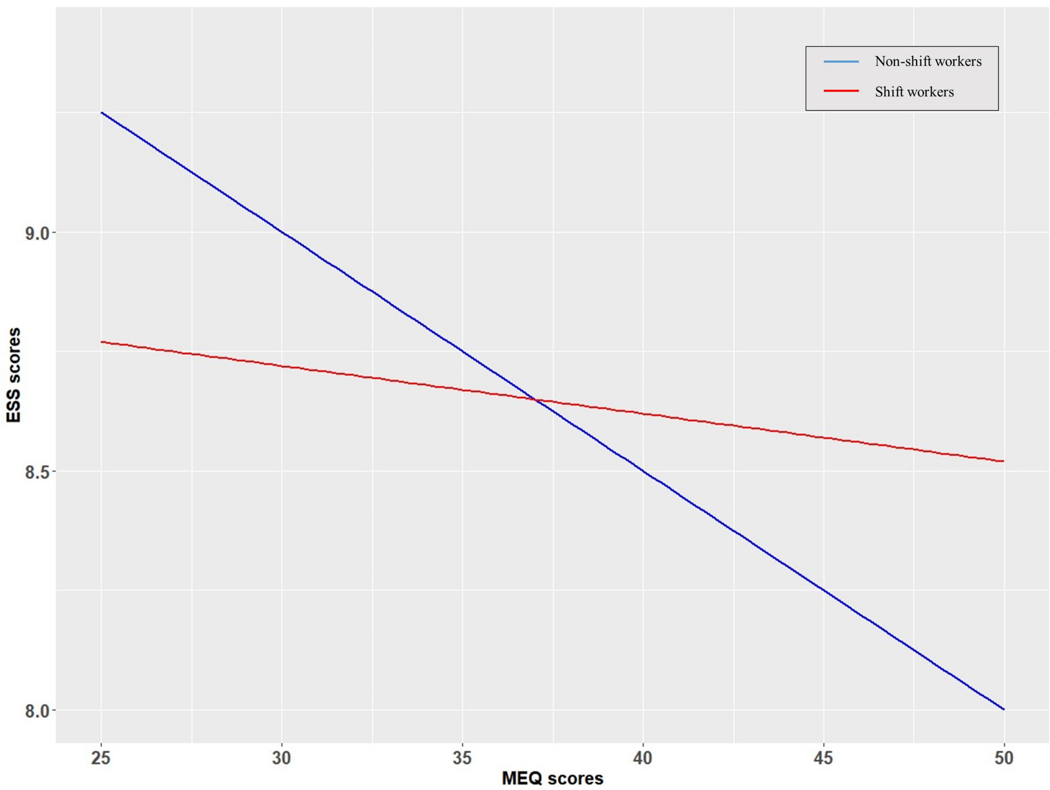

FIGURE 2
Relationships between circadian preferences and daytime sleepiness in shift workers (SWs) and non-SWs. Linear trendlines of SWs and non-SWs. X-axis: MEQ scores, y-axis: ESS scores. Red line: linear trendline of SWs. Blue line: linear trendline of non-SWs. MEQ, Morningness-Eveningness Questionnaire; ESS, Epworth Sleepiness Scale.

previous study measured the so-called "melatonin metabolite acrophase," which corresponds to the maximum melatonin concentration during a 24 h period (31). In that study, the melatonin metabolite acrophase changed after seven night shifts, and the change persisted even after SWs returned to day shifts. This result suggests that repeated night shifts may induce prolonged changes in the circadian rhythm and, potentially, the circadian preference. However, we cannot confirm a change in circadian preference after repeated shift work due to a lack of long-term follow-up data for this study.

We found that irregular SWs exhibited more eveningness than regular SWs. A previous study reported that irregular SW delayed the sleep midpoint (32), i.e., the circadian rhythm. A delayed circadian rhythm is closely associated with eveningness. As eveningness individuals exhibit more flexible sleep–wake cycles (33), eveningness SWs may experience less difficulty than others in adapting to irregular work schedules and may thus be more willing to choose such schedules. It is also possible that irregular schedules may increase the eveningness tendency. In previous studies, delayed sleep midpoints were observed when daily routines were disturbed (34), and irregular sleep and light exposure were associated with delayed circadian rhythms in college students (35). Moreover, the erratic irregular schedules of SWs may disrupt the circadian rhythm and sleep–wake cycle (36). However, it remains unclear whether irregular SW delays the circadian rhythm or induces eveningness.

We compared the eveningness of fixed evening and night SWs to that of regularly rotating SWs. The work schedules of the latter SWs usually included both day and night shifts; fixed night or evening SWs worked only at night or in the evening. Our findings suggest that circadian preference may modulate the tolerability of fixed night or rotating schedules. A previous study reported that fixed night work was more acceptable than rotating night work (37). However, among regular SWs, those with morningness may be more tolerant of rotating schedules, whereas those with eveningness may be more accepting of fixed night schedules. Eveningness is associated with greater night alertness and morning sleepiness; it is thus not surprising that eveningness individuals are more likely to choose fixed night/evening shifts than rotating day–night shifts. Another possible explanation for the higher eveningness among fixed evening/night SWs is that evening/night SWs might change their circadian preferences. A previous longitudinal study found that the number of night shifts worked over 2 years correlated with increased eveningness over time (38). Thus, repeated evening shifts may lead to a circadian preference for eveningness.

We found that non-SWs exhibiting evening preferences experienced higher levels of daytime sleepiness than non-SWs with morning preferences. However, we observed no correlation between SW circadian preference and sleepiness. In previous studies, eveningness subjects reported more daytime sleepiness than morningness individuals (9). Thus, the correlation between eveningness and daytime sleepiness in non-SWs is not surprising. However, we found no correlation between eveningness and daytime sleepiness among SWs. It may be that eveningness SWs are sleepiness-resistant and thus better handle varying shift schedules. Night shift sleepiness was less severe in eveningness than morningness individuals in a previous study (39). Moreover, a reduction in daytime sleepiness reflects the extent of adaptation (40); our findings thus support those of previous studies reporting that eveningness was associated with easier adaptation to shift work (9, 41). The less severe shift work-induced sleepiness in eveningness subjects may reduce the association between eveningness and sleepiness often seen in the general population.

This study had some limitations. First, cross-sectional studies cannot identify temporal or causal associations between SW schedules and circadian preferences. In other words, we cannot state that individuals exhibiting eveningness tended to choose specific types of shift work or that shift work changed their circadian preferences; longitudinal studies are required. Second, all data were self-reported and may have been affected by selection bias because all subjects volunteered to take part. Future studies using objective measures, such as structured interviews or polysomnography, would help validate our results. Additionally, studies regarding the correlations of biological circadian rhythm indices (e.g., melatonin, cortisol, and core body temperature) with circadian preferences in SWs could provide insights into those preferences. Third, workers with rotating shift schedules limited to daytime hours (7 a.m.–6 p.m.) were classified as SWs in this study, although such workers in Korea are rare.

Conclusion

SWs, especially those on irregular/nighttime shifts, exhibited more eveningness than non-SWs. A correlation between circadian preference and daytime sleepiness was evident in non-SWs but not SWs. Circadian preference was associated with shift work and the schedules thereof, but not with SW sleepiness.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Institutional Review Board of Samsung Medical Center (approval no. 2019-04-095). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

JA: Conceptualization, Data curation, Formal analysis, Visualization, Writing – original draft. HY: Writing – review & editing, Data curation, Validation, Formal analysis. SL: Data curation, Writing – review & editing, Methodology, Formal analysis. YH: Data curation, Investigation, Writing – review & editing, Methodology. SJ: Data curation, Writing – review & editing, Methodology, Conceptualization. SK: Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Supervision, Validation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Poor sleep quality and associated factors among healthcare professionals at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia

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Background: Poor sleep quality is linked to physiological dysfunction, which increases the risk of obesity, cardiovascular disease, cognitive impairment, and other medical conditions. Despite the known health risks of sleep disturbances, literature is still scant regarding sleep quality and its associated factors among healthcare professionals in Ethiopia. Therefore, this study aimed to determine the prevalence of poor sleep quality and its associated factors among healthcare professionals at the University of Gondar Comprehensive Specialized Hospital.

Methods: An institution-based cross-sectional study was conducted at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. A total of 418 healthcare professionals participated in the study. The study participants were chosen using the stratified random sampling method. Data were collected using a structured, self-administered questionnaire. The Pittsburgh Sleep Quality Index (PSQI) was used to assess the sleep quality of participants. Bi-variable and multivariable logistic regression models were used. $p \leq 0.05$ was used to declare statistically significant variables.

Results: The mean age of the study participants was 30.7 years (SD $\pm$ 6.3). The overall prevalence of poor sleep quality was 58.9% [95% CI (54.2, 63.6%)]. Being female [adjusted odds ratio (AOR) = 1.9, 95% CI (1.2, 2.9)], being a shift worker [AOR = 5.7, 95% CI (2.3, 14.3), not performing regular exercise [AOR = 2.08 (1.2–3.6)], being a khat chewer [AOR = 3.1, 95% CI (1.2, 7.6)], and having depressive symptoms [AOR = 2.6, 95% CI (1.3, 6.8)] were significantly associated with higher odds of having poor sleep quality.

Conclusion: The prevalence of poor sleep quality among healthcare professionals was found to be high. As a result, we recommend that healthcare providers at the University of Gondar Comprehensive Specialized Hospital focus on early regular screening for sleep disturbances and pay special attention to shift work schedules and behaviors such as khat chewing, exercise, and depressive symptoms.

KEYWORDS

poor sleep quality, Pittsburgh Sleep Quality Index, depression, health care professionals, Ethiopia

Introduction

Sleep quality is described as the feeling of a sleep experience, incorporating components of sleep initiation, maintenance, quantity, and enjoyment upon awakening (1). According to the American Academy of Sleep Medicine, an adult should sleep approximately seven or more hours per day (2). Poor sleep quality is closely linked to an increased susceptibility to a broad range of disorders, ranging from poor vigilance and memory to reduced mental and physical reaction times, reduced motivation, depression, insomnia, metabolic abnormalities, obesity, immune impairment, and even greater risk of cancer and cardiovascular disorders (3, 4). It is also linked to lower productivity and an increased chance of workplace injury (5, 6).

Worldwide, the prevalence of sleep problems ranges from 1.6% to 56.0% (7–9). Sleep problems are also common among healthcare professionals and significantly affect their quality of life, productivity, and ability to do their work (10). The prevalence of poor sleep quality among health professionals was 56.3% in Turkey (11), 73.8% in Vietnam (12), 86.8% in Malaysia (13), 42.3% in Saudi Arabia (14), 85.9% in Riyadh (10), and 54.2% in Nigeria (15). It is also estimated to be 53% in our country, Ethiopia (16). As a result, disturbed sleep or interrupted circadian rhythms may also initiate pathological condition in the human body (17). Additionally, factors including sex (18, 19), age (18, 20, 21), shift work (15, 22–24), coffee consumption (13), khat chewing (25, 26), alcohol consumption (20), depression (27, 28), not engaging in regular exercise (29–31), self-rated health (32), and extra use of smartphones are also among the most common risk factors of disturbed sleep–wake cycle (17).

Poor sleep quality can cause medical problems like fatigue and exhaustion, as well as psychological ones like increased irritation and loss of attention. These difficulties can impede communication and coordination among healthcare workers (29, 33, 34). Consequently, it is critical to investigate sleep quality and associated factors among healthcare workers (HCWs) in diverse settings in order to reduce the impact of sleep disorders and medical errors. Additionally, Ethiopian healthcare policy does not emphasize healthcare practitioners' sleep quality (35). Despite the well-known link between sleep disturbances and a variety of severe health problems, research on sleep quality in Ethiopian healthcare professionals is limited (16, 36).

As a result, the current study is meant to fill this gap. Therefore, this study aimed to assess the prevalence of poor sleep quality and associated factors among healthcare professionals at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia.

Materials and methods

Study setting

The study was conducted at the University of Gondar Comprehensive Specialized Hospital Northwest Ethiopia from February 1 to March 30, 2020. The University of Gondar Comprehensive Specialized Hospital is one of the biggest teaching hospitals in the Amhara region, serving over five million people requiring tertiary care. It is situated 728 km north of Ethiopia's capital city, Addis Ababa. The hospital provides both comprehensive and referral-level treatment. There are 938 full-time registered healthcare workers. This research's study population included all healthcare professionals working in the hospital.

Study design and population

An institution-based cross-sectional study was carried out among all healthcare workers who were permanently employed at the University of Gondar Comprehensive Specialized Hospital and were available during data collection. During the data collection time, healthcare professionals who were unable to communicate due to a serious illness were excluded.

Sample size determination and sampling procedure

The sample size for this study was determined using a single population proportion formula by assuming the prevalence of poor sleep quality among healthcare professionals (p = 50%), 95% confidence interval, and 5% margin of error. After adding a non-response rate of 10%, the final sample size became 423. There were a total of 876 healthcare professionals. Therefore, a stratified random sampling technique was applied based on their profession. First, a proportional allocation was used after identifying the number of healthcare workers in each profession. The study subjects were then chosen to form a total of 423 healthcare professionals using a computer-generated simple random sampling method from those strata.

Data collection tools and technique

Data were gathered from February 1 to March 30, 2020, using a self-administered questionnaire that included socio-demographic variables, work-related factors, substance use, depression (as assessed by the Beck's Depression Inventory), and the Pittsburgh Sleep Quality Index (PSQI). The PSQI is a validated tool used to assess adult sleep quality and patterns (37). Subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, medication use, and daily dysfunction are the seven groups of the instrument. The seven domains are then added to create a total score, with a score greater than 5 indicating "poor" sleep quality and a score of less than or equal to 5 indicating "good" sleep quality (38).

Study variables

Poor sleep quality was the dependent variable in this research. Socio-demographic variables (age, gender, marital status, having children, and profession), substance use variables (alcohol consumption, cigarette smoking, drinking coffee, and khat chewing), work-related variables (working shift, working hour, and work experience), and health status variables (depression, history of chronic illness, exercise, and self-rated health) are independent variables. To assess depression, we used the Beck Depression Inventory (BDI), which is a 21-item self-report rating assessment that assesses depression-related attitudes and symptoms (39). The Beck Depression Inventory, second edition (BDI-II) is one of the most widely used tools in research and application to assess the existence and degree of depression in the previous 2 weeks (40). The BDI-II assesses 21 symptoms and attitudes, which include Mood, Pessimism, Sense of failure, Lack of satisfaction, Guilt feelings, Sense of punishment, Self-dislike, Self-accusation, Suicidal wishes, Crying, Irritability, Social withdrawal, Indecisiveness, Distortion of body image, Work inhibition, Sleep disturbance, Fatigability, Loss of appetite, Weight loss, Somatic preoccupation, and Loss of libido (41, 42). Participants with BDI-II scores ranging from 0 to 13 were deemed normal. Participants with BDI-II scores of 14–19, 20–28, or 29–63 were classified as having mild, moderate, or severe depression, respectively (39). In terms of substance use, participants were considered current substance users if they had used cigarettes, khat, alcohol, or coffee at least once in the month preceding the survey (43–45). Khat (*Catha edulis*) is an herbal trade-related cultivated plant growing in most parts of the world, particularly in Eastern Africa and Arab countries (46, 47). It contains psychoactive substances cathinone and cathine, which can cross the blood–brain barrier to enter and stimulate the brain (47–49). A semi-structured question "Did you have a previous history of chronic illness?" was used to evaluate the history of chronic illness. A "yes" answer was considered as having a history of chronic illness. The questionnaire assesses shift work by asking if they have day and night shift work; if they answer positively with "yes", they were classified as having shift work. Shift work entails switching between day and night shifts. A healthcare shift worker is a healthcare professional who often works in a healthcare facility switching between day and night (50). Regular exercise is described as a subset of physical activity that is planned, structured, and repetitive, with the ultimate or intermediate goal of improving or maintaining physical health (51). According to WHO guidelines, 150–300 minutes of moderate-intensity physical exercise or 75–150 minutes of vigorous-intensity physical activity is recommended (52).

Statistical analysis

After checking for the completeness and consistency of the collected data, the data were entered into Epi-data version 3.02 and exported to SPSS version 25 for analysis. To express descriptive results, frequency with percent and mean with standard deviation were computed. The study fulfilled all chi-square assumptions, which assume that both factors are categorical, all observations are independent, and cells in the contingency table are mutually exclusive; there should be no zero cell values, and the expected value of cells should be 5 or higher in at least 80% of cells. A binary logistic regression was performed to determine the crude association between each independent variable and poor sleep quality. Variables in the bi-variable analysis with a p-value <0.25 were candidates for multivariable binary logistic regression analysis. The crude odds ratio (COR) and adjusted odds ratio (AOR) with 95% CI were calculated. For the multivariable analysis, variables with a p-value <0.05 were considered statistically significant.

Data quality management

To ensure the data quality, 1-day training was given for four BSc nursing data collectors. The questionnaire was also pretested, and regular supervision of the data collection process was also made to increase the completeness, accuracy, and consistency of the data. Incomplete questionnaires were discarded from the analysis. Cronbach's alpha was also calculated to test the reliability of the PSQI tool, and it was 0.72.

Ethical consideration

Ethical clearance was obtained from the Ethical Review Board of the University of Gondar with ethical clearance number 1840/2012. To ensure the confidentiality of respondents, informed written consent was obtained from each study participant, and their names were not written on the questionnaire, which reduced the authors' access to information that could identify individual participants during or after data collection.

Results

Socio-demographic characteristics of healthcare professionals

This survey had 418 participants. Initially, the plan was to collect data from 423 professionals, but due to incomplete and non-returned questionnaires, the response rate became 98.8%. Two hundred thirteen (51%) were female. The subjects' mean age was 30.7 years (SD 6.3). One-third (33.3%) of the individuals were married. More than half of the participants in the research were nurses, 226 (54.1%), with midwives accounting for the remaining 60 (14.4%) (Table 1).

Work- and health-related characteristics of the respondents

Three hundred eighty-five (92.1%) of the participants were on duty. Four hundred sixty (97.8%) of them worked fewer than 56 hours per week. In terms of substance use, 45 (10.8%), 260 (62.2%), and 35 (8.4%) of the subjects were current khat chewers, alcoholic drinkers, and cigarette smokers, respectively. Thirty-five (8.4%) of those who participated had a history of chronic disease. The majority of subjects (82.3%) reported moderate stress (Table 2).

Prevalence of poor sleep quality among healthcare professionals

The overall prevalence of poor sleep quality among healthcare professionals in this study was 58.9% [95% CI (54.2, 63.6%)].

TABLE 1 Socio-demographic characteristics of healthcare professionals working at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia, 2020 (n = 418).

Variables	Category	Frequency	Percentage
Age (in years)	20–30 31–40 41–50 >50	265 119 26 8	63.4% 28.5% 6.2% 1.9%
Sex	Male Female	205 213	49.1% 50.9%
Marital status	Single Married Divorced	261 139 18	62.4% 33.3% 4.3%
Number of children	0 1–2 3–4 >4	277 101 36 4	66.3% 24.1% 8.5% 1.1%
Working profession	Medical doctor Pharmacist Nurse Laboratory technologist Midwife Others*	27 35 226 46 64 20	6.5% 8.4% 54.0% 11.0% 15.3% 4.8%

*Anesthesiologist, psychiatrist, public health practitioner, and physiotherapist.

TABLE 2 Work- and health-related characteristics of healthcare professionals working at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia, 2020 (n = 418).

Variables	Categories	Frequency	Percentage
Working in shift	Yes No	385 33	92.1% 7.9%
Work experience (years)	1–9 10–19 20–29 ≥30	310 81 22 5	74.2% 19.4% 5.3% 1.2%
Working hours per week	≤56 >56	409 9	97.8% 2.2%
Current khat chewing	Yes No	45 375	10.8% 89.2%
Current alcohol drinking	Yes No	260 158	62.2% 37.8%
Current cigarette smoking	No Yes	383 35	91.6% 8.4%
Drinking coffee	Yes No	306 112	73.2% 26.8%
History of chronic illness	Yes No	35 383	8.4% 91.6%
Regular exercise	Yes No	76 342	18.2% 81.8%
Self-rated health	Excellent Very good Good Fair	119 152 120 27	28.5% 36.4% 28.7% 6.5%
Depression	Normal Mild Moderate and above	323 47 27 21	77.3% 11.2% 6.5% 5%

Participants' average night sleep duration and sleep latency were 6.5 hours (SD 1.27) and 18.6 minutes (SD 16.6), respectively. Three hundred five (73%) of the participants had less than 7 hours of sleep per day. Thirty-three (7.9%) and 73 (17.5%) had low habitual sleep efficiency (<65%) and used sleep medication in the past month, respectively (Table 3).

Associated factors of poor sleep quality

In the logistic regression analysis, variables with p-value <0.25 were included in the multivariable logistic regression model. Accordingly, sex, shift work, current khat chewing, depression, and not performing exercise were significantly associated with poor sleep quality ($p < 0.05$).

Female participants were two times [AOR = 1.9, 95% CI (1.2, 2.9)] more likely to experience poor sleep quality compared to male participants. Participants who worked in shifts were six times [AOR = 5.7, 95% CI (2.3, 14.3)] more likely to have poor sleep quality than their counterparts. Participants who did not have regular exercise were two times more likely to have poor sleep quality than those who had regular exercise. Current khat chewers were three times [AOR = 3.1, 95% CI (1.2, 7.6)] more likely to experience poor sleep quality than

TABLE 3 Sleep quality and its component scores among healthcare professionals working at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia, 2020 (n = 418).

Variables	Categories	Frequency	Percentage
Subjective sleep quality (score)	Very good (0)	158	37.8%
	Fairly good (1)	129	30.9%
	Fairly bad (2)	61	14.6%
	Very bad (3)	70	16.7%
Sleep latency (score)	Never (0)	95	22.7%
	<1 times per week (1)	234	56%
	1–2 times a week (2)	74	17.7%
	≥3 times a week (3)	15	3.6%
Sleep duration	>7 hours	113	27%
	6–7 hours	206	49.3%
	5–6 hours	71	17%
	<5 hours	28	6.7%
Sleep efficacy	>85%	209	50%
	75%–84%	127	30.4%
	65%–74%	49	11.7%
	<65%	33	7.9%
Sleep disturbance (score)	Never (0)	6	1.4%
	<1 times a week (1)	290	69.4%
	1–2 times a week (2)	118	28.2%
	≥3 times a week (3)	4	1%
Use of sleep medication (score)	Never (0)	345	82.5%
	<1 times a week (1)	48	11.5%
	1–2 times a week (2)	10	2.4%
	≥3 times a week (3)	15	3.6%
Daytime dysfunction (score)	Never (0)	121	28.9%
	<1 times a week (1)	185	44.3%
	1–2 times a week (2)	95	22.7%
	≥3 times a week (3	17	4.1%

those who did not chew khat. Participants with moderately severe depression were three times more likely to have poor sleep quality than those without depression [AOR = 2.6, 95% CI (1.3, 6.8)] (Table 4).

Discussion

The current study aimed to determine the prevalence and risk factors for poor sleep quality among healthcare professionals at the University of Gondar Comprehensive Specialized Hospital. In this study, the prevalence of poor sleep quality was 58.9% [95% CI (54.2, 63.6%)], indicating that a significant number of participants are affected by the issue. This finding is in line with the results of studies conducted in Turkey (55.3%) (11), Malaysia (57.8%) (13), and Nigeria (54.2%) (15). Compared to previous studies in France (64.8%) (53), Mexico (56.7%) (28), Colombia (74.9%) (54), Saudi Arabia (73.4%) (55), Riyadh (85.9%) (10), China (75%) (56), Malaysia (86.8%) (13), and Ethiopia (70.6%) (57), this research discovered a lower prevalence of poor sleep quality among healthcare workers. Differences in study population could account for the disparity in prevalence of poor sleep quality among studies as a potential cause of this variation. Unlike the current study, which included participants from all healthcare professions, the previous studies only included nurses; this was the case in earlier Ethiopian and Chinese studies, as well as physicians in the Malaysian and Riyadh studies. Our study's results outperform those of Nepal (48.03%) (58), Saudi Arabia (42.3%) (14), and Ethiopia (25.6%) (59). This disparity could be due to differences in the instrument used or differences in sample size. The previous research in Ethiopia, for example, used the shift work sleep disorder questionnaire to assess sleep quality, whereas the PSQI was used in this study.

The current research found sex, shift work, current khat chewing, depression, and a lack of regular exercise as determinants of poor sleep quality. Female gender was associated with an increased odds of poor sleep quality. A similar finding was reported from a study conducted in Austria (60), Pakistan (19), Spain (18), Saudi Arabia (61), and Ethiopia (62). This could be due to increased household and family responsibilities in women, which is typically associated with women working for extended periods of time at night, which could affect their sleep quality. Furthermore, in terms of the other differences in circadian timing between the sexes, it has been hypothesized that somewhat shorter circadian periods in women may cause them to be more out of circadian alignment, resulting in increased sleeplessness (63). This study also revealed that people who work in shifts have increased odds of poor sleep quality than non-shift workers. Consistent with the current study, studies in China (23), Spain (22), and Ethiopia (57) stated that people working in shifts had an increased risk of poor sleep quality than those working without shifts. A plausible explanation for this could be that working in a shift rotation could have an unpredictable working schedule that disrupts the circadian rhythm and restricts opportunities for sleep (15, 59).

As for the present study's result, current khat chewers have demonstrated three times higher odds of poor sleep quality than non-khat chewers. This finding aligns with studies performed in Yemen and Ethiopia (25, 26, 62, 64). This could be due to the effect of khat. Because of its primary active ingredient (cathinone), khat (*C. edulis*) is initially a stimulant with effects similar to those of amphetamine (26, 65). However, this euphoric condition is typically followed by depression, irritability, anorexia, and sleeping difficulties. Cathinone's effects are achieved by reduced dopamine uptake by nerve terminals, increased dopamine release, and inhibition of monoamine oxidase. As a result of the persistent stimulation of post-synaptic neurons following a high amount of dopamine in the synaptic cleft, all processes may result in poor sleep quality. After 8 hours of chewing, cathinone is scarcely detectable in the blood. The first-pass metabolism of cathinone in the liver results in the production of norepinephrine, which reduces sleep quality (20, 26, 66).

The present study found that participants who did not exercise regularly were more likely to have poor sleep quality, which is consistent with earlier research conducted in China and Brazil (29, 67, 68). This is because physical activity can produce positive changes in circadian rhythms and increase adenosine levels in the

TABLE 4 Factors associated with poor sleep quality among healthcare professionals working at the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia, 2020 (n = 418).

Variables	Categories	Poor sleep quality		OR (95% CI)	
		Yes	No	COR	AOR
Sex	Male Female	102 (24.4%) 144 (39.4%)	103 (24.6%) 69 (16.5%)	1 2.1 (1.4–3.1)	1 1.9 (1.2–2.9)*
Shift working	Yes No	239 (57.2%) 7 (1.7%)	146 (34.9%) 26 (6.2%)	6.1 (2.5–14.3) 1	5.7 (2.3–14.3)* 1
Current khat chewing	Yes No	38 (9.1%) 208 (49.8%)	7 (1.7%) 165 (39.5%)	4.3 (1.8–9.8) 1	3.1 (1.2–7.6)* 1
Drinking coffee	Yes No	191 (45.7%) 55 (13.2%)	115 (27.5%) 57 (13.6%)	1.7 (1.1–2.6) 1	1.2 (0.7–2.04) 1
Self-rated health	Excellent Very good Good Fair	60 (14.4%) 81 (19.4%) 80 (19.1%) 25 (6%)	59 (14.1%) 71 (17%) 40 (9.6%) 2 (0.5%)	1 1.1 (0.6–1.8) 1.9 (1.1–3.3) 12.2 (2.7–59.2)	1 0.9 (0.5–1.7) 1.3 (0.7–2.4) 1.2 (0.4–3.1)
Regular exercise	Yes No	29 (6.9%) 217 (51.9%)	47 (11.2%) 125 (29.9%)	1 2.8 (1.6–4.6)	1 2.08 (1.2–3.6)*
Depression	Normal Mild Moderate to severe	175 (41.9%) 35 (8.4%) 36 (8.6%)	148 (35.4%) 12 (2.9%) 12 (2.9%)	1 2.4 (1.23–4.92) 2.1 (0.9–4.6)	1 2.1 (0.9–4.5) 2.6 (1.3–6.8)*

COR, crude odds ratio; AOR, adjusted odds ratio.
* p ≤0.05.

body, both of which help to regulate sleep (69). Furthermore, exercise promotes the production and release of melatonin, which frequently leads to improved sleep quality (70). This indicates that regular exercise, as recommended by WHO (71), is critical for reducing not only non-communicable diseases but also sleep problems, which is why the American Sleep Disorder Association recommends physical activity as a crucial non-medicinal intervention for sleep disorders (72).

The current research found a link between sleep quality and moderate-to-severe depressive symptoms. This result is congruent with research from Turkey, Saudi Arabia, China, and Ethiopia (27, 28, 73–75). This could be because people who suffer from depression have lower melatonin production and delays in the circadian rhythm of melatonin (76, 77). Another potential explanation is that in depressed people, nocturnal melatonin release is often reduced, which may be linked to sleep disturbances (78, 79).

Limitations of the study

Our study is not free from limitations. Because the study is cross-sectional, we are unable to show a cause–effect relationship between independent variables and poor sleep quality. Additionally, we could not show the dose–response relationship between substance use and sleep quality. Another limitation of this research could be recall bias.

Conclusion

The current study found that poor sleep quality was highly prevalent among healthcare providers at the University of Gondar Comprehensive Specialized Hospital and had significant associations with sex, shift work, khat chewing, exercise, and depressive symptoms. As a result, we recommend that healthcare providers at the University of Gondar's Comprehensive and Specialized Hospital focus on early regular screening for sleep disturbances and pay special attention to shift work schedules and behaviors such as khat chewing, exercise, and depressive symptoms. Finally, we recommend other researchers perform additional investigations on factors like body mass index (BMI), sleep hygiene, and using the Internet, which have not been explored in the current research among healthcare professionals, because they have public health implications.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethical Review Board of University of Gondar. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

WT conceived the study, coordinated the process of data collection, was involved in data cleaning and statistical analysis, and prepared the first draft of the manuscript. AA, BD, AL, YA, and

YY supervised the data collection process and participated in statistical analysis and interpretation of the results, manuscript reviewing, and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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