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Detecting psychometric and diagnostic performance of the RU_SATED v2.0 multidimensional sleep health scale in community-dwelling adults combining exploratory graph analysis and ROC analysis

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ABSTRACT

Objective: The RU_SATED scale is increasingly used across the globe to measure sleep health. However, there is a lack of consensus around its psychometric and diagnostic performance. We conducted an empirical investigation into the psychometrics of the Chinese version of the RU_SATED (RU_SATED-C) scale, with a focus on structural validity and diagnostic performance.

Methods: 1171 adults were enrolled from three communities in Hangzhou, China in July 2022. The dataset was spilt in half, and we ran a bootstrapped exploratory graph analysis (bootEGA) in one half and a confirmatory factor analysis (CFA) in the other half to assess structural validity. Correlations with insomnia, wellness, anxiety, and depression symptoms were examined in order to assess concurrent validity; and Cronbach's α and McDonald's ω were calculated to assess internal consistency. Additionally, a Receiver Operating Characteristic (ROC) analysis established and externally validated the optimal score for identifying insomnia symptoms.

Results: A one-dimensional structure, as identified by bootEGA, was corroborated in the CFA [comparative fit index = 0.934, root mean square error of approximation = 0.088, standardized root mean square residual = 0.051]. A moderate correlation was shown with insomnia symptoms, while weak correlations were observed with wellness, anxiety, and depression symptoms. The RU_SATED-C scale displayed sub-optimal internal consistency where coefficients dropped if any item was removed. A recommended cutoff score of ≤13 was derived for probable insomnia with a satisfactory diagnostic performance.

Conclusion: The RU_SATED-C scale displayed a one-dimensional model, along with adequate concurrent validity, internal consistency, and diagnostic performance. Further work necessitates multi-scenario testing and additional validation using objective sleep assessments.

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List of abbreviations

AUC	Area under the curve
BMI	Body mass index
BootEGA	Bootstrapped exploratory graph analysis
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence interval
COSMIN	COnsensus-based Standards for the selection of health Measurement INstruments
DIS	Daytime Impact Subscale
GAD	Generalized Anxiety Disorder
GLASSO	Graphical least absolute shrinkage and selection operator
ICC	Intraclass correlation coefficient
MDSH	Multidimensional sleep health
PHQ	Patient Health Questionnaire
RMSEA	Root mean square error of approximation
ROC	Receiver operating characteristic
RU_SATED	Regularity, Satisfaction, Alertness, Timing, Efficiency, Duration
SCI	Sleep Condition Indicator
SPS	Sleep Pattern Subscale
SRMR	Standardized root mean square residual
STARD	Standard for Reporting of Diagnostic Accuracy
WHO-5	World Health Organization-Five Well-Being Index
WLSMV	Weighted least squares mean- and variance-adjusted estimator

1. Introduction

Sleep constitutes an essential pillar of health and wellness for individuals at all stages of life [1]. Decades of sleep research have focused on a narrow range of single sleep characteristics, sleep problems, or clinical treatments, largely centering on sleep duration, quality, or insomnia [2]. The notion of "sleep health" was initially introduced in 2014 and defined as "a multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being" [3]. In line with the World Health Organization (WHO) model, this definition places multidimensional sleep health (MDSH) as a positive and health-oriented attribute, as well as a multifaceted construct that can be quantified [3]. MDSH is gaining worldwide recognition, informing public health interventions [4–7]. A conceptualization of MDSH encourages a more holistic understanding of sleep health, where the focus is not just on the absence of sleep disorders, but pays attention to its contribution to overall well-being.

Population-based studies have highlighted associations between sleep health and numerous health-related outcomes, including mortality [8], physical activity [9], cardiometabolic outcomes [10], depression symptoms [11], mental well-being [12], and neurobehavioral symptoms and cognition [13]. Epidemiological studies [14–16] have shown that over 30 % of certain populations worldwide, limited to adults, report a sleep duration of less than 7 h a night, and up to 50 % of interviewees complain of difficulties falling or staying asleep. Healthy sleep is pivotal for public safety where an estimated one-third of motor vehicle crashes and injuries are related to sleep deprivation and fatigue [17]. There are also economic costs: the United States (US) loses approximately $411 billion per year due to insufficient sleep [18]. Unhealthy sleep also leads to higher absenteeism and lower productivity, potentially jeopardizing academic, vocational, and physical performance [19,20]. Observations in the Chinese populations, similarly, indicate a high prevalence of poor sleep quality and shorter sleep duration across various age groups [21–23]. This prevalent issue highlights the importance of addressing and implementing a coordinated approach to monitoring sleep health, promoting healthier sleep habits, and facilitating timely interventions to mitigate the detrimental effects of inadequate sleep.

Sleep health was initially conceptualized in a multidimensional framework including five characteristics: satisfaction, alertness, timing, efficiency, and duration, which have been incorporated into a self-report questionnaire—the SATED scale (v1.0) [3]. Regularity was later added to an updated six-item tool with the acronym RU_SATED (v2.0) [24]. All dimensions of the RU_SATED framework have been linked to adverse health outcomes [3]. To date, the SATED/RU_SATED scale has been validated in nine languages, including English [24], French [25], Japanese [26], Persian [27], Portuguese [28], Spanish [29], Catalan [29], simplified Chinese [30], and traditional Chinese [31]. Compared to another instrument measuring sleep health—the Sleep Health Index (SHI) [32], the RU_SATED scale covers a broader scope of sleep characteristics, but with fewer indicators of each sleep health parameter. Yet, its brevity has resulted in wide use in large epidemiological and clinical investiagations. In comparison to the RU_SATED scale, other leading measures of sleep, including the Sleep Condition Indicator (SCI) [33], Epworth Sleepiness Scale (ESS) [34], and Functional Outcomes of Sleep Questionnaire (FOSQ) [35], they either lack global dimensionality or aim to assess a particular sleep problem.

The RU_SATED scale has demonstrated reasonable reliability and validity in a variety of language versions. While the original conceptualization of MDSH was regarded as a single construct, there is no universally accepted consensus on the factor structure of the instrument. The RU_SATED scale has been recently adapted into simplified Chinese, demonstrating satisfactory measurement properties among healthcare students [30]; nevertheless, this research did not investigate the underlying factor structure and performance in diagnostic contexts. We further evaluated the measurement properties of the simplified Chinese version of the RU_SATED (RU_SATED-C) scale among a sample of community-dwelling adults. This study aimed to 1) provide additional psychometric data on the RU_SATED scale in a new sample, 2) assess the network structure and item stability using bootstrap exploratory graph analysis (bootEGA)—a novel approach estimating dimensionality and item stability of multivariate data from a psychometric network perspective [36,37], and 3) estimate diagnostic performance of the RU_SATED-C scale for identifying individuals with potential insomnia. Our findings are potentially relevant for providing support for the application of the RU_SATED scale, and in doing so, contribute to knowledge about MDSH.

2. Methods

2.1. Participants

This cross-sectional study recruited participants from three community health service centers in Hangzhou, China in July 2022. Community-dwelling residents were included if they 1) were aged 18 years and over, 2) were able to read and write in simplified Chinese, and 3) communicate in Mandarin (interviewer-administered). Participants were excluded if they 1) had difficulty understanding survey content, 2) did not finish completing the questionnaires; 3) were a current clinical diagnosis and were receiving psychological or medical treatment for any sleep disorder, including cognitive behavioral therapy for insomnia and prescription medicines (e.g., zolpidem, zaleplon, and eszopiclone), or 4) had a history of bipolar disorder, schizophrenia spectrum or other psychotic disorder, substance-related and addictive disorder, neurological diseases (e.g., cerebrovascular disease, neurodegenerative condition, and traumatic brain injury), or major physical diseases (e.g., cancer, heart disease, and acute pain). The assessment procedure and onsite quality control were meticulously performed by trained investigators following a standardized assessment protocol developed by the research team. A total of 1171 community residents completed this survey and anonymously responded to questionnaires. The sample size conformed to the recommended sample size required for the multivariate analyses proposed [38–40]: 1) ten individuals are suggested for each variable; 2) cross-validation using two separated datasets enables us to use the first dataset to establish hypotheses and the second dataset to confirm the findings; 3) a minimum of 300 respondents per subsample is recommended.

2.2. Procedures

The present study was conducted following principles outlined in the Declaration of Helsinki [41]. The research protocol was reviewed and approved by the Institutional Review Board of Hangzhou Normal University Division of Health Sciences, China (Reference No. 20190076) and School of Public Health, Hangzhou Normal University, China (Reference No. 20210014). All participants freely responded to the questionnaires and provided their informed consent prior to participation. Psychometrics and diagnostics of the RU_SATED scale were assessed adhering to checklists of the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) and Standard for Reporting of Diagnostic Accuracy (STARD) guidelines [42–45], respectively.

2.3. Measures

2.3.1. Sociodemographic variables

This study collected sociodemographic variables for all participants, including gender (male, female), age [young (18–35 years), middle-aged (36–60 years), older (> 60 years)], marital status (married, single), physical exercise [intending to improve health (yes, no)], hobby [enjoying a fixed and regular engagement in activities or projects (yes, no)], and body mass index (BMI) classification based on the WHO recommendation [underweight (BMI $\leq$ 18.5 kg/m^2), normal (18.5 < BMI < 25 kg/m^2), overweight (BMI $\geq$ 25 kg/m^2)] [46].

2.3.2. RU_SATED scale

The RU_SATED scale was used to measure individuals' MDSH levels [3,24]. The instrument consists of six items each capturing one dimension of MDSH: regularity (time to sleep and wake up per day), satisfaction (subjective assessment of sleep), alertness (ability to maintain attentive wakefulness), timing (placement of sleep within the 24-h day), efficiency (ease of falling asleep and returning to sleep), and duration (total amount of sleep obtained per 24 h). Each item is graded on five-point Likert scale from 0 (never) to 4 (always). The total score ranges from 0 to 24, with higher scores presenting better sleep health. The RU_SATED-C scale has been cross-culturally validated in a sample of healthcare students and found to have adequate measurement properties [Cronbach's α = 0.670–0.722; McDonald's ω = 0.676–0.725; comparative fit index (CFI) = 0.958–0.967, root mean square error of approximation (RMSEA) = 0.054–0.058] [30].

2.3.3. Sleep Condition Indicator

The SCI was administered for insomnia risk-screening [33,47]. This eight-item scale comprises two subscales with five items assessing Sleep Pattern (SP) and three items assessing Daytime Impact (DI), respectively. Each item is scored on a five-point Likert scale (0–4). The total score ranges from 0 to 32, with higher scores indicative of lower insomnia risk and better sleep. A cutoff score of ≤16 is proposed to indicate the presence of insomnia (sensitivity: 0.89, specificity: 0.82) [33]. The simplified Chinese version of the SCI (SCI-SC) has been used with community residents and demonstrates good measurement properties (Cronbach's α = 0.817, McDonald's ω = 0.799, CFI = 0.959, RMSEA = 0.069) [48].

2.3.4. World Health Organization-Five Well-Being Index

The World Health Organization-Five Well-Being Index (WHO-5) is a brief self-report tool to assess subjective well-being [49]. This measure is a positively phrased scale containing five items, each responded to using a six-point Likert scale (0–5). The final score was converted to a percentage scale from 0 (worst subjective well-being) to 100 (best subjective well-being). The simplified Chinese version of the WHO-5 (WHO-5-C) is available on the official website [50], and has been validated with adequate reliability and validity [Cronbach's α = 0.810–0.934, McDonald's ω = 0.820–0.935, intraclass correlation coefficient (ICC) = 0.803, CFI = 0.968–0.980] [51,52].

2.3.5. Patient Health Questionnaire-4

The Patient Health Questionnaire-4 (PHQ-4) is an ultra-brief screener designed to detect symptoms of depression and anxiety in primary care patients [53–55]. The measure consists of two subscales—the PHQ-2 for depression and the Generalized Anxiety Disorder-2 (GAD-2) for anxiety, deriving from the first two items of each of the measures PHQ-9 and GAD-7, respectively [56,57]. Each item is rated on a 4-point Likert scale ranging from 0 (not at all) to 3 (nearly every day). The total score ranges from 0 to 12 for the whole scale, and 0 to 6 for each subscale, with higher scores denoting greater symptoms of depression and anxiety. The Chinese version of the PHQ-4 (PHQ-4-C) is publicly available and has satisfactory reliability (Cronbach's α = 0.831–0.904, McDonald's ω = 0.894–0.904, ICC = 0.697) [30,58,59].

2.4. Data analysis

All statistical analyses were conducted using R (version 4.3.3). Missingness in this study ranged from 0.598 % to 3.245 % (< 5 %), and hence, mean or median scores were used to impute missing data [60,61]. Data were tested for normality before performing statistical analyses. Given the ordinal nature and non-normality of scores, differences in MDSH levels between groups were analyzed using non-parametric tests. Effect sizes were calculated using Freeman's theta coefficients to observe actual differences between groups, providing a more nuanced understanding of the observed differences [62]. The R packages used were "*ggpubr* (0.6.0)" [63], "*EGAnet* (2.0.6)" [36,37], "*lavvan* (0.6–17)" [64], "*ufs* (0.5.12)" [65], "*semTools* (0.5–6)" [66], and "*pROC* (1.18.5)" [67].

2.4.1. Structural validity

To determine and validate structural validity underlying the RU_SATED-C scale, the present study performed a bootEGA and a confirmatory factor analysis (CFA) using a split-half methodology. BootEGA is an exploratory graph analysis using network psychometrics, which can handle complex associations that factor analysis may miss particularly when there is local dependence [36,37]. It uses a community detection algorithm to reveal the dimensional structure of the scale, with bootstrapping providing confidence intervals for the dimensions, aiding the assessment of reliability and stability [36,37]. CFA then offers a confirmatory step with detailed fit indices and parameter estimates.

We first conducted bootEGA using graphical least absolute shrinkage and selection operator (GLASSO) with 1000 iterations to explore factor structure of the scale in half of the participants (N = 585). Item stability (the frequency of specific items clustering in corresponding community populations across replicated bootstrapped samples) was considered acceptable with the threshold value of ≥0.70 [36,37].

Based on the identified factor structure from bootEGA, we then conducted a CFA on the other half of sample (N = 586). Additionally, we examined the two-factor structure of the RU_SATED scale found in English (factor 1: items 2, 5, 6; factor 2: items 1, 3, 4) [24] and Japanese (factor 1: items 2, 3, 6; factor 2: items 1, 4, 5) [26] versions. A weighted least squares mean- and variance-adjusted (WLSMV) estimator was selected to accommodate categorical data [68,69]. We ascertained standard CFA goodness-of-fit indices and recommended threshold values, including chi-square (χ^2), CFI $\geq$ 0.900, RMSEA ≤0.100, and standardized root mean square residual (SRMR) $\leq$ 0.080 [70–72].

2.4.2. Concurrent validity

This study investigated concurrent validity by assessing Spearman correlations between the RU_SATED-C scale and the SCI-SC, WHO-5-C, and PHQ-4-C. Inter−item and item−total correlations were also estimated and classified as very strong (r > 0.900), strong (r = 0.700–0.900), moderate (r = 0.400–0.700), or weak (r < 0.400) [73]. We hypothesized that there would be 1) low inter−item correlations and moderate item–total correlations, as each item captures a distinct aspect of sleep, collectively constituting the construct of sleep health [3]; 2) a moderate correlation between the RU_SATED-C scale and SCI-SC given that both measures capture different aspects of sleep with related but dissimilar constructs [3]; and 3) weak correlations between the RU_SATED-C scale and the WHO-5-C and PHQ-4-C, considering associations between sleep health with mental health, whereas, their constructs are theoretically distinct [12].

2.4.3. Internal consistency

Internal consistency was used to assess relatedness of items in a scale or subscale by calculating ordinal Cronbach's α and McDonald's ω coefficients [74]. A correlation coefficient of ≥0.700 was set as the selection criterion [42]. Note that here we further tested internal consistency if any item was deleted when Cronbach's α and McDonald's ω coefficient lay within 0.600 and 0.700 [75]. If removal of a specific item resulted in a drop in Cronbach's α and McDonald's ω coefficients, it was deemed helpful and contributed to the construct's overall reliability [75].

2.4.4. Diagnostic performance

A Receiver Operating Characteristic (ROC) curve analysis was performed to determine the optimal cutoff score, sensitivity, and specificity of the RU_SATED-C scale for identifying individuals with heightened insomnia symptoms [76]. Data collected from one community was used for model development to obtain the optimal cutoff point (N = 742), while data from another two communities were applied for external validation (N = 429). The optimal cutoff on the ROC curve is located at the point nearest the upper left corner [77]. The area under the curve (AUC) ranges from 0.500 to 1.000, with a higher value accounting for better identification ability. A value of ≥0.700 was defined to reflect a sufficient diagnostic performance [42].

3. Results

3.1. Sociodemographic variables

A total of 1171 community residents were eligible (including 440 males) for inclusion in the final dataset. With a median age of 34 years, their ages ranged from 18 to 89 years. Total score distribution of the RU_SATED-C scale ranged from 3 to 24 (median = 15). Table S1 and Fig. S1 displayed participants' sleep health scores across different sociodemographic variables. MDSH levels in males were higher than females ($P < 0.05$, effect size = 0.080), and gradually increased with age ($P < 0.001$, effect size = 0.143). Additionally, those who were married and exercised presented greater MDSH levels ($P < 0.001$, effect size = 0.217; $P < 0.01$, effect size = 0.090), while underweight participants reported poorer MDSH ($P < 0.001$, effect size = 0.126). Table S2 contains further descriptive information.

3.2. Structural validity

BootEGA estimated a one-dimensional structure for the RU_SATED-C scale with an accuracy of 0.948 across 1000 bootstrap replicates (Fig. 1A). Items demonstrated high replication consistency within the identified dimension, with stability lying between the range of 0.96 to 1.00, indicating that they were adequately stable (Fig. 1B). CFA supported satisfactory fit for the one-factor structure, with fit indices indicating good model fit (CFI = 0.934, RMSEA = 0.088, SRMR = 0.051; Table 1). Furthermore, the two-factor structures found in the English and Japanese versions fit marginally better than a single-factor model, although the difference was negligible (Table 1). This suggests that while the two-factor structure may slightly better capture the data, the one-factor model remains a robust and parsimonious representation of the scale.

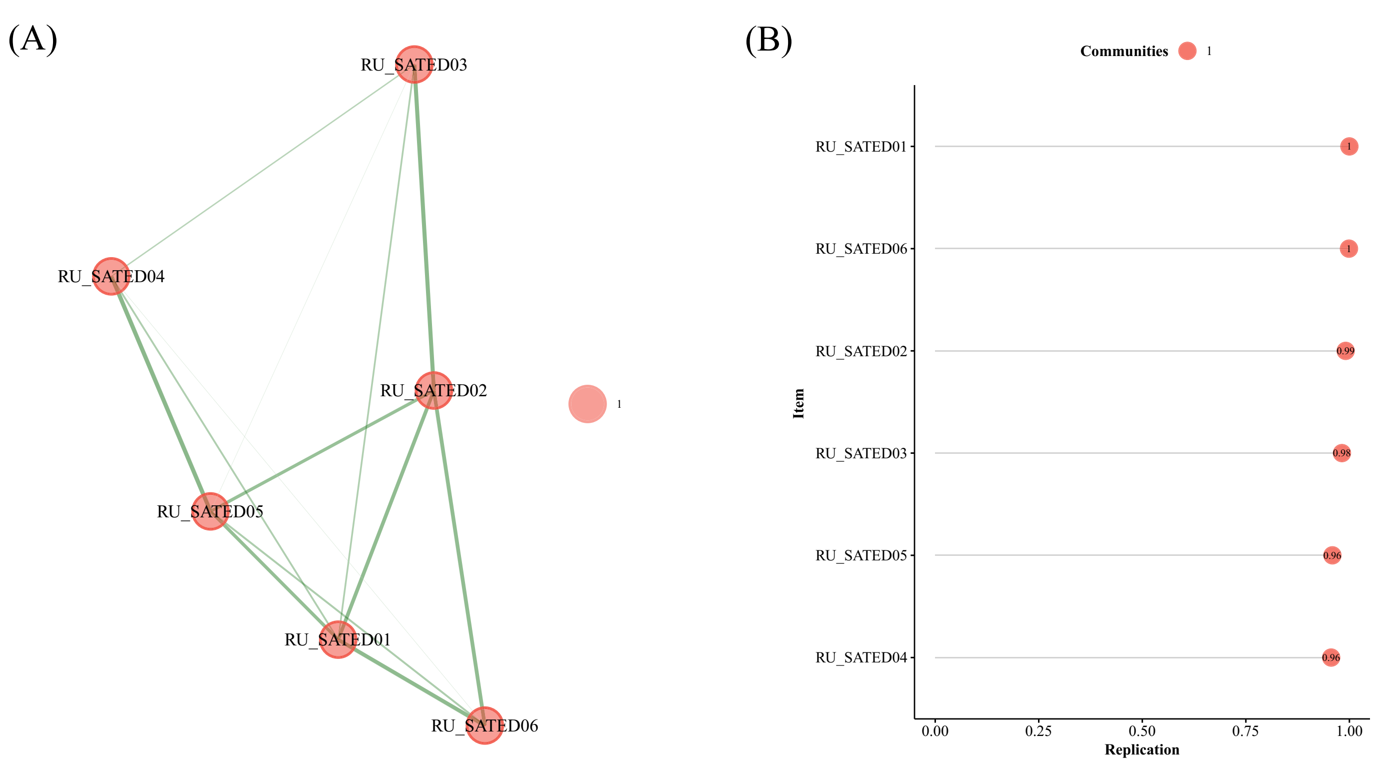

Fig. 1. Visualization of the bootEGA network and item stability on the Chinese RU_SATED scale (N = 585).
Note: BootEGA, bootstrap exploratory graph analysis; RU_SATED, Regularity, Satisfaction, Alertness, Timing, Efficiency, Duration; A presented dimensionality results while B presented item stability for bootEGA for the Chinese RU_SATED scale. Edge thickness was the degree of correlation, with positive correlations depicted as green. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Fit indices for alternative models of the Chinese RU_SATED scale ($N = 586$).

Model	$\chi^2(df)$	P	CFI	RMSEA (90 % CI)	SRMR
One-factor	49.832 (9)	< 0.001	0.934	0.088 (0.065, 0.113)	0.051
Two-factor (English)	44.221 (8)	< 0.001	0.942	0.088 (0.064, 0.114)	0.047
Two-factor (Japanese)	39.471 (8)	< 0.001	0.949	0.082 (0.058, 0.108)	0.045
Threshold	N/A	> 0.050	≥ 0.900	≤ 0.010	≤ 0.080

Note: RU_SATED, Regularity, Satisfaction, Alertness, Timing, Efficiency, Duration; χ^2, chi-square; *df*, degrees of freedom; CFI, comparative fit index; RMSEA, root mean square error of approximation; CI, confidence interval; SRMR, standardized root mean square residual; N/A, not applicable.

3.3. Concurrent validity

As depicted in Fig. S2, Spearman correlations indicated that total scores of the RU_SATED-C scale and SCI-SC were moderately correlated ($r = 0.478$). Weak correlations were observed between the RU_SATED-C scale and the WHO-5-C and PHQ-4-C ($r = 0.379$ and -0.268). Inter−item correlations of the RU_SATED-C scale ranged from 0.072 to 0.323 and coefficients for item−total correlations fell between 0.481 and 0.655. Overall, these findings were in accordance with the hypotheses.

3.4. Internal consistency

Cronbach's α and McDonald's ω for the RU_SATED-C scale were 0.660 and 0.666, respectively. There were drops in both coefficients if any item was removed (α-if-item-deleted: 0.584–0.655, ω-if-item-deleted: 0.592–0.657). In addition, adequate internal consistencies were

Table 2
External validation of the Chinese RU_SATED scale for identifying probable insomnia ($N = 429$).

RU_SATED	SCI		Total	Sensitivity	Specificity
	≤ 16	> 16			
Cutoff score: 13					
> 13	*18*	*257*	*275*		
≤ 13	*44*	*110*	*154*	*0.710*	*0.706*
Total	*62*	*367*	*429*		
Cutoff score: 14					
> 14	13	228	241		
≤ 14	49	139	88	0.790	0.621
Total	62	367	429		

Note: RU_SATED, Regularity, Satisfaction, Alertness, Timing, Efficiency, Duration; SCI, Sleep Condition Indicator; Italic fonts represented a relatively better cutoff score.

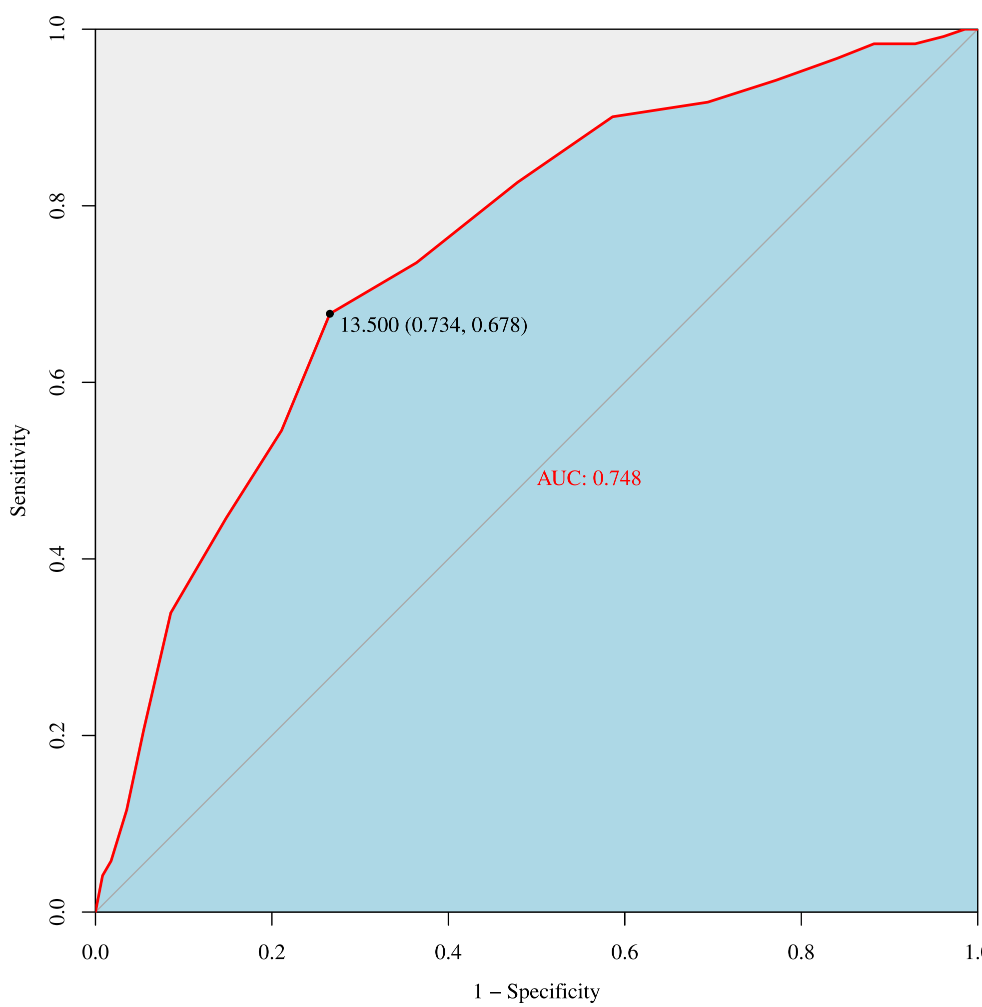

Fig. 2. ROC curve for the Chinese RU_SATED scale ($N = 742$).
Note: RU_SATED, Regularity, Satisfaction, Alertness, Timing, Efficiency, Duration; ROC, receiver operating characteristic; AUC, area under the curve.

shown in all scales and their subscales tested in the present study (Table S3).

3.5. Diagnostic performance

According to the ROC analysis (Fig. 2), a point of 13.5 on the RU_SATED-C scale was optimal to identify probable insomnia with an AUC of 0.748, maximizing sensitivity (0.678) and specificity (0.734). In order to round the cutoff value, we used a cut-off values of 13 and 14 in order to examine the ability to screen for insomnia, respectively (Table 2). The cutoff score of 13 (sensitivity: 0.710 and specificity: 0.706), validated in external samples, showed greater accuracy and balance compared to the score of 14 (sensitivity: 0.790 and specificity:0.621). We thus recommended that a cut-off of ≤13 for the RU_SATED scale was used to identify probable insomnia in a community sample.

4. Discussion

4.1. Main findings

The RU_SATED scale was originally designed to measure multiple aspects of sleep, providing a more complete picture of sleep than found using measures assessing specific aspects of sleep impairment [3]. The current study aimed to provide additional support for the psychometric performance of the RU_SATED-C scale in a community sample, investigate the factor structure of the scale, and examine its capacity for screening insomnia. The RU_SATED-C scale demonstrated a one-factor structure with adequate fit indices, concurrent validity, and internal consistency. Additionally, we identified the optimal cutoff score of ≤13 for detecting probable insomnia among Chinese community-dwelling adults.

4.2. Sociodemographic variables

In subgroup analyses, self-reported MDSH was better in males and in those who were married and exercised regularly. Conversely, individuals who were underweight reported poorer scores compared to those who were not. These findings were in line with expectations as females experience higher rates of poor sleep quality and insomnia symptoms than males [78]. Similarly, previous work has demonstrated that having a partner, being physically active, and having a normal BMI are all positively associated with heathy sleep behaviours [79]. Our findings, interestingly, corroborated the association between higher age and better MDSH level. This finding highlights an important distinction between sleep problems and sleep health given that most sleep problems get worse with age [80]. Compared to younger people, older people are generally more inclined to maintain consistent sleep schedules and derive satisfaction from the same quantity and quality of sleep [81,82].

4.3. Structural validity

Each item of the RU_SATED scale captures a unique pattern of the sleep-wakefulness cycle, collectively constituting the construct of "sleep health." These characteristics reflect different aspects of sleep, interconnected yet distinct from one another. The scale thus exhibited low inter−item correlations but revealed a single-factor structure. Overall, it appears that there is a one-factor structure of the RU_SATED scale that encompasses multidimensional aspects of sleep as a whole [3], conforming with the majority of language versions, including those published in Persian [27], Portuguese [28], Spanish [29], Catalan [29], and traditional Chinese [31]. However, there may also be distinctions between language versions—specifically, both the English [24] and Japanese [26] versions appear to fit best with a two-factor solution. Furthermore, within the French validation [25], model fit of the English two-factor model was mildly better than the one-factor structure. Similarly, we obtained negligible differences of goodness-of-fit results between the one-factor and two-factor structures. A possible reason for discrepancies across languages might be that certain aspects of health, habits, and beliefs may be influenced by socio-cultural norms, as well as economic factors [83,84]. Despite the two-factor solution showing slightly better performance, our exploratory and confirmatory factor analyses leaned towards the one-factor structure of the RU_SATED scale. Importantly, a one-dimensional structure fits well with the theoretical foundation of MDSH and previous research that views sleep health as a comprehensive construct. Nonetheless, the two-factor solution could also be considered if a more detailed dimensional structure is required, but a one-factor model remains a practical and parsimonious choice. Overall, the unidimensionality of the RU_SATED-C scale performed reasonably well in terms of structural validity.

4.4. Concurrent validity

With regard to concurrent validity, the RU_SATED-C scale was associated with the SCI-SC, WHO-5-C, and PHQ-4-C in the expected directions. Although insomnia and sleep health are distinct concepts, they are moderately linked due to their shared characteristics [3]. Consistent with our findings, the RU_SATED scale likewise showed similar associations with other insomnia scales. French [25], Japanese [26], Portuguese [28], Spanish [29], and Catalan [29] versions of the RU_SATED scale showed moderate correlations with the respective language versions of the Insomnia Severity Scale (ISI). In the cohort assessed with the Bergen Insomnia Scale (BIS), a marked change in sleep health (RU_SATED) scores was observed, suggesting a strong association between these two measurement tools [81]. It is worth noting that the relationship between sleep health and mental health (including depression, anxiety, and well-being) is often explained through the interplay and co-occurrence of sleep with mood states [85,86]. The potential associations among sleep health (RU_SATED) and both physical and mental health have also been highlighted by previous studies [29,30]. Such relationships underscored the complex interactions between sleep health, insomnia symptoms and emotional wellness, revealing how integral sleep health is to overall health.

4.5. Internal consistency

Internal consistency of the RU_SATED-C scale was sub-optimal and tended to decline with the removal of any item, emphasizing the importance of each item to the global reliability. This is consistent with historical findings among Chinese student sample [30]. The RU_SATED scale exhibited variable internal consistency across previous cross-cultural validations, with values of Cronbach's α or McDonald's ω fluctuating between 0.57 and 0.89, and nearly half of the studies indicating less-than-ideal results [24–31]. One explanation for such sub-optimal internal consistency might be the limited number of items on the scale, while another explanation might be the presence of multi-faceted components within a factor for MDSH [3,24]. Briefly, considering the multidimensional nature of sleep health and the sensitivity of internal consistency to the quantity of items, our findings illustrated an acceptable reliability for the RU_SATED-C scale.

4.6. Diagnostic performance

Insomnia has become a major public health concern, with gradually increasing prevalence. Approximately 10–15 % of the general population suffer long-term insomnia while around 25–35 % experience transient or occasional complaints [87–90]. Hence, analyzing potential links between sleep health and insomnia symptoms, as well as identifying high-risk individuals holds considerable implications for population health. Based on ROC analysis, we recommended the cutoff score of ≤13 for the RU_SATED-C scale to screen for probable insomnia. This study is one of few to examine the diagnostic performance of the RU_SATED scale. In a European population, the SATED scale was compared with sleep duration in evaluating self-rated health status with an AUC of 0.856 [82]. This evidence further substantiated the effectiveness of MDSH as a holistic framework for predicting health-related outcomes. Collectively, as a positive and health-oriented approach, the RU_SATED scale has the potential to facilitate early detection, inform targeted interventions, and promote the development of strategies aimed at mitigating the impact of insomnia symptoms on individuals and communities.

4.7. Contributions and future directions

The present study explored the psychometric properties of the RU_SATED-C scale among a broad community-based sample. It is the first study, to our knowledge, to investigate structural validity of the RU_SATED scale using both network and factor analytic psychometrics. The complementary approaches can contribute to a more nuanced understanding of the structure of the scale. Additionally, we pioneered an assessment of the RU_SATED-C scale's capacity to identify people with elevated insomnia symptoms and suggested a cutoff for probable insomnia across the globe. Adopting a positive and comprehensive viewpoint centered around MDSH might be more conducive for insomnia identification in public health. Our findings fill gaps and address discrepancies in research literature regarding the psychometric and diagnostic performance of the RU_SATED scale.

Several considerations need to be incorporated into future directions. First, the sample contained a high proportion of females, which might have influenced the response patterns observed in the data. Second, data were collected using a cross-sectional design, precluding the possibility of performing test–retest analyses, of exploring change in individual MDSH levels over time, but also of providing results generalizable to a nationwide setting. Third, all variables were self-reported, and therefore, responses regarding sleep, mental, and physical health could be subject to reporter bias. Fourth, insomnia was assessed using the SCI rather than a diagnostic interview, as such the diagnostic utility should be explored in future studies. Future work would benefit from utilising a longitudinal design using multi-trait, multi-occasion, and multimethod frameworks to evaluate the RU_SATED scale. We encourage data collection using objective methods (e.g., polysomnography, actigraphy), physician interviews, and other currently validated tools for measuring MDSH (e.g., the SHI).

5. Conclusion

At the 10th anniversary of the publication of the RU_SATED scale and framework, our analyses revealed that the instrument presented sound and reliable measurement properties among a Chinese community-based cohort. The current study supported a one-factor structure for the RU_SATED-C scale and derived a cutoff value of $\leq$13 to identify people with probable insomnia. Our findings contribute to the ongoing development of the MDSH model, add to emerging evidence supporting the conceptualization of sleep health, and call for action to drive implementation of sleep health policies.

Data statement

Anyone interested in using the formatted RU_SATED-C scale and its scoring rubric should be directed to the corresponding author. All rights related to the RU_SATED-C scale are reserved by the University of Pittsburgh. The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Ethical approval

The research protocol was reviewed and approved by the Institutional Review Board of Hangzhou Normal University Division of Health Sciences, China (Reference No. 20190076) and School of Public Health, Hangzhou Normal University, China (Reference No. 20210014). All participants freely responded to the questionnaires and provided their informed consents prior to participation.

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CRediT authorship contribution statement

Runtang Meng: Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization, Writing – review & editing, Writing – original draft. **Nongnong Yang:** Visualization, Validation, Software, Methodology, Formal analysis, Writing – review & editing, Writing – original draft. **Yi Luo:** Validation, Resources, Writing – review & editing. **Ciarán O'Driscoll:** Validation, Methodology, Writing – review & editing. **Haiyan Ma:** Validation, Resources, Writing – review & editing. **Alice M. Gregory:** Validation, Methodology, Writing – review & editing. **Joseph M. Dzierzewski:** Validation, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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References

[1] World Health Organization. Division of Mental, Health Prevention of Substance, abuse world federation of sleep research, societies. Worldwide project on sleep and health: Project overview. Geneva: World Health Organization; 1998.
[2] Pavlova MK, Latreille V. Sleep disorders. Am J Med 2019;132:292–9. https://doi.org/10.1016/j.amjmed.2018.09.021.
[3] Buysse DJ. Sleep health: Can we define it? Does it matter? Sleep 2014;37:9–17. https://doi.org/10.5665/sleep.3298.
[4] Chaput J-P, Gariépy G, Pendharkar SR, Ayas NT, Samuels C, Vallières A, et al. National strategy on the integration of sleep and circadian rhythms into public health research and policies: Report from the Canadian sleep and circadian network. Sleep Health 2022;8:551–63. https://doi.org/10.1016/j.sleh.2022.06.005.
[5] Meltzer LJ, Williamson AA, Mindell JA. Pediatric sleep health: It matters, and so does how we define it. Sleep Med Rev 2021;57:101425. https://doi.org/10.1016/j.smrv.2021.101425.
[6] Hall WA, Keys E, Ou C. A call to action about nurses promoting healthy sleep. Sleep Med 2023;108:53–4. https://doi.org/10.1016/j.sleep.2023.05.012.

[7] Chaput J-P. The integration of pediatric sleep health into public health in Canada. Sleep Med 2019;56:4–8. https://doi.org/10.1016/j.sleep.2018.06.009.
[8] Wallace ML, Stone K, Smagula SF, Hall MH, Simsek B, Kado DM, et al. Which sleep health characteristics predict all-cause mortality in older men? An application of flexible multivariable approaches. Sleep 2018;41. https://doi.org/10.1093/sleep/zsx189. zsx189.
[9] Kubala AG, Buysse DJ, Brindle RC, Krafty RT, Thayer JF, Hall MH, et al. The association between physical activity and a composite measure of sleep health. Sleep Breath 2020;24:1207–14. https://doi.org/10.1007/s11325-019-02007-x.
[10] Brindle RC, Yu L, Buysse DJ, Hall MH. Empirical derivation of cutoff values for the sleep health metric and its relationship to cardiometabolic morbidity: Results from the midlife in the united states (MIDUS) study. Sleep 2019;42. https://doi.org/10.1093/sleep/zsz116. zsz116.
[11] Barham WT, Buysse DJ, Kline CE, Kubala AG, Brindle RC. Sleep health mediates the relationship between physical activity and depression symptoms. Sleep Breath 2022;26:1341–9. https://doi.org/10.1007/s11325-021-02496-9.
[12] Appleton SL, Melaku YA, Reynolds AC, Gill TK, de Batlle J, Adams RJ. Multidimensional sleep health is associated with mental well-being in Australian adults. J Sleep Res 2022;31. https://doi.org/10.1111/jsr.13477. e13477.
[13] O'Hora KP, Zhang Z, Vajdi A, Kushan-Wells L, Huang ZS, Pacheco-Hansen L, et al. Neurobehavioral dimensions of Prader Willi Syndrome: Relationships between sleep and psychosis-risk symptoms. Front Psychiatry 2022;13:868536. https://doi.org/10.3389/fpsyt.2022.868536.
[14] Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, et al. Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: Methodology and discussion. J Clin Sleep Med 2015;11:931–52. https://doi.org/10.5664/jcsm.4950.
[15] Kerkhof GA. Epidemiology of sleep and sleep disorders in the Netherlands. Sleep Med 2017;30:229–39. https://doi.org/10.1016/j.sleep.2016.09.015.
[16] Chaput JP, Wong SL, Michaud I. Duration and quality of sleep among Canadians aged 18 to 79. Health Rep 2017;28:28–33.
[17] Czeisler CA, Wickwire EM, Barger LK, Dement WC, Gamble K, Hartenbaum N, et al. Sleep-deprived motor vehicle operators are unfit to drive: A multidisciplinary expert consensus statement on drowsy driving. Sleep Health 2016;2:94–9. https://doi.org/10.1016/j.sleh.2016.04.003.
[18] Hafner M, Stepanek M, Taylor J, Troxel WM, Van Stolk C. Why sleep matters — the economic costs of insufficient sleep: A cross-country comparative analysis. Santa Monica, CA: RAND Corporation; 2016.
[19] Atoui S, Chevance G, Romain A-J, Kingsbury C, Lachance J-P, Bernard P. Daily associations between sleep and physical activity: A systematic review and meta-analysis. Sleep Med Rev 2021;57:101426. https://doi.org/10.1016/j.smrv.2021.101426.
[20] Musshafen LA, Tyrone RS, Abdelaziz A, Sims-Gomillia CE, Pongetti LS, Teng F, et al. Associations between sleep and academic performance in us adolescents: A systematic review and meta-analysis. Sleep Med 2021;83:71–82. https://doi.org/10.1016/j.sleep.2021.04.015.
[21] Tao ZH, Feng YT, Liu J, Tao LY. Trends and disparities in sleep quality and duration in older adults in China from 2008 to 2018: A national observational study. Front Public Health 2023;11:998699. https://doi.org/10.3389/fpubh.2023.998699.
[22] Li L, Lok K-I, Mei S-L, Cui X-L, Li L, Ng CH, et al. Sleep duration and self-rated health in Chinese university students. Sleep Breath 2019;23:1351–6. https://doi.org/10.1007/s11325-019-01856-w.
[23] Wu R, Wang GH, Zhu H, Jiang F, Jiang CL. Sleep patterns in Chinese preschool children: A population-based study. J Clin Sleep Med 2018;14:533–40. https://doi.org/10.5664/jcsm.7038.
[24] Ravyts SG, Dzierzewski JM, Perez E, Donovan EK, Dautovich ND. Sleep health as measured by RU SATED: A psychometric evaluation. Behav Sleep Med 2019;19:48–56. https://doi.org/10.1080/15402002.2019.1701474.
[25] Coelho J, Lopez R, Richaud A, Buysse DJ, Wallace ML, Philip P, et al. Toward a multi-lingual diagnostic tool for the worldwide problem of sleep health: The French RU-SATED validation. J Psychiatr Res 2021;143:341–9. https://doi.org/10.1016/j.jpsychires.2021.09.008.
[26] Furihata R, Tateyama Y, Nakagami Y, Akahoshi T, Itani O, Kaneita Y, et al. The validity and reliability of the Japanese version of RU-SATED. Sleep Med 2022;91:109–14. https://doi.org/10.1016/j.sleep.2022.02.014.
[27] Nooshin P, Seyede Maryam Akbari K, Mohammad Reza B, Sadaf K. Factor analysis and validation of sleep health scale in nursing context. J Sleep Sci 2020;4:63–8.
[28] Brandolim Becker N, Martins RIS, Jesus SdN, Chiodelli R, Stephen Rieber M. Sleep health assessment: A scale validation. Psychiatry Res 2018;259:51–5. https://doi.org/10.1016/j.psychres.2017.10.014.
[29] Benítez I, Roure N, Pinilla L, Sapiña-Beltran E, Buysse DJ, Barbé F, et al. Validation of the satisfaction, alertness, timing, efficiency and duration (SATED) questionnaire for sleep health measurement. Ann Am Thoracic Soc 2020;17:338–43. https://doi.org/10.1513/AnnalsATS.201908-628OC.
[30] Meng R, Dong L, Dzierzewski JM, Mastrotheodoros S, Cao M, Yu B, et al. The RU_SATED as a measure of sleep health: Cross-cultural adaptation and validation in Chinese healthcare students. BMC Psychol 2023;11:200. https://doi.org/10.1186/s40359-023-01203-5.
[31] Cheng H-J, Chen Y-C, Lee S-C, Huang Y-H, Yeh S-T, Chen H-F, et al. Development and validation of SATED sleep health assessment scale-Chinese version (SATED-TW). Taiwan Gong Gong Wei Sheng Za Zhi 2023;42:494–505.
[32] Knutson KL, Phelan J, Paskow MJ, Roach A, Whiton K, Langer G, et al. The National Sleep Foundation's Sleep Health Index. Sleep Health 2017;3:234–40. https://doi.org/10.1016/j.sleh.2017.05.011.
[33] Colin AE, Simon DK, Peter H, Maria G, Leanne F, John C. The Sleep Condition Indicator: A clinical screening tool to evaluate insomnia disorder. BMJ Open 2014;4:e004183. https://doi.org/10.1136/bmjopen-2013-004183.
[34] Johns MW. A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. Sleep 1991;14:540–5. https://doi.org/10.1093/sleep/14.6.540.
[35] Weaver TE, Laizner AM, Evans LK, Maislin G, Chugh DK, Lyon K, et al. An instrument to measure functional status outcomes for disorders of excessive sleepiness. Sleep 1997;20:835–43.
[36] Golino HF, Epskamp S. Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research. PLoS One 2017;12:e0174035. https://doi.org/10.1371/journal.pone.0174035.
[37] Christensen AP, Golino H. Estimating the stability of psychological dimensions via bootstrap exploratory graph analysis: A monte carlo simulation and tutorial. Psych 2021;3:479–500. https://doi.org/10.3390/psych3030032.
[38] Everitt BS. Multivariate analysis: The need for data, and other problems. Br J Psychiatry 1975;126:237–40. https://doi.org/10.1192/bjp.126.3.237.
[39] Clark LA, Watson D. Constructing validity: New developments in creating objective measuring instruments. Psychol Assess 2019;31:1412–27. https://doi.org/10.1037/pas0000626.
[40] Stone M. Cross-validatory choice and assessment of statistical predictions. J R Stat Soc Ser B Methodol 1974;36:111–33. https://doi.org/10.1111/j.2517-6161.1974.tb00994.x.
[41] World Medical Association. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. JAMA 2013;310:2191–4. https://doi.org/10.1001/jama.2013.281053.
[42] Prinsen CAC, Mokkink LB, Bouter LM, Alonso J, Patrick DL, de Vet HCW, et al. COSMIN guideline for systematic reviews of patient-reported outcome measures. Qual Life Res 2018;27:1147–57. https://doi.org/10.1007/s11136-018-1798-3.
[43] Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, et al. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. J Clin Epidemiol 2010;63:737–45. https://doi.org/10.1016/j.jclinepi.2010.02.006.
[44] Mokkink LB, de Vet HCW, Prinsen CAC, Patrick DL, Alonso J, Bouter LM, et al. COSMIN risk of bias checklist for systematic reviews of patient-reported outcome measures. Qual Life Res 2018;27:1171–9. https://doi.org/10.1007/s11136-017-1765-4.
[45] Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig L, et al. STARD 2015: An updated list of essential items for reporting diagnostic accuracy studies. Radiology 2015;277:826–32. https://doi.org/10.1148/radiol.2015151516.
[46] World Health Organization. A Healthy Lifestyle–WHO Recommendations. https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle—who-recommendations; 2010.
[47] Wong ML, Lau KNT, Espie CA, Luik AI, Kyle SD, Lau EYY. Psychometric properties of the Sleep Condition Indicator and Insomnia Severity Index in the evaluation of insomnia disorder. Sleep Med 2017;33:76–81. https://doi.org/10.1016/j.sleep.2016.05.019.
[48] Meng RT, Lau EYY, Spruyt K, Miller CB, Dong L. Assessing measurement properties of a simplified Chinese version of Sleep Condition Indicator (SCI-SC) in community residents. Behav Sci 2022;12:433. https://doi.org/10.3390/bs12110433.
[49] World Health Organization. Regional Office for Europe. Wellbeing measures in primary health care/the depcare project: Report on a WHO meeting: Stockholm, sweden, 12–13 february 1998. World Health Organization. Regional Office for Europe; 1998. https://iris.who.int/handle/10665/349766.
[50] Psychiatric Research Unit, WHO Collaborating Center for Mental Health. The Chinese version of the WHO (five) in characters used in PR China. https://www.psykiatri-regionh.dk/who-5/Documents/WHO5_Chinese_PR.pdf; 2021. Accessed 30 January.
[51] Yang NN, Ma HY, Huang MY, Lau EYY, Fong DYT, Wang M, et al. Measurement properties and optimal cutoff point of the WHO-5 among Chinese healthcare students. Psychol Res Behav Manag 2023;16:5141–58. https://doi.org/10.2147/prbm.S437219.
[52] Fung S-F, Kong CYW, Liu Y-M, Huang Q, Xiong Z, Jiang Z, et al. Validity and psychometric evaluation of the Chinese version of the 5-item WHO well-being index. Front Public Health 2022;10:872436. https://doi.org/10.3389/fpubh.2022.872436.
[53] Instructions for Patient Health Questionnaire (PHQ) and GAD-7 measures. https://www.phqscreeners.com/; 2021. Accessed January 30.
[54] Löwe B, Wahl I, Rose M, Spitzer C, Glaesmer H, Wingenfeld K, et al. A 4-item measure of depression and anxiety: Validation and standardization of the Patient Health Questionnaire-4 (PHQ-4) in the general population. J Affect Disord 2010;122:86–95. https://doi.org/10.1016/j.jad.2009.06.019.
[55] Kroenke K, Spitzer RL, Williams JB, Löwe B. An ultra-brief screening scale for anxiety and depression: The PHQ-4. Psychosomatics 2009;50:613–21. https://doi.org/10.1176/appi.psy.50.6.613.
[56] Kroenke K, Spitzer RL, Williams JB. The Patient Health Questionnaire-2: Validity of a two-item depression screener. Med Care 2003;41:1284–92. https://doi.org/10.1097/01.Mlr.0000093487.78664.3c.
[57] Sapra A, Bhandari P, Sharma S, Chanpura T, Lopp L. Using Generalized Anxiety Disorder-2 (GAD-2) and GAD-7 in a primary care setting. Cureus J Med Sci 2020;12:e8224. https://doi.org/10.7759/cureus.8224.
[58] Huang MY, Ma HY, Spruyt K, Dzierzewski JM, Jiang C, He JX, et al. Assessing psychometric properties and measurement invariance of the Sleep Quality Questionnaire among healthcare students. BMC Psychol 2024;12:41. https://doi.org/10.1186/s40359-023-01276-2.

[59] Luo Y, Fei SD, Gong BX, Sun TD, Meng RT. Understanding the mediating role of anxiety and depression on the relationship between perceived stress and sleep quality among health care workers in the COVID-19 response. Nat Sci Sleep 2021; 13:1747–58. https://doi.org/10.2147/nss.S313258.

[60] Dziura JD, Post LA, Zhao Q, Fu Z, Peduzzi P. Strategies for dealing with missing data in clinical trials: From design to analysis. Yale J Biol Med 2013;86:343–58. http://medicine.yale.edu/yjbm/.

[61] Kline RB. Principles and practice of structural equation modeling. 4th ed. New York, NY, US: Guilford Press; 2016.

[62] Agresti A. Measures of nominal-ordinal association. J Am Stat Assoc 1981;76: 524–9. https://doi.org/10.1080/01621459.1981.10477679.

[63] Kassambara A. ggpubr: 'ggplot2' based publication ready plots. https://cran.r-project.org/web/packages/ggpubr/ggpubr.pdf; 2024.

[64] Rosseel Y. Lavaan: An R package for structural equation modeling. J Stat Softw 2012;48:1–36.

[65] Peters G-J. A collection of utilities. R package version 0.5.12. https://cran.r-project.org/web/packages/ufs/ufs.pdf; 2024.

[66] Jorgensen TD, Pornprasertmanit S, Schoemann AM, Rosseel Y, Miller P, Quick C, et al. Useful tools for structural equation modeling. R package version 0.5–6. https://cran.r-project.org/web/packages/semTools/semTools.pdf; 2024.

[67] Sachs MC. plotROC: A tool for plotting ROC curves. J Stat Softw 2017;79:2. https://doi.org/10.18637/jss.v079.c02.

[68] DiStefano C, Morgan GB. A comparison of diagonal weighted least squares robust estimation techniques for ordinal data. Struct Equ Model Multidiscip J 2014;21: 425–38. https://doi.org/10.1080/10705511.2014.915373.

[69] Flora DB, Curran PJ. An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. Psychol Methods 2004;9: 466–91. https://doi.org/10.1037/1082-989X.9.4.466.

[70] Quintana SM, Maxwell SE. Implications of recent developments in structural equation modeling for counseling psychology. Couns Psychol 1999;27:485–527. https://doi.org/10.1177/0011000099274002.

[71] Browne MW, Cudeck R. Alternative ways of assessing model fit. Sociol Methods Res 1992;21:230–58. https://doi.org/10.1177/0049124192021002005.

[72] Lt Hu, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Model Multidiscip J 1999;6:1–55. https://doi.org/10.1080/10705519909540118.

[73] Schober P, Boer C, Schwarte LA. Correlation coefficients: Appropriate use and interpretation. Anesth Analg 2018;126:1763–8. https://doi.org/10.1213/ANE.0000000000002864.

[74] Revelle W, Condon DM. Reliability from α to ω: A tutorial. Psychol Assess 2019;31: 1395–411. https://doi.org/10.1037/pas0000754.

[75] Hajjar S. Statistical analysis: Internal-consistency reliability and construct validity. Int J Quantitat Qualitat Res Methods 2018;6:27–38.

[76] Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology 1982;143:29–36. https://doi.org/10.1148/radiology.143.1.7063747.

[77] Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: A fundamental evaluation tool in clinical medicine. Clin Chem 1993;39:561–77. https://doi.org/10.1093/clinchem/39.4.561.

[78] Ohayon MM. Epidemiology of insomnia: What we know and what we still need to learn. Sleep Med Rev 2002;6:97–111. https://doi.org/10.1053/smrv.2002.0186.

[79] Luik AI, Zuurbier LA, Hofman A, Van Someren EJW, Tiemeier H. Stability and fragmentation of the activity rhythm across the sleep-wake cycle: The importance of age, lifestyle, and mental health. Chronobiol Int 2013;30:1223–30. https://doi.org/10.3109/07420528.2013.813528.

[80] Gulia KK, Kumar VM. Sleep disorders in the elderly: A growing challenge. Psychogeriatrics 2018;18:155–65. https://doi.org/10.1111/psyg.12319.

[81] Bjorvatn B, Waage S, Pallesen S, Buysse DJ, Saxvig IW. The association between different sleep health dimensions and sex, age, education, circadian preference, and chronic insomnia: A representative population-based study. Sleep Adv 2023;4. https://doi.org/10.1093/sleepadvances/zpad041. zpad041.

[82] Dalmases M, Benítez ID, Mas A, Garcia-Codina O, Medina-Bustos A, Escarrabill J, et al. Assessing sleep health in a european population: Results of the catalan health survey 2015. PLoS One 2018;13:e0194495. https://doi.org/10.1371/journal.pone.0194495.

[83] Hale L, Do DP. Racial differences in self-reports of sleep duration in a population-based study. Sleep 2007;30:1096–103. https://doi.org/10.1093/sleep/30.9.1096.

[84] Jeon M, Dimitriou D, Halstead EJ. A systematic review on cross-cultural comparative studies of sleep in young populations: The roles of cultural factors. Int J Environ Res Public Health 2021:18. https://doi.org/10.3390/ijerph18042005.

[85] Dong L, Martinez AJ, Buysse DJ, Harvey AG. A composite measure of sleep health predicts concurrent mental and physical health outcomes in adolescents prone to eveningness. Sleep Health 2019;5:166–74. https://doi.org/10.1016/j.sleh.2018.11.009.

[86] Furihata R, Hall MH, Stone KL, Ancoli-Israel S, Smagula SF, Cauley JA, et al. An aggregate measure of sleep health is associated with prevalent and incident clinically significant depression symptoms among community-dwelling older women. Sleep 2017;40. https://doi.org/10.1093/sleep/zsw075. zsw075.

[87] Schutte-Rodin S, Broch L, Buysse D, Dorsey C, Sateia M. Clinical guideline for the evaluation and management of chronic insomnia in adults. J Clin Sleep Med 2008; 4:487–504.

[88] Pallesen S, Sivertsen B, Nordhus IH, Bjorvatn B. A 10-year trend of insomnia prevalence in the adult norwegian population. Sleep Med 2014;15:173–9. https://doi.org/10.1016/j.sleep.2013.10.009.

[89] Morin CM, Jarrin DC. Epidemiology of insomnia: Prevalence, course, risk factors, and public health burden. Sleep Med Clin 2022;17:173–91. https://doi.org/10.1016/j.jsmc.2022.03.003.

[90] Wang C, Deng C, Han Q, Zhu DL, Li ZM, Li J. Pharmacological and non-pharmacological treatments for insomnia: A protocol for a systematic review and network meta-analysis. Medicine 2021;100:e26678. https://doi.org/10.1097/MD.0000000000026678.