



Latent profile of the insomnia severity index: A longitudinal study

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ABSTRACT

Study objectives: To identify the distinct classification of insomnia symptoms and to explore their association with sleep problems and depression.

Methods: Latent profile analysis was used to examine patterns of insomnia symptoms in two samples. Discovery and replication samples comprised 1043 (Mean age at baseline = 18.95 ± 0.93 years, 62.2% females) and 729 (Mean age at baseline = 18.71 ± 1.02 years, 66.4% females) college students, respectively. Participants completed measures of sleep problems (insomnia symptoms, sleep quality, susceptibility to insomnia, perceived consequences of insomnia, dream recall frequency, and percentage of recurring nightmares) and other psychological variables (rumination and depression). Binary logistic regression was used to analyze the effects of different types of insomnia symptoms at baseline on sleep problems and depression two years later.

Results: Four classes of insomnia symptoms were identified, and classified as “non-insomnia” (class 1, 45.7%), “mild subjective symptoms but severe subjective feelings” (class 2, 23.9%), “severe subjective symptoms but mild subjective feelings” (class 3, 22.0%), and “high insomnia risk” (class 4, 8.4%), respectively. Compared with the group classified as non-insomnia group, other classifications significantly predicted insomnia two years later, only class 4 significantly predicted depression, and class 3 significantly predicted susceptibility to insomnia, after adjusting gender, insomnia, depression, and susceptibility to insomnia at baseline.

Conclusions: The findings highlighted the importance of identifying the patterns of insomnia symptoms, and the need for tailored intervention to improve sleep problems. Additionally, when screening for insomnia symptoms, simplified screening using Insomnia Severity Index (ISI) dimensions or items should be considered.

1. Introduction

Insomnia is one of the most prevalent sleep disorders with an average prevalence rate of 10% [1,2] and is characterized by a high intensity of phenotypic heterogeneity that may influence treatment response [3]. Insomnia is a big public health problem due to associated adverse health outcomes and its subsequent impairments [4,5]. It is worth noting that college students, as one of the most sleep-deprived groups, are particularly vulnerable to disturbed sleep. One systematic review showed that the total number of university students' study with a weighted mean insomnia prevalence of 18.5%, which emphasizes that insomnia prevalence in them is considerably higher than that in the general population [6]. Also, insomnia symptoms have been prevalent among undergraduate students during the COVID-19 pandemic [7]. Therefore, more attention should be paid to insomnia in university students. Early recognition of insomnia symptoms is critical for the prevention of such adverse long-term outcomes.

The identification of insomnia phenotypes is still a work in progress and is an important trend in contemporary insomnia research [8–10]. In this context, the use of person-centered methods, such as latent class analysis (LCA) and latent profile analysis (LPA), to assess structure of psychopathology, enable a more precise understanding of symptom presentation, and is ideal for psychopathological research [11]. A growing number of studies attempted to explore subtype insomniac populations using bottom-up, data-driven methods such as latent class analysis and latent profile analysis attempting to find the roles of diverse factors in determining the presentation and severity of insomnia [12–14]. In addition to cluster analysis of objective sleep parameters [15], the addition of subjective measures and repeated validation also helped to identify subtypes of insomnia [8,12]. For instance, Yue et al. [16] identified three classes of sleep problems in adolescents, named “short and disturbed sleep”, “no post-lunch napping” and “no/mild sleep disturbance”, and also used repeated LCA among an independent sample, where it was shown that a similar three-class model fitted the data

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best. Latent class/profile models can be influenced by the response of specific sample patterns, so it is important to attempt to replicate these findings in an independent sample to increase confidence in the results.

The Insomnia Severity Index (ISI) and Pittsburgh Sleep Index (PSQI) are widely used as screening tools for sleep disorders [17,18]. The PSQI primarily assesses sleep quality in the general population and it does not fully meet diagnostic criteria for insomnia, nor does it target the degree of disability or mental distress associated with insomnia. In contrast, the ISI is primarily used in clinical research, covering the subjective consequences of insomnia and the degree of worry and distress caused by these difficulties. In addition, its contents partially meet the diagnostic criteria for insomnia [19]. Specifically, the ISI is a brief self-report instrument, measuring seven items including the severity of sleep onset, sleep maintenance, early morning awakening, satisfaction with current sleep patterns, interference with daily functioning, and noticeability of impairment attributed to the sleep problems. Recently, the ISI has been a reliable and valid measure of insomnia symptoms among general adults in different countries [6,20]. Therefore, given its usefulness and applicability to routine assessments, subtypes identified by ISI component scores may be helpful for clinical practice in community settings. Although recent studies used the Pittsburgh Sleep Quality Index (PSQI) to identify subtypes of sleep quality and insomnia symptoms in college students [13,14], the extent of impairment or distress associated with insomnia was not specifically assessed, and results lacked independent sample validation. Additionally, the heterogeneity of insomnia symptoms for college students has only been scarcely explored [13,14,21,22] and few studies reviewed thoroughly explored insomnia symptoms as measured by the Insomnia Severity Index to characterize insomnia. Only one study determined empirically-based ISI profiles in veterans with obstructive sleep apnea, named the “asymptomatic” profile, “moderate insomnia” profile, and “severe insomnia” profile [23]. An experience-driven approach to ISI response patterns may yield new information about insomnia symptoms in individuals. Therefore, it was necessary to confirm heterogeneous patterns of insomnia symptoms by using ISI in a study among college students. The first aim of this study was to explore the heterogeneity of insomnia symptoms in college students through different performances of individuals in specific items of ISI.

It is vital to maintain track of different types of insomnia symptoms to predict health-related anomalies. Therefore, studies examining different profiles of insomnia symptoms should also assess whether such profiles differentially predict mental health outcomes. As suggested by prior studies, insomnia symptoms appear to be more than just symptoms of physical or mental illness but might be more predictive of chronic mental health symptoms [24]. Therefore, to explore, whether different subtypes of insomnia symptoms bring different risks for sleep and depression with them, was the third aim of this study. By comparing the effects of different insomnia symptom categories on sleep and depression, it is possible to target sleep and behavioral interventions at subtypes with a higher risk of developing problems. Collectively, there are three main aims of the study. First, this study aims to identify the heterogeneity differences in insomnia symptoms among college students by using LPA. Second, whether the results of the latent profile of insomnia symptoms can be validated in an independent, homogeneous sample. Finally, it explores whether different profiles of insomnia symptoms have different effects on sleep problems and depression after two years. We anticipated that there are different predictive roles of insomnia profiles on sleep problems and depression.

2. Methods

2.1. Participants and procedure

The data used in this study came from the ongoing the Behavioral Brain Research Project of Chinese Personality (BBP) project [25], which was approved by the institutional review board (IRB) at the Faculty of

Psychology in Southwest University (H20059). All participants signed informed consent forms after having been informed of all the details of the study and received financial compensation after participation in the study. All participants completed a set of self-report online questionnaires between September 2019 and July 2023. This was a two-wave design with an interval between waves of 24 months. College freshmen in the class of 2019 ($n = 1043$) and class of 2020 ($n = 729$) completed the baseline survey in 2019 and 2020 (Time 1, T1), respectively. Of the 1043 initial participants, 559 participated in the follow-up survey after 2 years (Time 2, T2), of which 435 were classified as valid subjects. (effective response rate of 41.7%). In this study, we included a discovery sample (the class of 2019 college freshmen) and a replication cohort (the class of 2020 college freshmen). All participants provided written informed consent after receiving a detailed explanation of the study. Participants were allowed to withdraw from the study at any time.

2.2. Measures

2.2.1. Subjective insomnia symptoms and subjective feelings

The Insomnia Severity Index (ISI) consists of seven items and evaluates the perceived severity of insomnia over the past 2 weeks of symptoms on a five-point Likert scale [19]. Items are scored using a Likert-type scale with 5 response options (0 = not at all to 4 = very much). The total score range ranges from zero to 28, in which a higher score indicates more severe insomnia. A 10-point cut-off was used to define participants who had insomnia [26,27]. The first three items measure insomnia severity including difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS), and early morning awakening (EMA), while the last four items assess sleep satisfaction, noticeability of the sleep problems to others, worry about the sleep problems, and sleep problems interference with daily functioning. The Chinese version of the ISI has been validated showing good reliability and validity [28]. In this part of the study, Cronbach's alphas were 0.79 (T1) and 0.79 (T2).

2.2.2. Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was used to assess adolescents' overall sleep quality during the past month [17]. The Chinese version of PSQI has been widely used and was shown to have good psychometric properties [29]. The scale includes seven subscales including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Scores from subscales were summed up to a total score ranging from 0 to 21, with higher scores indicating poorer sleep quality. In this part of the study, Cronbach's alpha was 0.57 (T1) and 0.64 (T2).

2.2.3. Depression

The Self-rating Depression Scale (SDS) consists of 20 items and is a 4-point Likert scale used to assess an individual's mood symptoms over the past week [30]. The total score is obtained by adding up the scores of the 20 items. The Chinese version of the SDS has shown good psychometric properties in previous studies [31,32]. According to the Chinese norm, the cut-off value of the SDS standard score is 53 points, of which 53–62 is classified as mild depression, 63–72 is classified as moderate depression, and 73 and above as severe depression. In the study, Cronbach's alpha was 0.82 (T1) and 0.85 (T2).

2.2.4. Susceptibility to insomnia

The Ford Insomnia Response to Stress Test (First) is a 9-item self-reported measure of trait sleep reactivity from exposure to daily stressors [33]. The total score is the sum of all items, where higher scores indicate greater insomnia response to stressful events, and individuals with a score of ≥ 16 are considered more likely to experience insomnia in the future. In the present sample, Cronbach's alpha was 0.84 (T1) and 0.81 (T2).

2.2.5. Other variables

Rumination was evaluated by the rumination subscale of the Rumination-Reflection Questionnaire (RRQ), developed by Trapnell and Campbell [34]. RRQ is a 24-item self-report questionnaire assessing both self-rumination and self-reflection, with 12 items for each subscale. Higher rumination subscale scores indicate higher degrees of self-rumination. Perceived consequences of insomnia were evaluated by the Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS) [35]. The scale measures five dimensions including misattributions or amplification of insomnia consequences, diminished perception of control and predictability of sleep, unrealistic sleep expectations, misconceptions about the causes of insomnia, and faulty beliefs about sleep-promoting practices. The Mannheim Dream Questionnaire (MADRE) was used to assess dream recall frequency and percentage of recurring nightmares [36].

2.3. Statistical analysis

The independent sample *t*-test was used to assess differences between responders and non-responders on major variables at baseline. The results showed that there were significant age differences ($t = 5.35, p < 0.001$) between responders and non-responders, but no statistical differences in gender ($t = 1.26, p = 0.21$), sleep quality ($t = 0.40, p = 0.69$), insomnia ($t = 0.18, p = 0.86$), depression ($t = -0.14, p = 0.89$), or susceptibility to insomnia ($t = 1.14, p = 0.26$). Also, to assess whether the missing data between baseline and T2 was missing completely at random (MCAR), a Little's MCAR test was conducted using all study variables at T1, and the results showed that the MCAR assumption has been met ($\chi^2_{(12)} = 16.46, p = 0.17$). The primary analyses of the study included three steps. In the first step, Latent Profile Analysis (LPA) was conducted to explore the most likely number of possible classes based on the ISI scale. LPA was used to analyze the potential categorization model of continuous variables. To find the optimal number of classes, each model in the LPA was compared. For LPA, the fit of a 1-class model was first evaluated, then incrementally increasing models were evaluated until the best latent class solution was selected. The best-fitting model was selected by examining the indices of model fit and interpretability of the model. When conducting LPA, we used the following fit indexes to determine the optimal model: Akaike information criterion (AIC), Bayesian information criterion (BIC), adjusted BIC (aBIC), Lo-Mendell-Rubin (LMR), Bootstrapped Likelihood Ratio Test (BLRT), and Entropy. The AIC, BIC, and aBIC are usually compared to the difference of counterpart models. Smaller values of AIC, BIC, and aBIC suggest an improved model fit [37]. Entropy evaluates the quality of each class originating from LPA, with values equal to or greater than 0.80 indicating better results [37]. LMR and BLRT are used to compare the estimated model and a model with *k*-1 class or classes, where *k* was equal to the number of profiles [38]. In the LMR and BLRT, a lower and statistically significant *p*-value signifies a superior estimated model compared to the model with one less class.

In the second step, LPA was used to replicate the latent profile structure of the ISI scale. In the third step, binary logistic regression models were performed to examine the predictive effects of insomnia symptoms profiles (T1) on sleep problems including sleep quality, insomnia, and susceptibility to insomnia (T2). A Crude and an adjusted model were examined. In the crude model, we only involved insomnia symptom profiles as independent variables. For the adjusted model, some key confounders were controlled, such as gender, sleep quality, insomnia, and insomnia response to stress at baseline as the independent variable. All analyses were performed with M-plus 8.3 and IBM SPSS 25.0. *P* values of 0.05 were considered statistically significant.

3. Results

3.1. Sample characteristics

Table 1 contains demographic information. Baseline demographic characteristics include gender, parents' education, family residence, family economic status, and insomnia.

3.2. Latent profile determination

We explored the most likely number of classes based on the ISI scale. For the discovery sample, fit indices for one-profile to six-profile solutions are shown in Table 2. Although the five- and six-profile models demonstrated lower AIC, BIC, and aBIC values compared to other profile models, LMRT and BLRT were non-significant for them, indicating, that the four-profile model fit significantly better than the five- and six-profile models. Additionally, the smallest class of those models did not contain samples of less than 5%. Thus, the five- and six-profile were excluded. Compared to the remaining three types of models, the four-class model had the highest entropy value and thus was potentially more meaningful and interpretable. Therefore, the four-class model was selected as the optimal model for the discovery sample.

For the replication sample, four indices for one profile solution to six profile solutions are shown in Table 3. Although the five-profile model demonstrated lower AIC, BIC, and aBIC values, and LMRT and BLRT were significantly better compared to other profile models, the smallest class of the five-profile model contained less than 5% of the sample. Therefore, the four-class model was selected as the optimal model for the replication sample.

The four profiles of ISI are depicted in Figs. 1 and 2. Profile 1 ($n = 476, 45.7\%$), labeled as *non-insomnia group (NI)*, is characterized by low levels of difficulties in initiating and maintaining sleep, waking up too early, sleep satisfaction, sleep problem's interference with daily functioning, noticeability of sleep problems to others and worry about the sleep problems. Profile 2 ($n = 250, 23.9\%$), labeled as *mild subjective symptoms but severe subjective feelings group (MSSF)*, is characterized by low levels of insomnia symptoms and high levels of subjective feelings. Profile 3 ($n = 229, 22.0\%$), labeled as *severe subjective symptoms but mild subjective feelings group (SSMF)*, is characterized by high levels of insomnia symptoms and low levels of subjective feelings. Profile 4 ($88, 8.4\%$), labeled as *high insomnia risk group (HI)*, is characterized by high

Table 1
Demographic distribution of Chinese college students (N = 1043).

Variable	No	Percent (%)
Gender		
Male	319	30.6
Female	649	62.2
Father education		
≤ 9 years	487	46.69
> 9 years	476	45.64
Mother education		
≤ 9 years	534	51.20
> 9 years	433	41.51
Family Residence		
Urban	1949	35.5
Country	773	14.1
Town	1121	20.4
Rural	1654	30.1
Family economic status		
< 5000 CNY	174	16.68
5001 CNY-25000 CNY	398	38.16
25,001 CNY -65000 CNY	218	20.90
65,001 CNY-105000 CNY	123	11.79
> 1,050,000 CNY	55	5.27
Insomnia		
No	752	72.1
Yes	291	27.9

CNY: Chinese Yuan Renminbi.

Table 2
Model fit criteria for latent profile analyses of ISI in a sample of Chinese college students (N = 1043).

The Number of Profiles	AIC	BIC	aBIC	Entropy	P value	
					BLRT	LMRT
1	18879.020	18948.318	18903.852			
2	17461.214	17570.111	17500.236	0.859	<0.05	0.05
3	16911.036	17059.532	17059.532	0.812	<0.001	<0.001
4	15783.791	15971.886	15851.192	0.902	< 0.001	< 0.001
5	13541.540	13769.234	13623.131	0.916	0.0664	0.0682
6	13335.766	13603.058	13431.547	0.914	0.1115	0.1141

Table 3
Model fit criteria for latent profile analyses of ISI in a validated sample of Chinese college students (n = 729).

The Number of Profiles	AIC	BIC	aBIC	Entropy	P value	
					BLRT	LMRT
1	13403.372	13467.655	13423.201			
2	12270.899	12371.916	12302.059	0.880	0.0522	0.0545
3	11852.838	11990.588	11895.328	0.868	<0.001	<0.001
4	11284.744	11459.228	11338.566	0.910	< 0.001	< 0.001
5	9876.894	10088.111	9942.047	0.923	<0.05	<0.05
6	9749.756	9997.706	9826.239	0.918	0.1957	0.1997

AIC: Akaike information criterion, BIC: Bayesian information criterion, aBIC: sample-size adjusted Bayesian information criterion, LMRT: Lo-Mendell-Rubin likelihood ratio test, BLRT: Bootstrapped likelihood ratio test.

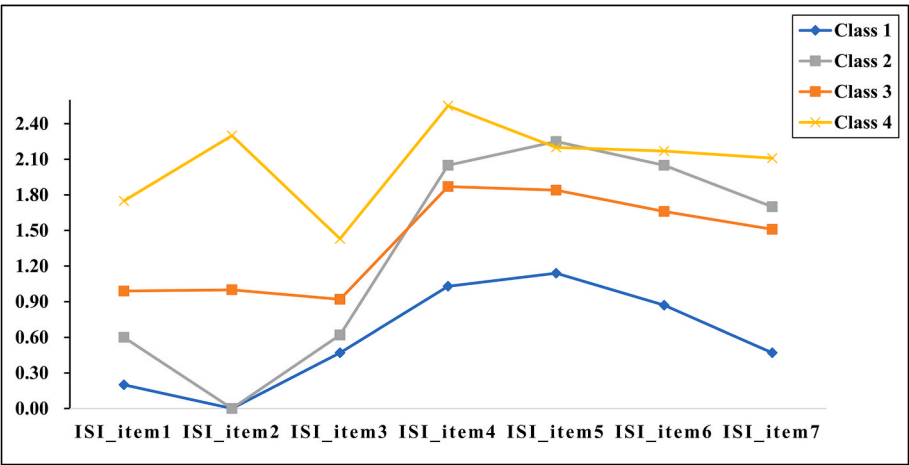


Fig. 1. Latent profiles of insomnia symptoms in the discovery sample (N = 1043). Class1: non-insomnia group (NI); Class 2: mild subjective symptoms but severe subjective feelings group (MSSF); Class 3: severe subjective symptoms but mild subjective feelings group (SSMF); Class 4: the high insomnia risk group (HI).

scores on all ISI domains. The results of the replication analysis were consistent with all results mentioned in this section.

The focus on the difference between subjective symptoms and subjective feelings can provide a better understanding of individual unique situations when it comes to insomnia. Therefore, although insomnia symptoms were mostly encountered in participants fitting the NI and HI profiles, we further analyzed heterogeneity, that is, the difference between MSSF-profiled participants and SSMF-profiled participants in subjective sleep indicators. As seen in Table 4, our analysis shows that the rumination scores in MSSF participants were significantly higher than in SSMF participants ($p < 0.01$). As SSMF profiled participants were observed to have higher scores than NI profiled participants for perceived consequences of insomnia, sleep disturbances, dream recall frequency, percentage of recurring nightmares, and susceptibility to insomnia ($p < 0.05$). This again supports the correctness of our classification of profiles.

3.3. Examining the predictive effect of ISI profiles on sleep problems and depression

Binary logistic regression models were conducted to examine the predictive effects of baseline ISI profiles on sleep problems, including sleep quality, insomnia symptoms, depression, and susceptibility to insomnia at T2. The NI group was designated as the reference group and we compared it with other groups. As seen in Table 5, after adjusting for gender, sleep quality, insomnia, depression, and susceptibility to insomnia at baseline respectively, the MSSF group ($OR = 3.00$, $95\%CI = 1.60-5.60$, $p = 0.001$), SSMF group ($OR = 2.80$, $95\%CI = 1.37-5.73$, $p = 0.005$) and HI group ($OR = 4.68$, $95\%CI = 1.69-13.00$, $p = 0.003$) could significantly predict insomnia over no insomnia counterparts. Interestingly, compared with the NI group, only the HI group had significant predictive effects on depression ($OR = 3.35$, $95\%CI = 1.39-8.11$, $p = 0.007$), while only the SSMF group significantly predicted susceptibility to insomnia ($OR = 4.37$, $95\%CI = 1.25-15.28$, $p = 0.021$).

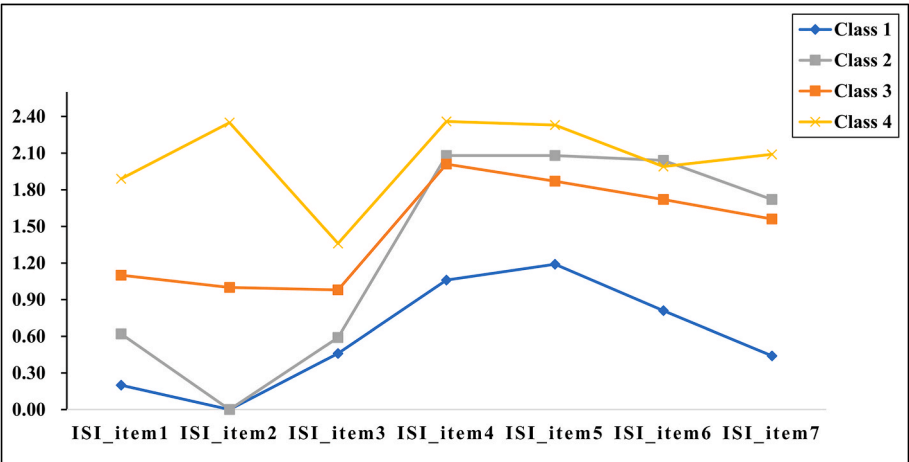


Fig. 2. Latent profiles of insomnia symptoms in the replication sample (n = 729). Class1: non-insomnia group (NI); Class 2: mild subjective symptoms but severe subjective feelings group (MSSF); Class 3: severe subjective symptoms but mild subjective feelings group (SSMF); Class 4: the high insomnia risk group (HI).

Table 4
Distribution of subjective sleep indicators by latent class of ISI (n = 479).

Variables	Class 2	Class 3	t	P-value
	n = 250 (23.9%)	n = 229 (22.0%)		
Rumination	45.57 ± 5.84	43.76 ± 6.00	3.30	0.001
Perceived consequences of insomnia	6.44 ± 1.55	5.87 ± 1.58	3.92	< 0.001
Sleep disturbances	0.86 ± 0.43	1.04 ± 0.42	−4.49	< 0.001
Dream recall frequency	2.63 ± 1.74	3.01 ± 1.68	−2.37	0.018
Percentage of recurring nightmares	2.44 ± 1.76	2.81 ± 1.89	−2.15	0.032
Insomnia Response to Stress	21.19 ± 5.27	22.40 ± 4.72	−2.59	0.010

ISI : Insomnia severity index.

4. Discussion

To our knowledge, this study is the first to examine patterns of insomnia symptoms through various ISI items in Chinese college students and to replicate this result in an independent sample. The study adopted latent profile analysis to explore identical patterns of insomnia symptoms in two independent samples exploring the effects on sleep problems and depression in college students. Four latent profiles of insomnia symptoms among college students were identified in both samples: “NI”, “MSSF”, “SSMF” and “HI”. The results of this study can be beneficial to education administrators and clinicians to better understand the heterogeneous classification characteristics of insomnia symptoms in college students and to develop more targeted intervention

measures.

4.1. Two dimensions of ISI

The findings of latent profile analysis confirmed a significant heterogeneity in insomnia symptoms. The key difference from previous studies was, that the group with high insomnia symptoms performed differently on each item on the ISI scale, which had been overlooked in previous studies. For instance, the MSSF group scored lower on the three subjective symptoms of insomnia (DIS, DMS, and EMA), but higher on the subjective feelings of insomnia (sleep satisfaction, sleep problem’s interference with daily functioning, damage to quality of life from sleep problems, and worry about the sleep problem). The opposite is true for the SSMF group. This is inconsistent with the original scoring guidelines that indicated the single-dimensional structure of ISI [19,27]. Therefore, we propose that the ISI is composed of two dimensions: subjective symptoms and subjective feelings. The results of exploratory factor analysis and confirmatory factor analysis in this study support this view (see Supplementary Materials). A different study explored the psychometric properties of the ISI with a total of 2066 Mainland Chinese undergraduates as participants, revealing a 3-factor solution which was confirmed by the results of multiple group analyses [39]. Although the two factors of ISI in this study are inconsistent with previous studies [39], a meta-analysis showed that the two-factor solution of the ISI is a vigorous presentation of dimensionality compared to a three-factor solution [40]. Furthermore, some studies supported a two-factor subscale of “severity” and “impact”, but there might be discrepancies among items under specific dimensions [41–43]. For instance, Yu [43] showed that the first factor of ISI assesses the severity of sleeping difficulties,

Table 5
Latent profile of insomnia symptoms at T1 predict sleep problems and depression at T2 (n = 425).

		Sleep quality		Insomnia		Depression		Susceptibility to insomnia	
		OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P
Crude model	Class1	1.00		1.00		1.00		1.00	
	Class2	1.75 (0.82–3.75)	0.152	3.61 (2.07–6.29)	< 0.001	1.63 (0.95–2.79)	0.075	1.49 (0.75–2.95)	0.253
	Class3	2.16 (0.97–4.81)	0.059	3.11 (1.69–5.73)	< 0.001	2.08 (1.18–3.68)	0.012	5.61 (1.66–18.96)	0.006
	Class4	4.83 (1.92–12.12)	0.001	6.32 (2.80–14.29)	< 0.001	5.77 (2.62–12.69)	< 0.001	7.11 (0.94–54.11)	0.058
Adjusted model ^a	Class1	1.00		1.00				1.00	
	Class2	1.17 (0.50–2.70)	0.718	3.00 (1.60–5.60)	0.001	1.43 (0.80–2.58)	0.228	1.41 (0.67–2.94)	0.363
	Class3	1.83 (0.79–4.25)	0.157	2.80 (1.37–5.73)	0.005	1.57 (0.84–2.94)	0.156	4.37 (1.25–15.28)	0.021
	Class4	2.22 (0.73–6.69)	0.158	4.68 (1.69–13.00)	0.003	3.35 (1.39–8.11)	0.007	4.69 (0.60–36.72)	0.141

Note: ^aAdjusting for gender, sleep quality, insomnia, depression, and susceptibility to insomnia at baseline.

through the first three items (DIS, DMS, EMA, and sleep satisfaction), and the second factor focused more on the impact of insomnia, via the last three items. The inconsistency between the results of this study and previous findings may be explained by the differences in the structure of ISI factors caused by the different study samples. Future studies will be needed, to further improve the scale.

Easy-to-use and cost-effective tools are essential for large-scale screening and reduction of insomnia symptoms. Our results show, that ISI provides a tool that operates easily in assessing insomnia in Chinese college students. It can be used not only in clinical practice, but also in general population screening. In future insomnia assessments, a brief screening of two ISI items should be considered to determine, if further evaluation of sleep complaints is needed [41], as, when screening for insomnia disorders, ISI is an acceptable measure to report scores for individual dimensions or items and would reduce the time required for testing and scoring. For research purposes, reporting scores on both dimensions is more likely to determine if there are differences in subjects' subjective insomnia symptoms and subjective feelings. This is of great importance for screening insomnia symptoms.

4.2. Four profiles of insomnia symptoms

Our results show that approximately half of the samples (45.7%) were categorized in the NI profile (the average score of the ISI was 4.09), while only 8.4% showed high insomnia symptoms (the average score of the ISI was 14.51), which was similar with previous studies [13,14,22]. For instance, Carpi et al. [13] using LPA based on the ISI and PSQI noted that 8.8% of college students in Italy had severe insomnia while 66.9% reported low insomnia severity. Another study pointed out that 8.8% of college students could be categorized as “sleep disturbances and daytime dysfunction” subtype, while 66.9% reported good sleep [22]. The results vary to some extent due to different measurement tools and samples. In addition, 23.9% of the samples were categorized as MSSF (the average score of the ISI was 9.41), which was characterized by mild overall subjectively reported insomnia symptoms, coupled with a variety of complaints, especially the perceived impact of more sleep problems on daytime function. Individuals fitting that profile may be associated with a puzzling tendency toward misperception of sleep, as individuals with poor subjective sleep are more likely to underestimate the quality and length of their sleep [44]. Specifically, individuals with subjectively distressed insomnia may not be aware of their true insomnia symptoms, where factors such as complaints about insomnia, poor daytime function, and poor satisfaction with insomnia are more likely to cause their poor sleep quality illusion, underestimate objective sleep indicators, and increase their risk of paradoxical insomnia [45]. 22.0% of our samples were identified as SSMF (the average score of the ISI was 9.78), which was characterized by high insomnia symptoms (DIS, DMS, and EMA), but better subjective feelings (i.e., sleep satisfaction, daily functioning, damage to quality of life from sleep problems, and worry about sleep problems). Although this subtype of insomnia individuals perceive serious insomnia symptoms, their subjective feelings are not so obvious, and they may be more likely to overestimate their subjective sleep quality and subjective sleep duration, and are more likely to produce positive sleep perceptions [46]. Therefore, it is of equal importance, to introduce objective and subjective sleep measures when assessing insomnia. It is necessary to conduct a targeted intervention for MSSF individuals to reduce their risk of paradoxical insomnia.

4.3. Predict effects of insomnia profiles

Binary logistic regression identified the predicted effects of different insomnia profiles on sleep quality, insomnia, depression, and susceptibility to insomnia 2 years later. Compared with subjects who were classified in the NI profile at baseline, the other three profiles for insomnia still significantly predicted insomnia problems two years later,

after adjusting gender and insomnia at baseline. In particular, incidences of persistent insomnia were higher among individuals with more severe insomnia at baseline, which was consistent with previous research [47]. Insomnia was a persistent condition, indicating that early identification and intervention of at-risk individuals is important. Compared with the NI group, the MSSF group had a higher risk of developing insomnia after two years than the SSMF group. Possible explanations for that could be: Although individuals fitting the MSSF profile may physiologically exhibit lower symptoms of insomnia, they may be more sensitive or anxious about sleep problems. This psychological burden leads to heightened attention to sleep problems and may adopt inappropriate coping strategies, such as poor sleep habits, ways of coping with stress, etc., which may contribute to the further development of insomnia problems two years later.

Also, compared with the NI group at baseline, only the HI group at baseline significantly predicted depression two years later after adjusting gender and depression at baseline, which was consistent with previous studies [48]. The fact, that persistent insomnia is more likely to contribute to the development of depression than insomnia, emphasizes the dose-response effect of insomnia duration on episodic depression. This result provides an indication that future research should focus more on the natural history of insomnia and assess insomnia at more than one point in time. Additionally, we found that the insomnia SSMF profile reconstructed at baseline predicted susceptibility to insomnia two years later, after controlling for gender and susceptibility to insomnia at baseline, compared with the NI profile. Psychologically, people with insomnia symptoms often exhibit higher levels of “neuroticism”, “internalization”, “anxiety”, and “traits associated with perfectionism”, which may contribute to the susceptibility and persistence of insomnia [49]. People with severe subjective feelings may feel subjective pain caused by obvious insomnia, but because of the insensitivity to the perception of insomnia symptoms, it might be accompanied by an insensitivity to the future occurrence of insomnia symptoms. However, this view needs to be confirmed with more evidence in future studies.

5. Limitations

There are several limitations of the study that should be considered. First, measures of insomnia symptoms relied on self-report questionnaires, which might be subject to individuals' psychiatric states and recall bias. Second, the data was collected in southwest China, and the age was limited to the range of 17–23. It is uncertain whether the findings can be generalized to all college students in other groups. Future research would therefore benefit from containing a larger and more diverse sample. Finally, we did not investigate protective and risk factors for each insomnia profile, more prospective studies will be needed to answer this question.

6. Conclusion

In summary, the study found four heterogeneous subtypes of insomnia symptoms in a sample of college students reporting various ISI items, this result was replicated in an independent dataset. The subtypes were identified based on two factors of ISI including subjective symptoms and subjective feelings through self-report measures, and were shown to predict insomnia, depression, and susceptibility to insomnia two years later. Furthermore, we suggest that college students who are classified with MSSF and SSMF should be given special attention and designated tailored interventions in clinical practice, to improve their insomnia.

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Contributors

Each author contributed substantially to the paper. Shuo Wang were involved in data analyses and manuscript preparation. Xu Lei supervised the writing of the manuscript. Simon Theodor Jülich commented on and revised the manuscript. All authors read and approved the final manuscript.

CRediT authorship contribution statement

Shuo Wang: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Simon Theodor Jülich:** Writing – review & editing. **Xu Lei:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sleep.2024.02.027>.

AIC: Akaike information criterion, BIC: Bayesian information criterion, aBIC: sample-size adjusted Bayesian information criterion, LMRT: Lo-Mendell-Rubin likelihood ratio test, BLRT: Bootstrapped likelihood ratio test.

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