

# Trajectories of Nonrestorative Sleep in First-year College Students: The Roles of Childhood Emotional Abuse and Resilience

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**Objective:** Nonrestorative sleep (NRS) is common among college students; however, its temporal changes and predictors are poorly understood. This study aimed to identify NRS trajectories among first-year Chinese college students and to examine how childhood emotional abuse (EA) and resilience predict these trajectories.

**Methods:** Six hundred and fourteen first-year Chinese college students were enrolled in a 12-month longitudinal tracking study, assessed by the Childhood Trauma Questionnaire-Short Form, 10-item Connor–Davidson Resilience Scale, Morning and Evening Questionnaire-5, and NRS Scale (NRSS). Data were analyzed employing latent growth curve modeling, latent class growth modeling, and multivariable logistic regression.

**Results:** The global score of NRSS (higher scores indicate fewer symptoms of NRS) showed a linear increase overall. EA predicted poorer restorative sleep at baseline ( $\beta = -0.255, p < 0.001$ ). Resilience predicted better restorative sleep over time ( $\beta_{T0} = 0.271, \beta_{T1} = 0.327, \beta_{T2} = 0.292$ , all  $p < 0.001$ ). Latent class analysis identified two NRSS trajectories: (a) high–increasing class (41.5% of the sample; declining NRS) and (b) low–stable class (58.5%; persistent high NRS). Higher levels of EA corresponded to greater likelihood of belonging to the low–stable class relative to the high–increasing class (OR=1.177, 95% CI [1.106, 1.252]). In contrast, higher resilience corresponded to lower likelihood of being in the low–stable class (OR=0.915, 95% CI [0.890, 0.941]).

**Conclusion:** EA is a predisposing factor for NRS among college students, while resilience is a protective factor for restorative sleep. It is essential to consider EA and resilience in any intervention efforts to reduce NRS.

**Keywords:** childhood emotional abuse, resilience, nonrestorative sleep, trajectories

## Introduction

Sleep disturbances are among the prevalent issues that plague the general population. Nonrestorative sleep (NRS) is characterized by a subjective complaint of feeling unrefreshed or lacking restoration upon awakening, which cannot be attributed to insufficient sleep duration. Crucially, NRS may represent a distinct dimension of sleep disturbance, separable from the more commonly assessed symptoms of insomnia disorder like sleep-onset difficulty, fragmented sleep, and premature awakening.<sup>1</sup> Individuals can experience NRS without traditional insomnia symptoms (eg, difficulty initiating or maintaining sleep), yet exhibit persistent daytime functional impairment, highlighting its unique clinical significance.<sup>2</sup> Compared to individuals with sleep initiation or maintenance difficulties (without NRS), those with NRS exhibited markedly higher rates of daytime impairments—including irritability and physical/mental fatigue—and sought medical consultation for sleep-related complaints twice as frequently.<sup>3</sup> NRS is closely linked to lower quality of life,<sup>4</sup> chronic pain,<sup>5</sup> suicidal ideation,<sup>6</sup> and poor mental health.<sup>7</sup> The occurrence of NRS among the general population ranges between 19.2% and 42.1%.<sup>8</sup> Research among college students indicated that 41% were experiencing NRS.<sup>9</sup> Although NRS is gaining recognition as a distinct diagnostic category, it has been less studied than other insomnia symptoms. The trends of NRS over time among college students and the specific predictors for NRS remain unclear.

Early traumatic experiences have been consistently linked to higher risks of both subjective and objective sleep health impairments.<sup>10,11</sup> People who experienced trauma during their early years tend to take more time to fall asleep,<sup>12</sup> sleep for shorter periods,<sup>13</sup> and report impaired subjective sleep quality.<sup>14</sup> Furthermore, the relationship between childhood trauma and subsequent sleep disturbances may endure into adulthood.<sup>15,16</sup> Among college students, those with adverse childhood experiences were 1.52 to 2.40 times more likely to experience past-year sleep difficulties.<sup>17</sup> Childhood emotional abuse (EA) refers to a non-physical form of aggression directed at children, including verbal attacks that target a child's self-worth or emotional stability, and actions intended to shame or degrade them.<sup>18</sup> A particularly robust connection between EA and sleep problems has been highlighted by several studies.<sup>16,19</sup> According to the stress-diathesis models,<sup>20</sup> adverse life events during critical childhood years can sensitize the stress axis, thereby increase individuals' vulnerability to sleep disorders. Indeed, a study among 941 college students has found that increased exposure to EA was correlated with more severe insomnia.<sup>21</sup> Collectively, these findings suggest EA as a potent predisposing factor for NRS, yet its prospective impact on NRS remains understudied.

While childhood trauma may predispose individuals to NRS, not everyone develops NRS. Therefore, individual factors like resilience might help explain this phenomenon. Resilience is conceptualized as a malleable adaptive process through which individuals achieve positive adaptation when dealing with severe challenges, especially high-stress or traumatic events.<sup>22</sup> Under the stress-diathesis model, early life stress can increase the risk of sleep disorders by sensitizing the stress response system, while resilience can mitigate this impact by reducing or neutralizing stress effects. For instance, individuals with greater resilience exhibited lower sleep reactivity to stress, decreased cognitive hyperarousal before sleep, and better emotional regulation, thereby mitigating the risk of insomnia.<sup>23</sup> In our prior cross-sectional work, resilience emerged as a significant inverse predictor of NRS severity in university students.<sup>24</sup> Complementing these findings, a randomized clinical trial on insomnia patients demonstrated that enhanced resilience after digital cognitive-behavioral therapy (CBT) played a protective role against insomnia relapse at one-year follow-up by mitigating transdiagnostic risk.<sup>25</sup> Collectively, these data position resilience as a safeguard for restorative sleep. However, based on our comprehensive literature review, the long-term association between resilience and NRS has not yet been studied.

First-year college students represent a critical at-risk population due to the confluence of developmental transition challenges (eg, academic autonomy, new social demands, nascent financial independence), environmental disruptions (sleep schedules, living arrangements), and heightened psychosocial stressors that may unmask latent vulnerability to sleep dysregulation. However, few studies have specifically examined sleep characteristics among first-year college students. Furthermore, the intensity of symptoms fluctuates temporally in sleep-disturbed individuals rather than remaining stable. College students disturbed by insomnia symptoms may recover over time, or they may exhibit delayed or chronic symptoms.<sup>26</sup> Prior research found substantial heterogeneity in college students' sleep trajectories.<sup>27</sup> Therefore, it is crucial to further investigate the college students' NRS and their developmental trajectories for early identification of high-risk populations.

The study aimed to verify the predictive effect of EA and resilience on the developmental trajectories of NRS among first-year college students through a short-term longitudinal design. We also took into account the influence of chronotype,<sup>28</sup> gender<sup>29</sup> and left-behind experience (defined as  $\geq 6$  months of parent-child separation before age 16 due to labor migration)<sup>30</sup> - established risk factors for sleep disturbances. Based on the literature, three hypotheses were examined:

H1. Several distinct NRS trajectories could be identified across freshman year.

H2. EA would positively predict NRS.

H3. Resilience would negatively predict NRS.

## Materials and Methods

### Participants and Procedure

A sample of 683 college freshmen was drawn from the Sleep Quality Improvement Project (SQIP) through cluster sampling from September 16th to 23rd, 2023. SQIP is a prospective observational cohort study aiming to identify

factors associated with sleep health to inform future interventions among college students in Guangdong Province, South China.<sup>31,32</sup> No interventions were administered during the study period. The inclusion criteria were (1) aged  $\geq 18$  years; (2) communication fluency in Mandarin; (3) capability to operate electronic devices for completing the online survey. The exclusion criteria included a diagnosis of psychiatric disorders and the intake of psychiatric medications within the past six months. The participants read through the instructions and signed the online informed consent prior to the survey. This study was conducted in full accordance with the Declaration of Helsinki and received approval from the Ethics Committee of the Third Affiliated Hospital of Guangzhou University of Chinese Medicine [PJ-KY-20230725-001]. Data collection at each assessment wave was implemented through web-based questionnaires administered via the Wenjuanxing digital survey platform. Participants completed the surveys using their mobile phones or personal computers at three measurement waves: baseline (T0), 6 months (T1) and 12 months (T2). Participants could leave the study at any moment based on their own will. Of the 683 enrolled participants, 614 completed the survey at T0. These respondents were asked to participate in the follow-up surveys, with 593 and 571 participants completing the survey at T1 and T2, respectively. Longitudinal data from all three time-points (T0, T1, T2) of the 614 participants were analyzed.

## Measures

### Childhood Emotional Abuse

At T0, EA was measured using the Chinese version of the emotional abuse subscale from the Childhood Trauma Questionnaire-Short Form (CTQ-SF),<sup>33</sup> a reliable and valid self-report measure.<sup>34</sup> The scale consists of 5 items, each rated on a 5-point Likert scale, ranging from 1 (never true) to 5 (very often true). Total scores range from 5 to 25, with higher scores reflecting greater childhood exposure to EA. The Cronbach's alpha for the emotional abuse subscale in this study was 0.85.

### Resilience

Resilience was measured with the 10-item Connor–Davidson Resilience Scale (CD-RISC-10),<sup>35</sup> a condensed version of the 25-item Connor–Davidson Resilience Scale.<sup>36</sup> Each item is rated 0–4 on a Likert scale, yielding total scores of 0–40, where higher values reflected greater resilience. The Cronbach's alpha of the scale was satisfactory across all assessment waves ( $\alpha_{T0} = 0.95$ ;  $\alpha_{T1} = 0.96$ ;  $\alpha_{T2} = 0.96$ ).

### Non-Restorative Sleep

NRS was measured using the NRS Scale (NRSS),<sup>37</sup> derived from Wilkinson and Shapiro's NRS scale.<sup>38</sup> The scale comprises 12 items, each rated on a 5-point Likert scale. The items are categorized into four distinct conceptual dimensions: refreshment from sleep, physical/medical symptoms, daytime functioning, and affective symptoms. Composite scores (ranging from 12 to 60) were inversely coded to reflect NRS intensity, with higher scores representing a lower extent of NRS. The Cronbach's alpha of the scale was good across all assessment waves ( $\alpha_{T0} = 0.81$ ;  $\alpha_{T1} = 0.83$ ;  $\alpha_{T2} = 0.84$ ).

### Covariates

At T0, chronotypes were assessed by the validated Morning and Evening Questionnaire-5 (MEQ-5),<sup>39</sup> a simplified version of the 19-item MEQ.<sup>40</sup> The questionnaire contains 5 items, with total scores ranging between 4 and 25, where higher values reflect earlier chronotypes. The Cronbach's alpha for MEQ-5 in this study was 0.71. Demographic data such as age, gender, and left-behind experience were gathered through self-reported questionnaires. Gender was dummy-coded (0=male, 1=female). Left-behind experience was defined as living separately from one or both parents for more than 6 months before sixteen years old, and coded as 0 (no) and 1 (yes).

## Statistical Analysis

IBM SPSS (Version 21.0), Mplus (Version 8.3), and JASP (version 0.16.4.0) were used for statistical analyses. First, descriptive statistics and correlation analyses were computed for the main variables. Second, comparisons between participants who completed all three waves and those who provided incomplete data were conducted via independent-

sample t-tests and chi-square tests. Third, the initial level (intercept) and the change trend (slope) of NRSS were analyzed through latent growth curve modeling, which included two steps. Linear unconditional modeling was used in Step 1 to determine the developmental trajectory of NRSS. The intercept represents a latent variable that is not influenced by time, and the factor loadings were constrained to 1 at each wave. For the linear slope factor with equal intervals, loadings were coded 0, 1, and 2. In Step 2, conditional modeling was conducted to examine the overall impacts of various factors on NRSS. Predictors were entered hierarchically: resilience was included as a time-specific predictor of NRS at each wave, whereas EA, chronotypes, gender and left-behind experience were treated as time-invariant covariates predicting both the initial level and the slope of NRS.

Fourth, the classification into latent trajectory classes was established for NRSS through latent class growth modeling. The full-information maximum likelihood (FIML) algorithm addressed missing data in class indicators. Multiple class solutions (ranging from 1 to 5) were systematically evaluated to identify the optimal latent class structure, with model selection guided by established statistical criteria. Several criteria were used to determine the optimal number of latent classes, including comparatively reduced values of both Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC), statistically significant results ( $p < 0.05$ ) from the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT) and the bootstrapped Likelihood Ratio Test (BLRT), an entropy score not lower than 0.70, and smallest class comprising  $\geq 5\%$  of participants. Between-group differences in NRSS across three time points were examined using Bayesian independent samples t-tests. The Bayes factor value exceeding 10 signifies robust support for the hypothesis that differences exist between the classes. Then, multivariable logistic regression was conducted within the most suitable latent class growth model to evaluate the associations of NRSS trajectories with EA, resilience, chronotypes, gender and left-behind experience.

## Results

### Descriptive Statistics

At baseline, the 614 participants had an average age of 18.4 (standard deviation [SD] = 0.60). The majority of the participants were Han Chinese (97.4%), residing in rural areas (70.8%). 268 participants (43.6%) were male and 173 participants (28.2%) had left-behind experience. The NRSS mean score was 42.2 (SD = 6.83) at baseline. Descriptive statistics and correlation matrix for measured variables are presented in Table 1.

Participants who took part in all three waves ( $n = 553$ ) did not differ in terms of gender ( $\chi^2[1] = 2.138, p = 0.144$ ), age ( $t[612] = 1.048, p = 0.295$ ), EA ( $t[612] = -0.867, p = 0.386$ ), left-behind experience ( $\chi^2[1] = 0.712, p = 0.399$ ), chronotypes ( $t[612] = -0.158, p = 0.875$ ), resilience ( $t[612] = 0.469, p = 0.639$ ) and NRSS ( $t[612] = 1.689, p = 0.092$ ) at baseline compared to participants with incomplete data for one or more waves ( $n = 61$ ).

**Table 1** Minimums, Maximums, Means, Standard Deviations, Spearman Correlations for Childhood Emotional Abuse, Resilience, Chronotypes, Gender, Left-Behind Experience, and NRSS

	Min	Max	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Childhood emotional abuse(T0)	5	25	7.76	3.56	I									
2. Resilience(T0)	0	40	26.38	6.89	-0.24**	I								
3. Resilience(T1)	0	40	26.44	7.24	-0.31**	0.63**	I							
4. Resilience(T2)	0	40	26.64	7.19	-0.22**	0.59**	0.58**	I						
5. Chronotypes(T0)	4	23	13.52	3.04	-0.07	0.12**	0.12**	0.14**	I					
6. Gender(T0)	0	1	0.56	0.50	-0.12**	-0.15**	-0.13**	-0.11**	-0.18**	I				
7. Left-behind experience(T0)	0	1	0.28	0.45	0.14**	0.02	-0.01	-0.03	0.001	-0.08	I			
8. NRSS(T0)	13	60	42.17	6.83	-0.20**	0.34**	0.31**	0.32**	0.17**	-0.15**	-0.09*	I		
9. NRSS(T1)	13	60	42.93	6.14	-0.34**	0.37**	0.48**	0.37**	0.25**	-0.11**	-0.15**	0.51**	I	
10. NRSS(T2)	22	60	43.18	6.37	-0.27**	0.30**	0.37**	0.45**	0.29**	-0.09*	-0.12**	0.47**	0.68**	I

Notes: \*  $p < 0.05$ . \*\*  $p < 0.01$ . T0, T1, and T2 represent the first survey (baseline), the second survey, and the third survey.

Abbreviations: Min, Minimum; Max, Maximum; SD, Standard Deviation; NRSS, global score of the Nonrestorative Sleep Scale.

## Latent Growth Curve Modeling (LGCM)

### Unconditional LGCM

The analysis demonstrated that the unconditional linear growth model for NRSS fitted data well [ $\chi^2(1) = 2.427, p = 0.119, CFI/TLI = 0.998/0.993, RMSEA(90\% CI) = 0.048(0.000, 0.129), SRMR = 0.013$ ]. The NRSS trajectory was substantial, with an initial average intercept of 42.324 ( $p < 0.001$ ) and an average slope of 0.454 ( $p = 0.001$ ), indicating a linear increase over time in NRSS. The variance of the intercept ( $\sigma^2 = 23.601, p < 0.001$ ) and slope ( $\sigma^2 = 3.328, p = 0.009$ ) were significant, indicating differences among college students in the baselines and growth rates of NRSS. A nonsignificant negative correlation was observed between slope and intercept values ( $r = -0.128, p = 0.340$ ), indicating no significant relationship between the growth rate and the initial level of NRSS.

### Conditional LGCM

The model fit was adequate [ $\chi^2(11) = 44.337, p < 0.001, CFI/TLI = 0.961/0.914, RMSEA(90\% CI) = 0.074(0.052, 0.097), SRMR = 0.081$ ], when the time-varying variable (resilience) and the four time-invariant variables (EA, chronotypes, gender, and left-behind experience) were added to the model. EA ( $\beta = -0.255, SE = 0.062, p < 0.001$ ), gender ( $\beta = -0.210, SE = 0.061, p = 0.001$ ) and left-behind experience ( $\beta = -0.149, SE = 0.060, p = 0.013$ ) negatively affected the intercept of NRSS at baseline (Table 2 and Figure 1). However, these factors did not affect the change trend of NRSS. Chronotypes significantly affected both the intercept ( $\beta = 0.200, SE = 0.059, p = 0.001$ ) and the slope ( $\beta = 0.277, SE = 0.104, p = 0.008$ ), suggesting that individuals with earlier chronotypes had higher NRSS initially and exhibited a faster-increasing rate of change over 12 months. Resilience positively predicted NRSS at T0 ( $\beta = 0.271, SE = 0.032, p < 0.001$ ), T1 ( $\beta = 0.327, SE = 0.026, p < 0.001$ ), and T2 ( $\beta = 0.292, SE = 0.031, p < 0.001$ ).

## Latent Class Growth Model (LCGM)

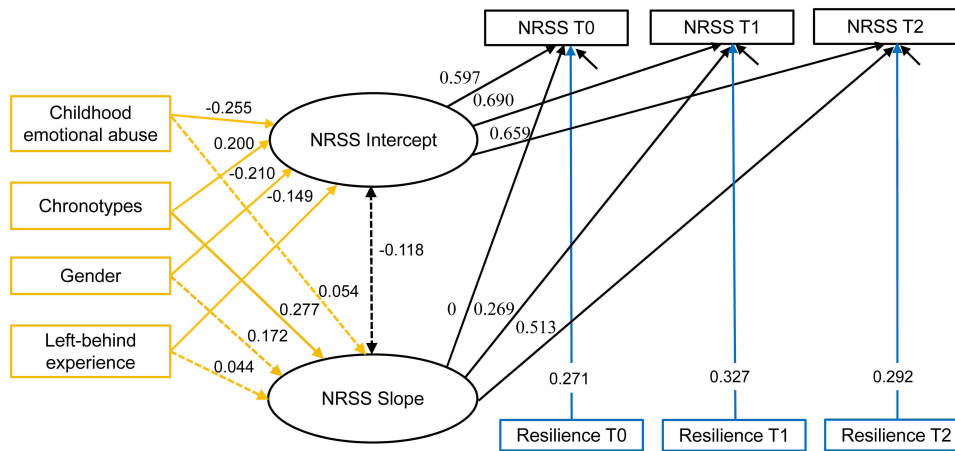
Table 3 displays the fit indices. Initially, the 4-class model and 5-class model were excluded because they represented a subgroup constituting fewer than 5% of the participants. As the number of classes grew, the AIC and BIC values declined, while the entropy for each model remained above 0.70. Furthermore, the BLRT yielded significant  $p$ -values. However, the LMR-LRT for the 3-class model did not produce significant  $p$ -value. Consequently, the 2-class model was selected as optimal. The NRSS trajectories for the two-class solution are illustrated in Figure 2. Each class is described according to its trajectory. The first class (high-increasing) had a high intercept ( $\beta = 46.788, SE = 0.591, p < 0.001$ ), corresponding to an

**Table 2** Covariate Effects for Conditional Linear Growth Modeling

Covariates	Beta	SE	p
<b>Covariates predicting the intercept</b>			
Childhood emotional abuse(T0)	-0.255	0.062	<0.001
Chronotypes(T0)	0.200	0.059	0.001
Gender(T0)	-0.210	0.061	0.001
Left-behind experience(T0)	-0.149	0.060	0.013
<b>Covariates predicting the slope</b>			
Childhood emotional abuse(T0)	0.054	0.091	0.556
Chronotypes(T0)	0.277	0.104	0.008
Gender(T0)	0.172	0.097	0.075
Left-behind experience(T0)	0.044	0.088	0.617
<b>Time-varying covariates</b>			
NRSS (T0) < - Resilience (T0)	0.271	0.032	<0.001
NRSS (T1) < - Resilience (T1)	0.327	0.026	<0.001
NRSS (T2) < - Resilience (T2)	0.292	0.031	<0.001

**Notes:** T0, T1, and T2 represent the first survey (baseline), the second survey, and the third survey.

**Abbreviation:** SE, Standard error; NRSS, global score of the Nonrestorative Sleep Scale.



**Figure 1** Conditional linear growth model of NRSS with time-invariant covariates (yellow lines) and time-varying covariates (blue lines). **Notes:** Dashed lines indicate non-significant effects. T0, T1, and T2 represent the first survey (baseline), the second survey, and the third survey. **Abbreviation:** NRSS, global score of the Nonrestorative Sleep Scale.

initial NRSS level approximating the 75th percentile (cutoff = 47), and a slightly increasing slope ( $\beta = 0.861$ ,  $SE = 0.269$ ,  $p = 0.001$ ). The second class (low-stable) had a low intercept ( $\beta = 39.083$ ,  $SE = 0.422$ ,  $p < 0.001$ ), near the 25th percentile (cutoff = 37), and an insignificant slope ( $\beta = 0.205$ ,  $SE = 0.188$ ,  $p = 0.276$ ), indicating stable NRS over time. Three hundred and fifty-nine students, constituting 58.5% of the sample, experienced a low-stable trajectory of NRSS. In contrast, the remaining 41.5% of the sample experienced a high-increasing trajectory of NRSS. Bayesian Factor Robustness analysis confirmed differences in NRSS between the high-increasing and low-stable classes at three time points [Figure 3(A-F)].

### Results of Multivariable Logistic Regression

The estimated effects of EA, resilience, chronotypes, gender, and left-behind experience on the odds of membership of the NRSS growth trajectory classes are presented in Table 4. EA (OR=1.177, 95% CI [1.106, 1.252]), female gender (OR=1.537, 95% CI [1.054, 2.241]), and left-behind experience (OR=1.714, 95% CI [1.128, 2.603]) substantially increased the probability of being in the low-stable class rather than the high-increasing class. In contrast, higher resilience at T0 (OR=0.915, 95% CI [0.890, 0.941]) and earlier chronotypes (OR=0.863, 95% CI [0.810, 0.921]) had significant relationship with decreased odds of being in the low-stable class.

### Discussion

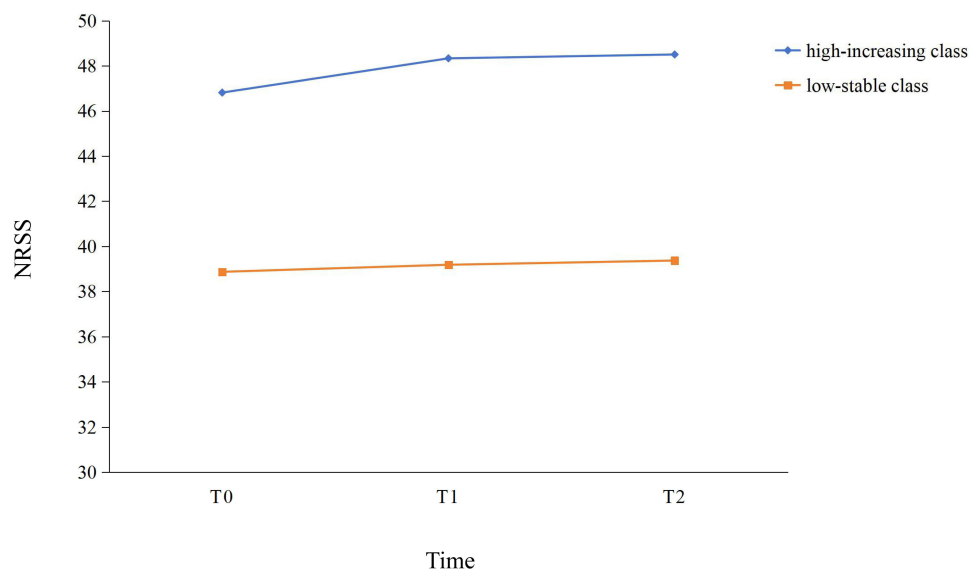
This study employed a longitudinal and person-centered methodology to investigate the trajectory of NRS over one year and the effects of EA and resilience in a cohort of first-year Chinese college students. Overall, the results indicated that first-year students exhibited two distinct NRS trajectories, with EA and resilience serving as key predictors. These

**Table 3** Model Fit Indices for Latent Class Growth Analysis

Number of Classes	AIC	BIC	Entropy	LMR-LRT p value	BLRT p value	Sample Size by Class Based on Most Likely Membership
1-class	11,679.301	11,701.401	—	—	—	614
<b>2-class</b>	<b>11,301.717</b>	<b>11,337.077</b>	<b>0.703</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>255/359</b>
3-class	11,195.729	11,244.349	0.710	0.172	<0.001	173/340/101
4-class	11,145.738	11,207.618	0.749	0.065	<0.001	143/3/167/301
5-class	11,106.915	11,182.055	0.783	<0.001	<0.001	299/12/119/3/181

**Note:** Bold type indicates the selected optimal model.

**Abbreviations:** AIC, Akaike information criterion; BIC, Bayesian information criterion; LMR-LRT, Lo-Mendell-Rubin likelihood ratio test; BLRT, bootstrapped likelihood ratio test.



**Figure 2** Developmental trajectories of NRSS from baseline to 12-month follow-up.

**Notes:** T0, T1, and T2 represent the first survey (baseline), the second survey, and the third survey.

**Abbreviations:** NRSS, global score of the Nonrestorative Sleep Scale.

findings reveal how early adversity and adaptive capacity shape NRS across the freshman year and offer actionable targets for preventive interventions in at-risk students.

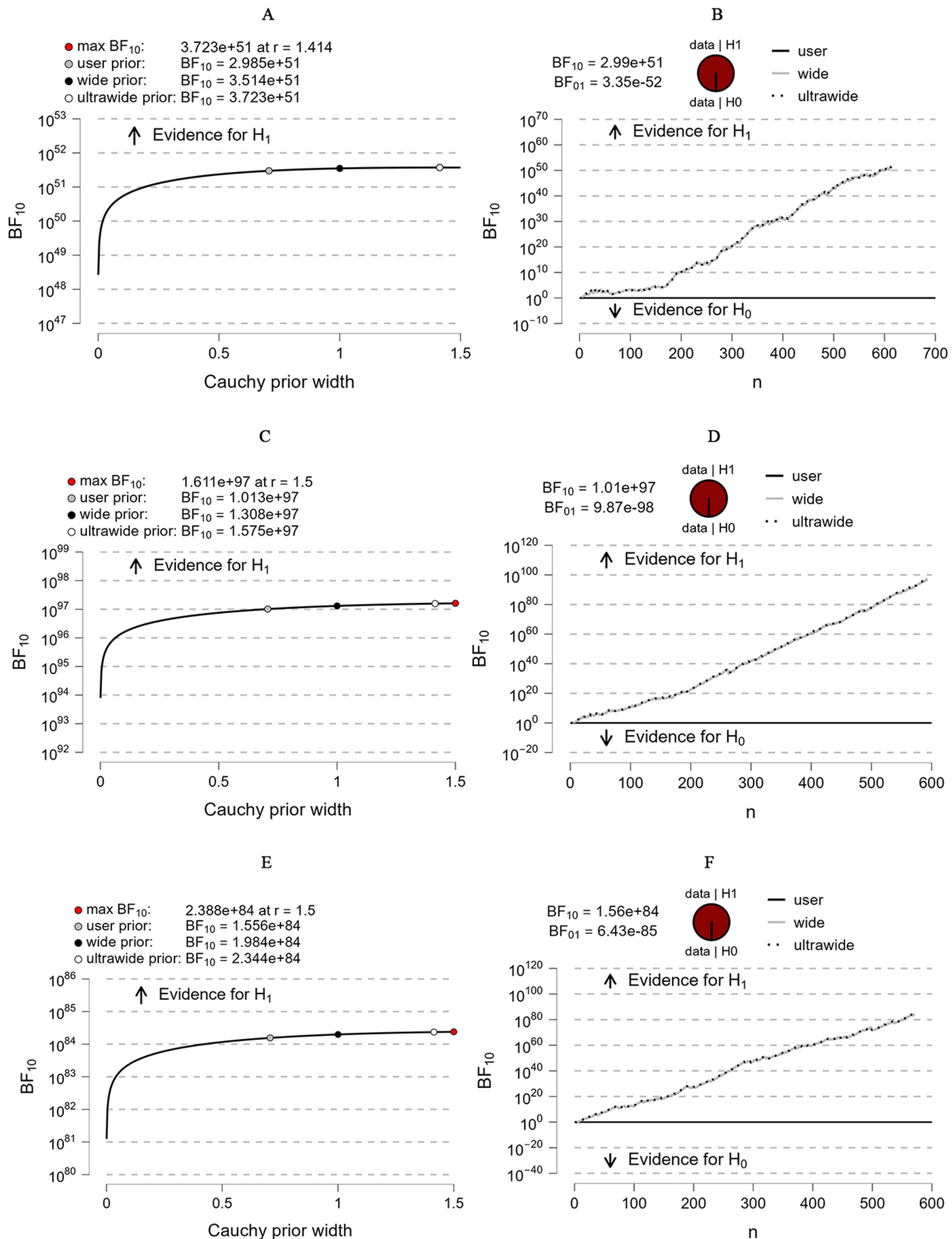
## Trajectories of NRS Among First-year College Students

The unconditional LGCM showed that the overall NRSS score rose linearly in the present study, indicating an increase in restorative sleep as students acclimated to college life. However, the study also revealed heterogeneity in the developmental trajectories of NRS across freshman year. Supporting Hypothesis 1, latent class analysis revealed two distinct NRS trajectories: 58.5% of the participants followed a low–stable course of NRSS (persistent high NRS), and 41.5% followed a high–increasing course of NRSS (declining NRS). More than half of the participants maintained relatively bad sleep conditions throughout the year, suggesting that early intervention targeting predisposing and protective factors is crucial for improving current sleep conditions within first-year college students.

## The Impact of EA on NRS

In line with Hypothesis 2, EA predicted lower initial NRSS (indicating more NRS) in the current study. This finding aligns with those of earlier research,<sup>41,42</sup> confirming that EA is a predisposing factor for NRS. A possible explanation for this association is that childhood maltreatment induces circadian rhythm disturbances that subsequently impair normal sleep regulatory mechanisms.<sup>43,44</sup> An alternative interpretation is that EA might increase sleep system's stress sensitivity, thereby increasing the risk of insomnia disorder.<sup>19</sup> Neurodevelopmental pathways may represent another critical mechanism underlying the association between EA and NRS. Emerging evidence implicates that childhood adversity disrupts neurodevelopment, which is associated with psychiatric disorders, including sleep disturbances.<sup>45</sup>

Besides, the multivariable logistic regression analysis showed that EA heightened the likelihood of belonging to the low–stable class relative to the high–increasing class of NRSS. This suggests that EA may lead to persistent high NRS in first-year college students. From the perspective of the stress-diathesis model, EA, as an interpersonal stressor, may hinder the development of effective stress-coping mechanisms and predispose individuals to heightened stress responses that persist into later life. Consequently, this could have long-term detrimental effects on sleep.<sup>46</sup> So, school counselors and teachers involved in providing psychological services should heighten their focus on the EA experiences of college students, particularly those with persistent NRS. Given the lasting impacts of EA, affected individuals may benefit from



**Figure 3** A comparison of differences in NRSS among two classes at T0, T1 and T2.

**Notes:** T0, T1, and T2 represent the first survey (baseline), the second survey, and the third survey. **(A)** Bayes factor robustness to priors: high-increasing class vs low-stable class at T0; **(B)** Sequential analysis: high-increasing class vs low-stable class at T0; **(C)** Bayes factor robustness to priors: high-increasing class vs low-stable class at T1; **(D)** Sequential analysis: high-increasing class vs low-stable class at T1; **(E)** Bayes factor robustness to priors: high-increasing class vs low-stable class at T2; **(F)** Sequential analysis: high-increasing class vs low-stable class at T2.

**Abbreviations:** NRSS, global score of the Nonrestorative Sleep Scale.



**Table 4** Multivariable Logistic Regression Analysis of NRSS Trajectory Group

Characteristics	OR	95% CI	Wald	p
Childhood emotional abuse(T0)	1.177	1.106, 1.252	26.577	<0.001
Resilience (T0)	0.915	0.890, 0.941	38.039	<0.001
Chronotypes(T0)	0.863	0.810, 0.921	20.170	<0.001
Gender(T0)	1.537	1.054, 2.241	4.984	0.026
Left-behind experience(T0)	1.714	1.128, 2.603	6.376	0.012

**Notes:** Referent group for outcome is high-increasing class. Wald represents the Wald  $\chi^2$  statistic for coefficient significance test; T0 represent the first survey (baseline).

**Abbreviation:** OR, odds ratio; CI, confidence intervals.

trauma-focused interventions that directly address trauma-related symptoms, including trauma-focused cognitive behavioral therapy, eye movement desensitization and reprocessing, and mindfulness-based approaches.<sup>47,48</sup>

## The Impact of Resilience on NRS

In line with Hypothesis 3, resilience was associated with improved restorative sleep over time among college students. In addition, participants with higher resilience had greater probability of being in the high-increasing NRSS trajectory class, indicating declining NRS. That is, higher resilience could significantly contribute to the enhancement of restorative sleep among college students by acting as a robust protective factor. These findings further confirm the interconnectivity of sleep and resilience. Resilience, as a psychobiological construct, modulates individuals' ability to maintain homeostasis and restore equilibrium following stress exposure, thereby buffering the detrimental influence of perceived stress on the pathogenesis of sleep disorders. Individuals with higher resilience tend to perceive daily life events as less stressful, which may also lead to a reduced frequency or duration of such events.<sup>49</sup> Individuals exhibiting low resilience are more susceptible to sleep disorders due to their limited capability to manage stress and poor regulation of emotional and physiological arousal, resulting in greater sleep reactivity and more pronounced physiological and emotional responses to stress.<sup>23,50</sup> Consequently, enhancing resilience, such as through an internet-based resilience training program focusing on positive outlook, motivation and work-life balance,<sup>51</sup> can effectively reduce NRS.

## The Impact of Chronotypes, Gender and Left-Behind Experience on NRS

In the current study, chronotypes influenced not only the initial status but also the rate of change of NRSS over time, as well as the class membership within the NRSS trajectories. To be specific, college students with later chronotypes, such as those who were evening-oriented, tended to consistently experience more NRS. These results align with prior evidence showing a close association between college students' chronotypes and NRS.<sup>52</sup> Given the intrinsic connection between human sleep-wake timing and circadian rhythmicity,<sup>53</sup> an individual's sleep-wake cycle is regulated by the external light-dark cycle and internal circadian rhythms. Variations in these phase relationships may trigger sleep disruptions and associated complaints. Consequently, college students with an evening chronotype typically exhibit greater circadian misalignment between their endogenous sleep-wake patterns and externally imposed academic schedules than those who prefer daytime activity. This desynchrony can lead to an irregular sleep-wake cycle, increasing tiredness and sleep problems. Moreover, college students with later chronotypes (such as eveningness) often delay their bedtime, which subsequently leads to impaired nocturnal sleep quality.<sup>54</sup>

Gender and left-behind experience were found to influence the starting level and class membership of the NRSS trajectories. Specifically, female college students and those with left-behind experience showed lower NRSS (indicating more NRS) at the baseline and greater probability of being in the low-stable class of NRSS. This suggests that they are more prone to experiencing chronic NRS. Neurobiological sex differences in neural architecture and functional organization may underlie differential NRS susceptibility.<sup>55</sup> For instance, sex hormone fluctuations in brain structures may affect circadian regulation, increasing vulnerability to insomnia.<sup>56</sup> Beyond neurobiological factors, cognitive and behavioral factors may also contribute to the observed phenomena. For instance, female individuals typically exhibit greater pre-sleep cognitive arousal characterized by bedtime worry compared to male counterparts, which may lead to

hyperarousal and subsequent disturbances in sleep latency.<sup>57</sup> Moreover, existing research has shown that being left behind at a young age, especially for a long time, is correlated with a lower degree of psychological flexibility.<sup>58</sup> This reduced flexibility, in turn, can predict both insomnia incidence and symptom severity.<sup>59</sup> Compounding this vulnerability, left-behind experiences are associated with higher exposure to maltreatment stemming from deficient parental care, inadequate supervision, and lack of protection, including emotional abuse.<sup>60</sup> The prolonged absence of primary caregivers can disrupt secure attachments and reduce monitoring, leaving individuals vulnerable to emotional abuse—characterized by rejection or indifference from overburdened alternative caregivers—which may in turn derail the neurobiological systems essential for restorative sleep. Our study indicates that psychological interventions targeting NRS should consider additional factors such as chronotypes, gender, and left-behind experience. Specifically, these interventions should prioritize female college students, individuals with later chronotypes, and those with a history of being left behind, emphasizing the importance of enhancing their restorative sleep.

## Limitations

Despite its contributions, the study has several methodological constraints that should be considered. Firstly, all study variables were self-reported, which might have contributed to shared method variance. Future research would benefit from incorporating objective sleep measures, such as actigraphy, to corroborate self-reported sleep experiences like NRS and to disentangle subjective perceptions from objectively quantifiable sleep disturbances. Secondly, the study's focus on Chinese first-year college students from Guangdong province might limit the applicability of the findings. Subsequent research should verify these outcomes across more heterogeneous populations to enhance generalizability. Thirdly, the study's limited number of time points could impede a thorough representation of the NRS trajectories. Future research with more measurement time points may facilitate a more detailed depiction of NRS trajectories. Fourthly, post-abuse protective processes (eg, timely supportive care and family relationships) were not assessed. Future studies should track these dynamic variables to clarify how the long-term impacts of EA are modified.

## Conclusions

First-year college students followed two distinct developmental courses of nonrestorative sleep. EA was a predisposing factor of NRS, while resilience was a protective factor for restorative sleep. Psychological interventions targeting childhood trauma and promoting resilience would be beneficial in decreasing NRS.

## Data Sharing Statement

The datasets analyzed in the current study are available from the first author and corresponding author on reasonable request. The data are not publicly available because of privacy or ethical restrictions.

## Ethical Approval

The study was conducted according to the guidelines of the Declaration of Helsinki. The author sought and got ethical approval from the Ethics Committee of the Third Affiliated Hospital of Guangzhou University of Chinese Medicine [PJ-KY-20230725-001].

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## Author Contributions

Wenna Liao: conceptualization, funding acquisition, software, investigation, methodology, formal analysis, visualization and writing – original draft. Xianghan Luo: project administration, investigation, resources, data curation, formal analysis, supervision, and writing – review & editing. Yongpeng Sun & Fanxu Kong: investigation, data curation, and writing – review & editing. Zengjie Ye: conceptualization, resources, funding acquisition, methodology, formal analysis,

validation, supervision, and writing – review & editing. All authors have read and approved the final manuscript, agree to be accountable for all aspects of the work, and consent to its publication in Nature and Science of Sleep.

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## Disclosure

The authors declare no conflicts of interest in this work.

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