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Research paper

Predicting depressive symptoms in college students: A nomogram integrating recent and early life events with social support

Runyu Wei [a,b,c,1], Lanlan Li [a,c,1], Ying Zhang [a,c,1], Yu Liu [a,b,c], Rui Wang [d], Shuqin Li [a,b,c,*], Yuhui Wan [a,b,c,*]

[a] Center for Big Data and Population Health of IHM (Anhui Medical University), School of Public Health, Anhui Medical University, No 81 Meishan Road, Hefei 230032, Anhui, China
[b] Key Laboratory of Population Health Across Life Cycle (Anhui Medical University), Ministry of Education of the People's Republic of China, No 81 Meishan Road, Hefei 230032, Anhui, China
[c] NHC Key Laboratory of Study on Abnormal Gametes and Reproductive Tract, No 81 Meishan Road, Hefei 230032, Anhui, China
[d] Teaching Affairs Office, Anqing Medical College, Anhui, China

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ABSTRACT

Objective: Depressive symptoms is a common psychological problem among college students, although it lacks a prognostic prediction model. This study aims to develop a nomogram for depressive symptoms in first-year college students.

Method: A longitudinal survey was conducted among 6672 first-year students from three colleges in Anhui province, China. Logistic regression, lasso regression, and random forest models were combined to identify the most significant predictors of depressive symptoms. A nomogram was constructed based on multifactor logistic regression models.

Results: Seven risk factors for depressive symptoms were identified: emotional abuse, peer violence, academic stress, punishment, health adaptation, positive childhood experiences (PCEs), and support utilization. The training set, validation set (internal validation) and testing set (external validation) of the binary logistic regression-based model showed good discrimination (area under the curve (AUC) 0.757, 95 % CI: 0.726–0.789; 0.699, 95 % CI: 0.648–0.751; 0.709, 95 % CI: 0.670–0.748, respectively), and accuracy (Brier scores of 0.061, 0.066, and 0.073, respectively). The nomogram shows good prediction of discrimination, calibration and generalization.

Conclusion: The comprehensive nomogram constructed in this study is a useful and convenient tool for assessing the risk of depressive symptoms among first-year college students. It will help healthcare professionals to assess the risk of depressive symptoms among first-year college students, identify high-risk groups and take more effective preventive measures.

1. Introduction

Most mental disorders begin during adolescence/youth (12–24 years of age), and three-quarters of all lifetime mental disorders emerge before the age of 25 (Tabor et al., 2021). Arnett (Arnett, 2000) has coined the term "emerging adulthood" to encapsulate this culturally constructed phase of extended adolescence that occurs in industrialized countries while pursuing higher education. College years are a critical stage in the transition from adolescence to adulthood, and college students are more prone to depression, anxiety and other negative emotions in the face of changes in their social roles, learning modes, and lifestyles (Ma et al., 2020; Xiang et al., 2020). During this period, they are generally sensitive to the shift in their surroundings, such as changes of living and learning environments (Arnett et al., 2014; Wu et al., 2020). Literature has indicated that depression is one of the most common mental disorders among college students (Duffy et al., 2019). A meta-analysis of 64 studies showed that the prevalence of depressive symptoms among college students was 33.6 % (Li et al., 2022). Exposure to various life events can have an impact on the health and quality of life of first-year college students (Martin-Gutierrez et al., 2021; Tang et al., 2022).

* Corresponding authors at: School of Public Health, Anhui Medical University, No 81 Meishan Road, Hefei 230032, Anhui, China.
E-mail address: 2004500039@ahmu.edu.cn (Y. Wan).
[1] These authors contributed equally to this work.

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College students are an important population that determines the economic growth and success of a nation (Auerbach et al., 2018), so the mental health of college students should be a key public health priority.

Stress vulnerability models generally assume that exposure to negative life events is a broad risk factor for the development of anxiety, depression, functional disorders, and psychosis (Dienstbier, 1989). Furthermore, the "cumulative stress hypothesis" contends that as stress accumulates over time, individuals become increasingly susceptible to mental disorders (Barthas et al., 2020). Early life adversity may increase vulnerability to stress and increase the risk of stress-related psychiatric disorders (Nikkheslat et al., 2020), and a review shows that major stressful life events prospectively predict premorbid symptoms of depression (Gotlib and Joormann, 2010). Often occurring during sensitive periods of brain development, adverse childhood experiences (ACEs) have been related to changes that may persist and worsen throughout childhood, into adolescence and young adulthood, leading to higher stress (Daníelsdóttir et al., 2024; Nurius et al., 2015). Additionally, a longitudinal study has indicated that stressful life events (SLEs) are a risk factor for unfavorable physical and mental health conditions among adolescents (Roth et al., 2023). In light of these theoretical frameworks, we selected early life events, with a particular focus on ACEs, and recent life events, such as stressful life events, as predictors of depressive symptoms among first-year college students. Moreover, the "buffering hypothesis" underscores that robust social support can counterbalance the deleterious effects of stress on health (Cohen and Wills, 1985). Social support may also be a helpful factor in buffering harm from adverse life events (Zhou et al., 2023). In addition, there is now research to confirm that positive life events can buffer the risk of physical or mental health conditions associated with negative life events (Huang et al., 2023; Yarrington et al., 2023). Consequently, we have incorporated positive childhood experiences (PCEs) and social support as pivotal factors in our analysis.

Few studies have examined the longitudinal effects of recent and early life events on first-year college students' depressive symptoms. The present study aims to examine the longitudinal effects of recent and early life events as well as social support on first-year college students' depressive symptoms and aims to develop a predictive model for assessing the risk of developing depressive symptoms in first-year college students. It aims to provide a theoretical basis for prevention and intervention strategies for depressive symptoms among first-year college students, with the ultimate goal of reducing the incidence of depressive symptoms.

2. Methods

2.1. Participants and procedures

This study was a prospective cohort of students from three medical colleges in Anhui Province, China. We selected first-year college students from three universities in Anhui Province using cluster sampling, but those taking medicines for psychological illness and suffering from serious health were excluded. More details can be seen in the study flowchart (Fig. 1). At baseline, a total of 7719 first-year college students were recruited to complete an anonymous online questionnaire assessing their mental health symptoms and recent/early-life events between November and December 2021. While school identification numbers were recorded for longitudinal tracking purposes, all responses were anonymized to ensure confidentiality during data collection. Six months later, between May and June 2022, follow-up data on depressive symptoms were collected. After excluding students taking medication for psychiatric illness and those who missed visits, as well as 696 samples that showed depressive symptoms at baseline, a total of 6772 samples were finally included in the analyses. Of these, 4619 samples of freshmen from the two colleges were collected and randomly divided into training and validation sets according to a ratio of 7:3. A sample of 2153 freshmen from the other college was used as the testing set for the model, again excluding samples that showed depressive symptoms at baseline. The study was reviewed by the Ethics Committee of Anhui Medical University (20200573), and informed consent was obtained from students prior to the survey.

2.2. Adverse childhood experiences

Adverse Childhood Experiences (ACEs) were defined as experiences of abuse during childhood and/or family dysfunction, as well as exposure to peer violence and community violence. In this study, the assessment of ACEs was carried out referencing the Adverse Childhood Experiences International Questionnaire (ACE-IQ) (World Health Organization, 2018). The complete questionnaire covered aspects of childhood abuse, family dysfunction, community violence, and peer violence.

For childhood abuse, which encompasses emotional neglect, physical neglect, emotional abuse, physical abuse, and sexual abuse, each type of adverse experience was comprised of two to three entries. Community violence consisted of two entries, including "witnessed someone being beaten up in your neighborhood or around your school or suffered a beating yourself". Peer violence included three entries, for example, "you were beaten up, kicked or locked indoors intentionally by

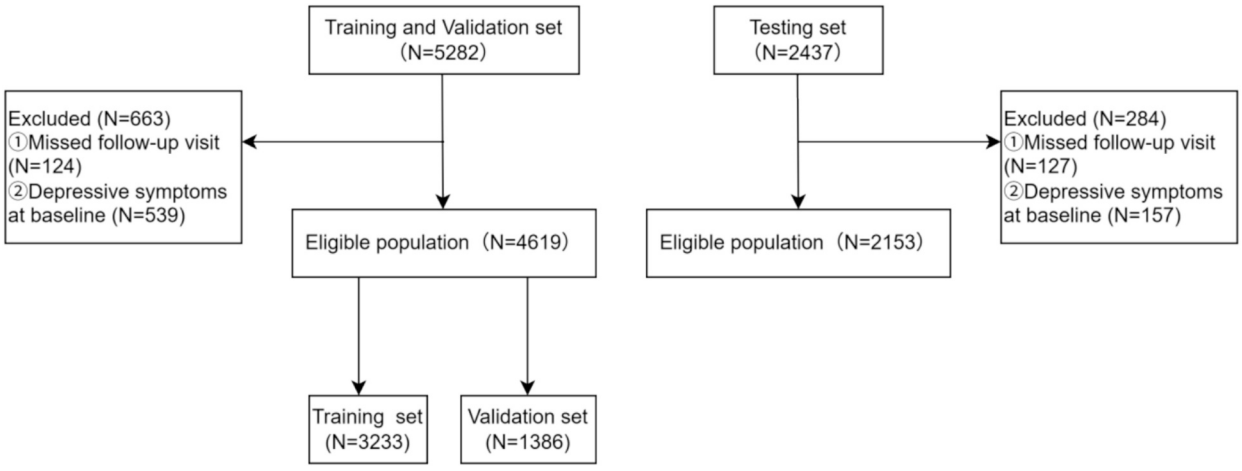

Fig. 1. Data selection flowchart. (A) Optimal parameter (lambda) selection in the lasso model used ten-fold cross-validation via minimum criteria. (B) Lasso coefficient profiles of the variables.

your peers or classmates". Each of these entries was rated on a − 5-point scale, where responses were scored as 1 = "never", 2 = "rarely", 3 = "sometimes", 4 = "most of the time", and 5 = "always". If students responded with "rarely", "sometimes", "most of the time", or "always" to any item within a particular category, they were categorized as having been "exposed to that type". Family dysfunction included five entries, like "witnessed your parents fighting". Each item had two response options: "yes or no". If a student answered "yes" to one or more of these entries, they were considered to be "exposed to that type". Cronbach's alpha coefficient was 0.760.

2.3. PCEs

PCEs that occurred prior to the age of 18 years were assessed using the Benevolent Childhood Experiences (BCEs) scale (Narayan et al., 2018). There are ten entries in the scale, and each item is rated on a 2-point scale of "0" (no) and "1" (yes). Cronbach's alpha coefficient for the Benevolent Childhood Experiences scale was 0.687.

2.4. Stressful life events

Stressful life events were assessed using the Adolescent Self-rating Life Events Check List (ASLEC) compiled by Liu et al. (Liu et al., 1997). The ASLEC is made up of 27 entries, each rated on a 5-point scale from "1" (no occurrence/no impact) to "5" (very serious impact occurs), with a higher score indicating a more severe negative life event in the most recent year. The ASLEC encompasses six factors: interpersonal relationships, academic stress, punishment, loss, health adaptation, and other (Liu et al., 1997). This scale has been widely used in studies of Chinese university students and has good reliability and validity. In this study, Cronbach's alpha coefficient for the ASLEC was 0.906.

2.5. Social support

The Social Support Rating Scale (SSRS) was developed by (Xiao and Yang, 1987), and the validity and reliability of the Chinese version of the SSRS has been confirmed by a number of studies (Xiao, 1994). The full scale includes ten entries, encompassing three factors, i.e., subjective support, objective support, and support utilization. Of these, subjective support encompasses four entries, and objective support and support utilization each contain three entries, with higher scores indicating that individuals receive more social support. In this study, the internal consistency was good, and the Cronbach's alpha coefficient was 0.979.

2.6. Depressive symptoms

Participants' depressive symptoms were assessed using the Patient Health Questionnaire (PHQ-9) (Kroenke et al., 2001), a nine-item self-report measure of depressive symptoms based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for major depressive disorder. The Chinese version of the PHQ-9 has satisfactory psychometric properties among Chinese university students. Respondents were asked to rate each item on a scale of 0 to 3 (0 = not at all, 1 = for a few days, 2 = for more than a week, and 3 = almost every day) according to the extent to which the symptoms had bothered them in the past two weeks. In the present study, we used a total score from 0 to 27 for the measure and a threshold of >9 to define depressive symptoms. In this study, the Cronbach's alpha values for the PHQ-9 at the baseline and follow-up surveys, respectively, were 0.827 and 0.902.

2.7. Covariates

Demographic factors included sex (male or female), residence (rural, urban), whether the student is an only child (yes or no), paternal education (junior high school and below, high school and above), maternal education (junior high school and below, high school and above), and perceived family economic level (low, medium, high).

2.8. Statistical analysis

Before conducting preliminary statistical analyses, we randomly divided the datasets collected from two colleges into a training set and a validation set at a ratio of 7:3. The training set was used to train the supervised model, fit the model, adjust its parameters, select input variables, and make other choices about the algorithm. The validation set (for internal validation) was then utilized to assess the effectiveness of the trained model without altering its parameters or effects. This helps primarily to verify whether the model is overfitted or underfitted, and based on the results, we can then decide whether to retrain the model or opt for another algorithm. Moreover, a testing set (for external validation) is employed. This is because both the training and validation sets have the same distribution, while the distribution of different samples and that of the samples used to train the model may vary.

The primary data analysis commenced with the calculation of descriptive statistics for the training set. Categorical variables were presented in the form of percentages, whereas continuous variables were reported as the mean plus or minus the standard deviation ($M \pm SD$). For continuous variables that did not follow a normal distribution, the Mann-Whitney *U* test was first utilized to discern statistically significant differences. Similarly, for categorical variables, the chi-square test was employed to identify statistically significant differences. Subsequently, two statistical approaches, namely univariate analysis and random forest analysis, were implemented to identify significant predictors of depressive symptoms. The random forest algorithm was utilized to compute the Mean Decreased Gini (MDG) for each variable. The MDG shows the extent to which each variable contributes to the risk of depressive symptoms and clarifies the relationship between the independent and dependent variables. In the random forest model, the parameter "ntree" determines the number of decision trees within the forest. The calculations associated with the random forest algorithm were adjusted based on the dependent variable. This adjustment was carried out to obtain the optimal model parameters and the ideal number of trees, thereby enhancing the performance and accuracy of the model. Finally, variables that exhibited statistical significance in the univariate analysis ($p < 0.05$) and those among the top 50 % of the variables ranked by their Mean Decreased Gini values in the random forest analysis were selected for inclusion in the subsequent analyses. These variables were considered crucial for further exploration and for building a more comprehensive understanding of the factors associated with depressive symptoms.

Following these procedures, the significant factors that were identified were used to construct the binary logistic regression model. Here lasso regression was used to remove covariates and to exclude highly correlated variables to ensure that the multifactor logistic regression model was not overfitted. Finally, based on the multivariate model consisting of the optimal predictors, a modal plot was created to predict the probability of depressive symptoms. Goodness-of-fit was assessed by calibration, where the predicted probability of goodness-of-fit was compared with the actual probability. The discriminatory power of the nomogram was evaluated using the receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC) value is the area covered by the ROC curve. The calibration plot was internally validated with 500 bootstrap samples. In addition, high quality external validation was performed to verify nomogram generalizability. Statistical analyses were performed using SPSS 23.0, R-software (version 4.4.1, http://www.R-project.org). Two-sided *p*-values <0.05 were considered statistically significant.

3. Results

3.1. Training set, validation set and testing set baseline features

The data selection process is shown in the flowchart in Fig. 1. Characteristics of the subjects are shown in Table 1. After exclusion of any samples with depressive symptoms at baseline, there were a total of 6772 first-year college students, with 2913 (43.0 %) males and 3859 (57.0 %) females and a mean age of 18.9 ± 0.9 years. Depressive symptoms were reported in 7.5 % of participants at follow-up.

3.2. Identifying predictors

Univariate factor analyses and random forests for depressive symptoms in first-year college students at follow-up are shown in Table 2. The default value of ntree was 500, and this value was tested and adjusted, and finally determined to be optimal in the predictive model for depressive symptoms when mtry = 1 and ntree = 50. In the univariate analysis of variance, 18 variables yielded significant results ($P < 0.05$). In conjunction with the random forest MDG ordination, the top 50 % of influencing factors were selected for inclusion in the subsequent analyses. These twelve variables included support utilization, subjective support, objective support, PCEs, academic stress, interpersonal relationships, health adaptation, loss, punishment, emotional abuse, peer violence, and "other".

We identified the independent predictive features in the training set using the non-zero coefficients in lasso regression (Fig. 2). The selection of the optimal parameter (lambda) in the lasso model was cross-validated by ten-fold. Lasso regression minimises the effect of multiple covariance and has the advantage of being highly predictive and robust in order to exclude variables with covariance. Finally, the variables "interpersonal relationships" and "other" were excluded from the predictive model of depressive symptoms.

Ten potential risk factors in the predictive model for depressive symptoms were included in the binary logistic regression model (Table 3). In the training set model, college students with experiences of emotional abuse (OR = 1.392, 95%CI = 1.004–1.928, $P = 0.049$) and peer violence (OR = 1.392, 95%CI = 1.004–1.928, $P = 0.047$) as their ACEs were more likely to develop depressive symptoms. Negative life events of academic stress (OR = 1.068, 95%CI = 1.017–1.121, $P = 0.008$), and health adaptation (OR = 1.095, 95%CI = 1.014–1.183, $P = 0.021$) were positively correlated to depressive symptoms. The analysis revealed no positive association between punishment (OR = 0.890, 95 % CI = 0.824–0.962, $P = 0.003$) and depressive symptoms. PCEs (OR = 0.870, 95%CI = 0.821–0.922, $P < 0.001$) were negatively associated with depressive symptoms. Support utilization in the social support dimension (OR = 0.948, 95 % CI = 0.903–0.995, $P = 0.032$) was negatively associated with depressive symptoms. Emotional abuse, peer violence, academic stress, punishment, health adaptation, PCEs and support utilization were found to be significant influences on depressive symptoms through the binary logistic regression analysis.

3.3. Construction and evaluation of nomogram

Based on the results of the binary logistic regression model, a nomogram was created to predict depressive symptoms (Fig. 3, Fig. 4). Illustrated in Fig. 3, this nomogram delineates the contribution of each factor as a score, culminating in a total score indicative of the predicted probability of depressive symptoms. The results indicated that, in relation to depressive symptoms, the health adaptation factor was associated with the highest risk score, which was 100. Significantly, the academic stress factor followed closely with a score of 98. In the external validation, the AUC (Fig. 4) was 0.709, with a 95 % CI of 0.670–0.748. The Brier scores were 0.061, 0.066, and 0.073, respectively, further demonstrating the high prediction accuracy of the nomogram. The Brier score measures the accuracy of probabilistic predictions. It is calculated

Table 1
Baseline characteristics of the data.

Variables	Training set	Validation set	Testing set	p-value
	Total (n = 3233)	Total (n = 1386)	Total (n = 2153)	
Sex				0.542
Male	1384 (43 %)	614 (44 %)	915 (42 %)	
Female	1849 (57 %)	772 (56 %)	1238 (58 %)	
Residence				<0.001
Rural	1913 (59 %)	825 (60 %)	1042 (48 %)	
Urban	1320 (41 %)	561 (40 %)	1111 (52 %)	
Only child				<0.001
Yes	614 (19 %)	283 (20 %)	603 (28 %)	
No	2619 (81 %)	1103 (80 %)	1550 (72 %)	
Paternal education				<0.001
Junior high school and below	2495 (77 %)	1033 (75 %)	1341 (62 %)	
High school and above	738 (23 %)	353 (25 %)	812 (38 %)	
Maternal education				<0.001
Junior high school and below	2665 (82 %)	1113 (80 %)	1512 (70 %)	
High school and above	568 (18 %)	273 (20 %)	641 (30 %)	
Perceived family economic level				0.379
Low	1107 (34 %)	447 (32 %)	737 (34 %)	
Medium/high	2126 (66 %)	939 (68 %)	1416 (66 %)	
Emotional neglect				0.003
No	719 (22 %)	285 (21 %)	396 (18 %)	
Yes	2514 (78 %)	1101 (79 %)	1757 (82 %)	
Physical neglect				0.117
No	2718 (84 %)	1161 (84 %)	1765 (82 %)	
Yes	515 (16 %)	225 (16 %)	388 (18 %)	
Emotional abuse				0.536
No	2720 (84 %)	1164 (84 %)	1833 (85 %)	
Yes	513 (16 %)	222 (16 %)	320 (15 %)	
Physical abuse				0.254
No	2561 (79 %)	1084 (78 %)	1665 (77 %)	
Yes	672 (21 %)	302 (22 %)	488 (23 %)	
Witnessing community violence				0.416
No	2815 (87 %)	1187 (86 %)	1869 (87 %)	
Yes	418 (13 %)	199 (14 %)	284 (13 %)	
Peer violence				0.447
No	2777 (86 %)	1173 (85 %)	1829 (85 %)	
Yes	456 (14 %)	213 (15 %)	324 (15 %)	
Sexual abuse				0.114
No	3104 (96 %)	1337 (96 %)	2048 (95 %)	
Yes	129 (4 %)	49 (4 %)	105 (5 %)	
Family dysfunction				0.791
No	2123 (66 %)	909 (66 %)	1395 (65 %)	
Yes	1110 (34 %)	477 (34 %)	758 (35 %)	
Interpersonal relationships	7.09 (2.72)	7.13 (2.70)	7.37 (2.65)	0.001
Academic stress	8.14 (3.11)	8.32 (3.19)	8.44 (2.97)	0.002
Punishment	7.88 (2.09)	7.90 (2.05)	7.91 (1.76)	0.852
Loss	3.84 (1.67)	3.79 (1.55)	3.99 (1.72)	<0.001
Health adaptation	5.65 (1.99)	5.66 (1.95)	5.76 (1.85)	0.121
Other	5.01 (1.71)	4.98 (1.62)	4.88 (1.45)	0.013
PCEs	8.42 (1.96)	8.46 (1.90)	8.78 (1.69)	<0.001
Subjective support	18.18 (5.05)	18.19 (5.08)	19.43 (4.45)	<0.001

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Table 1 (*continued*)

Variables	Training set	Validation set	Testing set	p-value
	Total (n = 3233)	Total (n = 1386)	Total (n = 2153)	
Objective support	23.51 (5.99)	23.62 (5.98)	24.58 (5.06)	<0.001
Support utilization	22.20 (6.21)	22.05 (6.11)	23.49 (5.43)	<0.001
Depressive symptoms				0.003
No	2963 (92 %)	1280 (92 %)	2027 (94 %)	
Yes	270 (8 %)	106 (8 %)	126 (6 %)	

as the mean squared difference between the predicted probability and the actual outcome. The calibration plot is depicted in Fig. 5 and the calibration curve functions as a visual instrument for assessing the calibration performance of a model. It measures the calibration level of the model by contrasting the relationship between the observed event rates and the predicted probabilities. When the calibration curve closely aligns with the diagonal line, it strongly suggests that the model demonstrates outstanding calibration performance. When the factors influencing depressive symptoms are visualised, it is possible to predict an individual's risk of developing depressive symptoms. Firstly, each independent influencing factor of depressive symptoms was projected upwards to the first row of the scale to obtain a score for each factor, and then the scores of all influencing factors were summed to obtain a total score. Secondly, an individual's risk of developing depressive symptoms is calculated based on the total score.

4. Discussion

The present study was a longitudinal study of 6772 first-year college students from Anhui Province in China, designed to investigate the role of recent and early life events in first-year college students' depressive symptoms and to select predictors to construct a model which predicts first-year college students' depressive symptoms at follow-up. The main findings of this study reveal several risk factors for the development of depressive symptoms in freshmen. These risk factors include emotional abuse, peer violence, academic stress, punishment, health adaptation, PCEs, and support utilization. The nomogram identifies individual characteristics, as well as significant influences on different dimensions of recent and early life events, making it more accurate in the prediction of depressive symptoms.

Previous studies have shown that females are more prone to negative emotions than males (Fang et al., 2022). Females are more emotionally expressive than men, their mental and emotional states are more susceptible to external factors than males', and females and males show different neurobiological responses when exposed to stressors (Eid et al., 2019; Heck and Handa, 2019). This is inconsistent with the findings of the present study, which may be due to the significant influence of life events on depressive symptoms among college students, thus somewhat masking or diminishing the role of sex factors on depressive symptoms.

The results of our longitudinal study showed that peer violence and emotional abuse remain important factors influencing mood symptoms, which is consistent with the findings of Hilda et al. (Daníelsdóttir et al., 2024). Although only two dimensions of peer violence and emotional abuse were screened in the present study and validated for their effects on depressive symptoms among college students in a longitudinal study, it does not mean that the other dimensions of ACEs did not have an effect. Results from previous studies have shown that experiencing peer violence in childhood is associated with depressive symptom outcomes (Lee et al., 2024) and that individuals who experienced bullying in childhood are more likely to experience violent victimisation (Beckwith et al., 2022). Thus adverse childhood experiences remain an important risk factor for the development of negative affect in adulthood.

In terms of stressful life events, academic stress, health adaptation

Table 2
Results for the training set of baseline features and random forests.

Variables	Univariate factor analysis			Random Forest
	No (n = 2963)	Yes (n = 270)	p-value	Mean Decreased Gini
Sex			0.991	1.64061908177318
Male	1269 (43 %)	115 (43 %)		
Female	1694 (57 %)	155 (57 %)		
Residence			0.973	2.05545530951058
Rural	1754 (59 %)	159 (59 %)		
Urban	1209 (41 %)	111 (41 %)		
Only child			0.653	1.88524107591922
Yes	566 (19 %)	48 (18 %)		
No	2397 (81 %)	222 (82 %)		
Paternal education			0.747	1.5629323723974
Junior high school and below	2284 (77 %)	211 (78 %)		
High school and above	679 (23 %)	59 (22 %)		
Maternal education			0.624	1.76825827352546
Junior high school and below	2439 (82 %)	226 (84 %)		
High school and above	524 (18 %)	44 (16 %)		
Perceived family economic level			0.022	2.16352199266655
Low	997 (34 %)	110 (41 %)		
Medium/high	1966 (66 %)	160 (59 %)		
Emotional neglect			0.003	1.06796769417702
No	679 (23 %)	40 (15 %)		
Yes	2284 (77 %)	230 (85 %)		
Physical neglect			0.007	1.62140260087257
No	2507 (85 %)	211 (78 %)		
Yes	456 (15 %)	59 (22 %)		
Emotional abuse			< 0.001	2.55574559331971
No	2522 (85 %)	198 (73 %)		
Yes	441 (15 %)	72 (27 %)		
Physical abuse			0.004	2.33923261151182
No	2366 (80 %)	195 (72 %)		
Yes	597 (20 %)	75 (28 %)		
Witnessing community violence,			< 0.001	2.1567056419547
No	2605 (88 %)	210 (78 %)		
Yes	358 (12 %)	60 (22 %)		
Peer violence			< 0.001	2.34630381302465
No	2574 (87 %)	203 (75 %)		
Yes	389 (13 %)	67 (25 %)		
Sexual abuse			0.063	1.58706695536343
No	2851 (96 %)	253 (94 %)		
Yes	112 (4 %)	17 (6 %)		
Family dysfunction			0.008	2.08388271608213
No	1966 (66 %)	157 (58 %)		

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Table 2 (*continued*)

Variables	Univariate factor analysis			Random Forest
	No (n = 2963)	Yes (n = 270)	p-value	Mean Decreased Gini
Yes	997 (34 %)	113 (42 %)		
Interpersonal relationships	7.02 (2.67)	7.89 (3.11)	<0.001	7.71144323424668
Academic stress	8.05 (3.03)	9.18 (3.71)	<0.001	8.78947407286581
Punishment	7.86 (2.08)	8.14 (2.12)	<0.001	4.73347025659953
Loss	3.81 (1.63)	4.14 (2.02)	0.002	5.34966860862805
Health adaptation	5.60 (1.96)	6.27 (2.26)	<0.001	7.14555076273573
Other	4.97 (1.68)	5.43 (1.96)	<0.001	6.39677883119919
PCEs	8.50 (1.89)	7.45 (2.40)	<0.001	9.65888779357463
Subjective support	18.36 (5.03)	16.17 (4.78)	<0.001	8.77175913533749
Objective support	23.72 (5.99)	21.26 (5.52)	<0.001	8.26599440029776
Support utilization	22.44 (6.19)	19.55 (5.91)	<0.001	9.98285511063013

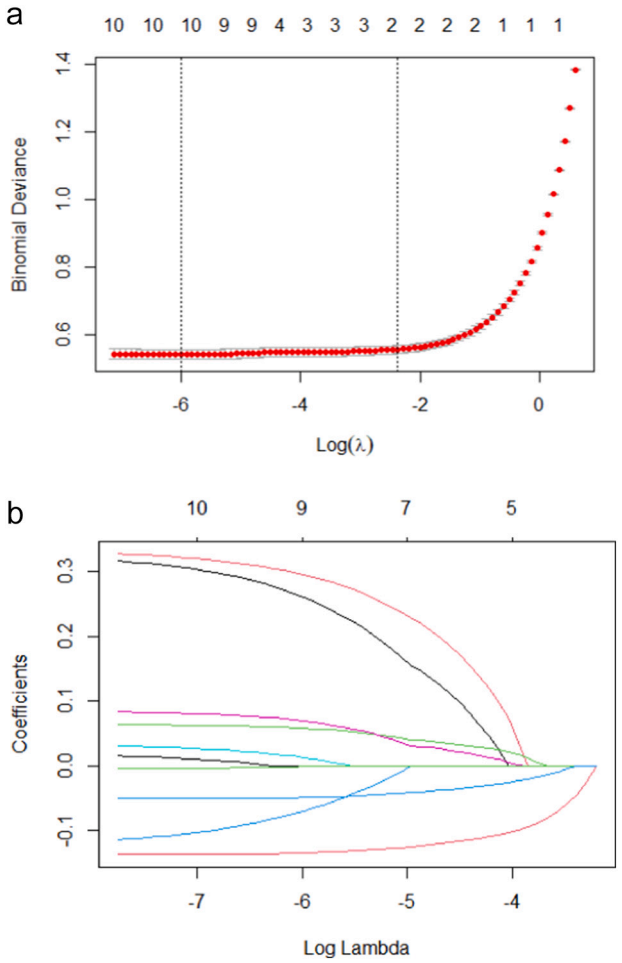

Fig. 2. The variable filtering process of the Lasso regression.

and punishment were significant predictors for depressive symptoms among first-year students. A review showed that academic stress was positively associated with at least one psychological symptom, such as depression, anxiety, or suicide (Steare et al., 2023). Most first-year college students leave their families for the first time to study in a different place, and inevitably experience difficulties in quickly adapting to the university environment, living independently, and coping with external pressures (Hua et al., 2024). It is worth noting that in this study, punishment was negatively associated with depressive symptoms among first-year college students This is in contrast to previous studies, in which the punishment had a significant effect on contingency symptoms in secondary school students in a study of Chinese adolescents (Ma et al., 2024). Nederhof and Schmidt (Nederhof and Schmidt, 2012) proposed a model which integrated the cumulative stress hypothesis with the developmental mismatch hypothesis and individual differences in susceptibility. The developmental mismatch hypothesis states that early experiences shape the brain and behavior; major differences in stressors between the early years of development and later life stages are mismatches that can cause disease (both physically, e.g., cardiovascular, and mentally, e.g., depression) (Hoogland and Ploeger, 2022; Lea et al., 2023). For instance, individuals who endured an unsafe and highly stressful upbringing often develop coping mechanisms to deal with stress (Santarelli et al., 2017). On the other hand, after six months of adjustment to the new living environment, the effects of punishment faced at the beginning of the school year may be diluted by time effects (Singham et al., 2017). This may explain why punishment at baseline may be a protective factor for depressive symptoms at follow-up, and provides new ideas for subsequent research. In addition, We did additional analyses of punishment (Table S1 in Supplement), which showed that punishment was a risk factor for depressive symptoms in an analytical model that included only punishment. When punishment was included in the model with the other dimensions of negative life events, punishment showed a protective effect, whereas when punishment was included in the model with PCEs and support use, it showed as a risk factor. As the inclusion of variables was preceded by a lasso regression to exclude variables with covariates, the results suggest that there may be moderating or mediating roles between these factors that we have not yet identified, providing new ideas for future studies.

Table 3
Multivariate logistic regression model for depressive symptoms.

Variables	β	S.E	p-value	OR (95%CI)
Emotional abuse(1)	0.331	0.166	0.047	1.392(1.004,1.928)
Peer violence(1)	0.331	0.168	0.049	1.392(1.001,1.935)
Academic stress	0.066	0.025	0.008	1.068(1.017,1.121)
Punishment	−0.116	0.040	0.003	0.890(0.824,0.926)
Loss	0.035	0.039	0.374	1.035(0.959,1.118)
Health adaptation	0.091	0.039	0.021	1.095(1.014,1.183)
PCEs	−0.139	0.030	< 0.001	0.870(0.821,0.922)
Subjective support	−0.007	0.029	0.809	0.993(0.938,1.052)
Objective support	0.005	0.021	0.813	1.005(0.964,1.048)
Support utilization	−0.054	0.025	0.032	0.948(0.903,0.995)

Note: OR: Odds Ratio, CI: Confidence Interval.

Our findings suggest that positive childhood experiences play a protective role against the development of negative emotions in first-year students, which has an opposite effect to ACEs. Luo (Luo et al., 2024) and Christina Bethell (Bethell et al., 2019), among others, have shown that PCEs are effective in attenuating the negative impacts of ACEs and in strengthening an individual's psychological resilience. A systematic review showed that higher levels of PCEs are consistently associated with better mental health outcomes, such as reduced depressive symptoms, anxiety and suicidal behaviours, as well as improved psychosocial well-being, including reduced perceived stress and increased life satisfaction (Cunha et al., 2024).

At the same time, we found that social support has a protective effect on the development of negative emotions in first-year college students, especially support utilization. This was consistent with our findings in Junqiang et al.'s study on university students, which showed that support utilization could alleviate depressive symptoms in university

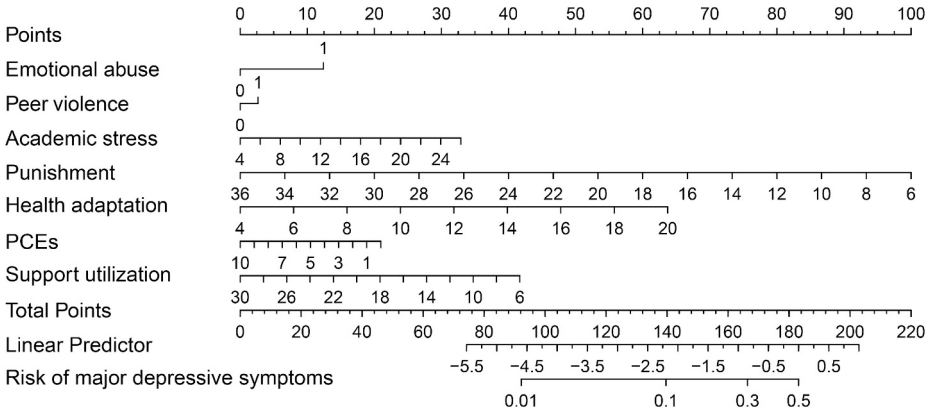

Fig. 3. Proposed nomogram of the likelihood of developing depressive symptoms after six months. Note: Emotional abuse and peer violence are measured by 0 for "No", 1 for "Yes". Freshman risk predictors were located on the axis for each variable, and then, based on each value, a line was drawn upward at a 90° angle to determine the score for that particular variable. These and the total score axes were labelled with numbers and a line drawn down at a 90° angle to the depressive symptoms axis to determine the risk of developing depressive symptoms at six months.

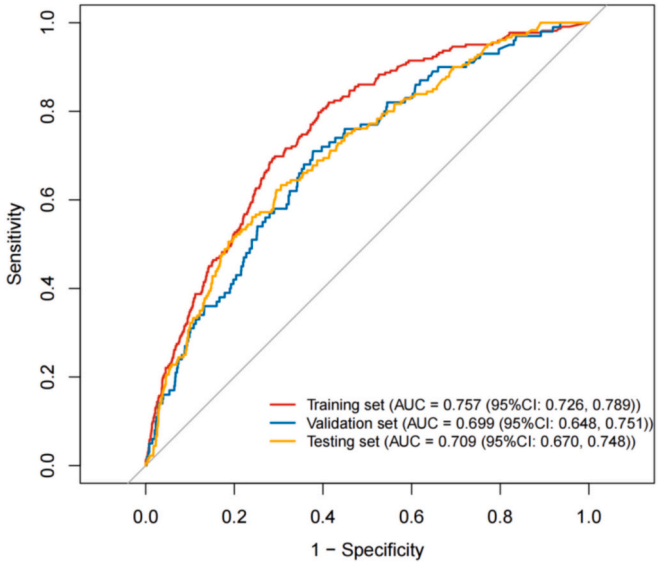

Fig. 4. ROC curve of the nomogram.

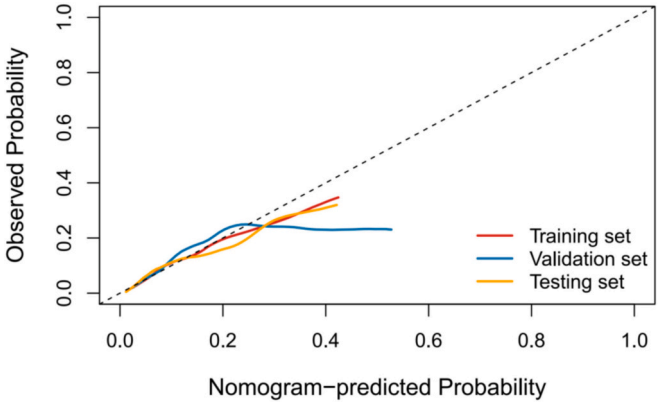

Fig. 5. Calibration curves of the model.

students (Fan et al., 2024). This is also supported by the "buffering hypothesis" (Cohen and Wills, 1985). Social support networks play a crucial role in shielding individuals from the detrimental impacts of negative events and stressors. By providing emotional, instrumental, and informational resources, these networks act as a buffer, reducing the potential harm that such experiences might otherwise cause (Gable and Bedrov, 2022; Margolis et al., 2019; Pei et al., 2023). Additionally, robust and supportive social networks have the capacity to assist individuals in fully capitalizing on positive events (Chang et al., 2023). They can enhance the positive emotions associated with these experiences, expand opportunities for personal growth and development that positive events may bring, and foster a more fulfilling and enriching life overall (Gable and Bedrov, 2022).

The nomogram combining emotional abuse, peer violence, academic stress, punishment, health adjustment, PCEs, and support utilization has a better predictive ability for the occurrence of depressive symptoms in first-year college students. By using the nomogram recommended in this study, educators and healthcare professionals can more easily assess, manage and communicate the risk of depressive symptoms in first-year college students on an individualized basis. This accurate method of risk assessment will help professionals identify high-risk populations and develop further practical preventive measures.

This study has certain strengths and practical implications. First, this study is based on a longitudinal study of a large-scale population which is then used to construct a nomogram to predict the risk of developing depressive symptoms among first-year college students. With the help of the nomogram, we can identify first-year college students who are potentially at risk for developing depressive symptoms and intervene in a timely manner based on risk factors. Secondly, this study adopted a longitudinal research design by tracking the development of the effects of recent and early life events on health status over time, thus providing more reasonable and credible evidence for the inference of causality. However, there are still some limitations in this study. Firstly, all variables were based on self-reports. In the absence of objectively measured data, recall bias and social desirability bias are inevitable. Secondly, our analysis was limited to the dimensions of recent and early life events and demographic factors as risk factors for freshmen. A more in-depth multifactorial exploration is required in the future. There could be a multitude of other factors, such as personality traits, family economic status, and cultural background, that might interact with these life events to influence the well-being of freshmen, and these aspects remain to be investigated. Thirdly, our study was confined to only three medical colleges in Anhui Province, China. As a result, the generalizability of these results to other university students both within and outside of China is questionable. To validate our findings, further research should be conducted on more diverse and nationally representative populations.

5. Conclusion

In summary, this study combined logistic regression, lasso regression, and random forest models to more accurately explore the factors that influence first-year college students' risk of developing depressive symptoms. Also, very importantly, we constructed a nomogram which predicts the risk of depressive symptoms and has good internal and external validation. This helps to distinguish first-year college students who are more likely to develop depressive symptoms from the general population and provides an authoritative scientific basis for developing effective prevention and intervention measures to reduce the risk of depressive symptoms.

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CRediT authorship contribution statement

Runyu Wei: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lanlan Li:** Investigation, Data curation. **Ying Zhang:** Investigation, Data curation. **Yu Liu:** Investigation, Data curation, Conceptualization. **Rui Wang:** Funding acquisition. **Shuqin Li:** Supervision, Investigation, Data curation. **Yuhui Wan:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

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Declaration of competing interest

We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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