

Relationship Between Adverse Childhood Experiences and Depressive Symptoms Among Nursing Students: Serial Mediation Effects of Family Communication, Perceived Stress, and the Moderating Effect of Self-Efficacy

Panyu Fan

Shanghai Jiao Tong University

Tingyan Wang

Shanghai Jiao Tong University

Xiaoying Zhang

Shanghai Jiao Tong University

Xinai Li

Shanghai International Studies University

Haosheng Li

University of Birmingham

Yijie Peng

Peking University

Huoshen Nadiya

Shanghai Jiao Tong University

Ya Su

Shanghai Jiao Tong University

Jian Chang

chang.jiancn@sjtu.edu.cn

Shanghai Jiao Tong University

Research Article

Keywords: Adverse childhood experiences, depressive symptoms, family communication, perceived stress, self-efficacy, nursing students

Posted Date: October 6th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10942462/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background

Adverse childhood experiences are associated with depressive symptoms, but the processes underlying this association remain insufficiently understood among nursing students. This study examined the association between adverse childhood experiences and depressive symptoms, serial indirect associations through family communication and perceived stress, and whether self-efficacy moderated the association between perceived stress and depressive symptoms.

Methods

This secondary cross-sectional analysis used data from 932 nursing students aged 18–35 years from 196 universities identified in a nationwide multicenter survey in China. Adverse childhood experiences, family communication, perceived stress, depressive symptoms, and self-efficacy were assessed using self-report scales. Covariate-adjusted serial mediation and exploratory moderated mediation models were estimated. University-level clustering was addressed using cluster-robust inference, and indirect associations were evaluated using 5,000 university-level cluster-bootstrap resamples.

Results

Greater exposure to adverse childhood experiences was associated with poorer family communication, higher perceived stress, and more severe depressive symptoms. The total indirect association was 0.343 (95% confidence interval 0.171 to 0.599). The specific indirect association through perceived stress was 0.294 (95% confidence interval 0.116 to 0.553), and the serial indirect association through family communication and perceived stress was 0.086 (95% confidence interval 0.040 to 0.138). The indirect association through family communication alone was not supported. The perceived stress-by-self-efficacy interaction was statistically supported (unstandardized coefficient 0.053, $P = 0.014$), with the stress–depressive symptom association slightly stronger at higher self-efficacy; however, the incremental explanatory contribution was small (change in explained variance = 0.010).

Conclusions

Perceived stress was the principal indirect pathway linking adverse childhood experiences with depressive symptoms, while family communication contributed through stress-related processes. Trauma-informed, non-stigmatizing student support may benefit from prioritizing stress assessment and management while considering family interaction contexts. The small and unexpected moderation finding requires cautious interpretation and longitudinal replication.

1. Introduction

Depression is one of the most common mental disorders worldwide and is associated with impaired social functioning, functional limitations, and reduced quality of life [1, 2]. The global burden of depression increased

between 1990 and 2019 and is projected to remain substantial through 2030 [3]. Mental health concerns are also common among university students. A systematic review and meta-analysis involving 93,679 Chinese university students estimated that the pooled prevalence of depressive symptoms was 34.7%, with a higher prevalence observed during the coronavirus disease 2019 pandemic [4].

Students in health-related disciplines may be particularly vulnerable to psychological distress because they must manage academic demands alongside the requirements of professional and clinical training [5, 6]. Nursing students are required not only to complete intensive theoretical coursework but also to undertake clinical placements involving patient care, interpersonal responsibilities, and emotional labor [7]. A systematic review and meta-analysis found that approximately one in three nursing students experienced depressive symptoms, with a higher pooled prevalence reported in Asian samples [8]. Depressive symptoms and related psychological distress have been associated with poorer academic engagement and performance among medical students and with burnout among practicing nurses [9, 10]. Identifying factors associated with depressive symptoms among nursing students is therefore important for informing targeted psychological support and promoting their academic, clinical, and professional development.

Adverse childhood experiences (ACEs) refer to potentially harmful or traumatic experiences occurring before the age of 18, including abuse, neglect, household dysfunction, and exposure to interpersonal or community violence [11]. ACEs have been consistently associated with depressive symptoms and other adverse health outcomes in adulthood [12]. A systematic review and meta-analysis of prospective longitudinal studies further indicated a dose–response association between cumulative ACE exposure and subsequent mental health outcomes [13]. ACE exposure is also common among university students. In a study of 1,993 university students in the United States, 72.3% reported exposure to at least one ACE [14]. In China, a study involving 13,307 university students found that 32.8% reported ACE exposure and that greater exposure was associated with more severe depressive symptoms [15]. Evidence specific to nursing students remains limited. A cross-sectional study of undergraduate nursing students found that approximately 17% reported four or more ACEs and that greater ACE exposure was associated with higher levels of depression, anxiety, and stress [16]. Although these findings support an association between ACEs and depressive symptoms among nursing students, the psychological and family-related processes underlying this association remain insufficiently understood.

Perceived stress may represent an important proximal process linking ACEs to depressive symptoms. It refers to the extent to which individuals appraise situations in their lives as unpredictable, uncontrollable, or overwhelming [17]. Stress proliferation theory proposes that primary stressors may generate additional stressors across different areas of life, resulting in an accumulation of stress exposure over time [18]. Consistent with this perspective, ACE exposure has been associated with higher perceived stress during early adulthood [19]. Stress sensitization theory further suggests that childhood adversity may increase individuals' sensitivity to subsequent stressful events, such that relatively lower levels of later stress may be associated with adverse psychological responses [20]. ACEs have also been associated with physiological wear and tear across the life course, suggesting that repeated or prolonged stress exposure may have enduring consequences for stress-regulation systems [21]. Previous research has indicated that later stressful experiences and self-related psychological factors may partly account for the association between childhood adversity and depressive symptoms in young adulthood [22]. These findings suggest that perceived stress may be a key pathway through which ACE exposure is associated with depressive symptoms among nursing students, who encounter substantial academic and clinical demands.

In addition to individual stress appraisal, the family environment represents an important social context for mental health. Previous studies among university and medical students have linked family health and family functioning with stress, depression, and other psychological outcomes [23, 24]. The risky families model proposes that family environments characterized by conflict, emotional disconnection, and limited support may contribute to sustained stress exposure and dysregulation of emotional and physiological stress-response systems [25]. Within the broader family environment, family communication represents a specific interactional process. In Olson's Circumplex Model, communication is conceptualized as a facilitating dimension of family functioning and involves listening, emotional expression, clarity, and supportive exchanges among family members [26]. Research has also linked family communication patterns with the mental health of adolescents at risk of psychological problems [27]. In particular, poorer parent–adolescent communication has been associated with higher levels of anxiety and depressive symptoms [28]. A study involving more than 5,000 adolescents further found that family communication moderated the association between ACEs and emotional and behavioral problems [29].

However, existing studies have mainly focused on the association between ACEs and mental health outcomes, while explanations regarding the underlying family environmental mechanisms remain limited [30]. Evidence concerning young adults, particularly nursing students with a history of childhood adversity, also remains relatively limited. Although ACEs occur before the age of 18, their impacts on adult mental health may stem not merely from the early events themselves, but also from persistent family interaction patterns throughout individuals' development. Poor current family communication may reflect insufficient emotional expression, supportive understanding, and collaborative problem-solving processes, and could be associated with elevated perceived stress. Furthermore, previous studies have confirmed that higher perceived stress correlates with greater severity of depressive symptoms [31, 32]. Therefore, family communication and perceived stress may form a serial pathway linking ACEs to depressive symptoms. Comprehensive examination of these factors may help further clarify the association patterns among family interaction environment, individual stress appraisal, and depressive symptoms in nursing students.

The strength of the association between perceived stress and depressive symptoms may also vary according to individual psychological resources. Self-efficacy refers to individuals' beliefs in their capacity to organize and perform the actions required to manage challenges and achieve desired outcomes and is a central construct within social cognitive theory [33]. Individuals with greater self-efficacy may perceive stressful situations as more manageable and may be more likely to adopt active coping strategies. Evidence from Chinese university students suggests that self-efficacy may modify the relationship between stress and depressive symptoms [24]. Similarly, a study of practicing nurses found that self-efficacy moderated the association between occupational stress and mental health problems [34]. Nevertheless, whether self-efficacy modifies the association between perceived stress and depressive symptoms among nursing students with different levels of ACE exposure remains unclear. Examining this moderating role may help clarify the conditions under which stress-related indirect associations vary.

Given the limited evidence regarding the processes linking ACEs with depressive symptoms among nursing students, this study examined these associations in a nationwide survey-derived sample of Chinese nursing students. Specifically, we tested a theoretically specified serial mediation model in which family communication and perceived stress were positioned as sequential mediators of the association between ACEs and depressive symptoms. We further examined whether self-efficacy moderated the association between perceived stress and

depressive symptoms. We hypothesized that greater ACE exposure would be associated with poorer family communication, higher perceived stress, and more severe depressive symptoms, and that family communication and perceived stress would form a significant serial indirect pathway. The moderating role of self-efficacy was examined to clarify the boundary conditions of the proposed indirect associations. The hypothesized model is presented in Fig. 1.

2. Methods

2.1 Study Design

The present study was a secondary cross-sectional analysis of data from the 2023 Psychology and Behavior Investigation of Chinese Residents (PBICR-2023), a nationwide, multicenter survey jointly conducted by the School of Public Health, Peking University, the Yangtze River Delta Health Research Institute of Shanghai Jiao Tong University, and Shandong Provincial Hospital[35]. The survey was conducted across China between June 20 and August 31, 2023. The study protocol was approved by the Biomedical Ethics Committee of Shandong Provincial Hospital on May 5, 2023 (approval number SWYX No. 2023 – 198) and registered in the Chinese Clinical Trial Registry on June 16, 2023 (registration number ChiCTR2300072573). The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [36].

PBICR-2023 combined population-size-based allocation, multistage geographic sampling, and quota-based recruitment. Cities were selected first, followed by urban communities and rural villages within the selected cities. Eligible adult residents were subsequently recruited according to age and sex based quotas informed by the Seventh National Population Census. Trained investigators administered anonymous electronic questionnaires during one-to-one, face-to-face survey sessions after confirming eligibility and obtaining informed consent. Inclusion criteria for the parent survey were: (1) age ≥ 18 years; (2) Chinese nationality; (3) permanent residence in China, defined as spending no more than one month outside China per year; (4) ability to complete the electronic questionnaire independently or with assistance from an investigator; and (5) ability to understand the meaning of all questionnaire items. Exclusion criteria were: (1) impaired consciousness or a severe psychiatric condition that precluded valid participation; (2) cognitive impairment; (3) current participation in another similar study or previous participation in a PBICR survey; and (4) declining to participate. Among 45,830 participants enrolled in the parent survey, 15,072 were identified as current university students from multiple universities and academic disciplines based on self-reported educational status. Nursing students were not recruited separately for the present study but were identified from the university student sample based on their self-reported academic major. Initially, 943 nursing students were identified, accounting for 6.26% of the university student sample. After excluding 11 participants whose ages fell outside the prespecified range of 18–35 years, 932 nursing students from 196 universities were included in the final analysis, representing 6.18% of the university student sample (Fig. 2).

2.2 Measures

2.2.1 Adverse Childhood Experiences (ACEs)

We used the Adverse Childhood Experiences International Questionnaire (ACEs-IQ) [37] to assess individual's adverse childhood situation before the age of 18. It includes physical, sexual, and emotional abuse or neglect, peer violence, and community or collective violence. However, Considering contextual relevance and very low applicability of several collective-violence items in the Chinese general population context, 17 ACE-IQ items were retained [38]. For example, items include "Before the age of 18, did an adult in your household often insult or belittle you?", "Did you live with anyone who had a drinking problem?", and "Were you ever threatened or injured with a knife?". A dichotomous scoring method was employed, with responses coded as "no" or "yes" (0 = no, 1 = yes). The total score was calculated as the sum of these binary items. The Cronbach's alpha for ACEs in this study was 0.807.

2.2.2 Patient Health Questionnaire-9 items (PHQ-9)

Depressive symptoms were measured with the 9-item Patient Health Questionnaire (PHQ-9) [39]. Each item was rated on a 4-point scale (0 = not at all, 3 = nearly every day). The scale consists of nine items, such as "Over the past two weeks, have you felt down, depressed, or hopeless?" and "Have you felt tired or had little energy?". The total score ranges from 0 to 27. The Cronbach's alpha in the present study was 0.927.

2.2.3 Short Form of the Family Communication Scale (FCS-SF)

The Family Communication Scale (FCS) is a simplified version of the 4-item scale developed from the FCS-10 [40], which provides a quicker reflection of the overall level of family communication. For example, items include "Family members are very good listeners" and "Family members try to understand each other's feelings". Items were rated on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Cronbach's alpha in this study was 0.943.

2.2.4 Perceived Stress Scale-4 items (PSS-4)

Perceived stress was assessed with the 4-item adapted version of the Perceived Stress Scale (PSS-4) [17, 41]. PSS-4 was used to assess the extent to which individuals perceived their lives as stressful over the past month. It includes dimensions such as a lack of control over important life events, insufficient confidence in handling personal problems, perceptions that things are not progressing as expected, and feelings of being overwhelmed by difficulties. All items are negatively worded and were rated on a five-point Likert scale ranging from 0 (never) to 4 (always). Total scores range from 0 to 16, with higher scores indicating higher levels of perceived stress. The scale has demonstrated satisfactory reliability and validity in its Chinese version [42]. The Cronbach's alpha in this study was 0.938.

2.2.5 Short Form of the New General Self-Efficacy Scale (NGSES-SF)

The study measured self-efficacy using a simplified version of NGSES. Using classical test theory and the Mokken model within item response theory, the NGSES was reduced from eight items to three items[43, 44]. The three items were: "When facing difficult tasks, I am confident that I will accomplish them," "I will be able to successfully overcome many challenges," and "I am confident that I can effectively perform many different tasks." Each item was rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). Total scores ranged from 3 to 15, with higher scores indicating greater self-efficacy. The Cronbach's alpha in this study was 0.944.

2.3 Statistical Analysis

Statistical analyses were conducted in R version 4.5.1 [45]. Measurement and path models were specified using the lavaan package [46]. Complete-case, unweighted analyses were performed because sampling probabilities for the nursing-student subsample were unavailable. Continuous and categorical variables were summarized as mean $\pm$ standard deviation (SD) and n (%), respectively. Sociodemographic differences in depressive symptoms were assessed using t tests or analyses of variance, with Benjamini-Hochberg false discovery rate (FDR) adjustment. Pearson correlations were calculated among the core variables, with Spearman correlations examined as a sensitivity analysis.

Harman's single-factor test and variance inflation factors were used as preliminary diagnostics of common method variance and multicollinearity. Item-level confirmatory factor analysis evaluated the distinctiveness of depressive symptoms, perceived stress, family communication, and self-efficacy. Ordinal item responses were analyzed using weighted least squares mean and variance adjusted estimation (WLSMV) [47]. The correlated four factor model was compared with merged factor and single factor alternatives. Discriminant validity was assessed using heterotrait-monotrait (HTMT) ratios, with values below 0.85 considered supportive [48].

An observed variable serial mediation model specified family communication and perceived stress as sequential mediators between adverse childhood experiences and depressive symptoms. Models were adjusted for sex, age, body mass index, household income, educational stage, residence, family type, living arrangement, and number of biological siblings. Universities were treated as clusters, and university-level intraclass correlation coefficients were estimated from empty random-intercept models. Path coefficient inference used CR2 cluster-robust standard errors with Satterthwaite-adjusted degrees of freedom [49]. Indirect effects were estimated using 5,000 university-level cluster-bootstrap resamples and were considered statistically supported when their 95% confidence intervals excluded zero.

Exploratory moderated mediation tested the perceived stress $\times$ self-efficacy interaction after mean-centering both variables. Simple slopes, conditional indirect effects, and indices of moderated mediation (IMM) were estimated at the mean and one standard deviation below and above the mean of self-efficacy. Sensitivity analyses excluded each of the five largest university clusters in turn and estimated the competing pathway adverse childhood experiences $\rightarrow$ perceived stress $\rightarrow$ family communication $\rightarrow$ depressive symptoms. All tests were two-sided with $\alpha = 0.05$.

3. Results

3.1 Sociodemographic characteristics of the study population

A total of 932 nursing students from 196 universities were included in this study, and the sample characteristics are presented in Table 1. Among the participants, 80.36% were female and 19.63% were male. The mean age was 21.19 ± 2.52 years, and the mean BMI was 21.14 ± 3.90 kg/m². Regarding the study's primary variables, the mean ACEs score was 0.73 ± 1.68 ; family communication was 14.99 ± 3.29 ; perceived stress was 4.68 ± 3.78 ; depressive symptoms were 7.17 ± 5.63 ; and self-efficacy was 10.75 ± 2.36 . Additional univariate comparisons of depressive symptom scores across sociodemographic groups, including FDR-adjusted results, are presented in **Additional file 1, eTable 1**.

Table 1
Sample characteristics and descriptive statistics of study variables (N = 932)

Characteristics	Category	n (%) / mean $\pm$ SD
Sex	Male	183 (19.63)
	Female	749 (80.36)
Age	-	21.19 $\pm$ 2.52
BMI	-	21.14 $\pm$ 3.90
Residence (last 3 months)	Urban	680 (72.96)
	Rural	252 (27.04)
Educational level	Master's & Doctor's	166 (17.81)
	Bachelor's	587 (62.98)
	Associate's	179 (19.21)
Living arrangement (past 3 months)	Living alone	175 (18.78)
	Not living alone	757 (81.22)
Number of biological siblings	0	224 (24.03)
	1	472 (50.64)
	2	141 (15.13)
	≥ 3	95 (10.19)
Monthly per capita household income (CNY)	0-4000	519 (55.69)
	4001–9000	294 (31.55)
	≥ 9001	119 (12.77)
Family type	Single-parent/Single-person family	71 (7.62)
	Married couple family	175 (18.78)
	Nuclear/Stem family	638 (68.46)
	Extended/Other family	48 (5.15)
ACEs	-	0.73 $\pm$ 1.68
Family Communication	-	14.99 $\pm$ 3.29
Perceived Stress	-	4.68 $\pm$ 3.78
Depressive Symptoms	-	7.17 $\pm$ 5.63
Self-Efficacy	-	10.75 $\pm$ 2.36
Note: Values are presented as mean $\pm$ SD for continuous variables and n (%) for categorical variables. ACEs=adverse childhood experiences; BMI=body mass index.		

3.2 Statistical diagnostics

Harman's single-factor analysis showed that the first unrotated factor accounted for 23.11% of the total variance. No substantial multicollinearity was observed among the predictors, with VIF values ranging from 1.066 to 1.244 and tolerance values ranging from 0.804 to 0.938. University-level ICCs were small for family communication (ICC = 0.018), perceived stress (ICC = 0.027), depressive symptoms (ICC = 0.078), and self-efficacy (ICC = 0.033). These values indicated limited but non-negligible university-level clustering.

An item-level confirmatory factor analysis was conducted to examine the empirical distinctiveness of depressive symptoms, perceived stress, family communication, and self-efficacy. The correlated four-factor model provided the most favorable fit among the models examined and substantially outperformed all merged-factor and single-factor alternatives. Although depressive symptoms and perceived stress showed the strongest latent association ($r = 0.753$), the corresponding HTMT ratio supported their empirical distinctiveness. Complete model-fit indices, model comparisons, latent correlations, and HTMT ratios are reported in **Additional file 1, eTables 2 and 3**.

3.3 Pearson correlations among study variables

Pearson correlation analyses (Table 2) indicated that all core variables were significantly associated with one another. ACEs were negatively correlated with family communication ($r = -0.309$) and self-efficacy ($r = -0.080$), and positively correlated with perceived stress ($r = 0.185$) and depressive symptoms ($r = 0.187$). Family communication was negatively correlated with perceived stress ($r = -0.179$) and depressive symptoms ($r = -0.126$), and positively correlated with self-efficacy ($r = 0.330$). Perceived stress was positively correlated with depressive symptoms ($r = 0.690$) and negatively correlated with self-efficacy ($r = -0.156$). Depressive symptoms were negatively correlated with self-efficacy ($r = -0.125$). Spearman rank correlations showed the same directions and statistical significance as the Pearson correlations (**Additional file 1, eTable 4**).

Table 2
Pearson correlation among perceived stress, family communication, ACEs, self-efficacy and depressive symptoms (N = 932)

Variable	ACEs	Family Communication	Perceived Stress	Depressive Symptoms	Self-Efficacy
ACEs	1	-0.309**	0.185**	0.187**	-0.080*
Family Communication	-0.309**	1	-0.179**	-0.126**	0.330**
Perceived Stress	0.185**	-0.179**	1	0.690**	-0.156**
Depressive Symptoms	0.187**	-0.126**	0.690**	1	-0.125**
Self-Efficacy	-0.080*	0.330**	-0.156**	-0.125**	1

Note: ** $P < 0.01$; * $P < 0.05$; ACEs=adverse childhood experiences.

3.4 Serial mediation analysis on ACEs and depressive symptoms

After adjustment for nine covariates, the serial mediation model was estimated using university-clustered CR2 standard errors. As shown in Table 3, Greater ACE exposure was associated with poorer family communication ($B = -0.593$, $SE = 0.057$, $P < 0.001$) and higher perceived stress ($B = 0.292$, $SE = 0.108$, $P = 0.014$). Higher family communication scores were associated with lower perceived stress ($B = -0.145$, $SE = 0.037$, $P < 0.001$), whereas higher perceived stress was associated with more severe depressive symptoms ($B = 1.007$, $SE = 0.045$, $P < 0.001$). The direct association between ACE exposure and depressive symptoms remained significant after inclusion of the mediators ($B = 0.208$, $SE = 0.073$, $P = 0.011$), whereas the direct association between family communication and depressive symptoms was not significant.

The Cluster-Bootstrap analysis with 5,000 resamples was further used to estimate the indirect effects and their confidence intervals (Table 4). The total indirect effect was 0.343 (95% CI [0.171, 0.599]). The specific indirect effect through perceived stress was 0.294 (95% CI [0.116, 0.553]), and the serial indirect effect through family communication and perceived stress was 0.086 (95% CI [0.040, 0.138]). By contrast, the specific indirect effect through family communication alone was not statistically significant ($B = -0.037$, 95% CI [-0.087, 0.010]). Full covariate-adjusted path coefficients are reported in **Additional file 1, eTable 5**. The serial mediation model is illustrated in Fig. 3.

Table 3
Path coefficients for the serial mediation model ($N = 932$)

Outcome Variable	Independent Variables	Effect (B)	Cluster-SE	Cluster-t	Cluster-P	Standardized Effect (β)	R ²
Depressive Symptoms	ACEs (c)	0.551	0.119	4.617	< 0.001	0.164	0.082
Family Communication	ACEs	-0.593	0.057	-10.338	< 0.001	-0.302	0.139
Perceived Stress	ACEs	0.292	0.108	2.715	0.014	0.130	0.079
	Family Communication	-0.145	0.037	-3.892	< 0.001	-0.126	
Depressive Symptoms	ACEs (c')	0.208	0.073	2.833	0.011	0.062	0.504
	Family Communication	0.063	0.039	1.597	0.120	0.037	
	Perceived Stress	1.007	0.045	22.356	< 0.001	0.676	
Note: c represents the total effect of ACEs on depressive symptoms before including mediators, and c' represents the direct effect after including mediators. SE=standard error; B=unstandardized coefficient; β = standardized coefficient; ACEs=adverse childhood experiences.							

Table 4
Indirect effects for the serial mediation model (N = 932)

Indirect Path	Effect(B)	Cluster- bootstrap SE	Cluster- bootstrap LLCI	Cluster- bootstrap ULCI	Standardized Effect(β)
total effect (c)	0.551	0.122	0.358	0.826	0.164
direct effect (c')	0.208	0.077	0.056	0.359	0.062
total indirect effect	0.343	0.109	0.171	0.599	0.102
ACEs→Family Communication→Depressive Symptoms	-0.037	0.024	-0.087	0.01	-0.011
ACEs→Perceived Stress→Depressive Symptoms	0.294	0.113	0.116	0.553	0.088
ACEs→Family Communication→Perceived Stress→Depressive Symptoms	0.086	0.025	0.040	0.138	0.026
Note: Bootstrap sample size = 5000; c represents the total effect of ACEs on depressive symptoms before including mediators, and c' represents the direct effect after including mediators. CI=confidence interval; LL=lower limit; UL=upper limit; B=unstandardized coefficient; β = standardized coefficient; ACEs=adverse childhood experiences					

Note

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$.

3.5 Exploratory moderated mediation analysis of Self-Efficacy

Using the same nine covariates, an exploratory moderated mediation analysis examined whether self-efficacy moderated the association between perceived stress and depressive symptoms. The interaction between perceived stress and self-efficacy was statistically significant after accounting for clustering within universities ($B = 0.053$, $P = 0.014$), although the increment in explained variance was small ($\Delta R^2 = 0.010$; Table 5). The estimated association between perceived stress and depressive symptoms was stronger at higher levels of self-efficacy, increasing from $B = 0.876$ at low self-efficacy to $B = 1.000$ at the mean and $B = 1.125$ at high self-efficacy (Fig. 4).

University-level cluster-bootstrap estimates showed a corresponding increase in the conditional indirect effects across levels of self-efficacy. For the ACEs→perceived stress→depressive symptoms pathway, the conditional indirect effect increased from 0.256 at low self-efficacy to 0.292 at the mean and 0.329 at high self-efficacy. For the serial pathway through family communication and perceived stress, the corresponding estimates were 0.075, 0.086, and 0.096. The indices of moderated mediation were 0.015 for the pathway through perceived stress, 0.004 for the serial pathway, and 0.020 for the combined indirect association operating through perceived stress (Table 6).

Table 5
Path coefficients for the moderated mediation model ($N = 932$).

Outcome Variable	Independent Variables	Effect(B)	Cluster-SE	Cluster- t	Cluster- P	Standardized Effect(β)	R^2	ΔR^2
Depressive Symptoms	Perceived Stress	1.000	0.044	22.662	< 0.001	0.673	0.514	0.010
	Self-Efficacy	-0.009	0.066	-0.141	0.889	-0.004		
	Perceived Stress $\times$ Self-Efficacy	0.053	0.020	2.620	0.014	0.097		

Note: The interaction term was computed using mean-centered perceived stress and self-efficacy scores.
 B =unstandardized coefficient; β = standardized coefficient.

Table 6

Simple slopes, conditional indirect effects, and moderated mediation indices by self-efficacy level ($N = 932$).

Effect	Level of Self-Efficacy	Estimate	Cluster-bootstrap SE	Cluster-bootstrap LLCI	Cluster-bootstrap ULCI
Perceived Stress→Depressive Symptoms	M - 1 SD	0.876	0.069	0.738	1.010
Perceived Stress→Depressive Symptoms	M	1.000	0.045	0.913	1.088
Perceived Stress→Depressive Symptoms	M + 1 SD	1.125	0.057	1.008	1.232
ACEs→Perceived Stress→Depressive Symptoms	M - 1 SD	0.256	0.099	0.100	0.486
ACEs→Perceived Stress→Depressive Symptoms	M	0.292	0.112	0.115	0.548
ACEs→Perceived Stress→Depressive Symptoms	M + 1 SD	0.329	0.127	0.127	0.617
ACEs→Family Communication→Perceived Stress→Depressive Symptoms	M - 1 SD	0.075	0.023	0.033	0.124
ACEs→Family Communication→Perceived Stress→Depressive Symptoms	M	0.086	0.025	0.040	0.137
ACEs→Family Communication→Perceived Stress→Depressive Symptoms	M + 1 SD	0.096	0.028	0.045	0.153
Total conditional indirect	M - 1 SD	0.331	0.098	0.176	0.559
Total conditional indirect	M	0.378	0.109	0.206	0.629
Total conditional indirect	M + 1 SD	0.425	0.124	0.230	0.717
IMM: ACEs→Perceived Stress→Depressive Symptoms	-	0.015	0.009	0.003	0.036
IMM: ACEs→Family Communication→Perceived Stress→Depressive Symptoms	-	0.004	0.002	0.001	0.009
IMM: Total indirect via Perceived Stress	-	0.020	0.010	0.005	0.043
Note: SD $\approx$ 2.364; IMM=index of moderated mediation; ACEs=adverse childhood experience					

3.6 Sensitivity analysis

Leave-one-large-cluster-out analyses yielded stable findings after each of the five largest university clusters ($n = 76, 65, 49, 37$, and 37) was excluded in turn. The indirect effects through perceived stress and through the serial

pathway remained similar in magnitude, and the perceived stress×self-efficacy interaction remained statistically significant in all analyses (**Additional file 1, eTable 6**).

To assess the robustness of the designated serial ordering, a competing model reversing the order of the two mediators was estimated using the same covariates and university-level cluster bootstrap. The hypothesized serial indirect effect through family communication and perceived stress was statistically supported ($B = 0.086$, 95% CI [0.040, 0.138]), whereas the competing serial indirect effect through perceived stress and family communication was not ($B = -0.002$, 95% CI [-0.007, 0.001]; **Additional file 1, eTable 7**).

4. Discussion

This study examined the association between ACEs and depressive symptoms among Chinese nursing students and further explored whether family communication and perceived stress were statistically related to this association, with self-efficacy examined as an exploratory moderator. Greater ACE exposure was associated with more severe depressive symptoms, and this association remained significant after family communication and perceived stress were included in the model. Perceived stress showed the largest specific indirect association with depressive symptoms, while family communication and perceived stress jointly constituted a statistically supported serial indirect pathway. In contrast, the indirect association through family communication alone was not statistically supported. The exploratory moderation analysis further indicated that the positive association between perceived stress and depressive symptoms was slightly stronger at higher levels of self-efficacy, although the additional variance explained by the interaction was small.

The results of this study indicated that ACEs were significantly and positively associated with depressive symptoms among nursing students, which is consistent with previous findings in nursing and university student populations [16, 50]. Recent systematic reviews and meta-analyses have also reported associations between ACE exposure and depressive outcome in adulthood across diverse populations and study designs[13]. The persistence of the association after family communication and perceived stress were included in the model indicates that these variables did not statistically account for the entire observed association between ACE exposure and depressive symptoms. Therefore, other psychological, biological, and situational factors related to ACEs and depressive symptoms may also be involved [51, 52] and should be explored in future research.

Perceived stress accounted for the largest specific indirect association between ACEs and depressive symptoms. This finding is consistent with previous research linking ACE exposure with elevated stress and poorer mental health among university students [46], as well as studies in other populations identifying perceived stress as an indirect statistical pathway associated with depressive symptoms [47]. One possible interpretation of this pattern can be informed by stress sensitization and stress proliferation perspectives. Stress sensitization theory proposes that childhood adversity may be associated with greater sensitivity to subsequent stressors [53], whereas stress proliferation theory suggests that early or primary stressors can generate additional stressors across different areas of life, leading to an accumulation of stress exposure over time [54, 55]. These perspectives offer a possible theoretical explanation for the observed association between ACE exposure and perceived stress, but the current cross-sectional data are insufficient to determine whether such processes occur over time. This interpretation may be particularly relevant to nursing students, who commonly encounter academic demands, clinical training pressures, and various responsibilities associated with preparing for professional practice [56]. Within this context, the significant indirect association observed in the present

study indicates that perceived stress is a potentially important correlate in the association between ACEs and depressive symptoms. Accordingly, assessing perceived stress and identifying major sources of stress may be relevant components of mental health support for nursing students with a history of ACE exposure.

The statistically supported serial indirect association involving family communication and perceived stress provides additional evidence that these two variables may be jointly relevant to the observed association between ACEs and depressive symptoms. Greater ACE exposure was associated with poorer current family communication, which was in turn associated with higher perceived stress and more severe depressive symptoms. A study on risky families offers a plausible explanation: family dysfunction can disrupt biological stress regulatory systems, impairing individuals' emotional processing capacity [25]. As an important component of family function, poor family communication patterns may themselves serve as a potential stressor, and thereby indirectly associated with the risk of developing depressive symptoms. In contrast, the indirect association through family communication alone was not statistically supported. This result differs to some extent from research concerning broader family functioning. For example, family functioning has been identified as a mediator between childhood trauma and depression severity among individuals with major depressive disorder or bipolar disorder [57]. However, family functioning represents a multidimensional construct that includes not only communication patterns but also other aspects such as emotional cohesion, adaptability, and relational organization [58]. Therefore, the mediating role of overall family functioning cannot be directly inferred to apply to family communication alone. Furthermore, previous studies examining the association between family communication and depressive symptoms have focused predominantly on children and adolescents [59, 60], whose developmental stages and family dependence may differ from those of young adults, including nursing students. These conceptual and population differences may partly explain why family communication alone did not demonstrate a statistically significant indirect association in the present study.

The absence of a significant independent indirect association for family communication does not mean there is no statistical association between family communication and depressive symptoms. In the serial mediation model of this study, the direct path between family communication and depressive symptoms failed to reach statistical significance after perceived stress was included, whereas the serial indirect association of family communication via perceived stress was supported. This finding suggests that family communication may be more closely related to individuals' stress perception process and may be linked to depressive symptoms through this statistical pathway. However, given the cross-sectional design adopted in the present study, this result cannot be used to infer temporal order or causal mechanisms, and further verification via longitudinal research is required.

Self-efficacy significantly moderated the association between perceived stress and depressive symptoms, but the direction of the interaction was contrary to the anticipated buffering effect. Previous studies have generally conceptualized self-efficacy as a psychological resource and have reported more favorable mental health outcomes among individuals with higher self-efficacy [61, 62]. In the present study, however, the positive association between perceived stress and depressive symptoms was slightly stronger at higher levels of general self-efficacy. Several considerations warrant caution in interpreting this unexpected finding. First, the interaction explained only a small additional proportion of variance in depressive symptoms ($\Delta R^2 = 0.010$), suggesting limited incremental explanatory value. Second, the three-item New General Self-Efficacy Scale assesses general confidence in managing tasks and challenges and may not fully capture domain-specific efficacy relevant to emotional regulation, stress management, clinical training, or help-seeking [44]. Third, the cross-sectional design

does not allow the direction of the interaction to be determined, and the result may be influenced by unmeasured contextual factors or model-specific characteristics. The finding should not be interpreted as evidence that self-efficacy is detrimental to nursing students' mental health. Rather, it indicates that general self-efficacy did not demonstrate the expected buffering pattern in this sample. Replication in longitudinal studies using more comprehensive and context-specific measures of self-efficacy is required before firm conclusions can be drawn.

The findings have several potential implications for nursing education and student support. Because perceived stress showed the largest specific indirect association in the statistical model, routine attention to students' perceived stress and access to stress-management resources may be relevant areas for future preventive and supportive programs. Such support may include confidential psychological services, coping-skills training, peer support, and structured supervision during clinical placements [63, 64]. The observed association involving family communication also suggests that family interaction contexts may be worth considering when assessing students' available social and emotional resources. However, ACE histories and family communication should not be treated as deterministic indicators of psychological difficulties, and any assessment should be voluntary, confidential, trauma-informed, and non-stigmatizing [65, 66]. Given the small and unexpected moderation result, interventions should not rely solely on increasing general self-efficacy; approaches that directly address stress appraisal and stress management may warrant greater priority. These implications should be regarded as directions for future intervention development rather than evidence of intervention effectiveness, which was not evaluated in the present study.

5. Limitations

This study has several limitations. First, its cross-sectional design precludes conclusions regarding temporal sequence or causality. Reverse or reciprocal associations among family communication, perceived stress, self-efficacy, and depressive symptoms cannot be excluded. The direct and indirect effects should therefore be interpreted as statistical associations rather than causal mechanisms. Second, all variables were assessed using self-report questionnaires and may have been affected by recall bias, social desirability bias, and shared method variance. The retrospective assessment of adverse childhood experiences may be particularly susceptible to recall error. Although perceived stress and depressive symptoms are conceptually distinct, their overlap as indicators of psychological distress may have strengthened the observed association. In addition, the use of short-form scales may have limited construct coverage and reduced the precision of estimates, particularly for interaction effects. Third, the serial mediation model was saturated, preventing evaluation of overall model fit or formal comparison with competing models using global fit indices. Although the competing serial model was examined as a sensitivity analysis, differences in indirect effects do not establish temporal ordering. Fourth, participants were a subsample of Chinese nursing students identified within a nationwide survey rather than a nationally representative nursing-student sample. Generalization to other nursing students, disciplines, or cultural contexts should therefore be cautious. Residual confounding from unmeasured variables also remains possible. Longitudinal, multi-institutional studies using multiple data sources and latent-variable models are needed to verify these findings.

6. Conclusion

Greater exposure to adverse childhood experiences was associated with more severe depressive symptoms among Chinese nursing students. Perceived stress represented the largest specific indirect pathway, while family

communication and perceived stress formed a significant serial indirect pathway. Family communication alone did not show a significant indirect association. Self-efficacy moderated the association between perceived stress and depressive symptoms, but the effect was small and contrary to the expected buffering pattern, requiring cautious interpretation and replication. Overall, the findings highlight perceived stress as an important proximal correlate and suggest that current family communication may be relevant through stress-related processes. Nursing education and student-support programs may consider prioritizing trauma-informed, confidential, and non-stigmatizing approaches to stress identification and management. Longitudinal research is required before causal conclusions or established intervention targets can be proposed.

Abbreviations

ACEs	adverse childhood experiences
ACE-IQ	Adverse Childhood Experiences International Questionnaire
BMI	body mass index
CI	confidence interval
CNY	Chinese yuan
CR2	cluster-robust variance estimator
FCS	Family Communication Scale
FCS-SF	Family Communication Scale–Short Form
FDR	false discovery rate
HTMT	heterotrait–monotrait ratio
ICC	intraclass correlation coefficient
IMM	index of moderated mediation
NGSES-SF	New General Self-Efficacy Scale–Short Form
PBICR-2023	2023 Psychology and Behavior Investigation of Chinese Residents
PHQ-9	Patient Health Questionnaire-9
PSS-4	Perceived Stress Scale-4

SD
standard deviation
SE
standard error
WLSMV
weighted least squares mean and variance adjusted.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Biomedical Ethics Committee of Shandong Provincial Hospital on 5 May 2023 (approval number SWYX No. 2023-198). Informed consent was obtained from all participants before participation.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was supported by the National Natural Science Foundation of China (grant no. 72204164) and the Shanghai Pujiang Program (grant no. 22PJC073). The funders had no role in the study design; collection, analysis, or interpretation of data; preparation of the manuscript; or the decision to submit the manuscript for publication.

Authors' contributions

PF: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing—original draft, Writing—review & editing. TW: Conceptualization, Data curation, Formal analysis, Methodology, Software, Writing—review & editing. XZ: Conceptualization, Data curation, Methodology, Writing—original draft, Writing—review & editing. XL: Data curation, Formal analysis, Software, Writing—review & editing. HL: Data curation, Investigation, Writing—review & editing. YP: Formal analysis, Writing—review & editing. HN: Project administration, Writing—review & editing. YS: Conceptualization, Project administration, Writing—review & editing. JC: Conceptualization, Project administration, Writing—review & editing. All authors read and approved the final manuscript.

Acknowledgements

The authors thank all the individuals who generously contributed their time to this study.

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Figures

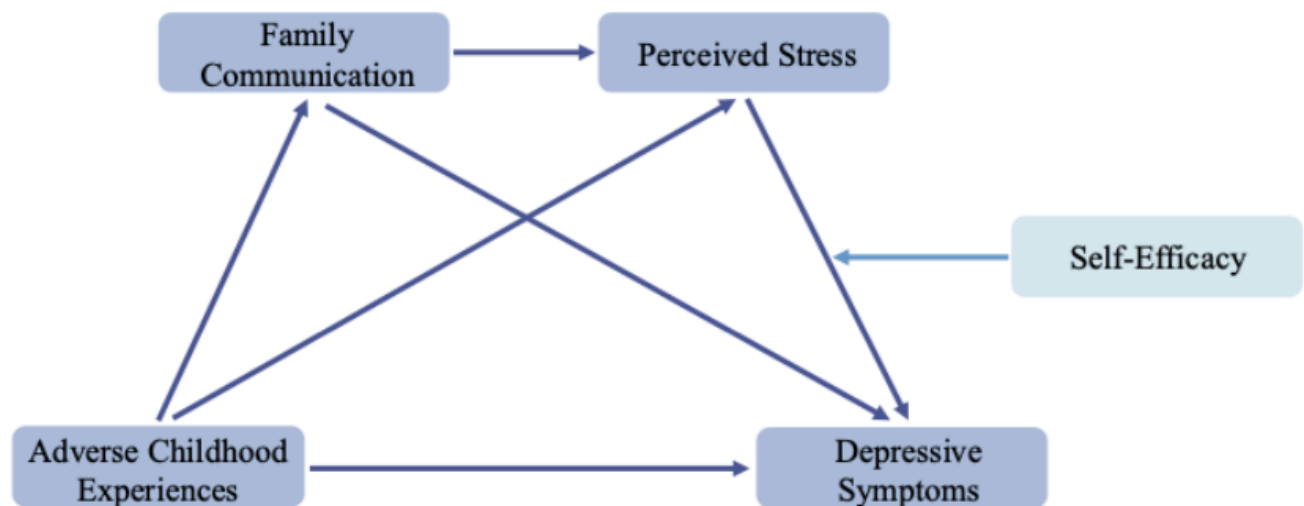


Figure 1

The hypothesized model.

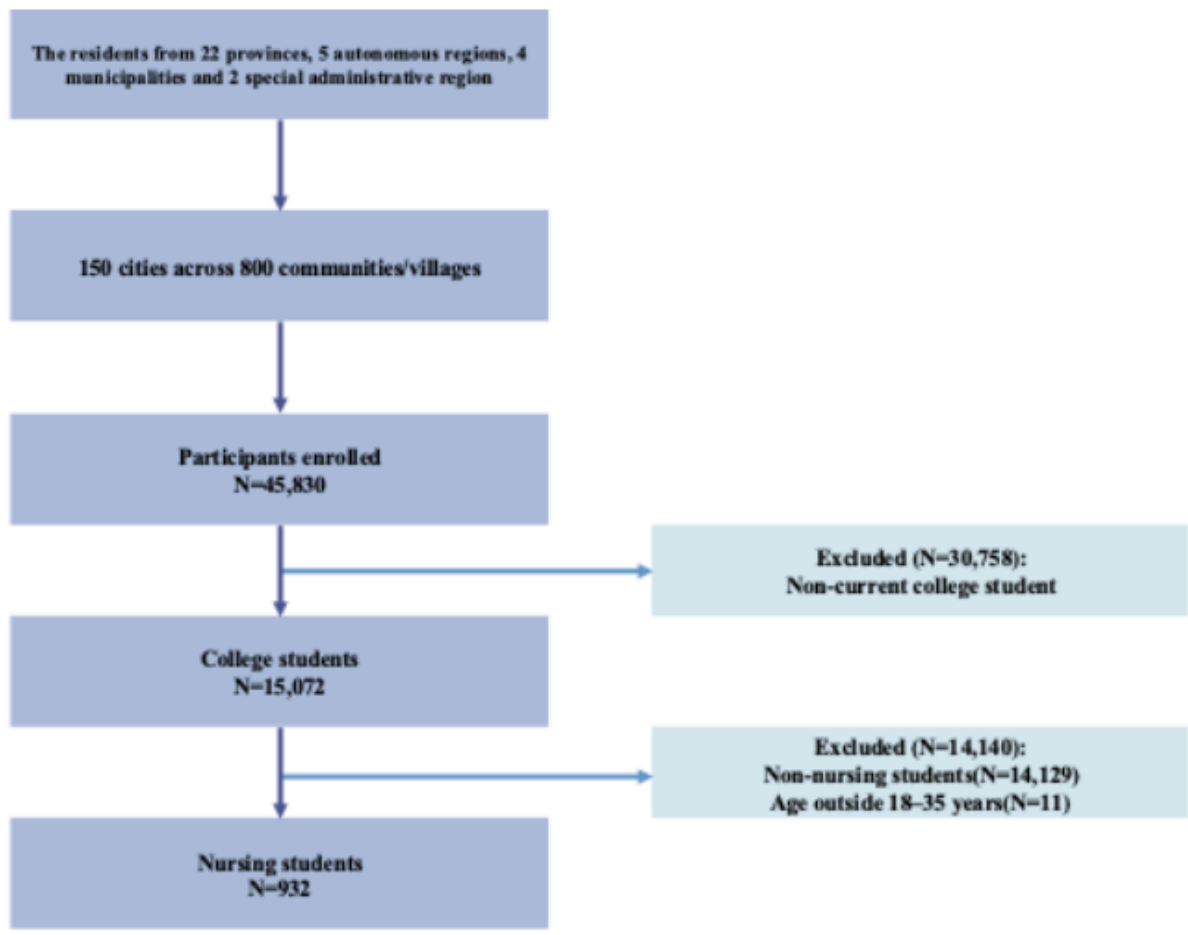


Figure 2

Flow Chart for Inclusion of Study Participants

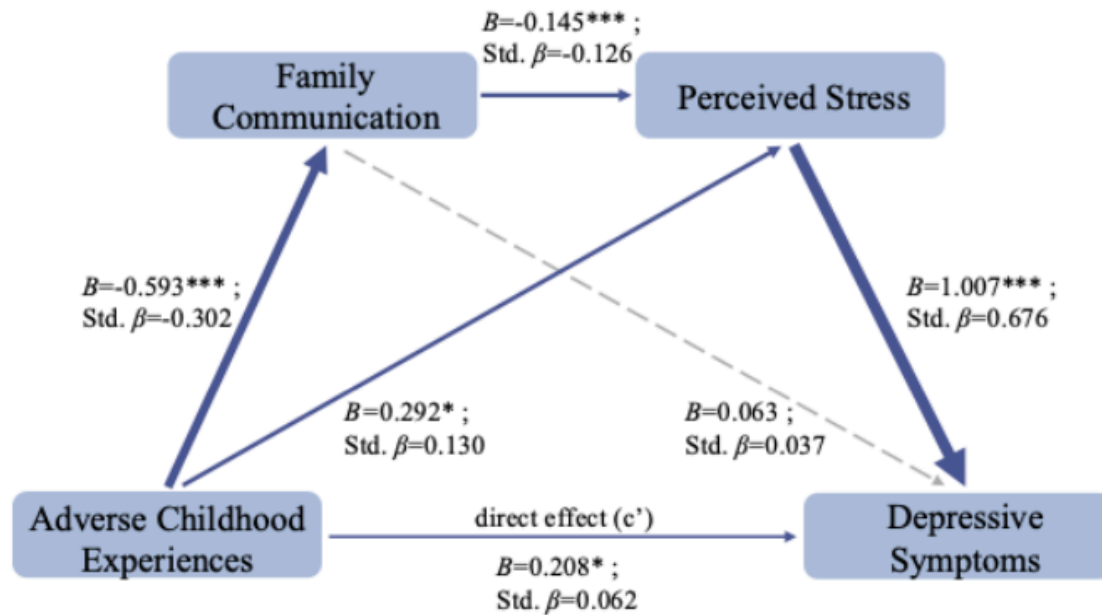


Figure 3

Serial mediation model diagram.

Note: $^{***} P \leq 0.001$; $^{**} P \leq 0.01$; $^{*} P \leq 0.05$.

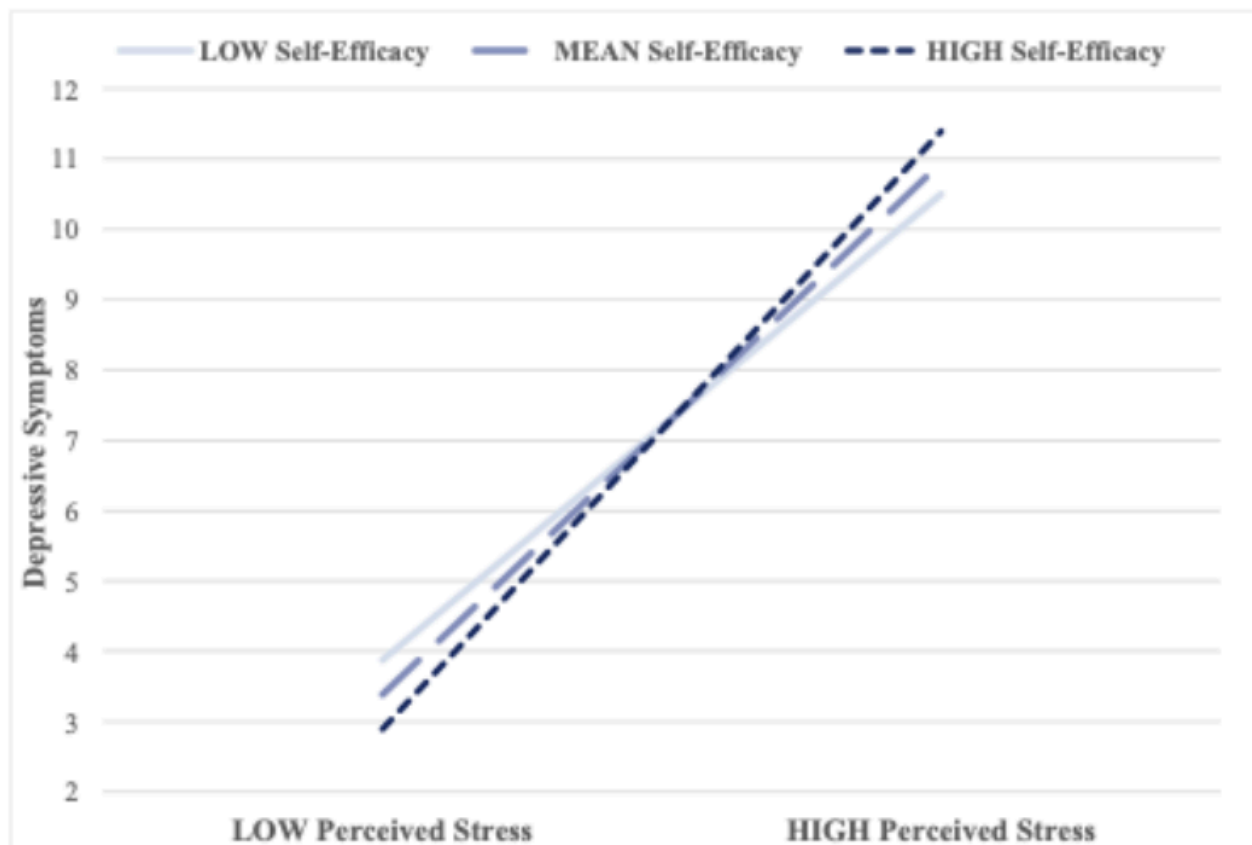


Figure 4

Moderating Effect of Self-Efficacy between Perceived Stress and Depressive Symptoms

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