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Development and Validation of a Nomogram to Predict Risk Factors for Anxiety Symptoms in Postgraduate Medical Students

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ABSTRACT

This study aims to develop a nomogram to accurately predict anxiety symptoms in postgraduate medical students, enabling early identification of high-risk individuals and provision of targeted interventions. A convenience sampling method was employed to select participants for a case-control study, comprising 126 individuals with anxiety symptoms as the case group and 774 age- and gender-matched individuals without anxiety symptoms as the control group. Multivariable logistic regression analysis was conducted to identify factors associated with anxiety symptoms, which were subsequently used to develop and validate a nomogram for predicting anxiety risk. The multivariate logistic regression analysis revealed that limited social support (OR = 0.95, 95% CI: 0.91–0.99), lower life satisfaction (OR = 0.91, 95% CI: 0.86–0.95), reduced subjective well-being (OR = 0.58, 95% CI: 0.41–0.83), and frequent consumption of tobacco and alcohol (OR = 1.75, 95% CI: 1.10–2.80) were independently associated with anxiety symptoms among postgraduate medical students ($P < 0.05$). Based on these four predictors, a nomogram was constructed to estimate individual anxiety risk, with the model demonstrating good predictive performance as indicated by a validated C-index of 0.787 (95% CI: 0.744–0.803, $P < 0.001$). Anxiety symptoms among postgraduate medical students are affected by multiple factors. The developed nomogram demonstrates strong accuracy, validity, and reliability, offering a practical tool for predicting anxiety risk in this population."

Keywords: Anxiety symptoms, Medical students, Nomogram, Case-control study

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Introduction

Postgraduate medical students represent a unique population facing substantial stress from both clinical practice and academic demands [1]. Empirical studies have consistently reported that anxiety and depression are prevalent among medical students globally [2] and specifically in China [3]. Undetected and untreated anxiety can adversely affect academic performance [4] and overall life satisfaction [5, 6]. Notably, compared to depression, the negative impacts of anxiety are often under-recognized [7]. Anxiety typically elicits negative emotions such as fear [8], which can disrupt work habits, professional attitudes, interpersonal relationships, and performance [9]. Physiologically, anxiety can negatively affect the nervous system [10], for instance by activating the sympathetic nervous system, causing vasoconstriction, elevated blood pressure, and increased heart rate, thereby increasing the risk of cardiovascular conditions such as hypertension, coronary heart disease, stroke, and heart failure, and potentially worsening preexisting conditions [11]. Anxiety and depression share overlapping etiological mechanisms [12], and prolonged anxiety can result in sleep disturbances, gastrointestinal issues, blood pressure fluctuations, unstable blood sugar, cognitive slowing, and delays in speech and motor responses due to chronic stress [13]. The frequent co-occurrence of anxiety and depression can lead to a cumulative burden of negative emotions, increasing the risk of self-harm or suicidal behaviors [14].

Postgraduate medical students face dual pressures: intensive clinical training and rigorous research responsibilities [15], alongside growing employment pressures in China due to increased enrollment in medical programs [16]. Consequently, the risks associated with advanced medical education, including psychological stress, are rising steadily.

Recently, researchers have explored various approaches to predicting anxiety symptoms across different populations [17-19]. However, anticipating the potential risk of anxiety in high-stress populations remains challenging. Nomograms have emerged as reliable tools for quantifying clinical risks by providing simple and intuitive visual predictive models. Their application in predicting anxiety symptoms has also been demonstrated in clinical settings [20, 21]. Compared with other statistical methods, nomograms offer clear, interpretable, and visually intuitive models that facilitate accurate screening and early intervention for anxiety symptoms [22].

The present study aims to develop a nomogram-based risk prediction model for anxiety symptoms among postgraduate medical students, creating a practical tool for assessing individual risk and guiding targeted interventions. Evidence suggests that mental health in medical students is influenced by personal characteristics, subjective perceptions, environmental factors, and behavioral patterns [23]. Accordingly, this study incorporated variables across four dimensions: personal traits (e.g., meaning in life), subjective experiences (e.g., subjective well-being and life satisfaction), external environment (e.g., social support and family functioning), and behavioral habits (e.g., tobacco and alcohol use).

A practical consideration in this study was the brevity of assessment tools. To ensure applicability in clinical and educational settings, only brief questionnaires and scales (each with fewer than ten items) were selected. Furthermore, to maintain accuracy and reliability, only instruments with validated reliability in Chinese populations were included. This approach ensures the development of a concise, reliable, and practical nomogram capable of effectively predicting the potential risk of anxiety symptoms among postgraduate medical students.

Materials and Methods

Participants

An online survey was completed by 937 individuals. Participants were postgraduate medical students from the Graduate Department of The Second Affiliated Hospital of Nanchang University and were recruited via convenience sampling. To reduce the influence of socially desirable responses [24], the survey included three attention-check questions, and only those who answered all correctly were retained for analysis. After excluding ineligible responses, the final sample included 900 students, with 826 (91.8%) enrolled in Master's programs and 74 (8.2%) in Doctoral programs. The sample comprised 453 men (50.3%) and 447 women (49.7%), ranging in age from 26 to 59 years (mean ± SD: 27.01 ± 3.03). Ethical approval for this study was obtained from the Biomedical Research Ethics Committee of The Second Affiliated Hospital of Nanchang University (Research and Clinical Review [2019] No. 096).

Research design

Case-control study

A case-control study was conducted in the Graduate Department of The Second Affiliated Hospital of Nanchang University. The study aimed to include all postgraduate medical students in the affiliated hospital through psychological census. However, students with a history of psychiatric disorders were considered potentially confounding and were therefore excluded. Following university regulations, postgraduate students diagnosed with a mental illness are required to submit medical documentation to the Graduate Department. With approval from the ethics committee, researchers obtained consent from the Graduate Department Deans to review these records, and students with documented mental illnesses were excluded from the study.

The primary assessment tool used was the 7-item Generalized Anxiety Disorder Scale (GAD-7), which evaluates the severity of anxiety symptoms among postgraduate medical students. Higher GAD-7 scores indicate more severe anxiety. Anxiety severity was categorized as follows: scores < 5 indicated no anxiety, 5–9 indicated mild anxiety, 10–14 indicated moderate anxiety, and scores ≥ 15 indicated severe anxiety. For the purposes of this study, a GAD-7 score greater than 5 was used to classify students as having anxiety symptoms.

Based on this criterion, 126 postgraduate medical students with GAD-7 scores above 5 were assigned to the case group, while 774 students scoring below 5 formed the control group. All procedures, including grouping according to GAD-7 scores, were completed online. Statistical analysis confirmed no significant differences in age or gender

between the case and control groups (P > 0.05), ensuring comparability of basic demographic characteristics. The prevalence of anxiety symptoms was significantly higher in the case group compared to the control group.

Questionnaire survey

Data on the mental health status of postgraduate medical students were collected through an online survey. The survey primarily consisted of structured questionnaires and standardized scales. Before starting, participants received a unified set of instructions and were asked to complete the survey within a specified time frame. Two trained faculty members from the Graduate Department were responsible for distributing the questionnaires, which included the Family APGAR Scale, Chinese Social Support Rating Scale, Subjective Well-being Scale, Meaning in Life Questionnaire, Satisfaction With Life Scale, Tobacco and Alcohol Use Scale, and the 7-item Generalized Anxiety Disorder Scale (GAD-7). Participants were informed that any questions or difficulties encountered during the survey could be addressed to the faculty members, who provided real-time guidance. The questionnaires were disseminated through various WeChat groups comprising the participating postgraduate students, and respondents were instructed to complete them immediately on their smartphones.

Measurement tools

Family function

A three-point scoring system was selected for the Family APGAR Scale (APGAR; Karimi *et al*., [25]), which includes five individual items. The reliability of this scale, as measured by Cronbach's alpha, was 0.89.

Social support

The Chinese Social Support Rating Scale (SSRS; Cheng *et al*., [26]), an 11-item instrument, employed a four-point scoring system. The scale demonstrated a Cronbach’s alpha of 0.75, indicating its reliability.

Life satisfaction

he SWLS, developed by Wang *et al*. (2009) [27], is a five-item instrument evaluated on a seven-point Likert scale. Analysis indicated a Cronbach’s alpha of 0.91, reflecting excellent reliability.

Subjective well-being

Campbell’s [28]) Subjective Well-being Scale asks participants a single question: “Overall, how happy do you feel you are?” and responses are recorded on a seven-point Likert scale. Because it contains only one item, its validity was assessed by comparing it with another established measure. The Satisfaction With Life Scale (SWLS; Wang *et al*., [27]) was used for this purpose, producing a criterion-related validity coefficient of 0.69.

Meaning in life

The MLQ [29] consists of ten items rated on a seven-point Likert scale, designed to evaluate individuals’ pursuit of meaning in life and their perceived sense of purpose. The reliability analysis for this study produced a Cronbach’s alpha of 0.86.

Alcohol and tobacco use

The Tobacco and Alcohol Use Scale, created by Ye *et al*. [30], includes four items and was scored using a six-point scale. The assessment demonstrated a Cronbach’s alpha of 0.72, indicating acceptable internal consistency.

Anxiety symptoms

The Generalized Anxiety Disorder Scale (GAD-7; Spitzer *et al.,* [31]) consists of seven items and was scored using a three-point scale. The scale demonstrated excellent reliability, with a Cronbach’s alpha of 0.93.

Statistical analysis

Participants completed the questionnaire and scales by scanning QR codes through Wenjuanxing, a platform offering services similar to Amazon Mechanical Turk. The researchers then collected the responses. Descriptive statistics for all variables were calculated using SPSS 25.0, followed by Chi-square tests, independent samples t-tests, univariate logistic regression, and multivariate logistic regression analyses. The Nomogram prediction model was developed using R. A p-value of less than 0.05 was considered statistically significant.

Results and Discussion

Comparison of baseline value between the case group and the control group

Among the postgraduate medical students, 126 participants (14.0%) with a GAD-7 score of ≥5 were assigned to the case group, while 774 participants (86.0%) were included in the control group. There were no significant differences in baseline characteristics between the two groups ($P \geq 0.05$). However, significant differences were observed between the case and control groups in terms of family function, social support, subjective well-being, life satisfaction, and alcohol and tobacco use ($P < 0.05$) **(Table 1).**

Table 1. Baseline value of the control group and the case group.

Variable		The control group (*n* = 774)	The case group (*n* = 126)	χ^2/t	*P*
Gender	Female	384 (49.62%)	63 (50.00%)	-0.08	0.936
	Male	390 (50.38%)	63 (50.00%)		
Age		26.99 ± 3.43	27.10 ± 2.71	-0.35	0.725
Family function		7.22 ± 2.50	5.33 ± 2.73	7.77	<0.001
Social support		36.06 ± 6.40	32.06 ± 5.25	8.37	<0.001
Subjective well-being		5.00 ± 0.87	4.21 ± 0.88	9.38	<0.001
Life satisfaction		22.67 ± 5.51	17.20 ± 5.73	10.29	<0.001
Meaning in Life		51.00 ± 9.26	47.40 ± 9.33	4.04	<0.001
Alcohol and tobacco use		1.09 ± 0.32	1.20 ± 0.58	-2.02	0.003

Univariate logistic regression analysis and multivariate logistic regression analysis of anxiety symptoms

The relationship between various psychosocial and behavioral factors and anxiety symptoms in postgraduate medical students was first examined using univariate logistic regression. Results indicated that poorer family function (OR = 0.77, 95% CI: 0.71–0.82), lower social support (OR = 0.89, 95% CI: 0.86–0.92), diminished subjective well-being (OR = 0.32, 95% CI: 0.24–0.42), reduced life satisfaction (OR = 0.85, 95% CI: 0.82–0.88), weaker meaning in life (OR = 0.96, 95% CI: 0.95–0.98), and increased alcohol and tobacco use (OR = 1.17, 95% CI: 1.19–2.64) were all linked to higher anxiety levels **(Table 2).** A subsequent stepwise multivariate logistic regression was conducted to identify independent predictors. The analysis revealed that lower social support (OR = 0.95, 95% CI: 0.91–0.99), decreased subjective well-being (OR = 0.58, 95% CI: 0.41–0.83), reduced life satisfaction (OR = 0.91, 95% CI: 0.86–0.95), and higher alcohol and tobacco consumption (OR = 1.75, 95% CI: 1.10–2.80) independently contributed to anxiety symptoms among the students ($P < 0.05$). Complete results are detailed in **Table 3.**

Table 2. Univariate logistic regression analysis of anxiety symptoms.

Variable	*β*	SE	*waldx²*	OR	95%CI	*P*
Gender	0.02	0.19	0.01	1.02	0.70–1.48	0.936
Age	0.01	0.03	0.13	1.01	0.96–1.07	0.724
Family function	-0.27	0.04	51.17	0.77	0.71–0.82	<0.001
Social support	-0.12	0.02	46.47	0.89	0.86–0.88	<0.001
Subjective well-being	-1.14	0.14	70.02	0.32	0.24–0.42	<0.001
Life satisfaction	-0.17	0.02	81.50	0.85	0.82–0.88	<0.001
Meaning in Life	-0.04	0.01	15.51	0.96	0.96–0.98	<0.001
Alcohol and tobacco use	1.77	0.20	8.02	1.77	1.19–2.64	0.005

Table 3. Multivariate logistic regression analysis of anxiety symptoms.

Variable	*β*	SE	*waldx²*	OR	95%CI	*P*
Social support	-0.06	0.02	7.04	0.95	0.91–0.99	0.008
Subjective well-being	-0.54	0.18	8.70	0.58	0.41–0.83	<0.001
Life satisfaction	0.10	0.03	16.05	0.91	0.86–0.95	0.003
Alcohol and tobacco use	0.56	0.24	5.35	1.75	1.10–2.80	0.021
Constant	3.62	0.86	17.70	37.43		<0.001

Nomogram for anxiety symptoms

Anxiety symptoms among postgraduate medical students were treated as the dependent variable (coded as 1 for presence and 0 for absence), while the independent predictors identified through multivariate logistic regression were used as explanatory variables. A Nomogram analysis was conducted in R to assign scores to each factor and calculate a total score for each participant. The total scores ranged from 135 to 290, corresponding to predicted risks of anxiety from 0.10 to 0.90. Higher total scores indicated a greater likelihood of experiencing anxiety symptoms. The points assigned to each variable, along with total scores and associated risk probabilities, are illustrated in **Figure 1.**

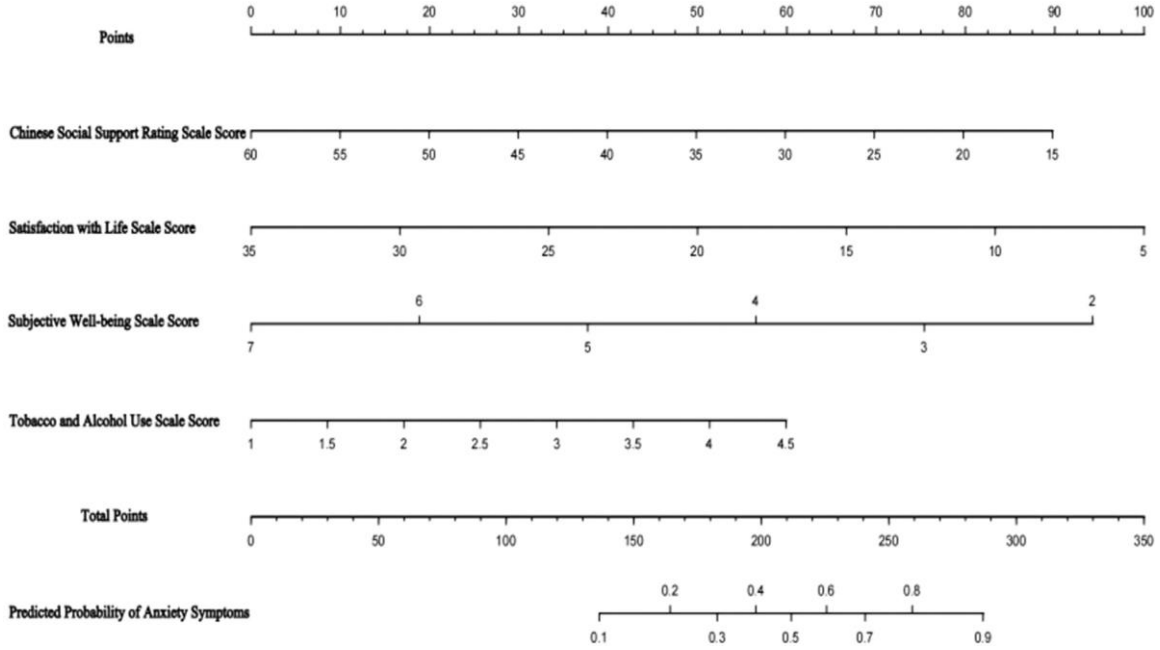

Figure 1. Nomogram for anxiety symptoms of postgraduate medical students.

In this study, four key predictors were selected and integrated to develop a Nomogram for visualizing anxiety risk among postgraduate medical students. Each scale—the Chinese Social Support Rating Scale, Satisfaction With Life Scale, Subjective Well-being Scale, and Tobacco and Alcohol Use Scale—can be evaluated using the top axis of the Nomogram, where points are assigned from 0 to 100 based on individual scores. The points corresponding to each variable are then summed to produce a total score, which is used to estimate the probability of anxiety symptoms along the risk line. For example, a student scoring 29 on the Chinese Social Support Rating Scale (59 points), 20 on the Satisfaction With Life Scale (50 points), 4 on the Subjective Well-being Scale (56 points), and 2.25 on the Tobacco and Alcohol Use Scale (24 points) would have a total Nomogram score of 189. According to the risk line, this total score corresponds to a 36% chance of experiencing anxiety symptoms.

DCA and ROC curve evaluation

The Nomogram demonstrated strong predictive performance for estimating the risk of anxiety symptoms among postgraduate medical students, achieving a concordance index of 0.787, indicating good discrimination and accuracy [32]. The calibration curve closely aligned with the ideal reference line, showing that predicted probabilities were generally consistent with observed outcomes **(Figure 2).** The ROC curve analysis yielded an AUC of 0.787 (95% CI: 0.744–0.803, $P < 0.001$), further confirming the model's reliable predictive ability **(Figure 3)**. Additionally, Decision Curve Analysis (DCA) indicated that the Nomogram provided considerable clinical benefit across a threshold probability range of 1%–65%, supporting its practical value for accurately forecasting anxiety symptoms in this population **(Figure 4).**

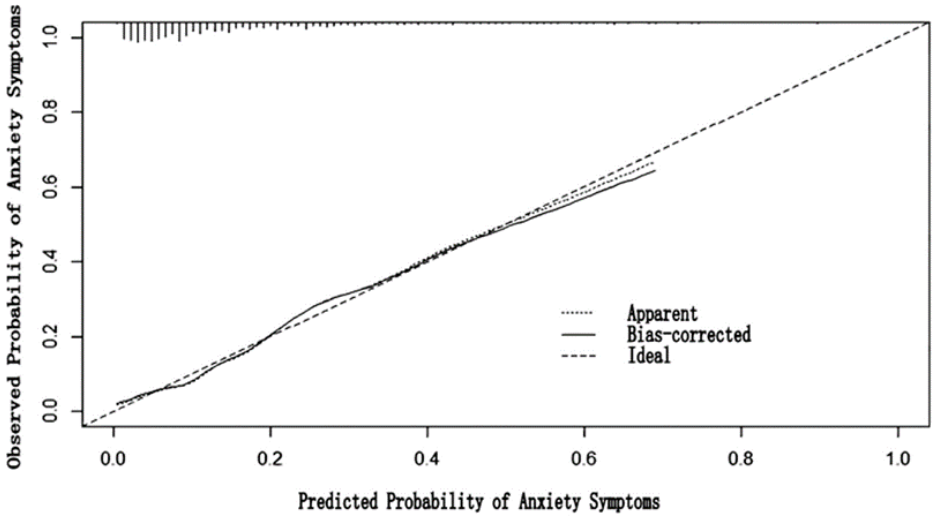

Figure 2. Nomogram assessment of anxiety risk in postgraduate medical students. Note: The horizontal axis displays the risk of anxiety predicted by the Nomogram, and the vertical axis shows the corresponding observed rates of anxiety symptoms.

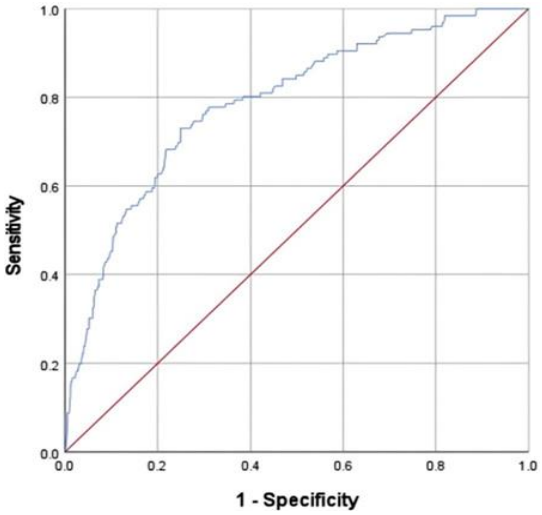

Figure 3. ROC curve illustrating the predictive performance of the Nomogram. The model achieved an AUC of 0.787 (95% CI: 0.744–0.803)..

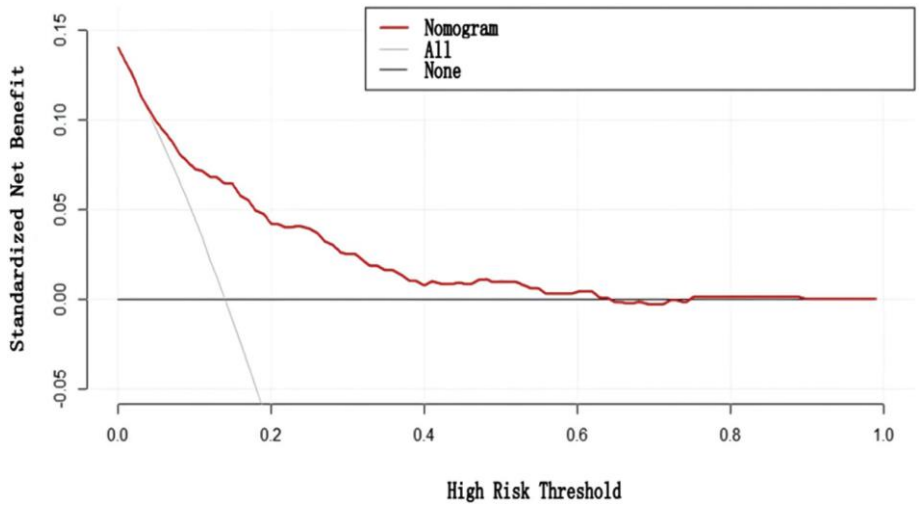

Figure 4. Correction curve and decision curve analysis of nomogram.

Anxiety symptoms are commonly experienced by medical students to varying degrees [33]. Beyond the well-known effects on physical and mental health, anxiety also negatively impacts cognitive functions such as goal-directed attention, working memory, and sensorimotor performance [34]. Previous research has shown that anxiety is prevalent throughout healthcare organizations [35]. For medical students, the persistent presence of anxiety can contribute to more severe insomnia [36], which may, in turn, impair academic performance and clinical competence [37]. Since most medical students continue into healthcare professions after graduation, these effects can have lasting implications, potentially affecting patient safety and care quality [35]. Therefore, addressing anxiety among postgraduate medical students is of critical importance for the broader healthcare system.

In the present study, 14.0% of postgraduate medical students reported anxiety symptoms, a lower prevalence than that reported among undergraduate medical students [38]. This difference may be explained by several factors. Postgraduate students often have more mature value orientations [39] and better emotional regulation abilities during their advanced training [40]. Moreover, many medical schools have recently incorporated mental health courses into postgraduate curricula, equipping students with strategies for self-support and help-seeking [41].

Multivariate logistic regression identified four independent predictors of anxiety symptoms among postgraduate medical students: insufficient social support, low subjective well-being, reduced life satisfaction, and frequent use of alcohol and tobacco. Greater social support allows students to access assistance during academic, clinical, or personal challenges, thereby decreasing the likelihood of anxiety [42]. Life satisfaction reflects a comprehensive evaluation of one's life, influencing personal goals, beliefs, and behavioral choices. Students with lower life satisfaction often feel a lack of purpose and fulfillment, which can exacerbate worries about their future and elevate anxiety risk during the long and uncertain path of medical training [43, 44].

Subjective well-being is closely tied to mental functioning, including adaptability, personal growth, and problem-solving capacity [45]. Postgraduate students with low well-being tend to struggle with adaptability, experience heightened stress, and have lower self-confidence, making it harder for them to recover from setbacks. In contrast, those with higher well-being are more willing to embrace academic and clinical challenges, approach problems creatively, and demonstrate greater efficiency and productivity, all of which reduce anxiety [46, 47].

Finally, frequent alcohol and tobacco use is associated with a greater risk of anxiety. Students who rely on these substances often use them to escape stress, exhibit lower self-control, and have weaker social support networks. Chronic use can impair physical, mental, and social functioning, further increasing the likelihood of experiencing anxiety over time [48, 49].

Previous research on anxiety risk factors among medical students has typically relied on generalized linear models, such as logistic regression, or structural equation modeling [50]. While these methods provide useful insights, they have some limitations. Different factors may influence the likelihood of anxiety symptoms to varying degrees, and their relative impact is not always clear. Moreover, prior studies often focus on group-level trends and do not allow for personalized risk assessments for individual students. The Nomogram effectively addresses these issues. By integrating multiple predictors into a single multi-factor regression model and displaying them on a graduated line graph, the Nomogram translates complex statistical outcomes into an intuitive scoring system, enabling individualized prediction of anxiety risk [51].

In this study, the Nomogram incorporated four independent predictors: social support, subjective well-being, life satisfaction, and alcohol and tobacco use. Its application can benefit both postgraduate medical students and medical school administrators. For students, the Nomogram provides a way to estimate their personal risk of developing anxiety symptoms. For instance, a student who has strong social support, feels satisfied with life, maintains high subjective well-being, and rarely consumes alcohol or tobacco would likely fall into a low-risk category. Although this predictive insight may seem minor, it can help students manage stress proactively and make informed decisions to maintain mental health, potentially preventing other psychological issues [32].

For administrators, the Nomogram offers a practical tool for early identification of high-risk students. By evaluating individual scores, university staff can determine which students are most vulnerable and provide targeted support and guidance. Social support, particularly perceived support, is a recognized protective factor for medical students' health [52]. Therefore, educational institutions should strengthen connections between students, families, and the broader community to enhance support networks. Similarly, attention should be paid to students' subjective well-being and life satisfaction, as higher levels are associated with better emotional regulation, stress resilience, and overall mental health [53]. Administrators in university-affiliated hospitals should monitor these

trends throughout training and clinical rotations, providing timely guidance, professional counseling, and financial or institutional support when needed [54, 55].

University counseling centers also play a key role by offering psychological counseling, health education, and guidance on developing healthy lifestyle habits. This includes strategies to reduce reliance on alcohol and tobacco while fostering effective coping mechanisms [56, 57].

In summary, the Nomogram serves dual purposes. From the students' perspective, it allows them to anticipate their anxiety risk and adjust behaviors or seek support to reduce it, such as cutting back on alcohol and tobacco or leveraging social support networks. From the institutional perspective, the Nomogram enables universities to identify high-risk students and implement targeted interventions to mitigate anxiety. As a result, the Nomogram is poised to play an increasingly important role in healthcare education, ultimately contributing to the physical and mental well-being of future clinicians in China.

Limitation

Several limitations of this study should be acknowledged. First, the factors included in the analysis may not fully capture all the influences on anxiety symptoms among postgraduate medical students. Although multiple sources were considered, it is possible that some important contributing factors were overlooked. Second, while the questionnaires and scales used are widely validated in the Chinese population, relying on a single instrument for each variable may limit measurement precision; using multiple complementary tools could provide more accurate assessments. Additionally, the collection of basic demographic and personal information was not exhaustive, which may have restricted the evaluation of certain characteristics on anxiety risk. Finally, the study was conducted at a single university-affiliated hospital during a specific time period, using a cross-sectional design, and therefore causal relationships between the predictors and anxiety symptoms cannot be established. Future longitudinal research is recommended to further verify the reliability and validity of the Nomogram model.

Conclusion

Anxiety symptoms in postgraduate medical students are influenced by multiple factors, including social support, life satisfaction, subjective well-being, and alcohol and tobacco use. To address this, we developed a Nomogram designed to predict the likelihood of anxiety symptoms in this population. The streamlined format of the Nomogram allows for quick assessment, saving time while enhancing efficiency. In addition, the tool can assist higher education administrators in identifying students at elevated risk for anxiety, enabling targeted screening, diagnosis, and interventions that are tailored to the specific needs of postgraduate medical students.

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