

# The non-HDL cholesterol to HDL cholesterol ratio exhibits a 'U'-shaped relationship with suicidal ideation in adolescents with depressive disorders: a cross-sectional study

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## Research Article

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# Abstract

## Background

Disordered lipid metabolism is a significant physical risk factor in the pathophysiological mechanisms underlying adolescent depressive disorders. The non-HDL-c to HDL-c ratio (NHHR) comprehensively reflects the degree of lipid imbalance. Previous studies have confirmed a linear association between lipid profile parameters and the risk of depression or suicide. However, the nonlinear relationship between the NHHR and suicidal ideation in adolescents with depressive disorders remains unclear—and whether a dose-response relationship exists between these two variables awaits clinical validation. Based on this background, our study focused on adolescents with depressive disorders and investigated the association pattern between the NHHR and suicidal ideation. We found that there is a 'U'-shaped nonlinear relationship between them, and identified a critical threshold value of the NHHR that influences the risk of suicidal ideation. Moreover, we determined the risk characteristics of suicidal ideation corresponding to both high and low levels of lipid metabolism. The objectives of this study were to refine the theoretical framework regarding lipid metabolism-related mechanisms underlying suicide risk in adolescents with depressive disorder and to provide an evidence-based reference for early screening and individualized intervention for suicidal ideation in this population.

## Methods

This cross-sectional study was conducted at Wutai Mountain Hospital in Yangzhou, Jiangsu Province, China, from January to June 2026, enrolling 291 adolescents with depressive disorders. Logistic regression was employed to assess the relationship between the NHHR and suicidal ideation, while a binary linear regression model was used to analyze the threshold effect.

## Results

After accounting for the potential influence of confounding variables, binary logistic regression analysis yielded results indicating that there was no statistically significant association between the NHHR and suicidal ideation ( $p > 0.05$ ). However, visual analysis of the smoothed curve revealed a 'U'-shaped relationship among these three variables and depressive symptoms, with the inflection point occurring at an NHHR index value of approximately 2.63. The effect sizes and their 95% confidence intervals on both sides of the inflection point were observed as follows: (95% CI: 0.017 to 0.453,  $p = 0.035$ ) and  $-0.297$  (95% CI:  $-0.567$  to  $-0.027$ ,  $p = 0.032$ ).

## Conclusion

Among adolescents with depressive disorder, a 'U'-shaped association was observed between the NHHR index and suicidal ideation: when the NHHR index reaches 2.63, the risk of suicidal ideation is at its highest, suggesting that an increased risk of suicidal ideation may be associated with either lower or higher levels of the NHHR index.

## Introduction

Adolescence is a critical developmental stage marked by an imbalance between physiological and psychological development. The asynchronous progression of physiological maturation and psychological development combined with the sudden emergence of adult role identity conflicts during adolescence renders this demographic a high-risk group for mental health issues [1]. Adolescent depressive disorders (DDs) are a prevalent mental health issue among teenagers worldwide, with adverse impacts on their psychological development, physical health, and social functioning [2]. In recent years, the annual incidence rate of adolescent DDs has shown a sustained upward trend, while the age of onset has exhibited a clear trend toward younger ages [3]. The core clinical manifestations of this disorder include persistent low mood and a marked reduction in interest in learning and daily activities, often accompanied by various somatic and psychological symptoms [4]. Individuals with this condition have a higher risk of engaging in suicidal behavior than the general population. Suicidal behavior refers to any actions taken by patients that actively endanger or threaten their lives [5]. Approximately 11.4 of every 100,000 people commit suicide, resulting in 804,000 deaths worldwide each year [6]. Suicidal ideation is highly predictive of suicidal behavior [7], which imposes a substantial burden on healthcare systems [8]. Therefore, it is imperative to enhance clinical attention toward suicidal ideation.

The brain's secondary messenger system relies heavily on cholesterol, which is closely associated with the mechanisms of mood stabilizers and antidepressants [9]. This relationship may indirectly influence the development of suicidal ideation. Numerous studies have confirmed that patients with DDs exhibit widespread lipid metabolism disturbances. A systematic review demonstrated [10] that these patients had significantly lower total cholesterol levels than healthy control groups. Beyond individual lipid parameters, lipidomic analyses revealed that DDs are associated with alterations in up to 97 distinct lipid species, suggesting their involvement in pathways such as inflammation, lipid peroxidation, and mitochondrial dysfunction [11]. When evaluated individually, traditional lipid biomarkers such as total cholesterol and high-density lipoprotein cholesterol reflect only one dimension of lipid metabolism and may fail to capture the dynamic balance between atherogenic lipoproteins and anti-atherogenic lipoproteins. To address this limitation, the NHHR was proposed as a novel composite lipid biomarker capable of integrating information from both anti-atherogenic components (HDL-c) and atherogenic components (non-HDL-c) [12]. Compared with single lipid components, this comprehensive approach enables a more holistic assessment of the atherogenic lipid burden. Furthermore, existing studies have demonstrated that the NHHR serves as an independent risk indicator for depression among adult Americans [12]. Approximately 90% of individuals with suicidal ideation suffer from treatable mental disorders, with depression being the predominant condition among them [13]. The NHHR is derived directly from standard fasting blood lipid profiles without requiring additional tests; its calculation

involves dividing the non-HDL-c level by the corresponding HDL-c level [14], offering exceptional clinical accessibility and scalability. Although growing evidence suggests an association between lipid metabolism and suicidal ideation, to our knowledge no previous studies have investigated the relationship between suicidal ideation and the NHHR in adolescents with DDs. Thus, our study aimed at a thorough analysis of the link between the NHHR index and suicidal ideation in adolescents. We hypothesized that the NHHR index is closely associated with suicidal ideation in adolescents with DDs. By monitoring and analyzing both variables, our study offers a precise basis for predicting such risks, thereby advancing research on prevention strategies and intervention measures.

## Methods

### Study Subjects

This cross-sectional study selected adolescent patients with DDs who sought medical care at Wutai Mountain Hospital in Yangzhou, Jiangsu Province, between November 2025 and May 2026 as the study subjects. Inclusion criteria: meeting the diagnostic criteria of the International Classification of Diseases, 10th Revision; diagnosed with a depressive episode or recurrent depressive disorder; age between 13 and 17 years; having undergone heart rate variability (HRV) assessment; and providing informed consent, with both the patient and their legal guardian voluntarily participating in this study. Exclusion criteria: presence of intellectual disability, dementia, substance abuse, or organic mental disorder; presence of severe somatic illness or other comorbidities; presence of language or cognitive impairment that would prevent completion of the scales; use of a pacemaker or implantable cardioverter-defibrillator, or undergoing radiofrequency ablation for arrhythmia treatment [15]; and withdrawal of informed consent. As this is a cross-sectional study, based on Kendall's sample size calculation method, the required sample size for multivariate analysis should be at least 5–10 times the number of independent variables [16]. Our study included 17 independent variables, with an initial target sample size ranging between 105 and 170. The final sample size incorporated in the study was 291 cases.

All eligible adolescent patients and their legal guardians received a printed standardized written information brochure prior to enrollment in the study. The investigators also verbally explained the study objectives, the testing procedure, potential non-invasive risks, data anonymization protocols, and the right to withdraw from the study at any time without conditions to each participant. The adolescent participants (13 to 17 years old) signed a written informed consent document, and so did their primary legal guardians. All consent documents have been securely archived in the hospital's clinical research archives.

### Subject's demographic data and physical measurement data

During the study period, the research team utilized a standardized questionnaire system to collect general and sociodemographic data from adolescents with DDs; the survey items included gender, age,

medical visit history, place of residence, monthly per capita family income, payment method, caregiver, family relationships, and adverse life events. Adverse life events here refer to stressful life events experienced by participants, such as school bullying, chronic family conflicts, and family trauma. The body mass index (BMI) was calculated using the formula: individual weight (in kilograms) ÷ square of height (in meters), with the results expressed in kg/m<sup>2</sup>. After at least 8 hours of fasting, fasting blood lipid profiles were measured, encompassing total cholesterol (TC) and HDL-c levels. A fully automated biochemical analyzer (AU5800, Beckman Coulter, Inc.) was used to analyze the blood lipid profiles of fasting individuals via enzymatic assays to determine TC and HDL-c levels. Non-HDL-c was calculated by subtracting HDL-c from TC. Subsequently, calculations were performed according to the specified formula:  $NHHR = (TC - HDL-c) / HDL-c$  [14].

## Autonomic nervous system function testing

All HRV signal recordings were conducted under standardized quiet resting conditions. All subjects sat in a soundproof examination room with soft ambient lighting and a constant temperature. A mandatory 10-minute pre-adaptation period was required prior to signal acquisition. All adolescents were instructed to fast for at least 2 hours to avoid metabolic interference. The total duration of continuous HRV signal recording was 5 minutes, during which the spontaneous respiratory rate was monitored in real time without manual adjustment. The HRV power spectrum can be utilized to assess sympathetic and parasympathetic nervous system activity. The low-frequency component (0.04–0.15 Hz) reflects the combined influence of sympathetic and parasympathetic nerve tension in the frequency-domain analysis of HRV, with sympathetic tension predominating. The high-frequency component (0.15–0.40 Hz) reflects only parasympathetic nerve tension (primarily vagal nerve tension). The low- to high-frequency (HF/LF) ratio reflects the balance between sympathetic and parasympathetic nerve tension [17]. Based on the HRV test results (using the HF/LF ratio as the primary indicator for autonomic nervous system tension balance) [18], patients were divided into three groups: the normal autonomic nervous system tension group (autonomic nervous system tension balance range:  $-1.5\sigma$  to  $1.5\sigma$ , representing a physiological sympathetic–vagus balance state); a severe sympathetic tension group (autonomic nervous system tension balance range  $\geq 1.5\sigma$ , indicating significant over-activity of the sympathetic nervous system); and a severe parasympathetic tension group (autonomic nervous system tension balance range  $\leq -1.5\sigma$ , indicating significant overactivity of the parasympathetic nervous system). Autonomic nervous function was assessed using an HRV analyzer (model ZSY-1; Shenyang Weijin Gene Technology Co., Ltd., China). The  $\sigma$  value represents a statistical comparison of the measurements obtained by this device and the data from an internal healthy population database.

## Psychological Status Assessment

The Beck Scale for Suicide Ideation (BSI) evaluates the intensity of a patient's suicidal ideation and suicide attempt tendencies over the past week. Scores range from 0 to 100, with higher scores indicating a greater risk of suicide [19]. The Hamilton Anxiety Scale (HAMA) evaluated anxiety levels. Scores range

from 0 to 56, where higher scores reflect more severe anxiety symptoms. The Hamilton Depression Rating Scale (HAMD) assesses depressive symptoms, comprising 24 items with a total score range of 0 to 76. Higher HAMD scores indicate more severe depressive symptoms. All psychiatrists received standardized training on interpreting the scores from these three scales prior to data collection.

## Statistical analysis

Continuous variables are presented according to their distribution patterns: for normal distributions, they are expressed as the mean  $\pm$  SD. For non-normal distributions, they are expressed as the median and interquartile range. Categorical variables are displayed using frequency counts and percentages. Statistical methods such as one-way ANOVA, the Kruskal–Wallis H-test, and the chi-squared test were employed to assess differences among the four quartile groups of the NHHR. When the NHHR was treated as a continuous variable and divided into quartile groups, a logistic regression model was used to analyze the linear relationship between the NHHR and suicidal ideation; after categorizing the NHHR, the *p*-values for trends were calculated. To identify potential multicollinearity among predictor variables, the variance inflation factor (VIF) method was applied: any covariate with a VIF exceeding 5.0 was excluded from the final analysis model; additionally, if a particular covariate's influence on estimating suicidal ideation based on the NHHR index resulted in a magnitude of change exceeding 10%, or if its *p*-value was less than 0.05, that covariate was considered a potential confounding factor. In the univariate analysis, a significance level of 10% was adopted. We established three independent analytical frameworks to evaluate the stability of the results: Model I, which included HAMA and HAMD factors; Model II, which adjusted for all potential confounding variables; and the baseline model, which was unchanged. A smoothing plot was utilized to examine the nonlinear correlation between the NHHR index and suicidal ideation. Furthermore, a segmented linear regression model was constructed within the generalized least squares framework to identify and analyze the threshold effect indicated by the smoothing plot. Bonferroni correction was applied to control for the inflated Type I error rate resulting from multiple hypothesis testing.

Statistical analyses were performed using R software (version 4.2.1) for statistical calculations. EmpowerStats software (version 2.0) was incorporated into the analysis workflow. In two-sided tests, a *p*-value  $< 0.05$  indicated statistical significance.

## RESULTS

### Baseline characteristics of study participants

Table 1 presents the demographic and clinical characteristics of participants stratified by NHHR quartiles. Although no statistically significant associations were observed between gender, diagnosis, place of residence, payment method, caregiver, or NHHR quartiles (all *p*  $> 0.05$ ), the remaining covariates showed significant correlations with the NHHR quartiles (all *p*  $< 0.05$ ).

Table 1  
Baseline characteristics of participants (N = 291)

| Item                                                                                                                                                                                                                                                                      | NHHR classify          |                        |                        |                       | p-value              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------------|------------------------|-----------------------|----------------------|
|                                                                                                                                                                                                                                                                           | Q1(7.46–8.32)          | Q2(8.32–9.18)          | Q3(9.18–10.04)         | Q4(10.04–10.90)       |                      |
| N                                                                                                                                                                                                                                                                         | 73                     | 73                     | 73                     | 72                    |                      |
| Age                                                                                                                                                                                                                                                                       | 15.671 ± 1.281         | 15.083 ± 1.320         | 15.234 ± 1.399         | 14.964 ± 1.419        | 0.007 <sup>a</sup>   |
| HAMA Score                                                                                                                                                                                                                                                                | 9(3, 15.5)             | 12(5, 18)              | 13(8, 20)              | 12(7.25, 20)          | 0.011 <sup>c</sup>   |
| HAMD Score                                                                                                                                                                                                                                                                | 19(7, 34.5)            | 15(10, 22.5)           | 22(13.5, 33)           | 21.5(11, 31.5)        | 0.047 <sup>c</sup>   |
| BMI                                                                                                                                                                                                                                                                       | 20.000(17.800, 24.145) | 20.000(17.800, 22.100) | 20.900(17.700, 23.850) | 20.75(17.863, 24.050) | 0.009 <sup>c</sup>   |
| TC                                                                                                                                                                                                                                                                        | 3.579 ± 0.827          | 3.987 ± 0.768          | 4.050 ± 0.774          | 4.857 ± 0.948         | < 0.001 <sup>a</sup> |
| HDL-C                                                                                                                                                                                                                                                                     | 1.338 ± 0.293          | 1.202 ± 0.238          | 1.031 ± 0.190          | 0.979 ± 0.182         | < 0.001 <sup>a</sup> |
| Gender                                                                                                                                                                                                                                                                    |                        |                        |                        |                       | 0.790 <sup>b</sup>   |
| Female                                                                                                                                                                                                                                                                    | 31(42.466%)            | 26(35.616%)            | 26(35.616%)            | 26(36.111%)           |                      |
| Male                                                                                                                                                                                                                                                                      | 42(57.534%)            | 47(64.384%)            | 47(64.384%)            | 46(63.889%)           |                      |
| Diagnose                                                                                                                                                                                                                                                                  |                        |                        |                        |                       | 0.924 <sup>b</sup>   |
| Depressive episode                                                                                                                                                                                                                                                        | 40(54.795%)            | 41(56.164%)            | 43(58.904%)            | 43(59.722%)           |                      |
| Recurrent depressive disorder                                                                                                                                                                                                                                             | 33(45.205%)            | 32(43.836%)            | 30(41.096%)            | 29(40.278%)           |                      |
| Medical Visit Details                                                                                                                                                                                                                                                     |                        |                        |                        |                       | 0.011 <sup>b</sup>   |
| First visit                                                                                                                                                                                                                                                               | 33(45.205%)            | 52(71.233%)            | 40(54.795%)            | 45(62.500%)           |                      |
| Return visit                                                                                                                                                                                                                                                              | 40(54.795%)            | 21(28.767%)            | 33(45.205%)            | 27(37.500%)           |                      |
| Variables are expressed as n (%), mean ± SD, or median (first quartile to third quartile); a: t-value; b: $\chi^2$ -value; c: U-value.                                                                                                                                    |                        |                        |                        |                       |                      |
| NHHR: non-HDL-c to HDL-c ratio; HAMD: 17-item Hamilton Depression Rating Scale; HAMA: 14-item Hamilton Anxiety Rating Scale; TC: total cholesterol; HDL-c: high-density lipoprotein cholesterol; BMI: body mass index; LF/HF: autonomic nervous system tone balance bias. |                        |                        |                        |                       |                      |

| Item                                                                                                                                                                                                                                                                      | NHHR classify |               |                |                 | p-value            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|----------------|-----------------|--------------------|
|                                                                                                                                                                                                                                                                           | Q1(7.46–8.32) | Q2(8.32–9.18) | Q3(9.18–10.04) | Q4(10.04–10.90) |                    |
| Place of residence                                                                                                                                                                                                                                                        |               |               |                |                 | 0.790 <sup>b</sup> |
| Rural area                                                                                                                                                                                                                                                                | 23(31.507%)   | 25(34.247%)   | 20(27.397%)    | 25(34.722%)     |                    |
| Town                                                                                                                                                                                                                                                                      | 20(27.397%)   | 18(24.657%)   | 19(26.028%)    | 23(31.944%)     |                    |
| City                                                                                                                                                                                                                                                                      | 30(41.096%)   | 30(41.096%)   | 34(46.575%)    | 24(33.334%)     |                    |
| Per capita monthly household income                                                                                                                                                                                                                                       |               |               |                |                 | 0.005 <sup>b</sup> |
| < 3000                                                                                                                                                                                                                                                                    | 42(57.535%)   | 30(41.096%)   | 34(46.575%)    | 24(33.333%)     |                    |
| 3000–8000                                                                                                                                                                                                                                                                 | 19(26.027%)   | 19(26.027%)   | 24(32.877%)    | 31(43.056%)     |                    |
| > 8000                                                                                                                                                                                                                                                                    | 12(16.438%)   | 24(32.877%)   | 15(20.548%)    | 17(23.611%)     |                    |
| Payment method                                                                                                                                                                                                                                                            |               |               |                |                 | 0.832 <sup>b</sup> |
| At one's own expense                                                                                                                                                                                                                                                      | 24(32.877%)   | 23(31.507%)   | 28(38.356%)    | 24(33.333%)     |                    |
| Medical insurance                                                                                                                                                                                                                                                         | 49(67.123%)   | 50(68.493%)   | 45(61.644%)    | 48(66.667%)     |                    |
| Caregiver status                                                                                                                                                                                                                                                          |               |               |                |                 | 0.652 <sup>b</sup> |
| Parents                                                                                                                                                                                                                                                                   | 24(32.877%)   | 27(36.986%)   | 21(28.767%)    | 26(36.111%)     |                    |
| Single parent (mother)                                                                                                                                                                                                                                                    | 30(41.096%)   | 24(32.877%)   | 31(42.466%)    | 32(44.444%)     |                    |
| Single parent (father)                                                                                                                                                                                                                                                    | 19(26.027%)   | 22(30.137%)   | 21(28.767%)    | 14(19.445%)     |                    |
| Family relationships                                                                                                                                                                                                                                                      |               |               |                |                 | 0.006 <sup>b</sup> |
| Intimate                                                                                                                                                                                                                                                                  | 19(26.028%)   | 30(41.096%)   | 37(50.685%)    | 17(23.611%)     |                    |
| Same as                                                                                                                                                                                                                                                                   | 27(36.986%)   | 27(36.986%)   | 21(28.767%)    | 27(37.500%)     |                    |
| Drift apart                                                                                                                                                                                                                                                               | 27(36.986%)   | 16(21.918%)   | 15(20.548%)    | 28(38.889%)     |                    |
| Variables are expressed as n (%), mean ± SD, or median (first quartile to third quartile); a: t-value; b: $\chi^2$ -value; c: U-value.                                                                                                                                    |               |               |                |                 |                    |
| NHHR: non-HDL-c to HDL-c ratio; HAMD: 17-item Hamilton Depression Rating Scale; HAMA: 14-item Hamilton Anxiety Rating Scale; TC: total cholesterol; HDL-c: high-density lipoprotein cholesterol; BMI: body mass index; LF/HF: autonomic nervous system tone balance bias. |               |               |                |                 |                    |

| Item                                                                                                                                                                                                                                                                      | NHHR classify |               |                |                 | p-value            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|----------------|-----------------|--------------------|
|                                                                                                                                                                                                                                                                           | Q1(7.46–8.32) | Q2(8.32–9.18) | Q3(9.18–10.04) | Q4(10.04–10.90) |                    |
| Adverse Experiences                                                                                                                                                                                                                                                       |               |               |                |                 | 0.033 <sup>b</sup> |
| No                                                                                                                                                                                                                                                                        | 61(83.562%)   | 53(72.603%)   | 45(62.500%)    | 61(83.562%)     |                    |
| Yes                                                                                                                                                                                                                                                                       | 12(16.438%)   | 20(27.397%)   | 27(37.500%)    | 12(16.438%)     |                    |
| LF/HF                                                                                                                                                                                                                                                                     |               |               |                |                 | 0.025 <sup>b</sup> |
| Normal                                                                                                                                                                                                                                                                    | 40(54.795%)   | 30(41.096%)   | 26(35.616%)    | 25(34.722%)     |                    |
| Markedly sympathetic bias                                                                                                                                                                                                                                                 | 21(28.767%)   | 30(41.096%)   | 28(38.356%)    | 21(29.167%)     |                    |
| Markedly biased toward the parasympathetic system                                                                                                                                                                                                                         | 12(16.438%)   | 13(17.808%)   | 19(26.028%)    | 26(36.111%)     |                    |
| Suicide idea                                                                                                                                                                                                                                                              |               |               |                |                 | 0.009 <sup>b</sup> |
| No                                                                                                                                                                                                                                                                        | 54(73.973%)   | 43(58.904%)   | 35(47.945%)    | 48(66.667%)     |                    |
| Yes                                                                                                                                                                                                                                                                       | 19(26.027%)   | 30(41.096%)   | 38(52.055%)    | 24(33.333%)     |                    |
| Variables are expressed as n (%), mean ± SD, or median (first quartile to third quartile); a: t-value; b: $\chi^2$ -value; c: U-value.                                                                                                                                    |               |               |                |                 |                    |
| NHHR: non-HDL-c to HDL-c ratio; HAMD: 17-item Hamilton Depression Rating Scale; HAMA: 14-item Hamilton Anxiety Rating Scale; TC: total cholesterol; HDL-c: high-density lipoprotein cholesterol; BMI: body mass index; LF/HF: autonomic nervous system tone balance bias. |               |               |                |                 |                    |

### Univariate analysis results for suicidal ideation

Table 2 presents the results of the univariate analysis of suicidal ideation. To examine whether suicidal ideation differs among adolescent patients with DDs based on their demographic characteristics, we constructed a univariate analysis model using suicidal ideation as the dependent variable and demographic characteristics as independent variables. Following the Shapiro–Wilk normality test and Levene's homogeneity of variance test, parametric statistical methods (independent samples t-test/rank-sum test) were employed to assess differences between groups. The results indicated that statistically significant differences were observed across the following factors: HAMA scores, HAMD scores, BMI, medical visit status, monthly per capita family income, caregiver status, family relationships, and LF/HF factors ( $p < 0.05$ ).

Table 2  
Results of the univariate analysis of suicidal ideation (N = 291)

| Item                                                                                                                                                                                                                                                                      | BSI                   |                        | p-value            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------|--------------------|
|                                                                                                                                                                                                                                                                           | No (N = 180)          | Yes (N = 111)          |                    |
| Age                                                                                                                                                                                                                                                                       | 15.013± 1.370         | 15.281 ± 1.350         | 0.754 <sup>a</sup> |
| HAMA                                                                                                                                                                                                                                                                      | 11.000(4.000, 17.500) | 13.000(9.000, 20.000)  | 0.005 <sup>c</sup> |
| HAMD                                                                                                                                                                                                                                                                      | 16.00(9.000, 29.750)  | 22.000(11.000, 33.000) | 0.016 <sup>c</sup> |
| BMI                                                                                                                                                                                                                                                                       | 20.851 ± 4.813        | 22.063 ± 4.773         | 0.011 <sup>a</sup> |
| TC                                                                                                                                                                                                                                                                        | 4.094 ± 1.000         | 4.151 ± 0.861          | 0.515 <sup>a</sup> |
| HDL-C                                                                                                                                                                                                                                                                     | 1.150± 0.281          | 1.119± 0.250           | 0.442 <sup>a</sup> |
| NHHR                                                                                                                                                                                                                                                                      | 2.680 ± 0.978         | 2.807 ± 0.855          | 0.129 <sup>a</sup> |
| Gender                                                                                                                                                                                                                                                                    |                       |                        | 0.059 <sup>b</sup> |
| Female                                                                                                                                                                                                                                                                    | 75(41.667%)           | 34(30.361%)            |                    |
| Male                                                                                                                                                                                                                                                                      | 105(58.631%)          | 77(69.369%)            |                    |
| Diagnose                                                                                                                                                                                                                                                                  |                       |                        | 0.575 <sup>b</sup> |
| Depressive episode                                                                                                                                                                                                                                                        | 101(56.111%)          | 79(59.459%)            |                    |
| Recurrent depressive disorder                                                                                                                                                                                                                                             | 79(43.889%)           | 45(40.541%)            |                    |
| Medical Visit Details                                                                                                                                                                                                                                                     |                       |                        | 0.001 <sup>b</sup> |
| First visit                                                                                                                                                                                                                                                               | 92(51.111%)           | 78(70.270%)            |                    |
| Return visit                                                                                                                                                                                                                                                              | 88(48.889%)           | 46(29.730%)            |                    |
| Place of residence                                                                                                                                                                                                                                                        |                       |                        | 0.113 <sup>b</sup> |
| Rural area                                                                                                                                                                                                                                                                | 51(28.333%)           | 42(37.838%)            |                    |
| Town                                                                                                                                                                                                                                                                      | 48(26.667%)           | 32(28.829%)            |                    |
| City                                                                                                                                                                                                                                                                      | 81(45.000%)           | 37(33.333%)            |                    |
| Variables are expressed as n (%), mean ± SD, or median (first quartile to third quartile); a: t-value; b: $\chi^2$ -value; c: U-value.                                                                                                                                    |                       |                        |                    |
| NHHR: non-HDL-c to HDL-c ratio; HAMD: 17-item Hamilton Depression Rating Scale; HAMA: 14-item Hamilton Anxiety Rating Scale; TC: total cholesterol; HDL-c: high-density lipoprotein cholesterol; BMI: body mass index; LF/HF: autonomic nervous system tone balance bias. |                       |                        |                    |

| Item                                                                                                                                                                                                                                                                      | BSI          |               | p-value              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------|----------------------|
|                                                                                                                                                                                                                                                                           | No (N = 180) | Yes (N = 111) |                      |
| Per capita monthly household income                                                                                                                                                                                                                                       |              |               | 0.041 <sup>b</sup>   |
| < 3000                                                                                                                                                                                                                                                                    | 90(50.000%)  | 43(38.739%)   |                      |
| 3000–8000                                                                                                                                                                                                                                                                 | 45(25.000%)  | 43(38.739%)   |                      |
| > 8000                                                                                                                                                                                                                                                                    | 45(25.000%)  | 25(22.522%)   |                      |
| Payment method                                                                                                                                                                                                                                                            |              |               | 0.065 <sup>b</sup>   |
| At one's own expense                                                                                                                                                                                                                                                      | 54(30.000%)  | 45(40.541%)   |                      |
| Medical insurance                                                                                                                                                                                                                                                         | 126(70.000%) | 66(59.459%)   |                      |
| Caregiver status                                                                                                                                                                                                                                                          |              |               | 0.036 <sup>b</sup>   |
| Parents                                                                                                                                                                                                                                                                   | 67(37.222%)  | 27(24.324%)   |                      |
| Single parent (mother)                                                                                                                                                                                                                                                    | 70(38.889%)  | 45(40.541%)   |                      |
| Single parent (father)                                                                                                                                                                                                                                                    | 43(23.889%)  | 39(35.135%)   |                      |
| Family relationships                                                                                                                                                                                                                                                      |              |               | < 0.001 <sup>b</sup> |
| Intimate                                                                                                                                                                                                                                                                  | 46(25.556%)  | 57(51.351%)   |                      |
| Same as                                                                                                                                                                                                                                                                   | 67(37.222%)  | 35(31.532%)   |                      |
| Drift apart                                                                                                                                                                                                                                                               | 67(37.222%)  | 19(17.117%)   |                      |
| Adverse Experiences                                                                                                                                                                                                                                                       |              |               | 0.054 <sup>b</sup>   |
| No                                                                                                                                                                                                                                                                        | 140(77.778%) | 75(67.568%)   |                      |
| Yes                                                                                                                                                                                                                                                                       | 40(22.222%)  | 36(32.432%)   |                      |
| LF/HF                                                                                                                                                                                                                                                                     |              |               | 0.001 <sup>b</sup>   |
| Normal                                                                                                                                                                                                                                                                    | 93(51.667%)  | 32(28.829%)   |                      |
| Markedly sympathetic bias                                                                                                                                                                                                                                                 | 52(28.889%)  | 46(41.441%)   |                      |
| Markedly biased toward the parasympathetic system                                                                                                                                                                                                                         | 35(19.444%)  | 33(29.730%)   |                      |
| Variables are expressed as n (%), mean $\pm$ SD, or median (first quartile to third quartile); a: t-value; b: $\chi^2$ -value; c: U-value.                                                                                                                                |              |               |                      |
| NHHR: non-HDL-c to HDL-c ratio; HAMD: 17-item Hamilton Depression Rating Scale; HAMA: 14-item Hamilton Anxiety Rating Scale; TC: total cholesterol; HDL-c: high-density lipoprotein cholesterol; BMI: body mass index; LF/HF: autonomic nervous system tone balance bias. |              |               |                      |

Multifactorial analysis results for suicidal ideation

For a multivariate analysis of suicidal ideation among adolescents with DDs, we used suicidal ideation as the dependent variable and incorporated predictor variables identified as statistically significant in univariate analyses into a binary regression model. The predictor variables included HAMA, HAMD, BMI, healthcare-seeking behavior, monthly per capita family income, caregiver status, family relationships, and LF/HF. The analysis was performed using binary stepwise regression ( $\alpha_{in} = 0.05$ ,  $\alpha_{out} = 0.10$ ).

Before formally fitting the model, we conducted a multicollinearity diagnostic step. Multicollinearity can lead to inaccurate parameter estimates and increase the standard errors of the regression coefficients, thereby compromising the stability and reliability of the model. Generally, indicators such as the VIF are used to test for the presence of severe multicollinearity among the predictor variables. In our study, all VIF values were < 10, indicating that no significant multicollinearity existed among the predictor variables and thus satisfying the basic assumptions of the regression model. The specific calculation method is detailed in Table 3.

Table 3  
Variable assignment methods for multiple linear regression

| Item                                | Assignment method                                                                                                          |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Suicide idea                        | No = 1, Yes = 2                                                                                                            |
| Medical Visit Details               | First visit = 1, Return visit = 2                                                                                          |
| Per capita monthly household income | < 3000 = 1, 3000–8000 = 2, >8000 = 3                                                                                       |
| Caregiver status                    | Parents = 1, Single parent (mother) = 2, Single parent (father) = 3                                                        |
| Family relationships                | Intimate = 1, Same as = 2, Drift apart = 3                                                                                 |
| LF/HF                               | 1.0–2.0 (Normal) = 1, > 2.0 (Markedly sympathetic bias) = 2, < 1.0 = 3 (Markedly biased toward the parasympathetic system) |
| HAMA, HAMD, BMI                     | Enter original values                                                                                                      |

Table 4 presents the results of the multivariate analysis of suicidal ideation. Binary stepwise regression revealed that the factors influenced suicidal ideation among adolescents with DDs: HAMA (OR = 1.035), BMI (OR = 1.068), monthly per capita family income (particularly > 8,000 RMB/month; OR = 2.071 vs. reference group), caregivers (single-parent mother; OR = 0.392 vs. reference group), family relationships (general OR = 4.898 vs. reference group), and LF/HF ratio (strongly sympathetic bias (> 2.0); OR = 0.487 vs. reference group); all  $p < 0.05$ .

Table 4  
Multivariate analysis results for suicidal ideation

| Item                                                                                                                                                                  | $\beta$ | SE    | OR(95%CI)            | p-value |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------|----------------------|---------|
| HAMA                                                                                                                                                                  | 0.034   | 0.016 | 1.035(1.003, 1.068)  | 0.034   |
| HAMD                                                                                                                                                                  | 0.008   | 0.011 | 1.008(0.987, 1.030)  | 0.437   |
| BMI                                                                                                                                                                   | 0.066   | 0.029 | 1.068(1.010, 1.130)  | 0.022   |
| Medical Visit Details                                                                                                                                                 |         |       |                      |         |
| First visit                                                                                                                                                           |         |       | Reference            |         |
| Return visit                                                                                                                                                          | -0.874  | 0.283 | 0.417(0.240, 0.726)  | 0.002   |
| Per capita monthly household income                                                                                                                                   |         |       |                      |         |
| < 3000                                                                                                                                                                |         |       | Reference            |         |
| 3000–8000                                                                                                                                                             | 0.180   | 0.353 | 1.197(0.600, 2.391)  | 0.610   |
| > 8000                                                                                                                                                                | 0.728   | 0.365 | 2.071(1.013, 4.233)  | 0.046   |
| Caregiver status                                                                                                                                                      |         |       |                      |         |
| Parents                                                                                                                                                               |         |       | Reference            |         |
| Single parent (mother)                                                                                                                                                | -0.936  | 0.373 | 0.392(0.189, 0.815)  | 0.012   |
| Single parent (father)                                                                                                                                                | -0.379  | 0.343 | 0.673(0.344, 1.316)  | 0.345   |
| Family relationships                                                                                                                                                  |         |       |                      |         |
| Intimate                                                                                                                                                              |         |       | Reference            |         |
| Same as                                                                                                                                                               | 1.589   | 0.366 | 4.898(2.388, 10.046) | < 0.001 |
| Drift apart                                                                                                                                                           | 0.329   | 0.370 | 1.390(0.673, 2.870)  | 0.374   |
| LF/HF                                                                                                                                                                 |         |       |                      |         |
| Normal                                                                                                                                                                |         |       | Reference            |         |
| Markedly sympathetic bias                                                                                                                                             | -0.719  | 0.342 | 0.487(0.249, 0.952)  | 0.035   |
| Markedly biased toward the parasympathetic system                                                                                                                     | -0.024  | 0.342 | 0.977(0.500, 1.908)  | 0.945   |
| Variables are expressed as n (%), mean $\pm$ SD, or median (first quartile to third quartile); a: t-value; b: $\chi^2$ -value; c: U-value.                            |         |       |                      |         |
| HAMD: 17-item Hamilton Depression Rating Scale; HAMA: 14-item Hamilton Anxiety Rating Scale; BMI: body mass index; LF/HF: autonomic nervous system tone balance bias. |         |       |                      |         |

**Results of the logistic regression analysis between NHHR and suicidal ideation**

The results of the preliminary, partial, and full statistical analyses are detailed in Table 5. The data indicate a significant association between the NHHR index and the risk of suicidal ideation (all  $p < 0.05$ ). Furthermore, after controlling for multiple potential confounding variables, individuals whose NHHR index fell within the second, third, and fourth quartiles showed significantly higher risks of suicidal ideation than those in the first quartile group in the unadjusted model, as well as in the third quartile group in Model II and the fourth quartile group in Model II (all  $p < 0.05$ ). No other significant differences were observed (all  $p > 0.05$ ).

Table 5  
Associations between the NHHR index and suicidal ideation across different models

| Item                                                                                                                                                                                                                                                                                                                        | Unadjusted model          |         | Model I                    |         | Model II                  |         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|---------|----------------------------|---------|---------------------------|---------|
|                                                                                                                                                                                                                                                                                                                             | OR(95%CI)                 | p-value | OR(95%CI)                  | p-value | OR(95%CI)                 | p-value |
| NHHR                                                                                                                                                                                                                                                                                                                        | -1.262<br>(-2.434,-0.089) | 0.036   | -1.4775<br>(-2.584,-0.369) | 0.009   | -1.662<br>(-2.778,-0.545) | 0.004   |
| NHHR:<br>Increase per<br>standard<br>deviation                                                                                                                                                                                                                                                                              | -1.637<br>(-2.929,-0.344) | 0.014   | -1.702<br>(-3.010,-0.394)  | 0.011   | -1.731<br>(-3.086,-0.377) | 0.013   |
| NHHR<br>quartiles                                                                                                                                                                                                                                                                                                           |                           |         |                            |         |                           |         |
| Q1(7.46–<br>8.32)                                                                                                                                                                                                                                                                                                           | Reference                 |         | Reference                  |         | Reference                 |         |
| Q2(8.32–<br>9.18)                                                                                                                                                                                                                                                                                                           | 2.532<br>(-1.327,6.392)   | 0.199   | 2.602<br>(-1.079,6.284)    | 0.167   | 0.518<br>(-3.142,4.179)   | 0.782   |
| Q3(9.18–<br>10.04)                                                                                                                                                                                                                                                                                                          | 4.834<br>(1.146,8.523)    | 0.011   | 3.238<br>(-0.346,6.822)    | 0.078   | 7.011<br>(-0.789,14.812)  | 0.081   |
| Q4(10.04–<br>10.90)                                                                                                                                                                                                                                                                                                         | -1.854<br>(-5.762,2.053)  | 0.568   | -1.837<br>(-5.182,1.507)   | 0.283   | -3.381<br>(-7.205,-0.456) | 0.027   |
| p-value<br>represents<br>the trend                                                                                                                                                                                                                                                                                          | 0.121                     |         | 0.025                      |         | 0.003                     |         |
| The unadjusted model underwent no modifications. Model I adjusted for HAMA and HAMD. Model II adjusted for age, gender, diagnosis, medical visit details, place of residence, per capita monthly household income, payment method, caregiver status, family relationships, adverse experiences, BMI, HAMA, HAMD, and LF/HF. |                           |         |                            |         |                           |         |
| Abbreviations: NHHR: non-HDL-c to HDL-c ratio; CI: confidence interval, SD: standard deviation, OR: odds ratio                                                                                                                                                                                                              |                           |         |                            |         |                           |         |

## Results of the nonlinear relationship between NHHR and suicidal ideation

Figure 1 shows a 'U'-shaped association between the NHHR index and suicidal ideation. Through an in-depth analysis using a two-segment linear regression model, the key threshold for the NHHR index was identified as 2.63. Above this inflection point, every one-unit increase in the NHHR index was associated with a significant 1.0% rise in suicidal ideation scores (OR = 0.235,  $p = 0.035$ ). Below the inflection point, higher NHHR indices were correlated with lower suicidal ideation scores (OR = - 0.297,  $p = 0.032$ ), as detailed in Table 6.

Table 6  
Results of the two-stage logistic regression model

| point of inflection NHHR                                                                                                                                                                                                                                               | OR     | 95%CI            | p-value |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------|---------|
| < 2.63                                                                                                                                                                                                                                                                 | 0.235  | 0.017 to 0.453   | 0.035   |
| ≥ 2.63                                                                                                                                                                                                                                                                 | -0.297 | -0.567 to -0.027 | 0.032   |
| Log-likelihood ratio test                                                                                                                                                                                                                                              |        |                  | 0.031   |
| Effect: suicidal ideation. Causes: age, gender, diagnosis, medical visit details, place of residence, per capita monthly household income, payment method, caregiver status, family relationships, adverse experiences, BMI, HAMA, HAMD, LF/HF to perform corrections. |        |                  |         |
| Abbreviations: NHHR: non-HDL-c to HDL-c ratio; CI: confidence interval, SD: standard deviation, OR: odds ratio.                                                                                                                                                        |        |                  |         |

## Discussion

Suicidal behavior triggered by suicidal ideation represents a critical issue in public health, with profound impacts on adolescents with DDs, their families, clinicians, and mental health professionals alike. Our study of 288 adolescent patients with DDs found an inverted 'U'-shaped association between the NHHR and suicidal ideation after comprehensive adjustments of potential confounding factors, with the inflection point located at 2.63. Based on these findings, we believe that the NHHR can serve as a predictive indicator of suicidal ideation, and that modulating the lipid profile reflected by the NHHR could reduce the risk of developing suicidal ideation and related behavior. These conclusions align with previous research findings, both of which demonstrated an inverted 'U'-shaped association. However, the positions of the inflection points differed due to variations in study samples and populations: Qing et al. [20] studied 29,288 adult subjects with suicidal ideation, whereas our study comprised only 288 adolescent patients with suicidal ideation. Based on these observations, we propose that the NHHR may function as a potential biomarker for predicting suicidal ideation in adolescents with DDs, and that modulating the lipid profile reflected by the NHHR could mitigate the risk of developing suicidal ideation and related behavior. Based on existing research findings, an increasing body of evidence suggests that the NHHR offers significant advantages as an indicator for assessing the risk of lipid-related disorders [21, 22]. The observed 'U'-shaped association in this study can be explained by the dual regulatory mechanism through which lipid metabolism influences nervous system function [23, 24]. Cholesterol is a crucial component of brain cell membranes and serves as a key substrate for the synthesis of neurotransmitters and mood-regulating substances, exerting profound effects on emotional regulation and stress responses within the central nervous system [25]. An abnormally low NHHR indicates insufficient lipid supply in the body, which may impede the synthesis and metabolism of central nervous system neurotransmitters, exacerbate emotional dysregulation in adolescents with depression, and further increase their risk of suicidal ideation [26]. Conversely, an elevated NHHR reflects severe dysregulation in lipid metabolism. Such an imbalance can induce chronic low-grade inflammation and mitochondrial dysfunction in the central nervous system, aggravate brain neuronal damage, and amplify

negative emotions and the risk of suicide [27]. Consistent with the findings reported by Qing et al. [20] in adult populations, our study confirms a nonlinear correlation between NHHR values and suicidal ideation. However, the inflection point differs significantly between these groups, strongly indicating that age and developmental stage are important confounding factors that influence the association between lipids and suicide risk. Adolescents are at a critical transition period between neural development and metabolic maturation, where both their lipid metabolic homeostasis and central nervous system plasticity exhibit marked differences compared to adults, thereby resulting in a unique threshold pattern of suicide risk among this population [28].

It is noteworthy that our study found that autonomic nervous system function and sociological factors play a crucial synergistic regulatory role in the development of suicidal ideation among adolescent patients with depression. HRV frequency-domain parameters serve as the gold standard for assessing autonomic nervous system function. Specifically, the LF component is predominantly governed by the sympathetic nervous system but co-regulated by the parasympathetic nervous system. By contrast, the HF component reflects only the vagus nerve-mediated parasympathetic tone. The core value of the LF/HF ratio lies in its ability to quantify the dynamic balance between the sympathetic and parasympathetic nervous systems: an elevated ratio suggests relative hyperactivity of the sympathetic nervous system, while a reduced ratio indicates dominance of the parasympathetic nervous system. Such an imbalance in the homeostasis between these two systems represents one of the central pathological mechanisms underlying DDs [29]. The multivariate analysis conducted in this study revealed that this ratio serves as an independent influencing factor for the severity of depression in adolescents, demonstrating a significant positive correlation between dysregulation of the sympathetic–parasympathetic nervous balance and suicidal ideation in adolescents. This indicates that autonomic nervous dysfunction constitutes a key neurophysiological basis for the onset and exacerbation of suicidal ideation in adolescents [30]. These findings are consistent with previous research [31] indicating that patients with DDs who harbor suicidal ideation are more susceptible to significant alterations in their autonomic nervous system function. Adolescents represent a critical stage of physiological and psychological development, during which the autonomic nervous system continues to mature [32], rendering them particularly prone to dysregulation and highly vulnerable to external factors such as psychological stress or family environment. When exposed to negative stimuli—including estranged family relationships or academic pressure—the body's stress response pathways become overactivated, leading to abnormally elevated sympathetic nervous system excitability. This disrupts the body's autonomic homeostasis, triggering core depressive symptoms such as emotional dysregulation and somatic discomfort, thereby contributing to the emergence of suicidal ideation [33]. Compared with adult patients with depression, adolescents have underdeveloped autonomic nervous systems, exhibiting less tolerance to neural imbalances and weaker compensatory capacities. Consequently, abnormal LF/HF ratios are more pronounced in adolescents with depression and carry greater clinical significance as an indicator [34]. For adolescent patients with depression, the combined effects of physiological lipid metabolism disturbances, autonomic nervous system dysregulation, and adverse

social factors further elucidate the high degree of heterogeneity observed in their manifestation of suicidal ideation.

As a novel composite lipid index, the NHHR comprehensively reflects both pro-atherogenic and anti-atherogenic lipid levels in clinical applications [35], offering excellent clinical accessibility and operational feasibility. It can be directly calculated based on routine fasting blood lipid test results, without requiring additional diagnostic tests. By integrating LF/HF ratios with sociodemographic characteristics, the NHHR enables the development of a multi-dimensional suicide risk screening system for adolescent patients with depression, facilitating precise risk stratification. For patients whose NHHR values approach the critical threshold of 2.63, clinical healthcare providers can implement targeted psychological interventions, lipid metabolism regulation strategies, and family environment guidance measures to reduce their risk of suicidal ideation, thereby providing new approaches for early suicide prevention in adolescents.

## Strengths and limitations

This study examined several indicators associated with the risk of suicidal ideation in adolescents with depressive disorder. These indicators are readily available in routine clinical practice and offer high cost-effectiveness. They provide clinicians with a means to identify patients who may harbor suicidal ideation at an early stage and to implement timely interventions to reduce the occurrence of suicidal behavior. However, this study does have several limitations. First, due to the cross-sectional design, we were unable to establish causal relationships between the variables; we could only observe correlations among them. This design limitation restricts our ability to understand the continuity and developmental trajectory of suicidal ideation. Second, the limited time span of this study constrained our ability to observe long-term changes and influences on these indicators. Future research should employ longitudinal designs to address this shortcoming. Furthermore, our sample may be subject to selection bias, as all participants were recruited from the same medical center, which may limit the generalizability of the findings. Additionally, although we controlled for multiple potential confounding factors, there may still exist other unmeasured variables that could influence the relationship between the NHHR and suicidal ideation. Finally, since the participants were unable to specify the types and dosages of the medications they had taken prior to admission, the potential interference of pre-admission medication cannot be fully excluded. It is worth adding that our study did not encompass all possible biomarkers and sociopsychological factors associated with the development of suicidal ideation, thereby limiting our ability to gain a comprehensive understanding of suicidal ideation in adolescents with DDs. Future research should consider incorporating a broader range of patient populations, with the exploration of additional potential influencing factors, and the adoption of a multicenter collaborative approach to develop a more generalizable and predictive model. This will enable more accurate predictions and better intervention strategies for suicidal ideation in adolescents with DDs.

## Conclusion

In summary, among adolescent patients with DDs, we found a stable ‘U’-shaped association between NHHR levels and suicidal ideation. When the NHHR threshold reached 2.63, the risk of suicide peaked. Autonomic nervous system dysfunction and adverse social factors exacerbated the risk of suicide in these adolescents. The NHHR may serve as a promising and cost-effective biomarker for the early detection of suicidal ideation in adolescent patients with DDs. Targeted monitoring and intervention focusing on lipid metabolism balance, autonomic nervous function, and family and social environments can effectively reduce the risk of suicide among depressed adolescents, thereby providing a reliable basis for clinical suicide prevention and adolescent mental health management.

## Abbreviations

|        |                                                    |
|--------|----------------------------------------------------|
| NHHR   | The non-HDL cholesterol to HDL cholesterol ratio   |
| CI     | Confidence interval                                |
| HDL-c  | High-density lipoprotein cholesterol               |
| DDs    | Depressive Disorders                               |
| ICD-10 | International Classification of Diseases, Revision |
| HRV    | Heart rate variability                             |
| BMI    | Body mass index                                    |
| TC     | Total cholesterol                                  |
| LF     | Low-frequency                                      |
| HF     | High-frequency                                     |
| BSI    | Beck Scale for Suicide Ideation                    |
| HAMA   | Hamilton Anxiety Scale                             |
| HAMD   | Hamilton Depression Rating Scale                   |
| VIF    | Variance Inflation Factor                          |
| SD     | Standard deviation                                 |

## Declarations

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### **Authors' contributions**

Ting W: Investigation, Writing - original draft, Software and Methodology, Funding Support; Ya QZH: Writing - original draft, Methodology, Funding Support; Jiao JS: Writing - original draft, Investigation, Software and Methodology; Ping ZH: Writing - original draft, Investigation; Wen HX: Writing - original draft, Funding Support; Nan L: Writing - original draft, Investigation, data curation and Funding Support; Jia L: Supervision, Conceptualization, Writing - review & editing, Investigation. The author(s) read and approved the final manuscript.

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### **Availability of data and materials**

The datasets generated and/or analysed during the current study are not publicly available due to individual privacy but are available in summary/group level form from the corresponding author on reasonable request.

### **Institutional review board statement**

All participants signed the informed consent form before entering the study, and all procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki Ethics approval and consent to. This study earned the approval of the Ethics Committee of the Yangzhou Wutai Mountain Hospital (WTSLL2025009).

### **Consent for publication**

All participants provided informed consent, including consent to publish scientific manuscripts based on collected data, in order to participate in the study.

### **Competing interests**

The authors declare no competing interests.

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## Figures

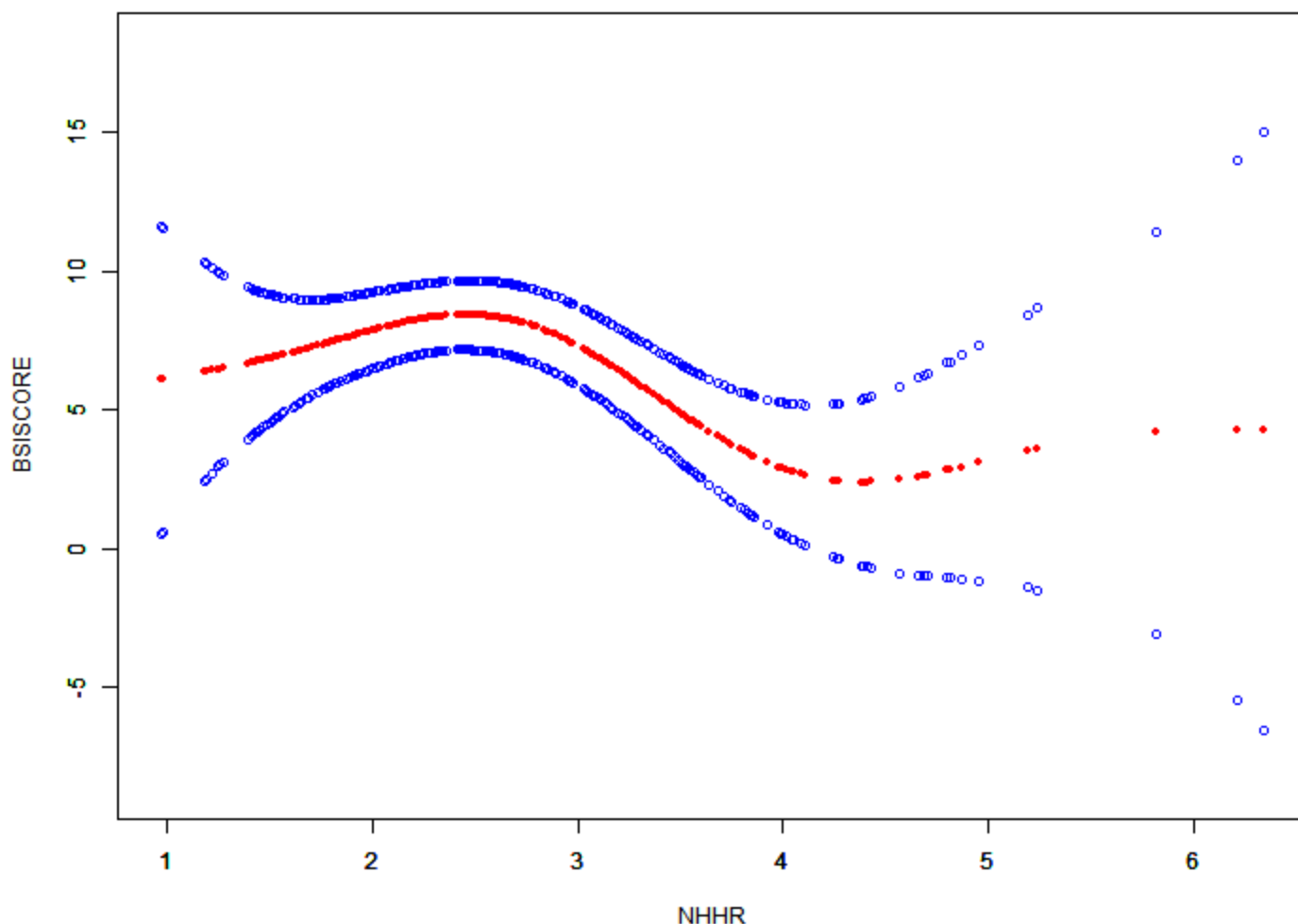


Figure 1

Relationship between NHHR scores and suicidal ideation scores. After adjusting for age, gender, diagnosis, medical visit details, place of residence, per capita monthly household income, payment method, caregiver status, family relationships, adverse experiences, BMI, HAMA, HAM-D, and LF/HF, a nonlinear relationship was observed between NHHR and suicidal ideation (nonlinear regression test,  $p < 0.05$ ).