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Quantitative Assessment of College Students' Mental Health Based on AHP–TOPSIS Algorithm

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Abstract. With the intensification of social competition, college students' mental health problems are becoming more and more prominent, and the construction of a scientific assessment system has become an urgent need. Based on the three-level screening framework of the Chinese College Students' Mental Health Screening Scale (Serious Psychological Crisis, General Psychological Problems, General Stress and Adaptation Distress), this study integrates 22 assessment dimensions, and constructs a quantitative assessment model by combining the hierarchical analysis of hierarchies (AHP) and the ideal solution method (TOPSIS). It was found that employment pressure, sleep disturbance and academic pressure were the core factors affecting college students' mental health. A TOPSIS analysis of a sample of 34 college students showed that the overall psychological health level of the group was moderate, and nearly a quarter of the students had significant psychological distress. The study suggests that the AHP–TOPSIS model combined with localized scales can effectively realize the multilevel quantitative assessment of college students' mental health, and provide accurate decision support for mental health education and intervention in colleges and universities.

Keywords: Mental health of college students, AHP–TOPSIS algorithm, Quantitative assessment

1. Introduction

China attaches great importance to the mental health of college students. In April 2023, the Ministry of Education and seventeen other departments jointly issued the Special Action Plan for Comprehensively Strengthening and Improving Students' Mental Health Work in the New Era (2023–2025), which requires colleges and universities to offer mandatory classes on mental health, regularly monitor students' mental health, and improve the four–level warning network of "Schools–Faculties–Classes–Dormitories/Individuals". With the intensification of social competition, college students are faced with multiple psychological loads, such as academic pressure, employment challenges, and interpersonal relationships, and mental health problems are becoming more and more prominent. It has been found that more than 20% of college students have no psychological problems, of which 7.8% have serious psychological defects [1]. However, existing assessment tools

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have limitations in cultural adaptability and dimensional coverage, and there is an urgent need to develop a scientific assessment system suitable for Chinese college students [1,2].

Among the foreign mental health assessment tools, the Symptom Checklist–90 (SCL–90) scale developed by Derogatis covers nine dimensions of psychological symptoms such as somatization, depression, etc., but its empirical validity in the normal population and Chinese subjects has been questioned [1,3]; the Counseling Center Assessment of Psychological Symptoms–34 (CCAPS–34) developed by Locke focuses on seven dimensions, including depression, anxiety, and stress, but does not adequately consider developmental topics specific to Chinese college students, such as academic adjustment and employment anxiety [4]. Mental Health Continuum–Short Form (MHC–SF) developed by Keyes constructs positive mental health dimensions from the perspective of mental flourishing, but is deficient in the sensitivity of symptom screening [5]. In addition to this, meta–analytic studies have found that the Self–Depression Scale (SDS), Beck Depression Inventory (BDI), Center for Epidemiologic Studies Depression Inventory (CES–D), Self–Assessment Anxiety Scale (SAS), Anxiety Susceptibility Index (ASI), Positive and Negative Affect Scale (PANAS), Satisfaction with Life Scale (SWLS), Social Behavioral Questionnaire (SBQ) and General Health Questionnaire (GHQ–28) are widely used as recognized scales [6-8].

Domestically, in order to be more applicable to Chinese college students and their emerging common problems (e.g., Internet addiction), Fang and other scholars constructed the Chinese College Students' Mental Health Screening Scale based on a three–level screening system, which integrates a multilevel assessment logic of severe psychological crisis, general psychological problems and developmental distress. The scale was validated by 810 Chinese college students, and the internal consistency reliabilities of the dimensions reached 0.70–0.89; the model fit indicators were good; the factor loadings ranged from 0.40 to 0.89, $p< 0.001$, with good structural validity; and the validity scales with the SCL–90 correlation validity were significant ($r= 0.25–0.57$, $p< 0.001$) [1]. Yi further revised the scale by replacing the 4-point scale with a 5-point scale, adding the option of “between two possibilities”, and optimizing the 13 questions, which resulted in higher reliability for each dimension and significantly improved the accuracy of risk assessment [2].

2. Construction of mental health assessment dimensions for college students

Based on the three–level screening logic of the China Mental Health Screening Scale for College Students, the division of assessment dimensions not only reflects the gradient of the severity of psychological problems, but also takes into account the practical needs from crisis intervention to developmental guidance, forming a progressive assessment system of “emergency risk–impaired functioning–adaptive development”. This forms a progressive assessment system of “emergency risk–impaired functioning–adaptive development”.

2.1. Primary screening: severe psychological crisis

2.1.1. Dimensional composition

Contains 2 core dimensions, namely, suicidal intent (e.g., suicidal thoughts, plans, and behaviors) and hallucinatory delusional symptoms (e.g., hallucinations, delusions of victimization, etc.) [1,2].

2.1.2. Reason for construction

This level focuses on extreme mental states that may directly threaten an individual's life or lead to serious loss of social functioning, and is a “red line indicator” in mental health assessment. In

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clinical practice, suicidal ideation and hallucinatory delusions belong to the category of mental health emergencies, with sudden onset and high risk. For example, the DSM–5 clearly lists suicidal ideation and behavior as “clinical indicators requiring urgent intervention,” while hallucinatory delusions often indicate the possibility of serious mental disorders. The core purpose of the first level of screening is to quickly identify high–risk individuals, buy time for crisis intervention, and prevent extreme events from occurring. At the same time, the construction of this level also echoes the prevention and control requirements of “individual–level crisis” in the Ministry of Education's “four–level warning network”, reflecting the assessment priority of “life first”.

2.2. Secondary screening: general psychological problems

2.2.1. Dimensional composition

Contains 15 dimensions divided into two categories–externalizing psychological problems (8 dimensions: sleep disturbances, eating problems, self–injurious behaviors, internet addiction, obsessive–compulsive, impulsive, hostile aggression, and dependence) and internalizing psychological problems (7 dimensions: somatization, social fears, sensitivity, low self–esteem, paranoia, depression, and anxiety) [1,2].

2.2.2. Reason for construction

This level targets the common psychological problems in the college student population that have caused significant impacts on daily life functioning, and is the intermediate level connecting “crisis” and “adaptation”. Externalizing problems are more often manifested as disturbances to the external environment or other people, while internalizing problems are based on an individual's internal experience of suffering, which together constitute the core manifestation of impaired psychological functioning. The purpose of the secondary screening is to comprehensively assess the specific manifestations and severity of psychological problems, to provide a basis for targeted intervention, and to avoid the transformation of mild to serious problems.

2.3. Tertiary screening: general stress and adaptation distress

2.3.1. Dimensional composition

Contains five dimensions, i.e., relationship distress, employment stress, academic stress, relationship distress, and school adjustment difficulties [1,2].

2.3.2. Reason for construction

This level focuses on the stage–by–stage challenges faced by college students in their growth and development, and belongs to the category of “developmental distress”, reflecting the preventive and developmental values of mental health assessment. College students are at the critical stage of “establishing identity”, and their adaptive status in the fields of academics, employment and socialization directly affects the cultivation of their psychological resilience. The core purpose of the three–level screening is to identify the weaknesses of individuals in the process of adaptation, improve their coping ability through early intervention, and promote the transformation from “maladaptation” to “positive development”.

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3. Theoretical basis and application of AHP–TOPSIS algorithm

3.1. Principles and steps of hierarchical analysis process (AHP)

The hierarchical analysis method was proposed by Saaty in the 1970s to achieve the combination of qualitative and quantitative analysis by decomposing complex problems into a three–level structure of objectives, guidelines, and options [9]. Its core steps are as follows:

3.1.1. Building a recursive hierarchy

The assessment of college students' mental health was divided into: goal level (mental health level), guideline level (22 assessment dimensions), and program level (students to be assessed).

3.1.2. Constructing a judgment matrix

Through expert consultation or data–driven, a judgment matrix $A = (a_{ij})_{n\times n}$ is constructed for each dimension of the criterion level, where a_{ij} denotes the importance of the dimension i relative to dimension j, which satisfies $a_{ij} > 0$, $a_{ij} = 1/a_{ji}$, $a_{ii} = 1$, and is usually scaled on a scale of 1–9 [10].

3.1.3. Computing the weight vector

The geometric mean (square root method) was used to calculate the weights $w = (w_1, w_2, \ldots, w_n)^T$;

Compute the product of the elements of each row of the judgment matrix: $M_i = \prod_{j=1}^{n} a_{ij}$;

Compute the nth root of the product of each row: $\overline{w}_i = \sqrt[n]{\overline{M}_i}$;

Normalize the vector: $w_i = \overline{w}_i / \sum_{j=1}^{n} \overline{w}_j$.

3.1.4. Consistency test

Calculate the maximum eigenvalue: $\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)_i}{w_i}$, where $(Aw)_i$ is the i th element of the vector Aw.

Coherence indicators: $CI = \frac{\lambda_{max}-n}{n-1}$, Stochastic Consistency Indicators RI, when $CR = CI/RI < 0.1$, the judgment matrix consistency is acceptable [10].

3.2. Principles and steps of TOPSIS (the method of ideal solution)

The ideal solution method is based on the idea that “the best solution is closest to the positive ideal solution and farthest from the negative ideal solution”, and is applicable to multi–criteria decision-making problems [11]. The core steps are as follows.

3.2.1. Constructing a decision matrix

Let the subject of assessment be m students, with n assessment dimensions and a decision matrix $X = (x_{ij})_{m\times n}$, where x_{ij} is the score of Student i in dimension j.

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3.2.2. Data standardization

Vector normalization is used: $z_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{m} x_{ij}^2}$, eliminating the effect of magnitude [12].

3.2.3. Construction of weighted standardized matrices

Introduce the weights w_j calculated by AHP gives $v_{ij} = z_{ij} \times w_j$.

3.2.4. Determining positive and negative ideal solutions

Positive ideal solution $V^+ = \left(v_1^+, v_2^+, \ldots, v_n^+\right)$, where $v_j^+ = \max\left\{v_{1j}, v_{2j}, \ldots, v_{mj}\right\}$ (benefit–based metrics) or $\min\{v_{1j}, \ldots, v_{mj}\}$ (cost–based metrics); and negative ideal solution $V^- = \left(v_1^-, v_2^-, \ldots, v_n^-\right)$, with the opposite definition [11].

3.2.5. Calculation of distance

The distance of each scheme to the positive ideal solution: $d_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}$;

The distance to the negative ideal solution: $d_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}$.

3.2.6. Calculating the closeness factor

$C_i = d_i^- / \left(d_i^+ + d_i^-\right)$, the closer C_i is to 1, the higher the level of mental health [12].

3.3. Integrated application framework for AHP–TOPSIS

The advantages of the combination of AHP and TOPSIS are (1) AHP solves the problem of subjective assignment of dimension weights and ensures logical rationality through consistency tests; (2) TOPSIS utilizes distance metrics to achieve accurate ranking and avoid single–indicator bias [13]. In mental health assessment, AHP can determine the weights of dimensions based on expert experience, while TOPSIS realizes the quantitative ranking of students' mental health status through comprehensive distance calculation, which assists the identification of high–risk groups [13].

4. Calculation analysis of samples

4.1. Source of data

The data for this study came from a sample of 34 Chinese college students, 19 males and 15 females, with an age range of 18–23 years old, collected on the Credamo platform. The study was measured using the Chinese College Student Mental Health Screening Scale, which consists of 96 questions covering 22 dimensions and is scored on a 5–point scale (1 = “not at all like me”, 5 = “very much like me”).

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4.2. Results of AHP–TOPSIS analysis

4.2.1. Determination of indicator weights

The weights of the 22 dimensions were calculated and the results are shown in Table 1.

Table 1. Weights of dimensions

	Information entropy value e	Information utility value d	Weight (%)
Hallucinations, delusional symptoms	0.969	0.031	4.498
Suicidal intent	0.965	0.035	5.188
Sleep disorder	0.956	0.044	6.4
Eating problems	0.962	0.038	5.614
Self–injurious behavior	0.983	0.017	2.481
Internet addiction	0.962	0.038	5.512
Obsessive–Compulsive	0.97	0.03	4.406
Compulsion	0.978	0.022	3.307
Hostile attacks	0.982	0.018	2.583
Dependency	0.963	0.037	5.494
Somatization	0.982	0.018	2.665
Social anxiety	0.967	0.033	4.909
Sensitivities	0.967	0.033	4.876
Low self–esteem	0.974	0.026	3.802
Paranoia	0.965	0.035	5.158
Depression	0.968	0.032	4.708
Anxiety	0.974	0.026	3.873
Obsessed with love	0.98	0.02	2.987
Employment pressure	0.935	0.065	9.512
Academic pressure	0.959	0.041	6.031
Intrapersonal trouble	0.985	0.015	2.19
Difficulty adapting to school	0.974	0.026	3.804

As shown in Table 1, employment stress has the highest weight (9.51%), followed by sleep disturbance (6.40%) and academic stress (6.03%); relationship disturbance has the lowest weight (2.19%), indicating that employment stress has the most significant impact in the assessment of college students' mental health.

4.2.2. Results of TOPSIS evaluation

Based on the weighted normalization matrix, the distance of each sample from the positive and negative ideal solutions and the composite score are calculated, and the results are shown in Table 2.

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Table 2. The TOPSIS evaluation results

	Positive ideal solution distance(D+)	Negative ideal solution distance(D–)	Composite score index	Sequence
1	0.223	0.850	0.792	3
2	0.724	0.394	0.352	33
3	0.353	0.709	0.667	13
4	0.499	0.669	0.573	20
5	0.364	0.741	0.671	12
6	0.424	0.673	0.613	18
7	0.523	0.560	0.517	28
8	0.057	0.977	0.945	1
9	0.670	0.550	0.450	30
10	0.631	0.506	0.445	31
11	0.371	0.764	0.673	11
12	0.522	0.627	0.545	25
13	0.263	0.857	0.765	6
14	0.570	0.642	0.530	27
15	0.406	0.739	0.646	15
16	0.358	0.750	0.676	10
17	0.532	0.603	0.531	26
18	0.714	0.393	0.355	32
19	0.260	0.866	0.769	5
20	0.388	0.654	0.627	17
21	0.435	0.650	0.599	19
22	0.424	0.726	0.631	16
23	0.394	0.760	0.659	14
24	0.337	0.717	0.680	9
25	0.630	0.535	0.459	29
26	0.285	0.806	0.739	7
27	0.349	0.765	0.687	8
28	0.747	0.378	0.336	34
29	0.201	0.903	0.818	2
30	0.237	0.829	0.778	4
31	0.495	0.631	0.560	22
32	0.478	0.639	0.572	21
33	0.484	0.597	0.552	23
34	0.543	0.652	0.546	24

The higher the composite score, the better the mental health status. The results show that subject 8 has the highest score, and the performance is optimal in the dimensions of employment pressure and academic pressure; subject 28 has the lowest score, and the score in the dimensions of

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depression and anxiety may be significantly high; and the mean of the overall sample's composite score is 0.587, which indicates that the group's mental health status as a whole is at a moderate level.

5. Discussion

This study found that employment pressure is the primary factor affecting the psychological health of college students, which is consistent with the phenomenon of “employment anxiety” caused by the intensification of competition in the current job market and the expansion of enrollment in colleges and universities. Besides, the high weights of sleep disturbance and academic pressure indicate that work–life disruption and study burden are still the main psychological burdens of college students.

In addition, the TOPSIS composite score showed that only a few of the 34 college students were at a high mental health level (C>0.7), while a certain percentage scored below 0.5, suggesting that some of the students suffered from more pronounced psychological distress. Among them, the depression and anxiety dimension scores were significantly negatively correlated with the composite score, verifying the critical impact of internalized psychological problems on overall mental health.

It is worth noting that the Chinese College Student Mental Health Screening Scale used in this study realized a multilevel assessment through 22 dimensions, and the differentiation of the dimensions indicates that it can capture the specific psychological needs of Chinese college students, which is superior to the SCL-90 scale that focuses only on symptoms, which is also consistent with the findings of previous studies [1,2]. This is also in line with the findings of previous studies [1,2].

6. Conclusion

This study constructed a quantitative assessment model of college students' mental health based on the AHP–TOPSIS algorithm, and the results showed that employment pressure, sleep disturbance and academic pressure are the core dimensions affecting college students' mental health; the overall mental health level of the group is moderate, and nearly one quarter of the students have obvious psychological distress, which requires targeted interventions; and the AHP–TOPSIS model can effectively realize multi–level and quantitative assessment of mental health for the decision support of college mental health education. The AHP–TOPSIS model combined with the Chinese College Student Mental Health Screening Scale can effectively realize the multi–level and quantitative assessment of mental health, and provide decision–making support for mental health education in colleges and universities.

The sample size of this study was insufficient, with 34 subjects covering only a few colleges and universities, and the limited representativeness of the sample may have led to bias in the calculation of weights. Future studies need to expand the sample to more than 300 and include students from different regions and majors. In addition, this study is cross–sectional data, which cannot reflect the time–series changes in mental health. The long–term effectiveness of the interventions can be analyzed through follow–up surveys in the future.

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