Postprint: Measuring the Importance of Influencing Factors and Moderating Effects on University Students' Proactive Health

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Abstract

Background: The goal of the Healthy China Strategy is health for all. As the backbone of the youth population and highly educated members of families and society, university students exert a powerful radiating influence on national health. University students possess relatively good health awareness, but their health behaviors are suboptimal. Achieving proactive health among university students faces a series of challenges, requiring conceptual transformation and action support.

Objective: To explore the influencing factors of proactive health and provide reference recommendations for health education in universities.

Methods: A stratified cluster sampling method was used to select 4,036 university students from 6 universities in Shandong Province for a questionnaire survey. A self-designed questionnaire (including a general information survey form and a proactive health scale) was employed for the investigation. Intergroup comparisons were conducted using t-tests. Pearson correlation analysis and multiple linear regression analysis were used to explore the influencing factors of proactive health, and random forest metric analysis was employed to evaluate the importance of these factors.

Results: The proactive health score was (24.61$±4.65)*points.Femalestudentsscoredhigheronproactivehealtht*
gradeuniversitystudentsscoredhigherthanhigher−gradestudents.Theimportancescoresforhealthresponsibi
*childrelationship, andhealthinvestmentamonguniversitystudentswere*32, 491.77, 13, 331, 10, 051.22, *and*9, 902
0.024, $P < 0.001$, 95 = 0.026, $P < 0.001$, 95 = 0.033, $P < 0.001$, 95 = 0.033, $P <$ 0.001, 95 $=0.019, P<0.001, 95%CI: 0.027, 0.161) positively moderated the relationship between health responsibility and proactive health.

Conclusion: Health responsibility is a key factor influencing proactive health. Health knowledge promotion, health needs communication, curriculum practical

activities, hope status, and dietary conditions have positive interactive effects with health responsibility, promoting individual proactive health. The interpersonal layer lacks interaction with individuals, and the organizational and community layers have relatively minor importance. Proactive health can be promoted through measures such as creating a positive ecological environment, forming diversified health promotion relationships, establishing an educational model integrating classroom, extracurricular, and self-practice activities, and improving the collaborative pathway of health policies.

Full Text

Importance Measurement and Moderating Effect of Influencing Factors for Proactive Health in Undergraduates

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Abstract

Background: The goal of the Healthy China strategy is health for all. Undergraduates, as the backbone of the youth population and highly educated members of families and society, exert a strong radiating influence on population-wide health. While undergraduates generally possess good health awareness, their health behaviors are suboptimal. Realizing proactive health among undergraduates faces a series of challenges that require both conceptual transformation and action support. **Objective:** To explore the influencing factors of proactive health and provide reference recommendations for health education in universities. **Methods:** A total of 4,036 undergraduates from 6 universities in Shandong Province were selected through stratified cluster sampling for a questionnaire survey using self-designed instruments (including a general information questionnaire and a proactive health scale). Inter-group comparisons were performed using t-tests, while Pearson correlation analysis and multiple linear regression analysis were used to explore influencing factors of proactive health. Random forest metric analysis was employed to evaluate the importance of influencing factors. **Results:** The proactive health score was $(24.61\$\pm4.65).Femalestudentsscoredhigherthanmalestudents, andlower-gradeundergraduatesscoredhigherthanhigher-gradestudents.Theimportancescoresforhealthresponsibility, childrelationship, andhealthinvestmentwere32, 491.77, 13, 331, 10, 051.22, and9, 902.84, respectively.Healthkn$ $0.024, P < 0.001, 95 = 0.026, P < 0.001, 95 = 0.033, P < 0.001, 95 = 0.033, P < 0.001, 95\ \$=0.019$, P<0.001, 95%CI: 0.027, 0.161) positively moderated the relationship between health responsibility and proactive health. **Conclusion:** Health responsibility is the key factor affecting proactive health. Health knowledge publicity, health needs communication, curriculum practice ac-

tivities, hope state, and dietary situation have positive interactive effects with health responsibility, thereby promoting individual proactive health. The interpersonal layer lacks interaction with the individual layer, while the organizational and community layers show smaller importance. Proactive health can be promoted by creating a positive ecological environment, forming diversified health promotion relationships, building an education model integrating classroom, extracurricular, and self-practice activities, and improving collaborative pathways for health policies.

Keywords: proactive health; influencing factors; importance measurement; moderating effect; undergraduate

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1. Methods

1.1 Survey Subjects

From May to June 2022, stratified cluster sampling was employed. First, universities in Shandong Province were stratified into three layers based on discipline characteristics, with two universities randomly selected from each layer (totaling 6 universities). Then, stratification by grade was conducted, with 4-5 classes randomly selected from each grade. All students in the selected classes were surveyed electronically (the 6 universities had a total enrollment of 127,985 students, sampled at a 3% proportion). A total of 4,320 questionnaires were distributed, 4,090 were returned, and 4,036 valid questionnaires were obtained, yielding a valid response rate of 93.4%.

1.2 Survey Instruments

1.2.1 Questionnaire Design Based on the social-ecological model, a general information questionnaire was used to collect demographic data including gender, grade, and major, as well as evaluations of the social ecology across individual level (health responsibility, health investment, hope state), interpersonal level (parent-child relationship, teacher-student relationship, peer relationship), organizational level (health education content, teaching methods, curriculum practice activities), community level (school fitness facilities, dietary situation, accommodation environment), and policy level (health knowledge publicity, health information platform services, health needs communication).

A self-designed questionnaire was used to evaluate proactive health status, consisting of three parts: the first part assessed health habits through three dimensions (physical exercise, regular lifestyle, dietary nutrition); the second part assessed mental health through two dimensions (stress management, life appreciation); and the third part assessed social health through interpersonal relationships. The scale used a 5-point Likert scoring system ("never, occasionally, about half the time, often, always" corresponding to values of 1-5), with higher scores indicating better proactive health.

1.2.2 Reliability and Validity Testing Based on analysis and interpretation of proactive health connotations and reference to scales on healthy lifestyle, health behavior, and health beliefs, the researchers initially developed a conceptual framework for undergraduate proactive health through focus group discussions, comprising three dimensions: health habits, mental health, and social health. According to this dimensional structure, extensive literature review was conducted based on the "Healthy China 2030" Planning Outline, health promotion policy system construction documents, and the 4PCS theoretical model of proactive health, yielding 50 measurement items. Two clinical medicine professors and two health management professors were invited to modify, merge, and delete items in group discussions regarding appropriateness and representativeness, resulting in 38 assessment items.

Two surveys were conducted using stratified random sampling. The first survey collected 105 valid samples for pilot testing. Item analysis using dispersion degree method, discriminant analysis, and correlation coefficient analysis formed a 3-dimension, 29-item assessment tool. The second survey collected 366 valid samples; 129 were randomly selected for exploratory factor analysis, deleting items with factor loadings <0.5, ultimately determining 26 items with a cumulative variance contribution rate of 62.593% (10 items on health habits including exercise, regular life, and nutrition; 10 items on mental health including stress management and life appreciation; and 6 items on social health measured through interpersonal relationships). The remaining 237 samples were used for confirmatory factor analysis. The internal consistency coefficient for the overall proactive health scale was 0.881, with subscale coefficients ranging from 0.762 to 0.839. Structural validity indices (CFI=0.913, TLI=0.904, ^{2}/df=3.212, RMSEA=0.054, SRMR=0.052) met statistical standards.

1.2.3 Survey Methods and Quality Control After coordinating with relevant university departments and schools, teachers or counselors were recruited as survey administrators. They explained the survey purpose and content to students, obtained informed consent, and conducted anonymous surveys through the Wenjuanxing platform. The same IP address could only respond once. Three quality control personnel checked questionnaires for missing items and response quality, excluding those with missing basic information, completion rates <95%, response times <120 seconds, or obvious errors.

1.3 Statistical Analysis

Questionnaires were uniformly coded, and data were organized and analyzed using SPSS 23.0. Normally distributed continuous variables were expressed as ($\bar{x}\pm s$). Inter-group comparisons used t-tests. Pearson correlation analysis and multiple linear regression analysis were used to explore influencing factors of proactive health. Random forest metric analysis was employed to evaluate factor importance.

2. Results

2.1 Basic Characteristics of Survey Subjects

Among the 4,036 respondents, 1,811 were male (44.9%) and 2,225 were female (55.1%). Lower-grade students (freshmen and sophomores) numbered 2,216 (54.9%), while higher-grade students (juniors and seniors) numbered 1,820 (45.1%). Non-medical majors accounted for 3,045 (75.4%), and medical majors for 991 (24.6%).

2.2 Comparison of Proactive Health Scores Across Different Characteristics

The overall proactive health score was (24.61$\pm$4.65). Inter-group comparisons showed no statistically significant differences in proactive health scores across different majors (P>0.05). Female students scored significantly higher than male students, and lower-grade undergraduates scored significantly higher than higher-grade students (P<0.05).

Scores for each dimension were: health responsibility (4.26$\pm$0.79), $healthinvestment(3.86\pm1.00)$, $hopestate(38.$ $childrelationship(4.21\pm0.98)$, $teacher-studentrelationship(4.11\pm0.91)$, $peerrelationship(4.17\pm0.88)$, $healthe$

2.3 Single-Factor Analysis of Influences on Undergraduate Proactive Health

Pearson correlation analysis revealed that health responsibility (r=0.865), health investment (r=0.632), hope state (r=0.412), parent-child relationship (r=0.652), teacher-student relationship (r=0.478), peer relationship (r=0.495), health education content (r=0.492), teaching methods (r=0.493), curriculum practice activities (r=0.524), school fitness facilities (r=0.451), dietary situation (r=0.467), accommodation environment (r=0.438), health knowledge publicity (r=0.721), health information platform services (r=0.567), and health needs communication (r=0.584) were all positively correlated with proactive health (all P<0.01).

2.4 Importance Measurement Analysis of Influencing Factors

Random forest can display the effect of each independent variable on the dependent variable. Compared with traditional single-classification algorithms, random forest offers high accuracy, fast training speed, overfitting prevention, and good tolerance for outliers and noise. Random forest is an ensemble classifier model integrating multiple decision trees for classification and regression problems, using Bagging algorithms and majority voting for final classification.

This study established a random forest model with proactive health as the dependent variable and factors from individual, interpersonal, organizational, community, and policy levels as independent variables. Two key parameters were tuned: mtry (number of variables randomly sampled at each split) and ntree

(number of regression trees). The mtry default was set to one-third of the number of explanatory variables. When ntree=500, out-of-bag (OOB) error stabilized, making 500 the optimal ntree value. Testing different mtry values showed that when mtry=6, model error reached a basically stable minimum. Variable importance was scored using IncNodePurity, which measures the impact of each variable on observation heterogeneity at each node of classification trees through residual sum of squares, with higher values indicating greater importance.

The importance ranking of proactive health influencing factors showed that health responsibility, health knowledge publicity, parent-child relationship, and health investment had large importance values (mean=4,706.08), with two factors from the individual level, one from the interpersonal level, and one from the policy level. The importance of health information platform services, health needs communication, curriculum practice activities, hope state, peer relationship, teaching methods, accommodation environment, teacher-student relationship, school fitness facilities, health education content, dietary situation, grade, gender, and major gradually decreased. Health responsibility (with a score far exceeding other items) was the key factor affecting proactive health, while health knowledge publicity, parent-child relationship, and health investment were important factors. Total variance explained R^2=0.852, as shown in Figure 1 [Figure 1: see original paper].

2.5 Moderating Effect Analysis

Before multiple linear regression, multicollinearity among independent variables was tested. The maximum variance inflation factor (VIF) was 7.555 (<10), indicating no serious multicollinearity. The model log-likelihood ratio test P-value was <0.05, confirming model validity. Health knowledge publicity (β=0.134, P<0.01), parent-child relationship (β=0.085, P<0.01), health investment (β=0.138, P<0.01), health needs communication (β=0.041, P<0.01), curriculum practice activities (β=0.076, P<0.01), hope state (β=0.052, P<0.01), dietary situation (β=0.030, P<0.01), and health responsibility (β=0.562, P<0.01) significantly influenced proactive health (VIF values for these eight variables ranged from 1.317 to 3.891), and were included in the final regression model.

Based on social-ecological theory stating that "different systems have hierarchical differences, and influencing factors at different levels interact" [20], we tested the moderating effects of health knowledge publicity, parent-child relationship, health investment, health needs communication, curriculum practice activities, hope state, and dietary situation on the relationship between health responsibility (individual level, key factor) and proactive health. First, these variables were centered to reduce multicollinearity between variables and their product terms and improve result interpretability [21]. The product terms of health responsibility with each variable were then generated.

When the product terms of health responsibility with health knowledge publicity (Model 1-1), health needs communication (Model 1-2), curriculum practice

activities (Model 1-3), hope state (Model 1-4), and dietary situation (Model 1-5) were entered into regression equations sequentially, goodness-of-fit increased ($P<0.05$). Regression results in Table 1 show that the product terms of health responsibility with health knowledge publicity, health needs communication, curriculum practice activities, hope state, and dietary situation were influencing factors of proactive health scores. These variables demonstrated positive moderating effects: higher scores strengthened the effect of health responsibility on proactive health. The moderating effect path is shown in Figure 2 [Figure 2: see original paper].

3. Discussion

Health for all is the responsibility of the state, society, and healthcare industry, but even more so of every family and individual [22]. Our findings show that health responsibility is the key factor affecting proactive health, demonstrating the scientific validity of the concept that "citizens are the first person responsible for their own health" and highlighting the importance of cultivating health responsibility among undergraduates. Health investment includes diet, healthcare, exercise, and living environment [23] and is an important factor affecting proactive health. Influenced by gender, grade, major, and family economic status [24], undergraduates' health investment shows significant differences, and reducing these disparities can promote overall proactive health. Hope state positively motivates proactive health and effectively strengthens the positive association between health responsibility and proactive health. Understanding concerns of different grade levels and conducting positive psychological education on academic, career, and life hope can promote proactive health.

The social-ecological model suggests that among proximal systems, the most important influencing factor is the interpersonal level, followed by individual and organizational levels [25]. This study found that parent-child relationship is an important factor affecting proactive health with a positive linear relationship, and that family education has lasting effects. Disharmonious family environments and lack of family education are detrimental to undergraduate proactive health. Since undergraduates spend most of their time at school, peer and teacher-student relationships occupy important positions in their lives, yet these showed small importance for proactive health, differing from studies by Daxia Jinliang [26] and Qu Luping [27]. Our results indicate that the interpersonal layer did not interact with health responsibility, suggesting that psychological and emotional support obtained through personal social relationships needs strengthening.

Although the social-ecological model can partially reveal relationships between various levels and health promotion, how intervention strategies at individual, organizational, community, and policy levels interact and reflect on individual health behaviors remains to be explored [28]. Our results show interactions between individual-level and organizational-, community-, and policy-level intervention strategies, consistent with studies by Yuan Guangfeng [29] and others.

Health knowledge publicity, health needs communication, curriculum practice activities, and dietary situation all positively moderated the relationship between health responsibility and proactive health. Although the policy level is a distal factor, its impact on adolescent health behaviors can sometimes exceed that of proximal factors. In this study, the policy level showed greater importance for proactive health than organizational and community levels, aligning with views of Du Jianjun [30] and others. Undergraduates serve as important alternative health information seekers for their parents, exhibiting behaviors of using the internet to search for health information on behalf of older generations [31]. Enhancing policy effectiveness in health knowledge publicity and health needs communication positively impacts health management for both undergraduates and their family members.

Curriculum practice activities showed a positive linear relationship with proactive health, consistent with studies by Ren Weicun [32] and others. Health education is the primary means of health management intervention, involving a series of practical techniques and methods with strong operability. Practice activities based on personal and family health needs can stimulate proactive health. School dietary and service environments also showed positive linear relationships with proactive health, consistent with studies by Feng Chen [33] and others. Community-based interventions combining environmental and policy, educational, and behavioral change strategies can promote student health behaviors [34]. Our results show small importance of organizational and community levels, suggesting that synergistic intervention strategies in curriculum education and campus services should be strengthened.

This study found that curriculum practice activities (organizational level), dietary situation (community level), and health knowledge publicity and health needs communication (policy level) positively interact with health responsibility to enhance individual proactive health. The proximal interpersonal level of the social-ecological model did not interact with the individual level, while the organizational and community levels showed small promoting effects. Multi-agent participation and multi-level interventions should become priorities in health education. Based on these findings, we propose the following recommendations: (1) Create a positive ecological environment for proactive health by integrating the concept of "being the first person responsible for one's own health" into university management, family communication, and self-education, providing high-quality campus services to promote health investment, and applying positive psychology to professional training programs. (2) Form diversified health promotion relationships. Recognizing that parents, teachers, and peers have dual identities as both "educators" and "learners" in health education [35], build interactive communication platforms to enhance mutual understanding and joint improvement. (3) Develop an education model integrating classroom, extracurricular, and self-practice activities. Innovate experiential teaching methods, strengthen practice teaching base construction, and conduct health knowledge and skills competitions to promote active learning. (4) Improve collaborative pathways for health policies. Add proactive health elements to public and profes-

sional courses, and develop health publicity task lists for administrative management and campus services through extensive cooperation, needs-based training, and precise services to enhance health information resource utility.

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Author Contributions: ZHAO Meng was responsible for conceptualization, design, and manuscript writing; XU Mengyuan collected and organized research materials; ZHAO Zhongtao performed data analysis and table editing; LOU Pengyu was responsible for manuscript revision, quality control, and final approval, and takes overall responsibility for the paper.

Conflict of Interest: The authors declare no conflict of interest.

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Note: Figure translations are in progress. See original paper for figures.