Association Analysis between Health-Promoting Behaviors and Chronic Disease Comorbidity among Older Adults in Ningxia: Postprint

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Abstract

Background With the intensification of population aging, the health of older adults has become key to successful aging. Multimorbidity of chronic diseases is an important factor threatening the health of older adults, and the relationship between health-promoting behaviors and chronic disease multimorbidity in this population has been rarely explored.

Objective To understand the multimorbidity patterns of chronic diseases and the distribution of health-promoting behaviors among older adults in Ningxia, analyze the association between health-promoting behaviors and chronic disease multimorbidity, and provide references for health management and intervention strategies for older adults.

Methods From January to July 2021, a random cluster sampling method was used to select individuals aged 65 years and above in Ningxia Hui Autonomous Region for survey. The Apriori algorithm was applied to analyze multimorbidity patterns among older adults in Ningxia, and a multivariate Logistic regression model was used to analyze the association between multimorbidity and health-promoting behaviors.

Results A total of 2,010 older adults aged 65 years and above were included, with a multimorbidity rate of 31.00%. The most common dyadic multimorbidity pattern was coronary heart disease and hypertension (25.36%), and the most common triadic multimorbidity pattern was hypertension, coronary heart disease, and stroke (4.49%). Association rules revealed 16 multimorbidity patterns, 15 of which were related to hypertension, 10 to coronary heart disease, and 7 to asthma. The multivariate Logistic regression model showed that, compared with poor health-promoting behaviors, older adults with fair (OR=0.364, 95%CI: 0.185–0.714), good (OR=0.488, 95%CI: 0.251–0.948), and excellent (OR=0.426,

95%CI: 0.213–0.853) health-promoting behaviors had reduced risk of chronic disease multimorbidity. Among them, dimension scores of physical activity (OR=0.960, 95%CI: 0.925–0.997) and stress management (OR=0.963, 95%CI: 0.938–0.989) were negatively associated with chronic disease multimorbidity, while the dimension score of health responsibility (OR=1.038, 95%CI: 1.013–1.063) was positively associated with chronic disease multimorbidity.

Conclusion The multimorbidity patterns among older adults in Ningxia are complex and associated with health-promoting behaviors. Interventions that promote health behaviors and improve healthy lifestyles can reduce multimorbidity risk in this population.

Full Text

Association Analysis of Health Promotion Behaviors and Comorbid Chronic Diseases in the Elderly in Ningxia

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Abstract

Background: As population aging intensifies, elderly health has become critical to successful aging. Chronic disease comorbidity represents a major threat to elderly health, yet its relationship with health promotion behaviors remains underexplored. **Objective:** To examine chronic disease comorbidity patterns and the distribution of health promotion behaviors among elderly residents in Ningxia, and to analyze the association between health promotion behaviors and chronic disease comorbidity, providing evidence for health management and intervention strategies. **Methods:** From January to July 2021, a random cluster sampling method was used to survey individuals aged 65 and above in Ningxia Hui Autonomous Region. Apriori algorithm was applied to analyze comorbidity patterns, and multivariate logistic regression models were used to examine associations between comorbidity and health promotion behaviors. **Results:** A total of 2,010 elderly individuals aged 65+ were included, with a comorbidity prevalence of 31.00%. The most common binary comorbidity pattern

was coronary heart disease and hypertension (25.36%), while the most common ternary pattern was hypertension, coronary heart disease, and stroke (4.49%). Association rules identified 16 comorbidity patterns, 15 of which involved hypertension, 10 involved coronary heart disease, and 7 involved asthma. Multivariate logistic regression showed that compared with poor health promotion behaviors, elderly with fair (OR=0.364, 95%CI: 0.185-0.714), good (OR=0.488, 95%CI: 0.251-0.948), and excellent (OR=0.426, 95%CI: 0.213-0.853) behaviors had reduced chronic disease comorbidity risk. Specifically, physical activity (OR=0.960, 95%CI: 0.925-0.997) and stress management (OR=0.963, 95%CI: 0.938-0.989) scores were negatively associated with comorbidity, while health responsibility (OR=1.038, 95%CI: 1.013-1.063) scores showed a positive association. **Conclusion:** Comorbidity patterns among Ningxia' s elderly population are complex and associated with health promotion behaviors. Interventions promoting healthy behaviors and lifestyles may reduce comorbidity risk.

Keywords: Elderly; Comorbidity pattern; Health promotion behavior

Introduction

With the growing elderly population and increasing burden of elderly care, achieving healthy aging has become a crucial task in the national strategy for actively responding to population aging. Chronic disease comorbidity refers to an individual simultaneously having two or more chronic diseases [1]. The prevalence of chronic disease comorbidity is high among Chinese elderly [2], seriously affecting their health status, increasing risks of rehospitalization and mortality, and exacerbating psychological, economic, and global disease burdens [3]-[4]. Health promotion behavior represents an individual' s active adoption of health responsibilities and positive behavioral patterns to achieve and maintain optimal health status [5]. Implementing health-promoting behaviors helps prevent disease onset or delay disease progression, reduces mortality, and enhances well-being, self-actualization, and personal fulfillment [7]-[9], thereby facilitating successful aging. Based on this foundation, this study analyzes chronic disease comorbidity patterns and their association with health promotion behaviors among elderly individuals, aiming to promote population-wide healthy lifestyles, reduce risk factors for comorbidity, prevent comorbidity occurrence, and provide references for elderly health management and intervention strategies.

Methods

Study Design and Participants

From January to July 2021, we conducted a survey using random cluster sampling, selecting four urban communities and four villages from all communities

and administrative villages in Ningxia Hui Autonomous Region. Elderly individuals meeting inclusion criteria and providing informed consent were surveyed. **Inclusion criteria:** age $ $65 years, local residence $ $1 year, receiving routine elderly health management, no severe cognitive impairment, no communication barriers, capable of completing questionnaires, and voluntary participation. **Exclusion criteria:** severe physical disability; hearing, vision, or language impairments; inability to cooperate with the survey. Based on study objectives, we excluded invalid data with missing key variables (chronic disease status, health promotion behaviors), resulting in a final analytical sample of 2,010 individuals. This study was approved by the Ethics Committee of Shizuishan Municipal Center for Disease Control and Prevention (Approval No. 2020-01).

Measurements

1) General Information Questionnaire: Included age, gender, household registration, education level, marital status, and economic status.

2) Patient Health Questionnaire-9 (PHQ-9): Widely used for depression screening, this 9-item scale scores from 0–27 points: 0–4 indicates no depression, 5–9 mild, 10–14 moderate, 15–19 moderately severe, and 20–27 severe depression [10]. In this population, the Cronbach' s α reliability coefficient was 0.891.

3) Mini-Mental State Examination (MMSE): Demonstrating good reliability and validity for assessing cognitive function in elderly, with total scores of 30 points. Cognitive impairment was defined as $ $17 points for illiterate, $ $20 for primary school education, and $ $24 for junior high school or above [11]. The Cronbach' s α reliability coefficient was 0.877 in this population.

4) Chronic Disease Status: Based on previous research [11]-[12], we selected common chronic diseases in elderly that are physician-diagnosed and less prone to information bias. During the survey, we found most elderly had not received formal psychological diagnosis, tended to consider all joint pain as arthritis, and had lipid test results affected by multiple factors preventing clear diagnosis. To avoid compromising data validity, we excluded psychological diseases, arthritis, and dyslipidemia. The final chronic diseases included in this study were hypertension, diabetes, coronary heart disease, stroke, asthma, chronic lung disease, chronic kidney disease, and Parkinson' s disease.

5) Health Promotion Lifestyle Profile-C (HPLP-C): This scale demonstrates good reliability and validity for assessing health promotion behaviors in Chinese elderly populations [14]. It comprises six dimensions: nutrition, health responsibility, self-actualization, interpersonal relationships, physical activity, and stress management, with 40 total items. Each item uses a 4-point Likert scale (1=never, 2=sometimes, 3=often, 4=routinely), with total scores ranging from 40–160 points, classified into four levels (40–69, 70–99, 100–129, and 130–160, representing poor, fair, good, and excellent health promotion behaviors). Based on total scores, behaviors can also be dichotomized as healthy (100–160

points) and unhealthy (40–99 points) [15]. The Cronbach' s α reliability coefficient was 0.946 in this population.

Statistical Analysis

Questionnaire data were double-entered using EpiData 3.1 to establish the database. SPSS 26.0 was used for data analysis. Measurement data were expressed as $\bar{x} \pm s$, and count data as frequency and percentage (%). Chi-square tests were used to analyze comorbidity rates and health promotion behaviors across different characteristics, with linear trend tests for ordinal variables. SPSS Modeler 18.0 was used with the Apriori algorithm to analyze chronic disease comorbidity patterns through association rules. Unconditional logistic stepwise regression models ($\alpha_{entry} = 0.05$, $\alpha_{exit} = 0.10$) were used to analyze associations between health promotion behaviors and comorbidity, with test level $\alpha = 0.05$ (two-tailed).

Results

Distribution of Health Promotion Behaviors Among Elderly with Different Characteristics in Ningxia

The study included 2,010 participants: 963 males (47.9%) and 1,047 females (52.1%), with mean age (72.3 ± 6.5) years. Urban residents accounted for 873 (43.4%) and rural residents 1,137 (56.6%); 1,525 (75.9%) were married and 485 (24.1%) unmarried. The average health promotion behavior score was (108.8 ± 21.7) points, ranging from 46–160 points. Comparisons across different characteristics revealed statistically significant differences in health promotion behavior distribution by household registration, marital status, economic status, cognitive status, and comorbidity status (P<0.05). Trend tests showed no statistically significant trend in health promotion behaviors with age (P>0.05), but behaviors improved with higher education levels (P<0.05). Results are shown in Table 1 .

Prevalence and Comorbidity Distribution of Chronic Diseases Among Elderly with Different Characteristics in Ningxia

Among the 2,010 elderly participants, 1,386 (68.96%) had chronic diseases. The distribution by number of chronic diseases was: 0 diseases (624 cases, 31.04%), 1 disease (763 cases, 37.96%), 2 diseases (431 cases, 21.44%), and $ $3diseases(192cases, 9.55$ $2 diseases) was present in 623 individuals (31.00%). Statistically significant differences in comorbidity rates were found by gender, household registration, marital status, economic status, and depressive symptoms (P<0.05). Trend tests revealed that comorbidity rates decreased with increasing health promotion behavior levels (P<0.05), but showed no significant trends with age or education level (P>0.05). Results are shown in Table 2

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Common Comorbidity Patterns of Chronic Diseases Among Ningxia Elderly

Binary and Ternary Comorbidity Patterns Among 623 elderly with chronic disease comorbidity, the most common binary pattern was coronary heart disease and hypertension (25.36%), followed by hypertension and diabetes (22.15%), and stroke and hypertension (9.15%). The most common ternary pattern was hypertension, coronary heart disease, and stroke (4.49%).

Association Rule Analysis of Comorbidity Patterns Based on empirical threshold values to obtain an appropriate number of association rules [18], we set minimum support at 1.0%, minimum confidence at 50%, and lift at 1. A total of 16 association rules were identified: 4 binary patterns, 9 ternary patterns, and 3 quaternary patterns. Among these, 15 rules involved hypertension, 10 involved coronary heart disease, and 7 involved asthma (Table 3). The top 3 rules by support were: (1) coronary heart disease and hypertension; (2) diabetes and hypertension; (3) stroke and hypertension. The top 3 by confidence were: (1) asthma, coronary heart disease, and hypertension; (2) diabetes, coronary heart disease, and hypertension; (3) stroke, coronary heart disease, and hypertension. The top 3 by lift were: (1) asthma, coronary heart disease, hypertension, and chronic lung disease; (2) asthma, coronary heart disease, and chronic lung disease; (3) hypertension, asthma, and chronic lung disease. The differing patterns identified by support, confidence, and lift indicate complex chronic disease comorbidity combinations among Ningxia' s elderly.

Association Analysis Between Health Promotion Behaviors and Chronic Disease Comorbidity in Ningxia Elderly

Using comorbidity status (non-comorbidity=0, comorbidity=1) as the dependent variable, we constructed four models. Model 1 included health promotion behaviors and their six dimension scores (nutrition, health responsibility, self-actualization, interpersonal relationships, physical activity, stress management) as independent variables. Model 2 adjusted for age and gender based on Model 1. Model 3 additionally adjusted for household registration, education level, marital status, and economic status. Model 4 further adjusted for depressive symptoms and cognitive impairment. Variable assignments are shown in Table 4 .

All four models showed that elderly with fair, good, and excellent health promotion behaviors had reduced comorbidity risk compared to those with poor behaviors ($P<0.05$). Among the six dimensions, health responsibility, physical activity, and stress management scores showed statistically significant associations with chronic disease comorbidity ($P<0.05$). Model 4 results indicated that compared with poor health promotion behaviors, elderly with fair (OR=0.364, 95%CI: 0.185-0.714), good (OR=0.488, 95%CI: 0.251-0.948), and excellent

(OR=0.426, 95%CI: 0.213-0.853) behaviors had reduced chronic disease comorbidity risk. Physical activity (OR=0.960, 95%CI: 0.925-0.997) and stress management (OR=0.963, 95%CI: 0.938-0.989) scores were negatively associated with comorbidity, while health responsibility (OR=1.038, 95%CI: 1.013-1.063) scores showed a positive association. Additionally, females (OR=1.447, 95%CI: 1.163-1.800) and elderly with depressive symptoms (OR=1.295, 95%CI: 1.050-1.596) had higher comorbidity risk. Rural elderly (OR=0.643, 95%CI: 0.495-0.835) and those with primary school education (OR=0.543, 95%CI: 0.395-0.748) had lower comorbidity risk compared to urban elderly and those with less than primary school education, respectively. Results are shown in Table 5 .

Discussion

Chronic disease comorbidity has become a major public health issue affecting elderly health in China, making comorbidity prevention and health promotion critically important. This study analyzed associations between health promotion behaviors and chronic disease comorbidity patterns among Ningxia's elderly to inform comorbidity prevention and health management. Results showed that Ningxia' s elderly demonstrated good health promotion behaviors overall, with a chronic disease comorbidity rate of 31.00%. This rate is lower than the 45.92% reported by Xu et al. [19] in their analysis of Chinese elderly aged 60+, but higher than the 21.72% reported by Fan et al. [20] in Henan Province. These discrepancies may relate to differences in participant age, geographic region, sample size, and chronic disease types and quantities [21]. Additionally, females showed higher comorbidity rates than males, and urban elderly had higher rates than rural elderly, consistent with Li' s findings [13]. Furthermore, health promotion behaviors differed across various demographic characteristics, indicating that chronic disease prevention requires tailored health management measures and targeted health promotion interventions based on elderly individuals' specific circumstances.

Association rule analysis revealed complex chronic disease interrelationships, with most comorbidity patterns involving hypertension, coronary heart disease, and asthma, aligning with previous research [22]. Hypertension was the most common component, followed by coronary heart disease and asthma. Therefore, chronic disease prevention should simultaneously monitor blood pressure, cardiac symptoms, and respiratory symptoms to reduce risk factors for these conditions. Health management for elderly should focus on patients with hypertension, coronary heart disease, and asthma, implementing early chronic disease management and interventions to prevent comorbidity development. Standardized management protocols should be developed for single chronic diseases and different comorbidity patterns to meet patients' health management needs, enabling early detection, diagnosis, and treatment to prevent adverse outcomes from comorbidity.

Our findings also revealed a positive association between health responsibility and chronic disease comorbidity. This may occur because improved living standards and disease experience enhance elderly individuals'self-care awareness [23], leading them to consciously assume health responsibility and focus on nutritional supplementation. However, lacking scientific guidance may compromise the correctness, scientific validity, and effectiveness of self-care behaviors. Therefore, maintaining elderly individuals' subjective motivation for self-care must be complemented by comprehensive efforts to strengthen health education, promoting scientifically sound and effective healthy lifestyles, reasonable dietary practices based on individual conditions, and reduction of disease risk factors. Physical activity showed a negative association with comorbidity, consistent with previous research demonstrating that appropriate exercise not only prevents chronic disease onset but also slows disease progression, reduces treatment burden, and decreases mortality risk [25]-[26]. As national fitness initiatives deepen and elderly fitness awareness increases, we should further promote integration of universal fitness and healthy aging, improve exercise environments, create favorable physical activity atmospheres, and provide professional exercise guidance tailored to elderly individuals' health status. Effective stress management also showed a negative association with comorbidity, consistent with prior findings that positive stress management facilitates positive emotions and reduces health hazards from stress [27]. Under dual pressures from disease and aging, elderly individuals are prone to anxiety, depression, and other negative emotions [28], which hinder treatment and recovery. Therefore, adequate family and social support should be provided to enhance stress management capabilities and mitigate physical and psychological stress damage, while also addressing stress origins to reduce its generation.

Additionally, rural elderly and those with primary school education showed lower comorbidity risk, possibly because rural and less-educated elderly individuals lack health management awareness and cannot promptly identify health problems [29]. The study also identified female gender and depressive symptoms as risk factors for chronic disease comorbidity. Therefore, attention must be paid to rural elderly populations' physical and psychological health, encouraging participation in regular health examinations and chronic disease screening, while providing targeted health consultations for different genders and education levels to enhance awareness of early disease prevention and treatment.

Elderly health status significantly impacts socioeconomic development, making healthy aging and slowed health decline urgent priorities. We should actively respond to the Healthy China Strategy, promote healthy lifestyles, clarify comorbidity patterns, implement comprehensive chronic disease prevention and control, reduce comorbidity risk, provide scientific nutritional guidance based on disease conditions, encourage effective health responsibility assumption, advocate appropriate exercise, and maintain elderly physical and mental health and quality of life.

Study Limitations: This cross-sectional study provides insufficient evidence

for causal relationships between health promotion behaviors and chronic disease comorbidity, warranting prospective studies. Additionally, participants were limited to Ningxia' s elderly population, requiring cautious generalization of findings.

Author Contributions: HE Yuzheng contributed to study conception and design, data verification, statistical analysis, and initial manuscript drafting. YU Jiqing participated in data organization. ZHENG Jianzhong and TONG Yan were responsible for quality control and overall article supervision.

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

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