

## Postprint: Impact of Chronic Disease Multimorbidity on Activities of Daily Living Among Rural Elderly in the Southern Mountainous Region of Ningxia Hui Autonomous Region: A Latent Class Analysis

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### Abstract

**Background** With the acceleration of population aging, multimorbidity has become a major public health problem threatening the health of older adults. There is a close association between multimorbidity and activities of daily living (ADL), but research on the impact of multimorbidity and multimorbidity patterns on ADL is relatively scarce. **Objective** To understand the impact of multimorbidity on ADL among rural older adults in the mountainous areas of southern Ningxia Hui Autonomous Region, and to provide a reference basis for improving the quality of life of older adults. **Methods** From June to July 2022, a face-to-face household survey was conducted among 20,821 residents in 4 counties of Ningxia Hui Autonomous Region using a multi-stage stratified random cluster sampling method. The survey content included demographic characteristics, chronic disease prevalence, and ADL impairment status. This study focused on 4,362 older adults aged  $\geq 60$  years, using latent class analysis to identify multimorbidity patterns among older adults, and logistic regression analysis to explore the impact of multimorbidity and different multimorbidity patterns on ADL. **Results** The prevalence of chronic diseases among the 4,362 older adults was 62.52% (2,727/4,362), the incidence of multimorbidity was 23.75% (1,036/4,362), and the incidence of ADL impairment was 18.36% (801/4,362). Five multimorbidity patterns were identified based on latent class analysis: coronary heart disease multimorbidity group, rheumatoid arthritis multimorbidity group, diabetes multimorbidity group, hypertension multimorbidity group, and multi-system disease multimorbidity group. Multivariate logistic regression analysis results showed that after adjusting for gender, age, education level, marital status, occupation type, annual per capita household income, smoking status, alcohol consumption, exercise status, and self-rated health status, the risk of

ADL impairment among older adults with multimorbidity was 1.909 times that of older adults without multimorbidity (95%CI=1.581~2.305,  $P<0.05$ ), and the risk of ADL impairment among older adults in the rheumatoid arthritis multimorbidity group was 1.834 times that of older adults in the hypertension multimorbidity group (95%CI=1.245~2.701,  $P<0.05$ ). Conclusion Older adults with multimorbidity have a higher risk of ADL impairment than those without multimorbidity, and differences exist in the risk of ADL impairment among older adults with different multimorbidity patterns, with the risk of ADL impairment being higher in the rheumatoid arthritis multimorbidity group than in the coronary heart disease multimorbidity group. Greater attention should be paid to older adults with chronic multimorbidity, and appropriate measures should be taken to improve their health status and enhance their quality of life.

## Full Text

### The Influence of Chronic Disease Comorbidity on Activities of Daily Living in Rural Elderly in Mountainous Areas of Southern Ningxia Based on Latent Class Analysis

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## Abstract

### Background

With the acceleration of population aging, chronic disease comorbidities have become a major public health problem threatening the health of the elderly. There is a close correlation between chronic disease comorbidity and activities of daily living (ADL), yet research on the impact of chronic disease comorbidity and comorbidity patterns on ADL remains relatively scarce.

### Objective

To understand the impact of chronic disease comorbidity on ADL among rural elderly in the mountainous areas of southern Ningxia Hui Autonomous Region, and to provide a reference for improving the quality of life of the elderly.

### Methods

From June to July 2022, a multi-stage stratified random cluster sampling method was used to conduct a face-to-face household survey among 20,821

residents in four counties of Ningxia Hui Autonomous Region. The survey content included demographic characteristics, chronic disease prevalence, and ADL impairment. This study included 4,362 elderly individuals aged  $\geq 60$  years as subjects. Latent class analysis was used to identify chronic disease comorbidity patterns, and logistic regression analysis was used to explore the effects of chronic disease comorbidity and different comorbidity patterns on ADL.

### Results

Among the 4,362 elderly participants, the prevalence of chronic diseases was 62.52% (2,727/4,362), the prevalence of chronic disease comorbidity was 23.75% (1,036/4,362), and the rate of ADL impairment was 18.36% (801/4,362). Based on latent class analysis, five comorbidity patterns were identified: coronary heart disease comorbidity group, rheumatoid arthritis comorbidity group, diabetes comorbidity group, hypertension comorbidity group, and multi-system disease comorbidity group. After adjusting for gender, age, education level, marital status, occupation type, annual per capita household income, smoking status, alcohol consumption, exercise status, and self-rated health status, elderly individuals with chronic disease comorbidity had 1.909 times higher risk of ADL impairment than those without comorbidity (95%CI=1.581~2.305,  $P<0.05$ ). The risk of ADL impairment in the rheumatoid arthritis comorbidity group was 1.834 times higher than that in the hypertension comorbidity group (95%CI=1.245~2.701,  $P<0.05$ ).

### Conclusion

Elderly individuals with chronic disease comorbidity have a higher risk of ADL impairment than those without comorbidity, and the risk varies across different chronic disease comorbidity patterns. The risk of ADL impairment in the rheumatoid arthritis comorbidity group is higher than that in the coronary heart disease comorbidity group. Greater attention should be paid to elderly patients with chronic disease comorbidity, and appropriate measures should be taken to improve their health status and quality of life.

### Keywords

Multiple chronic conditions; Activities of daily living; Aged; Rural health; Latent class analysis; Ningxia Hui Autonomous Region

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## Introduction

As population aging intensifies, chronic disease comorbidity has become a severe challenge facing healthcare systems worldwide [1-2]. Chronic disease comorbidity refers to an individual having at least two chronic conditions simultaneously [3]. In China, the prevalence of chronic disease comorbidity among people aged  $\geq 60$  years reached 69.5% in 2015 [4]. Community studies across countries with different income levels, including high-income, low-income, and middle-income nations, have reported adult comorbidity prevalence rates ranging from 15% to

43% [5]. By 2035, the prevalence of chronic disease comorbidity among people aged  $\geq 65$  years in the United Kingdom is projected to increase to 68% [6]. The etiology of chronic disease comorbidity is complex, with multiple behavioral factors and shared risk factors across different diseases contributing to its development [7]. Chronic disease comorbidity significantly impacts the daily living abilities of older adults [8-9]. Activities of daily living (ADL) refer to basic daily movements that individuals perform to maintain independence, such as dressing and bathing [10]. ADL serves as an important indicator for evaluating physical and cognitive function in the elderly and is considered a crucial component of healthy aging and independent living [11]. However, current research on ADL in older adults has primarily focused on patients with single chronic diseases or simply compared those with and without comorbidity, with relatively insufficient investigation into the relationship between specific chronic disease comorbidity patterns and ADL [12-15]. This study aims to examine the impact of chronic disease comorbidity and comorbidity patterns on ADL among rural elderly populations, thereby accumulating evidence to improve quality of life and promote healthy aging.

## Methods

### Study Subjects

From June to July 2022, we conducted a cross-sectional survey using a multi-stage stratified random cluster sampling method in Yanchi County, Haiyuan County, Xiji County, and Pengyang County of Ningxia Hui Autonomous Region. The specific sampling procedure was as follows: based on economic development levels, all administrative villages in each county's townships were stratified into three tiers (good, medium, and poor). Using a random number table, we selected 40% of villages from each tier as sample villages. Within each sample village, we selected 20-33 households using systematic sampling (33 households per village in Yanchi County's 40 villages and Haiyuan County's 76 villages; 20 households per village in Xiji County's 58 villages and Pengyang County's 33 villages). All permanent residents (local residence  $\geq 6$  months) in each selected household were included in the survey. We excluded individuals with severe cognitive impairment, serious mental illness, other underlying conditions affecting survey participation, or those with language/communication difficulties who were unwilling or unable to cooperate. Ultimately, 20,821 rural residents were surveyed. This study focused on elderly individuals aged  $\geq 60$  years, and after excluding samples with missing or unclear key variables, 4,362 rural elderly participants were included in the final analysis.

### Survey Tools

The research team developed the survey questionnaire, which was reviewed by experts before implementation. Relevant content included: (1) demographic characteristics (gender, age, education level, marital status, occupation type, annual per capita household income); (2) lifestyle factors (smoking, alcohol

consumption, exercise status); and (3) health status (self-rated health, chronic disease prevalence, ADL impairment). The chronic disease assessment covered hypertension, diabetes, intervertebral disc disease, cerebrovascular disease, chronic gastritis/enteritis, coronary heart disease, rheumatoid arthritis, chronic obstructive pulmonary disease, and other chronic conditions (bronchial asthma and chronic kidney disease were combined into an “other” category due to low prevalence). Based on the Law of the People’s Republic of China on the Protection of Persons with Disabilities and the Katz Index, we assessed ADL using six items: eating, dressing, getting in/out of bed, toileting, indoor mobility, and bathing. Each item had four response levels: “can do independently,” “has some difficulty,” “needs help,” and “cannot do at all.” Responses of “has some difficulty,” “needs help,” or “cannot do at all” were considered impaired for that item, and impairment in any of the six items was classified as ADL impairment [16-17]. The Cronbach’s  $\alpha$  coefficient for this scale in our study was 0.962.

### Survey and Quality Control

Trained investigators conducted face-to-face household surveys, asking questions and recording responses on-site. Questionnaires were checked and collected immediately after completion. Before the survey, we developed detailed training manuals and provided centralized training for all investigators. During data collection, questionnaires were reviewed at three levels (investigator, team leader, and quality control officer) to ensure completeness and validity. After data collection, we performed double data entry using EpiData 3.1 software.

### Statistical Analysis

We used EpiData 3.1 for data entry, Mplus 8.3 for latent class analysis of chronic disease comorbidity patterns, and SPSS 25.0 for data management and statistical analysis. Categorical data were expressed as frequencies and percentages, while continuous data were expressed as mean  $\pm$  standard deviation ( $\bar{x}\pm s$ ). Chi-square tests were used for comparisons of categorical data between groups. Univariate and multivariate logistic regression analyses were used to identify influencing factors. Statistical significance was set at  $P < 0.05$ .

## Results

### Basic Characteristics of Elderly Participants

A total of 4,362 rural elderly individuals were included in the study. The sample consisted of 2,246 males (51.49%) and 2,116 females (48.51%). Age distribution was: 60-69 years (2,399 participants, 55.00%), 70-79 years (1,513 participants, 34.69%), and  $\geq$  80 years (450 participants, 10.32%). Education levels were: illiterate (2,380 participants, 54.56%), primary school (1,410 participants, 32.32%), junior high school (426 participants, 9.77%), and high school or above (146 participants, 3.35%). Marital status was: married (3,602 participants, 82.58%) and unmarried/widowed/divorced (760 participants, 17.42%).

Occupation types were: farming (2,749 participants, 63.02%) and non-farming (1,613 participants, 36.98%). Annual per capita household income, divided by quartiles, included: low-income group (874 participants, 20.04%), lower-middle income group (873 participants, 20.01%), middle-income group (870 participants, 19.94%), upper-middle income group (876 participants, 20.08%), and high-income group (869 participants, 19.92%).

Lifestyle factors showed that 819 participants (18.78%) smoked, 229 (5.25%) consumed alcohol, and 1,555 (35.65%) exercised regularly. Regarding health status, 146 participants (3.35%) rated their health as very good, 1,129 (25.88%) as good, 1,546 (35.44%) as fair, 1,319 (30.24%) as poor, and 222 (5.09%) as very poor. Chronic disease prevalence was 62.52% (2,727 participants), with the top three conditions being hypertension (1,933 participants, 44.31%), diabetes (385 participants, 8.83%), and cerebrovascular disease (377 participants, 8.64%). Chronic disease comorbidity was present in 1,036 participants (23.75%). ADL impairment was observed in 801 participants (18.36%), while 3,561 participants (81.64%) had normal ADL.

### **Chronic Disease Comorbidity Patterns in the Elderly**

Latent class analysis revealed that as the number of classes increased, the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample-size adjusted BIC (ABIC) gradually decreased. The Lo-Mendell-Rubin Test (LMRT) became non-significant ( $P > 0.05$ ) at the 6-class solution, while the 5-class solution had an entropy value closest to 1. Therefore, we identified and defined five comorbidity patterns, as shown in Table 1. The five patterns were: coronary heart disease comorbidity group (high prevalence of coronary heart disease and hypertension), rheumatoid arthritis comorbidity group (high prevalence of rheumatoid arthritis and hypertension), diabetes comorbidity group (high prevalence of diabetes), hypertension comorbidity group (high prevalence of hypertension), and multi-system disease comorbidity group (high prevalence of intervertebral disc disease, cerebrovascular disease, and chronic gastritis/enteritis). The conditional probability graphs for these five chronic disease comorbidity classifications are presented in Figure 1 [Figure 1: see original paper].

### **Comparison of ADL Impairment Rates Across Characteristics**

ADL impairment rates differed significantly across groups defined by gender, age, education level, marital status, occupation type, annual per capita household income, smoking status, alcohol consumption, exercise status, and self-rated health status (all  $P < 0.05$ ). ADL impairment rates also differed significantly between elderly individuals with and without chronic disease comorbidity ( $P < 0.05$ ). Furthermore, ADL impairment rates varied significantly across the five chronic disease comorbidity patterns ( $P < 0.05$ ), as shown in Table 2.

## Logistic Regression Analysis of Chronic Disease Comorbidity Impact on ADL

**Unadjusted Analysis:** Using ADL impairment as the dependent variable (no=0, yes=1) and chronic disease comorbidity as the independent variable (no=0, yes=1), univariate logistic regression showed that elderly individuals with chronic disease comorbidity had higher ADL impairment risk compared to those without comorbidity [OR(95%CI)=2.607(2.214~3.070),  $P<0.05$ ].

**Adjusted Analysis:** After adjusting for gender, age, education level, marital status, occupation type, annual per capita household income, smoking status, alcohol consumption, exercise status, and self-rated health status, multivariate logistic regression revealed that elderly individuals with chronic disease comorbidity had 1.909 times higher risk of ADL impairment than those without comorbidity (95%CI=1.581~2.305,  $P<0.05$ ), as shown in Table 3 .

## Logistic Regression Analysis of Comorbidity Patterns on ADL

**Unadjusted Analysis:** Using ADL impairment as the dependent variable (no=0, yes=1) and comorbidity patterns as independent variables (with coronary heart disease comorbidity group as reference), univariate logistic regression showed that compared with the coronary heart disease comorbidity group, the rheumatoid arthritis comorbidity group had higher ADL impairment risk [OR(95%CI)=1.435(1.021~2.017),  $P<0.05$ ], while the hypertension comorbidity group had lower risk [OR(95%CI)=0.704(0.537~0.925),  $P<0.05$ ].

**Adjusted Analysis:** After adjusting for gender, age, education level, marital status, occupation type, annual per capita household income, smoking status, alcohol consumption, exercise status, and self-rated health status, multivariate logistic regression showed that the risk of ADL impairment in the rheumatoid arthritis comorbidity group was 1.834 times that of the hypertension comorbidity group (95%CI=1.245~2.701,  $P<0.05$ ), as shown in Table 4 .

## Discussion

The prevalence of chronic diseases among rural elderly in southern Ningxia's mountainous areas was 62.52%, with a chronic disease comorbidity rate of 23.75%. Compared with a national study of elderly populations, both rates in our study were lower [18]. Among the nine chronic diseases included, the top three in prevalence were hypertension (44.31%), diabetes (8.83%), and cerebrovascular disease (8.64%). The ADL impairment rate was 18.36%, which is higher than the 18.9% reported by Xing et al. [19] for national samples aged  $\geq 65$  years, possibly reflecting regional economic disparities. After adjusting for covariates, elderly individuals with chronic disease comorbidity had 1.909 times higher risk of ADL impairment than those without comorbidity (95%CI=1.581~2.305), consistent with previous findings [20-22]. This may be because chronic disease comorbidity involves complex etiologies, long disease

courses, difficult treatment, and tends to result in adverse health outcomes, thereby increasing ADL impairment risk.

The rural elderly in southern Ningxia generally had low education levels, with 63.02% engaged in farming and relatively heavy physical labor. Due to geographical constraints and lagging economic development, medical resources are relatively scarce, preventing residents from receiving timely and effective treatment for health problems. Long-term physical labor and unhealthy lifestyle habits also contribute to higher rates of chronic disease comorbidity and ADL impairment. Therefore, urgent attention is needed to address chronic disease comorbidity among rural elderly in this region through appropriate measures to improve their health and quality of life.

Based on self-reported data on nine chronic diseases, we identified five comorbidity patterns through latent class analysis. Across these patterns, multiple conditions were associated with hypertension, which not only has high prevalence but also increases risk for other chronic diseases [23]. Our five patterns differ from previous studies: one national study of middle-aged and elderly populations identified patterns of mild disease, arthritis, cardiovascular disease, lung/asthma, and multi-system disease [24]; another study based on 14 chronic diseases identified musculoskeletal, hypertension, respiratory, digestive, and cardiovascular systems [25]. These discrepancies may be due to differences in age groups, populations, regions, and research objectives.

Using the coronary heart disease comorbidity group as reference, the hypertension comorbidity group showed lower ADL impairment risk (OR=0.704, 95%CI=0.537~0.925), consistent with previous research [26-28]. Studies have shown that hypertension, heart disease, and diabetes are all associated with ADL impairment in the elderly [26-27], and cardiometabolic comorbidity is linked to disability risk in middle-aged and older adults [28]. The rheumatoid arthritis comorbidity group showed higher ADL impairment risk compared with the coronary heart disease group (OR=1.435, 95%CI=1.021~2.017). After full adjustment, the rheumatoid arthritis comorbidity group had 1.834 times higher risk than the coronary heart disease group (95%CI=1.245~2.701), aligning with previous findings [29-30]. Shi et al. [29] found that visceral-arthritis comorbidity patterns significantly impact elderly health, while Guo et al. [30] reported significant associations between cardiovascular-musculoskeletal comorbidity and disability among Chinese elderly.

Compared with non-comorbid elderly individuals, those with chronic disease comorbidity have higher ADL impairment risk. Different comorbidity patterns show varying ADL impairment risks, with the rheumatoid arthritis comorbidity group showing higher risk than the coronary heart disease group. To address these health challenges, greater attention should be given to elderly individuals with chronic disease comorbidity through targeted interventions. First, health education should be strengthened to improve awareness of chronic disease comorbidity, with educational campaigns guiding elderly individuals to understand risks and preventive measures while fostering healthy lifestyle habits.

Second, primary healthcare infrastructure should be enhanced to improve accessibility and enable elderly individuals to receive more convenient, high-quality medical services. Third, management models should shift from single-disease to comorbidity management, leveraging medical consortium service models to explore new tiered diagnosis and treatment approaches for precise and efficient comorbidity management. Finally, policy support should be strengthened with increased investment in prevention and treatment of chronic disease comorbidity among the elderly to provide more comprehensive protection.

This study's strengths include using latent class analysis to categorize chronic disease comorbidity patterns based on self-reported data from rural elderly in southern Ningxia, offering a new perspective for understanding comorbidity complexity and its impact on ADL impairment. This approach provides more precise classification for comorbidity management. However, limitations exist: first, using 2022 cross-sectional data from rural areas of southern Ningxia limits generalizability and causal inference; second, chronic disease information was self-reported, introducing recall bias, and conditions like bronchial asthma and chronic kidney disease were combined into an "other" category due to low prevalence, which may have constrained the latent class analysis.

**Author Contributions:** SONG Mingsha conceptualized the study, designed the research, performed data analysis, and wrote the manuscript, taking overall responsibility for the paper; WANG Youyun and LI Chunsheng contributed to data cleaning and manuscript proofreading; QIAO Hui provided theoretical guidance, content review, and quality control.

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

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