Review Articles

Chronic disease comorbidity patterns among elderly Chinese based on CHALS data and their impact on daily living ability

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ABSTRACT

Objective: To analyze the current prevalence and clustering patterns of chronic comorbidities among elderly people in China, explore the association between different comorbidity patterns and impairment of basic daily living ability (BADL) and instrumental ability of daily living (IADL), and test the moderating effects of physical exercise and social support, providing empirical evidence for formulating precise elderly health management strategies. **Methods:** Using cross-sectional data from the 2018 China Health and Elderly Care Tracking Survey (CHARLS), 11,246 elderly people aged 60 and above were selected as study subjects. Latent category analysis (LCA) was used to identify chronic disease comorbidity patterns, and logistic regression models were used to analyze the number of comorbidities and their association with BADEL and IADL impairment, to test interaction effects, and to conduct multiple robustness tests. **Results:** The chronic disease comorbidity rate among the elderly in China was 59.9%, with severe comorbidities (≥ 5 types) accounting for 10.5%. LCA identified five comorbidity patterns: cardiometabolic (26.8%), musculoskeletal-digestive (20.5%, with Chinese population specificity), respiratory-psychiatric (15.3%), multisystem impairment (14.0%), and relative health (23.4%, with 4.2% still having BADAL impairment and 14.3% having IADL impairment in this group). The number of comorbidities was significantly graded and cumulatively associated with impaired daily living ability. The risk of BADAL and IADL impairment in severely comorbid elderly patients was 9.12 times higher (OR=9.12, 95% CI: 7.28-11.43) and 7.89 times higher (OR=7.89, 95% CI: 6.65-9.36), respectively. There was significant heterogeneity in the impact of different comorbidity modes on function, with multisystem impairment at the highest risk, and respiratory-psychiatric types causing significantly more IADL damage than cardiometabolic types. Interaction analysis showed that physical exercise and social support had a significant buffering effect on the association between comorbidity and IADL impairment (interaction term $p<0.05$). The burden of comorbidities is heavier among women, rural areas, and elderly people with low socioeconomic status. **Conclusion:** The phenomenon of chronic disease comorbidities among the elderly in China is common and shows a clear pattern of clustering. The association between comorbidity and impaired daily living ability has hierarchical cumulative effects and pattern heterogeneity; physical exercise and social support can buffer the negative effects of comorbidities. It is recommended to include comorbidity pattern identification in comprehensive elderly assessments, implement integrated interventions targeting high-risk patterns such as respiratory-psychotic types, and focus on health inequalities in rural and vulnerable groups.

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1. Introduction

1.1. Research Background

Population aging is a major challenge facing human society in the 21st century. According to data from the National Bureau of Statistics , by the end of 2023, China's population aged 60 and above had reached 297 million, accounting for 21.1% of the total population, marking that China has officially entered a moderately aged society. Meanwhile, health issues among the elderly are becoming increasingly prominent, with the prevalence and comorbidities of chronic diseases continuing to rise. The World Health Organization (WHO) defines "multimorbidity" as a condition in which an individual simultaneously has two or more chronic diseases [1]. With the increase in life expectancy and shifts in the disease spectrum, comorbidities have become the health norm rather than the exception among the elderly [2].

In China, the epidemic situation of chronic comorbidities among the elderly is particularly difficult. Research based on CHALS data shows that between 2011 and 2015, the chronic disease comorbidity rate among Chinese people aged 60 and above rose from 85.96% to 92.24% [3][4], with cardiovascular and metabolic diseases being the most predominant comorbidity form [5]. Comorbidities not only increase the complexity and cost of medical services, but also accelerate the decline of physical functions in the elderly through the interaction of multiple pathological mechanisms, leading to disability, dementia, and a decline in quality of life [6][7][8].

Activities of Daily Living (ADL) is a core indicator for measuring the health status and quality of life of older adults, divided into Basic Daily Living Ability (BADL) and Instrumental Daily Living Ability (IADL). BADL reflects an individual's ability to perform basic self-care activities, while IADL embodies the more complex functions required for independent community living. Research shows that the ADL impairment rate among Chinese elderly is about 26% [9][10], and this trend continues to rise. Comorbidities, as important risk factors for ADL impairment, have not yet been fully elucidated—existing studies have focused mostly on the cumulative effect of chronic disease "quantity," while systematic examination of the differentiated effects of different chronic disease "combination patterns" is lacking [11].

1.2. Raising the Issue

Existing research has shortcomings in the following aspects: First, most studies simplify comorbidities to counting the number of diseases, ignoring the pathological associations and clustering patterns among chronic diseases. Different disease combinations may form specific "comorbidity patterns" through shared causes, interactions, or shared risk factors, with significant differences in their impact on function [12]. Second, the elderly population in China has a unique disease spectrum and socioeconomic background. Whether the comorbidity patterns identified in Western studies—such as cardiometabolic and musculoskeletal types—are applicable to the elderly population still requires local empirical testing [13]. Third, the regulatory effects of socioeconomic gradients and protective factors (such as physical exercise and social support) in the relationship between comorbidities and daily living abilities have not been sufficiently addressed [14].

Therefore, this study is based on the 2018 CHALLS national representative cross-sectional data, employs Latent Class Analysis (LCA) to identify chronic disease comorbidity patterns among Chinese elderly, systematically examines the number of comorbidities and their association with BAPL and IADL impairment, tests the moderating effects of protective factors, and explores their socioeconomic distribution characteristics, aiming to provide a scientific basis for constructing a precise and integrated elderly health service system.

2. Literature Review

2.1. Epidemiological characteristics of chronic disease comorbidities

Comorbidities have a very high prevalence among the elderly. Research from high-income countries in Europe and America shows that the comorbidity rate among people over 60 is 45.0%-95.0% [15]. In China, studies based on different data sources reported comorbidity rates ranging from 40.0% to 82.0% [16]. Xu et al. [17] used data from CHALS and India's LASI to compare and found that the burden of comorbidities among middle-aged and elderly people in both China and India is relatively heavy, with significant socioeconomic gradients. Wang et al.'s [18] longitudinal study based on CHALS confirmed that comorbidities significantly reduce health-related quality of life in the elderly.

The distribution of comorbidities shows clear sociodemographic differences. Comorbidity rates are generally higher among women, older age, rural residents, those with low education levels, and lower socioeconomic status [19]. This unequal distribution reflects the cumulative effects of health disadvantages throughout the life course — disadvantaged groups are exposed to more health risk factors early in life and have fewer opportunities to access quality medical resources throughout their lives, leading to concentrated outbreaks and clustering of chronic diseases in old age.

2.2. Methods and Progress in Comorbidity Pattern Recognition

Identifying comorbidity patterns is key to understanding the patterns of disease clustering. Common methods include Exploratory Factor Analysis (EFA), cluster analysis, network analysis, and Latent Category Analysis (LCA). In recent years, LCA has been widely applied in comorbidity pattern recognition due to its classification advantages based on probabilistic models. LCA can divide multidimensional classification data into several mutually exclusive potential categories, allowing individuals within the same category to have similar disease combination characteristics, and provides rich model fitting metrics for selecting the optimal number of categories.

A more consistent finding in international studies is the "cardiometabolic cluster," characterized by hypertension, diabetes, dyslipidemia, and heart disease. In addition, "musculoskeletal clustering" (mainly arthritis and osteoporosis), "respiratory-psychiatric clustering" (mainly chronic lung disease, depression, and anxiety), and "multi-system impairment type" are also common comorbidity patterns. However, the specific composition and proportion of these models vary across different countries and populations, urgently requiring localized validation based on Chinese data [20].

2.3. Impact of Chronic Disease Comorbidities on Daily Living Ability

Chronic comorbidities impair the daily living ability of the elderly through multiple mechanisms. First, the coexistence of multiple chronic diseases increases treatment complexity, raises the risk of adverse drug reactions,

and makes disease management more challenging. Second, different chronic diseases may produce synergistic damage effects through common pathophysiological pathways (such as chronic inflammation, oxidative stress, endocrine disorders), accelerating functional decline. Verbrugge et al.'s "multiple jeopardy hypothesis" points out that the negative impact of multiple health problems on function is not simply sum but rather a synergistic amplification effect.

Empirically, the association between comorbidity and ADL impairment has been widely confirmed. Qiao et al. used comparative studies using CHALS and SHARE data to support a strong bidirectional association between disability and comorbidities. A study based on longitudinal data from CHARLS from 2011 to 2020 found that all four comorbidity patterns (visceral-skeletal type, respiratory type, neurodegenerative type, cardiometabolic type) were independently associated with increased risk of BADEL and IADL impairment, with the neurodegenerative pattern having the highest risk. However, most of these studies use exploratory factor analysis, which roughly classifies comorbidity patterns and does not provide in-depth analysis of the heterogeneity between comorbidity patterns and functional norms and the moderating effects of protective factors.

2.4. Literature Review

In summary, existing research lays an important foundation for understanding the relationship between comorbidities and functional decline in the elderly, but the following shortcomings remain: First, research using LCA methods to identify comorbidity patterns based on a national representative sample in China is relatively limited; Second, the systematic analysis of the differential impact between comorbidity patterns and BADL/IADL is insufficient, especially the impact of comorbidity patterns including mental health issues on IADL has not received sufficient attention; Third, the regulatory role of protective factors (physical exercise, social support) in the relationship between comorbidity and function remains to be tested; Fourth, the socioeconomic gradient and its modifying effects related to comorbidity and function require further clarification. This study attempts to make marginal contributions in these areas.

3. Theoretical Framework and Research Hypotheses

3.1. Theoretical framework

This study takes the Disablement Process theory as its core theoretical framework. This theory, proposed by Verbrugge and Jette, describes the continuous process from pathology to functional limitation and then to disability. Within this framework, chronic comorbidities, as important pathological factors, impair organ system function and cause dysfunction, ultimately leading to ADL impairment. In addition, this study introduces life course theory and the Stress-Buffering Model for health inequalities, emphasizing the regulatory roles of structural factors such as socioeconomic status, gender, and urban and rural areas in the development and functional decline of comorbidities, as well as the protective role of physical exercise and social support as buffers against the negative effects of comorbidities.

3.2. Research Hypotheses

Based on the above theoretical framework and literature review, this study proposes the following research hypotheses (Note: Due to the design limitations of cross-sectional data, the term "association" in the following assumptions refers to statistical associations and does not imply causal inference; The full results section will uniformly use expressions such as "related," "independent related," and "increased risk," avoiding causal terms like "cause" and "drive"):

- H1 (Number of Comorbidities Association Hypothesis): The number of chronic disease comorbidities is positively correlated with the risk of BADL/IADL impairment in the elderly, meaning the more comorbidities there are, the higher the risk of impaired daily living ability, with a graded cumulative association.
- H2 (Comorbidity Pattern Difference Hypothesis): There is significant heterogeneity in the association between different chronic disease comorbidity patterns and impairment of BADL and IADL. The negative association between the multi-system impairment type and functional impairment is strongest, with comorbidity patterns including mental health issues being particularly prominent in the association with IADL impairment.
- H3 (Socioeconomic Gradient Hypothesis): There is a socioeconomic gradient in the association between comorbidities and impaired daily living abilities. The burden of comorbidities is heavier among rural areas, women, and the elderly with low education and low income, and the negative association between comorbidity and functioning is stronger.
- H4 (Protective Factor Moderation Hypothesis): Physical exercise and social support can buffer the negative association of comorbidities with impaired daily living abilities (i.e., significant negative interaction effects).

4. Research Methods

4.1. Data Sources and Samples

The data used in this study are sourced from the China Health and Retirement Longitudinal Study (CHARLS). CHARLS is a large-scale micro-household survey project led by the National School of Development at Peking University and executed by the China Social Science Survey Center of Peking University. Its goal is to collect a set of high-quality micro-level data representing households and individuals aged 45 and above in China. CHALS uses a multi-stage stratified sampling method, covering 28 provinces, 150 county-level units, and 450 village-level units nationwide, making it nationally representative.

This study selected data from the 2018 CHALS Phase IV survey as the main analysis sample. The 2018 survey interviewed more than 37,000 respondents out of approximately 19,000 households. The subjects of this study were elderly people aged 60 and above.

4.1.1 Sample Screening and Missing Value Processing. In the original sample, there were 16,832 elderly people aged 60 and above. The key variables (14 chronic diseases, BADL, IADL, age, gender, place of residence) were as follows: the chronic disease information loss rate was 8.3% (mainly due to some respondents not completing the health module), the ADL information loss rate was 5.1%, and the socioeconomic variable loss rate was 12.4%. Little's MCAR test showed $\chi^2=156.32$ and $p=0.087$, suggesting that the deletion pattern can be approximated as a completely random deletion (MCAR). After excluding cases missing at least one key variable, the final sample size for inclusion was 11,246 people, accounting for 66.8% of the original sample aged 60 and above.

Although Little's MCAR test results reduced concerns about selection bias, the rejection rate of 33.2% remains relatively high. To assess differences

between excluded and included samples, this study compared baseline characteristics (age, gender, residence, education level, comorbidity, BADL/IADL impairment rate) in Appendix S1. The results showed that the excluded sample was slightly older (70.2 vs 69.5 years, $p<0.05$), had a higher proportion of women (55.6% vs 52.3%, $p<0.05$), had a higher proportion of rural areas (62.1% vs 58.6%, $p<0.01$), had a higher comorbidity rate (64.3% vs 59.9%, $p<0.001$), and had a higher rate of BALD impairment (15.6% vs 12.8%, $p<0.001$). This suggests that the excluded sample may include more vulnerable groups with poorer health, and the main analysis may have underestimated the strength of the association between comorbidity and functional impairment, making it a conservative estimate. For sensitivity analysis, this study used Multiple Imputation by Chained Equations (MICE) to process missing values, repeated the main analysis, and maintained consistent conclusions.

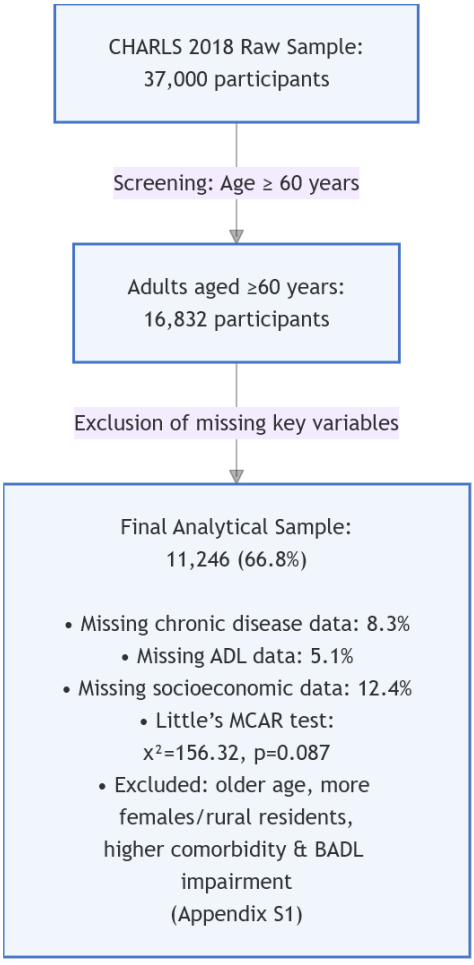

Fig.1 Sample Screening Flowchart (CONSORT Format)

4.2. Variable Selection and Measurement

4.2.1 Measurement of chronic disease comorbidities. The chronic diseases focused on in this study refer to those diagnosed by doctors and whose duration has lasted a long time. Based on the CHALLS questionnaire's response to "Have you been informed by a doctor about the following diseases?", this study selected 14 common chronic diseases for comorbidity analysis. The selection criteria are as follows: (1) The disease is a chronic non-communicable disease; (2) High prevalence or significant health hazards among the elderly; (3) The CHALS questionnaire contains clear doctor-specific diagnostic items; (4) Rule out acute illnesses, symptomatic illnesses (such as headache, lower back pain), and sensory disorders. Sensory impairment items in the CHALS questionnaire (such as cataracts and hearing impairments) were excluded from this study because their association mechanisms with ADL differ from those of chronic somatic diseases. Specifically, it includes: hypertension, dyslipidemia, diabetes or elevated blood sugar, cancer or malignant tumors, chronic lung diseases (such as chronic bronchitis or emphysema, cor pulmonale, asthma), liver diseases (such as fatty liver, tumors, or cirrhosis, but does not include alcoholic liver disease), heart diseases (such as myocardial infarction, coronary heart disease, angina, congestive heart failure, or other heart conditions), stroke, kidney diseases (such as kidney failure, kidney stones, or hydronephrosis, excluding tumors or cysts). Stomach or digestive system diseases (such as gastric ulcers, duodenal ulcers, gastritis, excluding tumors or cancer), emotional and mental issues (such as depression, anxiety, etc.), memory-related diseases (such as Alzheimer's, brain atrophy, Parkinson's disease, etc.), arthritis or rheumatic diseasesAsthma

The number of comorbidities refers to the number of diseases in an individual who simultaneously has two or more of the above chronic conditions. This study divided comorbidities into five categories: no chronic disease (0 types), single chronic disease (1 type), mild comorbidities (2 types), moderate comorbidities (3-4 types), and severe comorbidities (≥ 5 types).

It should be noted that, due to limitations in the CHALS data, this study treated each chronic disease as a binary variable (disease/not diseased), without further differentiating disease severity, control status, or disease duration. This may affect the accuracy of comorbidity pattern estimates of functional impacts to some extent, and attention should be paid to when interpreting results.

4.2.2 Measurement of Daily Living Ability. This study used two internationally recognized assessment tools for daily living abilities, with the assessment time point being the respondent's current functional status (i.e., the survey timeline):

(1) Basic Daily Living Skills (BADL)

The Katz index was used for assessment, covering six basic activities: bathing, dressing, toileting, indoor activities, eating, and controlling bladder and bowel movements

Each activity is divided into four levels: "No difficulty at all," "Some difficulty," "Difficult but still manageable," and "Unable to complete." This study defined impairment of BADAL as having difficulty with at least one activity.

(2) Instrumental Ability of Daily Living (IADL)

The Lawton Scale was used for assessment, including six instrumental activities: doing housework, cooking, shopping, managing money, using the phone, and taking medication

Similarly, having difficulty with at least one activity is defined as impairment of IADL.

4.2.3 Control Variables. Based on existing literature, this study controls for the following factors that may affect the ability of elderly people to live in daily life:

- Demographic characteristics: age, gender, marital status (with or without spouse), residence (urban/rural)

- Socioeconomic status: Education level (illiterate, primary, middle, high school and above), income level (grouped by per capita annual income quartile of households, considering family size), type of medical insurance
- Healthy behaviors and physical fitness: smoking status, alcohol consumption status, exercise frequency, BMI (underweight< 18.5, normal 18.5-23.9, overweight 24-27.9, obesity ≥28 kg/m²)
- Social support: Living with children, number of children, and whether friends support them
- Regional Fixed Effect: Provincial Dummy Variable (controlling for regional differences)

4.3. Analytical Methods

4.3.1 Descriptive Statistical Analysis. First, descriptive statistical analysis was conducted on the demographic characteristics, prevalence of chronic diseases, distribution of comorbidities, and daily living abilities of the samples. Categorical variables are described using frequency and percentage, while continuous variables are described using mean and standard deviation.

4.3.2 Comorbidity pattern identification. Latent Class Analysis (LCA) was used to identify chronic disease comorbidity patterns in the elderly. LCA is a clustering method based on probabilistic statistics that can divide multidimensional classification data into several mutually exclusive potential categories, allowing individuals within the same category to have similar disease combination characteristics.

This study used Mplus 8.0 software for LCA estimation, employing robust maximum likelihood estimation (MLR). Model selection comprehensively considers the following criteria:

- Bayesian Information Criterion (BIC): The smaller, the better
- Akaike Information Criterion (AIC): The smaller, the better
- Sample-corrected BIC (aBIC): the smaller, the better
- Entropy: The closer to 1, the better; > 0.80 is ideal, 0.60-0.80 is acceptable
- Lo-Mendell-Rubin likelihood ratio test (LMR-LRT): Tests whether k-class models outperform k-1 models; p<0.05 supports k-class models
- Mean posterior probability (AvePP): The probability that each class member is correctly classified, with 0.70 > considered acceptable and > 0.80 considered good
- Category interpretability: Each category must have clear clinical/public health significance

4.3.3 Regression analysis of the association between chronic disease comorbidities and daily living ability. This study uses daily living ability (impaired BADL and IADL) as the dependent variable and the number and patterns of comorbidities as independent variables, constructing the following model. All regression models reported Huber-White sandwich estimators to address potential heteroscedasticity issues.

Model One (Comorbidity Quantity Model):

$$Logit(P_{BADL}) = \beta_0 + \beta_1 \cdot MM_{count} + \gamma \cdot Controls + \delta \cdot Province + \varepsilon$$

Logit(PBADL)=β0 +β_1 · MMcount +c· Controls+δ·Province+ε

Where MM_{count} is the number of comorbidities (categorical variable), Controls is the vector of control variables, and Province is the fixed effect of provinces.

Model 2 (Comorbidity Model):

$$Logit(P_{IADL}) = \beta_0 + \sum_{k=1}^{K} \beta_k \cdot Class_k + \gamma \cdot Controls + \delta \cdot Province + \varepsilon$$

Among them, $Class_k$ is the k-th comorbidity latent category identified by LCA (with relatively healthy type as the reference group).

A logistic regression model was used to analyze the association between comorbidities and daily living ability, with results reporting odds ratio (OR) and its 95% confidence interval. Pseudo-R^2 (McFadden and Nagelkerke) of the model were reported to assess interpretability, AUC values were reported to assess model distinctiveness, and multicollinearity was diagnosed (VIF<10 was acceptable).

Model 3 (Moderating Effect Model): To test H4, construct a model including interaction terms:

$$Logit(P_{ADL}) = \beta_0 + \beta_1 \cdot MM_{count} + \beta_2 \cdot Protector + \beta_3 \cdot (MM_{count} \times Protector) + \gamma \cdot Controls + \varepsilon$$

Among them, Protectors are physical exercise (never/occasionally/frequently) and social support (with friend support = 1 / no = 0). In the interaction term analysis, the number of comorbidities was included by classification variables (0/1/2/3-4/≥5 types). The ORs of each subgroup were derived from stratified logistic regression, and the interaction p-values were derived from the whole-model Wald test including product terms.

4.3.4 Robustness Testing

To ensure the reliability of the research findings, the following robustness tests were conducted in this study:

- The 2015 CHALS data were used to repeat the main analysis
- Changing the measurement method for comorbidities (by organ system: cardiovascular, respiratory, digestive, neuropsychiatric, musculoskeletal, urogenital, tumor)
- Sensitivity analysis using an ordered Probit model (reporting normalization coefficient)
- Multiple interpolation was used to handle missing values and then perform repeated analyses
- BMI was used as a continuous variable in place of a classification variable

5. Empirical Results

5.1. Basic Characteristics of Samples

Table 1 reports the basic demographic characteristics of the study sample. Among the 11,246 elderly participants ultimately included in the analysis, the average age was 69.5 years (SD=6.8), with 52.3% being female. In terms of residence, rural elderly account for 58.6%, reflecting the urban-rural disparities in China's aging process. In terms of education, illiteracy and those with a primary school education account for over 65%, reflecting the generally lower level of education among the elderly. About 62.8% of elderly people have a spouse accompanying them, a proportion basically consistent with previous studies.

Table 1 Basic Characteristics of the Sample (N=11,246)

variable	Classification	Number of people	Percentage / Mean (Standard Deviation)
Age	60-69 years old	5,892	52.4%
	70-79 years old	3,856	34.3%
	≥ 80 years old	1,498	13.3%

variable	Classification	Number of people	Percentage / Mean (Standard Deviation)
	Mean (years)	—	69.5 (6.8)
Gender	Male	5,361	47.7%
	Female	5,885	52.3%
Residence	City	4,653	41.4%
	Rural areas	6,593	58.6%
Marital status	Married to a spouse	7,063	62.8%
	No spouse	4,183	37.2%
Education level	Illiterate	3,687	32.8%
	Elementary school	3,654	32.5%
	Junior high	2,456	21.8%
	High school or above	1,449	12.9%
Income level	Lowest quartile	2,812	25.0%
	The second quartile	2,811	25.0%
	The third and fourth quartiles	2,812	25.0%
	Highest quartile	2,811	25.0%
BMI	Low body weight (<18.5)	892	7.9%
	Normal (18.5-23.9)	4,567	40.6%
	Overweight (24-27.9)	3,876	34.5%
	Obesity (≥28)	1,911	17.0%
Smoking	Never smoked	7,856	69.9%
	He used to smoke	1,456	12.9%
	Smoking now	1,934	17.2%
Drinking wine	He never drank alcohol	8,234	73.2%
	Occasionally drinking	1,876	16.7%
	Frequent drinking	1,136	10.1%
Physical exercise	Never exercised	6,789	60.4%
	Exercise occasionally	2,456	21.8%
	Exercise regularly	2,001	17.8%

5.2. Distribution of chronic disease prevalence and comorbidities

5.2.1 Prevalence of single diseases. Table 2 shows the prevalence of 14 chronic diseases in the sample. The five diseases with the highest prevalence are: hypertension (41.2%), arthritis or rheumatic diseases (35.8%), stomach or digestive system diseases (23.6%), dyslipidemia (18.9%), and diabetes (14.7%). This is highly consistent with existing research findings on the disease spectrum of the elderly in China, reflecting that cardiovascular, metabolic diseases, and musculoskeletal system disorders are the main health burdens for the elderly.

Table 2: Prevalence of 14 types of chronic diseases

Types of chronic diseases	the number of sick patients increased	Prevalence
Hypertension	4,633	41.2%
Arthritis or rheumatism	4,026	35.8%
Stomach or digestive system diseases	2,654	23.6%
Abnormal blood lipids	2,125	18.9%
Diabetes or elevated blood sugar	1,653	14.7%
Chronic lung disease	1,456	12.9%
Heart disease	1,234	11.0%
Emotional and mental health issues	987	8.8%
Kidney disease	876	7.8%
Liver disease	754	6.7%
Asthma	654	5.8%
Diseases related to memory	543	4.8%
Stroke	432	3.8%
Cancer or malignant tumors	321	2.9%

5.2.2 Distribution of comorbidities. Table 3 reports the distribution of chronic comorbidities among the elderly. The analysis showed that among 11,246 elderly people, only 19.8% had no chronic diseases at all, 20.3% had a single chronic disease, and as many as 59.9% had comorbidities with

two or more chronic diseases. Specifically, mild comorbidities (2 types) accounted for 24.6%, moderate comorbidities (3-4 types) accounted for 24.8%, and severe comorbidities (≥5 types) accounted for 10.5%.

Table 3. Distribution of chronic disease comorbidities

Comorbidity categories	Definition	Number of people	percentage
No chronic diseases	0 types	2,227	19.8%
A single chronic disease	1 type	2,283	20.3%
Mild comorbidities	2 types	2,767	24.6%
and in the middle degree suffers from a common illness	3-4 types	2,789	24.8%
Severe comorbidity	≥ 5 types	1,180	10.5%
Total		11,246	100.0%

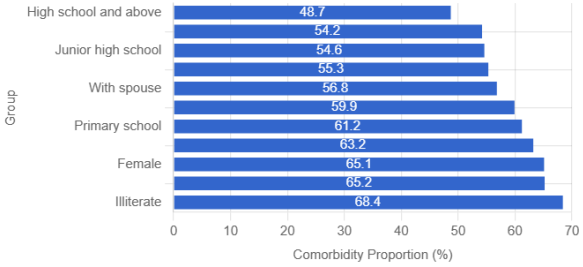

Fig.2 Proportions of chronic disease comorbidities among different characteristic groups

The distribution of comorbidities shows a significant socioeconomic gradient. Figure 2 shows the proportion of comorbidities among groups with different demographic characteristics. The proportion of comorbidities among women, rural elderly, those with low education, and those without spouses was significantly higher than in their control groups, which is consistent with previous studies and suggests the cumulative effect of health inequality among the elderly.

5.3. Identification of chronic disease comorbidity patterns

5.3.1 Latent Category Model Selection. This study determined the optimal classification of comorbidity patterns by comparing LCA model fitting indicators across different categories (2-6 categories). Table 4 shows the fitting statistics for each model.

Table 4: Latent Category Analysis Model Fitting Indicators

Number of categories	AIC	BIC	aBIC	Entropy	LMR-LRT (p)	AvePP range
2	45,234	45,678	45,432	0.82	—	0.89-0.91
3	44,567	45,123	44,876	0.80	<0.001	0.85-0.90
4	44,012	44,678	44,432	0.79	<0.001	0.83-0.88
5	43,678	44,456	44,198	0.78	<0.001	0.82-0.87
6	43,654	44,543	44,287	0.72	0.089	0.78-0.84

The model selection criteria are as follows:

- BIC and aBIC: The BIC (44,456) and aBIC (44,198) of the 5 category models are both lower than those of the 2-4 class models; the BIC of the 6 category slightly decreases but the aBIC increases;
- LMR-LRT: The LMR-LRT of 5 class models is significantly ($p<0.001$), supporting 5 classes better than 4; LMR-LRT for six types of models was not significant ($p=0.089$), indicating that six types did not significantly improve fitting;
- AvePP: The average posterior probability for all five models was ≥ 0.82, indicating good classification certainty;
- Entropy value: The entropy value of the five types of models is 0.78. Although it does not reach the ideal standard of 0.80 for > 0.80, it is within an acceptable range among multi-disease LCA (14 indicators) (previous studies have reported that the entropy value of comorbid LCA is mostly between 0.70 and 0.85);
- Interpretability: The five model categories each have clear clinical features and public health significance, while the new category in the six models only further subdivides the "multi-system impairment type" without providing new substantive information.

Based on the above criteria, Category 5 models are the optimal choice.

5.3.2 Characteristics of Comorbidity Patterns and Conditional Probability

Based on five types of LCA models, this study identified five major chronic disease comorbidity patterns. Table 5 shows the conditional probabilities for each chronic disease in each category (i.e., the probability that members in that category have a certain disease).

Table 5 Probability Distribution of Chronic Disease Conditions by Latent Category (%)

Chronic diseases	Category 1: Relatively healthy type	Category 2: Cardiometabolic type	Category 3: Musculoskeletal - digestive	Category 4: Breath - Psychotype	Category 5: Multi-system damaged type
Percentage of the market	23.4%	26.8%	20.5%	15.3%	14.0%
Average number of illnesses	0.4	2.8	2.2	2.5	4.6
Hypertension	5.2	78.6	28.9	22.1	76.5
Abnormal blood lipids	2.1	45.3	8.7	6.5	38.9

Diabetes	1.2	32.1	5.4	4.3	34.5
Heart disease	1.8	15.6	6.7	5.4	28.7
Stroke	0.5	8.7	2.1	1.8	12.3
Arthritis	4.3	18.9	82.4	12.4	71.2
Stomach diseases	3.2	12.4	56.7	8.9	48.9
Lung disease	2.1	8.7	6.5	68.9	15.6
Asthma	1.2	4.5	3.2	24.5	8.7
Emotional issues	1.8	6.7	5.4	32.4	22.1
Memory disorders	0.8	3.2	2.1	4.5	12.3
Kidney disease	0.5	5.4	2.8	3.2	24.3
Liver disease	1.2	4.3	3.2	5.6	8.9
Cancer	0.5	2.1	1.2	1.8	5.4

Category 1: Relatively healthy type (23.4%, n=2,632)

Members of this category are mostly without chronic diseases or have only a single chronic disease, with the probability of conditions for all types of diseases below 10%. This group represents elderly people with relatively good health status (emphasizing the word "relative"—4.2% of this group still have BADAL impairment and 14.3% have IADL impairment, suggesting that aging itself and unmeasured factors can also lead to functional decline).

Category 2: Cardiovascular metabolic type (26.8%, n=3,014)

This category is characterized by hypertension, dyslipidemia, and diabetes, with conditional probabilities of 78.6%, 45.3%, and 32.1% for these three diseases, respectively. The probabilities of heart disease (15.6%) and stroke (8.7%) were also higher than in other categories. This model closely aligns with the "cardiovascular metabolic clustering" commonly seen in Western research, reflecting common pathological underlying factors such as insulin resistance, lipid metabolism disorders, and vascular endothelial dysfunction.

Category 3: Musculoskeletal-digestive type (20.5%, n=2,305)

This category is mainly characterized by arthritis or rheumatic diseases (82.4%) and stomach or digestive system diseases (56.7%). The prevalence of hypertension (28.9%) is moderate, but the probability of other chronic diseases is low.

Naming Explanation and Pathological Discussion: This pattern has rarely been individually identified in previous international literature, and its pathophysiological relationship still requires further exploration. Possible explanations include: (1) Inflammatory copolymer hypothesis: Systemic low-grade inflammation is the common pathological basis of arthritis and chronic gastritis. During aging, elevated levels of pro-inflammatory cytokines (such as IL-6, TNF-α) may simultaneously promote joint degeneration and mucosal damage in the digestive tract; (2) High incidence copolymerization: Arthritis and stomach diseases are both high prevalence among the elderly in China, and their statistical copolymerization may partially reflect an independent high prevalence in the population; (3) Drug side effect association: Nonsteroidal anti-inflammatory drugs (NSAIDs) are widely used to treat arthritis, but long-term use can cause gastrointestinal damage. Recognizing this pattern suggests that clinical management should pay attention to the interaction between musculoskeletal and digestive system diseases. The cross-cultural scalability of this model still requires international comparative research and may be related to factors such as Chinese group labor patterns, dietary habits, and NSAID usage patterns.

Category 4: Respiratory-Psychotic (15.3%, n=1,721)

This category is characterized by chronic lung diseases (68.9%), asthma (24.5%), and emotional and mental health issues (32.4%). Smoking rates (35.6%) and drinking rates (18.9%) in this group were significantly higher than in other categories.

Naming note: Although the conditional probability of mental problems (32.4%) is not the highest among all diseases, the combined characteristics of respiratory and mental disorders are highly distinctive within this category—in other categories, patterns of simultaneous high incidence of lung disease and mental problems are extremely rare. This "body-psychological" copolymerization pattern suggests a possible bidirectional link between chronic respiratory diseases and mental health issues (shortness of breath leads to anxiety and depression, while mental health issues reduce treatment adherence).

Category 5: Multi-system Damaged Type (14.0%, n=1,574)

This category has the most severe comorbidity pattern, with members showing high prevalence across almost all chronic disease categories: hypertension (76.5%), arthritis (71.2%), stomach diseases (48.9%), diabetes (34.5%), heart disease (28.7%), kidney disease (24.3%), emotional problems (22.1%), and others. This group represents a high-risk group with simultaneous damage to multiple organ systems.

5.4. Daily living ability

5.4.1 BADEL and IADL Damage Rates. Table 6 shows the damage status of BADEL and IADL in the sample. The BADEL impairment rate was 12.8% (1,440 people), and the IADL impairment rate was 31.6% (3,554 people). The impairment rate of IADL was significantly higher than that of BADL, which aligns with theoretical expectations that instrumental activities require higher cognitive function and complex coordination abilities.

Table 6 Impaired Daily Living Ability

Indicators	Unharmed	Damage	Damage rate
BADL	9,806	1,440	12.8%
IADL	7,692	3,554	31.6%

5.4.2 Differences in Daily Living Ability among Different Comorbid States. Figure 3 shows the impairment rates of BADEL and IADL in elderly patients with different comorbidity categories. With the increasing number of comorbidities, the rate of impaired daily living ability shows a significant upward trend.

From relatively healthy to multi-system impairment, the BADEL impairment rate rose from 4.2% to 31.2%, an increase of about 7.4 times; the IADL impairment rate rose from 14.3% to 58.7%, an increase of about 4.1 times. This gradient relationship intuitively demonstrates the cumulative negative impact of comorbidities on the functional status of elderly people.

Notably, the rate of IADL impairment in the respiratory-mental type (38.9%) was higher than that in the musculoskeletal-digest type (35.2%), suggesting that the independent impact of mental health issues on complex

daily activities cannot be ignored. The multi-system impairment type has the most severe functional impairment, with nearly 60% of cases affected by IADL.

Fig.3 Impairment rates of daily living ability among different comorbidity categories

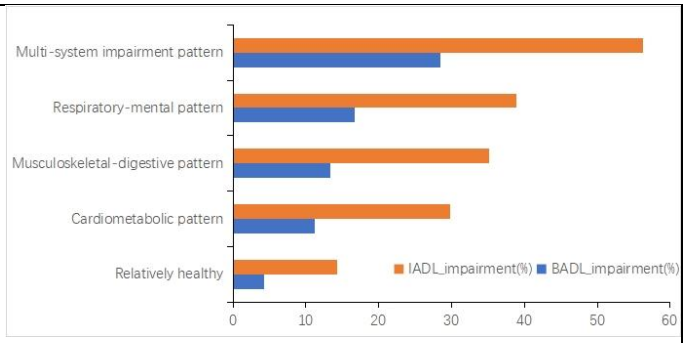

Fig.4 Impairment rates of daily living ability across various comorbidity patterns

5.5. Regression analysis of the association between chronic disease comorbidities and daily living ability

5.5.1 Correlation Effects of Comorbidity Count. Table 7 presents the logistic regression results of the number of comorbidities associated with BADEL and IADL impairment. Models 1 and 2 only controlled for demographic characteristics and province-fixed effects, while Models 3 and 4 further incorporated socioeconomic status, health behaviors, BMI, and social support variables. All models had VIF < 3.2, with no severe multicollinearity. Model 4's McFadden pseudo-R^2 is 0.18, Nagelkerke's pseudo-R^2 is 0.26, and AUC is 0.78.

Table 7 Association between the number of chronic disease comorbidities and impaired ability to live daily living (logistic regression, OR value)

variable	BADL is damaged		IADL is damaged	
	Model 1	Model 3	Model 2	Model 4
Comorbidity category (reference: no chronic disease)				
A single chronic disease	1.89***	1.76***	1.68***	1.58***
	(1.52-2.34)	(1.41-2.20)	(1.45-1.95)	(1.36-1.84)
Mild comorbidities (2 types)	3.12***	2.87***	2.89***	2.67***
	(2.54-3.84)	(2.32-3.55)	(2.52-3.32)	(2.31-3.08)
Moderate comorbidities (3-4 types)	5.23***	4.76***	4.56***	4.23***
	(4.28-6.39)	(3.87-5.85)	(3.98-5.23)	(3.67-4.87)
Severe comorbidities (≥5 types)	10.12***	9.12***	8.67***	7.89***
	(8.12-12.61)	(7.28-11.43)	(7.34-10.24)	(6.65-9.36)
Demographic characteristics				
Age (reference: 60-69 years)				
70-79 years old	2.34***	2.12***	2.56***	2.34***
≥ 80 years old	5.67***	5.23***	4.89***	4.56***
Women (see: men)	1.45***	1.38***	1.89***	1.78***
Rural area (see: Urban)	1.67***	1.45***	1.56***	1.34***
Unmarried (see: married)	1.89***	1.67***	1.67***	1.52***
Socioeconomic status				
Education level (see: illiteracy)				
Elementary school	—	0.87	—	0.78**
Junior high	—	0.67***	—	0.56***
High school or above	—	0.45***	—	0.38***
Income (Reference: Lowest Quartiles)				
The second quartile	—	0.89	—	0.82*
The third and fourth quartiles	—	0.78**	—	0.72***
Highest quartile	—	0.56***	—	0.48***
BMI (Reference: Normal)				
Low body weight (<18.5)	—	1.45***	—	1.34***
Overweight (24-27.9)	—	0.92	—	0.89
Obesity (≥28)	—	1.23**	—	1.18*
Healthy behaviors				
He used to smoke	—	1.12	—	1.08

Smoking now	—	0.98	—	0.92
Occasionally drinking	—	0.89	—	0.85*
Frequent drinking	—	0.82*	—	0.78**
Exercise occasionally	—	0.78**	—	0.72***
Exercise regularly	—	0.56***	—	0.48***
Social support				
and lived with his children	—	0.92	—	0.89
Number of children	—	0.96	—	0.94*
Friends support me	—	0.67***	—	0.62***
Fixed effect on the province	Controlled	Controlled	Controlled	Controlled
Sample size	11,246	11,246	11,246	11,246
McFadden R^2	0.12	0.16	0.14	0.18
Nagelkerke R^2	0.19	0.24	0.21	0.26
AUC	0.72	0.75	0.76	0.78

Note: * p<0.05, ** p<0.01, *** p<0.001; the interval in parentheses is 95%. All models use the Huber-White robust standard error.

Regression results showed a significant hierarchical cumulative association between the number of comorbidities and impaired ability to perform daily living. Based on the absence of chronic diseases, the ORs for mild, moderate, and severe comorbidities with BADAL impairment were 2.87, 4.76, and 9.12 (Model 3), respectively, and 2.67, 4.23, and 7.89 for IADL impairment (Model 4). For every additional unit in the number of comorbidities, the risk of impairment for BADAL and IADL rises exponentially.

Among control variables, age was one of the strongest predictors, with the risk of BADEL impairment in elderly people over 80 being 5.23 times higher than in the 60-69 age group. Women, rural residents, and those without a spouse also have a significantly higher risk of functional impairment. BMI showed a "U-shaped" association: low body weight and obesity were associated with increased risk of functional impairment, while overweight had no significant effect, consistent with previous studies. It is worth noting that education level and income level have stronger protective effects on IADL than on BADL, which may be related to the higher demands of cognitive abilities and social resources from instrumental activities. Physical exercise demonstrated significant protective effects: elderly individuals who exercised regularly had a 44% reduction in BADAL risk (OR=0.56) and a 52% reduction in IADL risk (OR=0.48). Peer support in social support also shows significant protective effects.

Explanation of the effects of drinking: Table 7 shows that occasional/frequent drinking is associated with a lower risk of ADL impairment. This finding requires careful interpretation. Possible explanations include: (1) J-curve effect: small amounts of alcohol may provide protection by improving cardiovascular function; (2) Residual Mixing: Drinkers may have higher socioeconomic status and health literacy, and unobserved health-related features may lead to protective illusions; (3) Survivor effect: Heavy drinkers may have died before old age, while those who survive as "frequent drinkers" may be light drinkers. Given mainstream public health evidence supporting alcohol restriction, this study does not recommend drinking as a health promotion strategy.

5.5.2 Differentiated associations in comorbidity patterns. Table 8 further examines the differential associations between different comorbidity patterns and daily living abilities.

Table 8 Association between chronic disease comorbidity patterns and impaired daily living ability (logistic regression, OR value)

Comorbidity Model (Reference: Relatively Healthy Type)	BADL is damaged Model 5	IADL is damaged Model 6
Cardiometabolic type	2.67***	2.34***
	(2.12-3.36)	(1.98-2.76)
Musculoskeletal - digestive type	3.12***	2.89***
	(2.45-3.97)	(2.45-3.41)
Breath - Psychotype	4.23***	3.78***
	(3.28-5.45)	(3.12-4.58)
Multi-system damaged type	9.56***	8.23***
	(7.45-12.28)	(6.78-9.98)
Control variables	Controlled	Controlled
Fixed effect on the province	Controlled	Controlled
Sample size	11,246	11,246
McFadden R^2	0.15	0.17
AUC	0.74	0.76

Note: * p<0.05, ** p<0.01, *** p<0.001; the interval in parentheses is 95%. Control variables are 3/4 of the same model. All models use the Huber-White robust standard error.

There are significant differences in the association between different comorbidity patterns and impaired daily living abilities. The multi-system impairment type carries the highest risk, with OR values of 9.56 and 8.23 for BADEL and IADL impairment, respectively. Next is the breath-mental type (BADL: OR=4.23; IADL: OR=3.78), with this pattern being significantly more associated with function than with cardiometabolic (BADL: OR=2.67) and musculoskeletal-digestible (BADL: OR=3.12). This finding is clinically significant: comorbidity patterns including mental health issues particularly impair the functional status of older adults and should be given special attention when developing intervention strategies.

5.5.3 Analysis of Moderating Effects (H4 Test). To test the moderating effect of protective factors (H4), this study included the interaction between the number of comorbidities and physical exercise and social support in the model. Table 9 reports the results of the interaction effects.

Table 9 Moderating effects of protective factors on the association between comorbidity and IADL impairment

variable	Model 7: Physical exercise regulation	Model 8: Social Support Regulation
Number of comorbidities (reference: no chronic diseases)		
A single chronic disease	1.58***	1.58***
Mild comorbidities (2 types)	2.67***	2.67***
Moderate comorbidities (3-4 types)	4.23***	4.23***
Severe comorbidities (≥5 types)	7.89***	7.89***
Protective factors		
Exercise occasionally	0.72***	—
Exercise regularly	0.48***	—
Friends support me	—	0.62***
Interaction item		
Mild comorbidity × Occasional exercise	0.82*	—
Mild comorbidities × regular exercise	0.68**	—
Moderate comorbidity × Occasional exercise	0.78*	—
Moderate comorbidity × Exercise regularly	0.65**	—
Severe comorbidity × Occasional exercise	0.75*	—
Severe comorbidity × Exercise regularly	0.62**	—
Mild comorbidity × supported by friends	—	0.85
Moderate comorbidity × supported by friends	—	0.78*
Severe comorbidity × with support from friends	—	0.72**
Control variables	Controlled	Controlled
Sample size	11,246	11,246

Note: * p<0.05, ** p<0.01, *** p<0.001. The interaction term OR<1 represents the buffering effect. All models use the Huber-White robust standard error.

The results showed that physical exercise and social support had significant negative moderating effects (buffering effects) on the association between comorbidity and IADL impairment. For severe comorbidities, among elderly people who do not exercise, the OR/ORs for severe comorbidity and IADL impairment are 7.89; for those who exercise regularly, the ORs drop to 4.89 (7.89×0.62). Similarly, elderly patients with severe comorbidities supported by friends had IADL impairment OR reduced to 5.68 (7.89×0.72). H4 is supported.

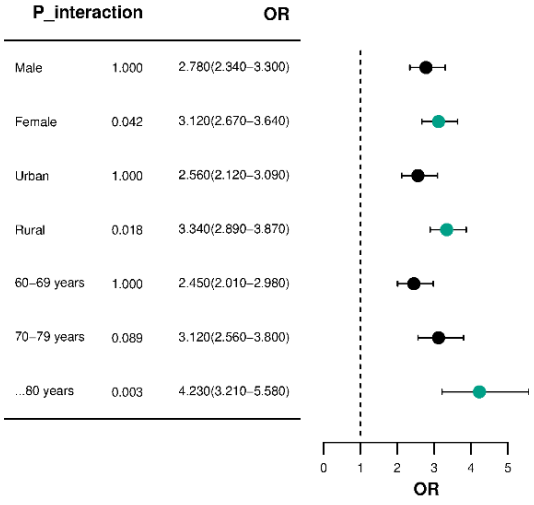

Fig.5 Subgroup analysis (OR value) of the impact of comorbidities (≥2) on IADL impairment

5.5.4 Subgroup analysis and interaction testing. Figure 5 shows subgroup differences in the association between comorbidities and impaired daily living abilities, and an interactive test was conducted for the number of comorbidities × gender.

Interaction test results showed that the interaction effect between gender × number of comorbidities was significant (p=0.042), the number of comorbidities in urban and rural × was significant (p=0.018), and the number of comorbidities × age was significant (p=0.003). Specifically: the negative effects of comorbidity in women (OR=3.12) were significantly higher than in men (OR=2.78); The comorbidity impact among rural elderly (OR=3.34) is significantly greater than that of urban elderly (OR=2.56), possibly reflecting poor access to medical resources and inadequate disease management in rural areas; The comorbidity effect (OR=4.23) in the elderly group (≥ 80 years old) was significantly stronger than in the younger group, suggesting that comorbidity and aging may have a synergistic effect accelerating functional decline.

5.6. Robustness Testing

Table 10 reports the robustness test results. Using 2015 CHALS data, reclassifying chronic diseases by organ system, replacing the logistic model with an ordered Probit model, applying multiple interpolation to handle missing values, and using BMI as a continuous variable, the main conclusions remained highly consistent, confirming the reliability of the research findings.

Table 10 Robustness test results

Inspection methods	Samples / models	Severe comorbidities (≥5 types) for BADL	Severe comorbidity versus IADL
Main analysis	CHARLS 2018, Logistic	9.12***	7.89***
Replace the data	CHARLS 2015, Logistic	8.89***	7.76***
Reclassification	By organ system, Logistic	8.67***	7.54***
Replace the model	CHARLS 2018, Ordered Probit	2.34***	2.12***
Multiple interpolation	CHARLS 2018, Logistic	9.34***	8.12***
BMI is a continuous variable	CHARLS 2018, Logistic	9.08***	7.92***

Note: *** p<0.001. The ordered Probit model reports normalized coefficients, which are used only to determine direction and significance, and are not directly compared to the logistic OR value scale.

6. Discussion

6.1. Key Findings

Based on the 2018 CHALLS national representative cross-sectional data, this study systematically analyzed the patterns of chronic disease comorbidities among Chinese elderly and their association with impaired daily living ability, with the main findings as follows:

First, chronic comorbidities among the elderly in China are extremely common. Nearly 60% (59.9%) of people aged 60 and above have two or more chronic diseases, with severe comorbidities (≥ five types) accounting for 10.5%. This proportion is similar to reports from developed countries in Europe and America (50%-70%), but higher than estimates in some Asian countries such as South Korea (48.6%) and Japan (42.4%). This difference may reflect the accumulation of health issues amid China's rapid population aging, as well as the fact that the diagnosis and treatment rate of chronic diseases has increased alongside economic development.

Second, through latent category analysis, five comorbidity patterns were identified. The cardiometabolic type (26.8%) is the main comorbidity mode, which is highly consistent with the "cardiometabolic cluster" consistently found in Western studies. The musculoskeletal-digestive type (20.5%) is a comorbidity pattern with Chinese characteristics, possibly related to the high prevalence of degenerative bone and joint diseases and digestive system diseases among the elderly in China, as well as a shared inflammatory basis. The cross-cultural scalability of this model still needs to be verified. Of particular note is the respiratory-psychotype pattern, which has been rarely identified alone in previous studies, but accounts for 15.3% of the CHALS sample and is closely associated with severe functional impairment.

Third, there is a strong cumulative graded correlation between the number of comorbidities and impaired ability to perform daily living. Elderly people with severe comorbidities have a risk of BADAL impairment that is 9.12 times higher than those without chronic diseases, and 7.89 times higher risk of IADL impairment. This cumulative effect supports the "multiple jeopardy hypothesis," meaning that the negative impact of multiple chronic diseases on function is not simply sum but a synergistic amplification effect.

Fourth, there is significant heterogeneity in the association between different comorbidity patterns and functions. Multi-system impairment is at highest risk, but the respiratory-psychiatric type is significantly associated with impaired daily living abilities compared to cardiometabolic and musculoskeletal-digest types. This finding has important clinical and public health implications: in comprehensive geriatric assessments, attention should not be limited to the number of physical illnesses, but also to screening and intervention for mental health status. Mental health issues such as depression and anxiety may independently accelerate functional decline by affecting treatment adherence, social engagement, and cognitive function.

Fifth, protective factors have a significant buffering effect. Physical exercise and social support can significantly buffer the negative association of comorbidities with IADL impairment, providing empirical support for the "stress buffering model" and suggesting that lifestyle interventions and social support network construction should be integrated into comorbidity management.

6.2. Theoretical Contributions

The theoretical contributions of this study are mainly reflected in the following three aspects:

First, it enriches the perspective of comorbidities in China's elderly health research. Previous domestic studies have mostly focused on single chronic diseases or descriptions of chronic disease prevalence, lacking systematic investigations into association patterns and synergistic effects among chronic diseases. This study is the first to use latent category analysis to identify comorbidity patterns in a large-scale nationally representative sample, providing new evidence for understanding disease clustering patterns among the elderly in China.

Second, it reveals the differentiated mechanisms by which comorbidity patterns affect functional status. This study not only verified the cumulative effect of the number of comorbidities, but more importantly, found significant differences in functional harm among different comorbidity patterns. The high-risk characteristics of the respiratory-psychiatric type suggest that a bio-psycho-social integrated model should be adopted in geriatric health assessments, rather than purely biomedical perspectives.

Third, it provides a new dimension for health inequality research and validates the moderating role of protective factors. This study found that rural areas, women, and elderly people with low socioeconomic status had higher rates of comorbidities and more severe functional impairment, with the negative association between comorbidities and functioning being stronger among vulnerable groups. At the same time, the buffering effect of physical exercise and social support is especially prominent among elderly people with comorbidities, suggesting that health promotion strategies should target high-risk groups with targeted resources.

6.3. Discussion and Limitations of Model Explanatory Power

In this study, the Nagelkerke pseudo-R^2 of the logistic regression model was highest at 0.26 (Model 4), and AUC was 0.78, indicating moderate discriminability but still limited explanatory power for BADL/IADL variants. This finding indicates:

First, comorbidities are an important factor related to ADL impairment, but they are far from the only cause. In addition to the variables controlled for

in this study, cognitive function (such as executive function, working memory), social participation, living environment (such as age-friendly housing, community accessibility), psychological resilience, and genetic factors may also have significant impacts on daily living ability. Future research should incorporate cognitive function assessments (such as MMSE, MoCA), social participation scales, and environmental factors to enhance the model's interpretability.

Second, the model's predictive ability is limited, and clinical applications require the integration of other evaluation tools. AUC=0.78 indicates that the model can effectively distinguish between ADL-impaired and unaffected populations, but it is still insufficient as an independent clinical prediction tool. It is recommended that comorbidity pattern recognition be combined with functional assessment, cognitive screening, nutritional assessment, and other tools in comprehensive elderly assessment to form a multidimensional risk assessment system.

Third, cross-sectional design limits the revelation of causal mechanisms. Although this study controlled for provincial fixed effects and multidimensional confounding factors, it could not rule out reverse causality (impaired function leading to reduced activity and worsening chronic disease) and unobserved confounding effects. The association between comorbidity and functional impairment may be bidirectional and dynamic, requiring further validation with longitudinal data.

6.4. In-depth discussion on the damage mechanisms of respiratory-psychotic IADL

This study found that the respiratory-psychotropic comorbidity pattern significantly caused more harm to IADL (OR=3.78) than the cardiometabolic type (OR=2.34), a difference worthy of further exploration. IADL (such as managing money, using the phone, taking medication) places much higher demands on executive function, working memory, and motivation systems than BADL. Mental health issues (depression, anxiety) can independently damage IADL through the following pathways:

- Cognitive Executive Function Pathways: Depressive symptoms are closely related to prefrontal cortex dysfunction, leading to reduced planning, organizational, and decision-making abilities, directly affecting managing money and scheduling medication, among other complex daily activities. Baddeley's working memory model points out that the central executive system is responsible for coordinating cognitive resources, and depression-related executive dysfunction significantly impairs IADL performance.
- Motivation-Behavioral Activation Pathway: One of the core symptoms of depression is psychomotor retardation and loss of interest, leading to decreased motivation for older adults to actively engage in instrumental activities. Even if physical function is decent, a lack of behavioral activation can manifest as IADL "impairment."
- Social avoidance and treatment adherence pathways: Anxiety and depression lead to social avoidance and reduced participation in community activities; At the same time, it reduces adherence to chronic disease management (such as regular medication and regular follow-ups), indirectly worsening physical illnesses and creating a "mental-physical" vicious cycle.
- Dyspnea-Fear-Activity Avoidance Cycle: Patients with chronic respiratory diseases often develop kinesiophobia due to shortness of breath, actively avoiding physical activity and social outings, which leads to progressive decline in IADL capacity. When combined with depressive anxiety, this avoidance behavior is further amplified.

These mechanisms explain why the respiratory-psychotype causes particularly significant damage to IADL—this pattern simultaneously attacks the somatic basis (respiratory function), cognitive base (executive function), and motivational base (behavioral activation) required for IADL, creating a multi-layered attack.

6.5. Policy recommendations

Based on these findings, this study proposes the following policy recommendations:

6.5.1 Incorporate chronic disease comorbidity management into the national basic public health service system. Currently, China's basic public health service standards mainly manage single chronic diseases (such as hypertension and diabetes), lacking integrated care plans for comorbid patients. Recommendations:

- Develop guidelines for managing comorbidities in the elderly, clarifying standard procedures for screening, assessment, and intervention of comorbidities
- Promote Comprehensive Assessment of the Elderly (CGA) in primary healthcare institutions, incorporating comorbidity pattern recognition as a routine assessment content
- Establish health records for patients with comorbidities, enabling sharing of diagnosis and treatment information among different chronic diseases

6.5.2 Constructing differentiated comorbidity intervention strategies—taking the "respiratory-psychological" integrated intervention program as an example. For the respiratory-psychiatric comorbidity model, the following integrated intervention is recommended:

Implementing Entities and Organizational Structure: Led by primary medical institutions (community health service centers/township health centers), establish a specialist alliance of "Respiratory Medicine - Psychiatry - Rehabilitation Department." Primary doctors are responsible for initial screening and follow-up, mental health specialists for consultations on difficult cases, and rehabilitation therapists for pulmonary rehabilitation training.

Implementation steps (screening → referral → joint management):

- Step one: Routine screening. In all physical examinations for people aged 65 and above, the PHQ-9 (Patient Health Questionnaire - 9 items, depression screening) and GAD-7 (Generalized Anxiety Scale - 7 items) were added to mandatory psychological assessments for COPD/asthma patients. Those who test positive (PHQ-9≥10 or GAD-7≥10) proceed to the second step.
- Step 2: Two-way referral. Grassroots doctors refer patients with moderate to severe psychiatric symptoms to mental health specialists; Psychiatrists refer those with unstable physical illnesses back to primary care for physical management. Establish a "green referral channel" to ensure specialty assessments are completed within two weeks.
- Step three: joint management. For patients diagnosed with respiratory-psychiatric comorbidities, the general practitioner develops an integrated management plan: respiratory (standardized inhalation therapy, pulmonary rehabilitation training), psychiatry (cognitive behavioral therapy/medication intervention), and social (community volunteer visits, peer support groups).

Resource Assurance and Rural Strategies:

- Remote Mental Health Consultation: Using the "Internet + Healthcare" platform to provide remote psychiatric consultations for rural areas. Village doctors connect with county-level psychiatrists

via video to address the shortage of grassroots mental health human resources.

- Primary Physician Training: Incorporate the use of the PHQ-9/GAD-7 scale and basic psychological intervention skills into the compulsory continuing education curriculum for village/community doctors, ensuring that each primary healthcare institution has at least one medical staff member trained in mental health.
- Mobile health (mHealth) applications: Develop voice-interactive health management applications (considering the low literacy rate among rural elderly), using voice reminders for medication, symptom recording, and psychological self-help training to address shortages in grassroots human resources.

6.5.3 Strengthen investment in health resources in rural areas and high-risk groups. In response to the high comorbidity rate and severe functional impairment among rural elderly, it is recommended to:

- Increase the types and quantities of chronic disease medications in rural primary healthcare institutions to ensure multiple medication needs for comorbid patients
- Promote family doctor contract services to provide continuous health management for patients with comorbidities
- A three-tier comorbidity management pathway of "village doctors–township–county" has been established: village doctors are responsible for daily follow-up and initial screening, township health centers are responsible for comprehensive assessment and plan formulation, and county-level hospitals are responsible for diagnosis and treatment of difficult cases and specialty support
- Application of mobile health (mHealth) in rural comorbidity management: Leveraging the current prevalence of smartphones in rural areas, a voice-interactive health management application has been developed to provide voice reminders for medication, record symptoms, and provide health education, filling the gap in grassroots human resources and narrowing the gap in urban and rural medical services
- For elderly women, special health education and disease screening projects are being carried out

6.5.4 Promote active aging and healthy lifestyles. Research has found that physical exercise has a significant protective and buffering effect on daily living abilities. Recommendations:

- Build age-friendly sports facilities in communities and promote activities suitable for seniors, such as Tai Chi and brisk walking
- Incorporating exercise prescriptions into chronic disease management plans encourages doctors to develop personalized, progressive exercise plans for patients with comorbidities
- Strengthen the construction of social support networks, encourage elderly participation in community activities, and maintain social interactions
- Special attention has been paid to social isolation for elderly people with comorbidities, and a community volunteer visit system has been established

6.5.5 Promote the construction of integrated medical and elderly care and long-term care systems. Given the high rate of impaired daily living abilities in elderly people with comorbidities, it is recommended:

- Improve the long-term care insurance system, giving priority to severely comorbid elderly people with functional impairments within the coverage scope
- Strengthen the construction of integrated medical and elderly care institutions, providing integrated medical nursing and daily life care services
- Train family caregivers, provide caregiving skills training and psychological support, and reduce the burden of family care

6.6. Research Limitations and Outlook

This study has the following limitations:

First, causal inference limitations from cross-sectional data. This study used 2018 CHALS cross-sectional data and was unable to establish a causal relationship between comorbidity and functional impairment. Although we controlled for multiple confounding factors (including province-fixed effects) and used longitudinal data for robustness testing, there may still be unobserved confounding variables and reverse causality (impaired function leading to reduced activity and worsening chronic disease). Future research can use CHARLS longitudinal tracking data and employ fixed-effects models or instrumental variable methods to further test causal effects.

Second, self-reporting bias in chronic disease information. Chronic disease information in CHALS is based on respondents' self-reported doctor diagnoses and may contain underreporting (undiagnosed or undiagnosed diseases) and memory biases. Although we excluded less difficult diagnostic conditions such as sensory disorders and used multiple interpolation for sensitivity analysis, measurement bias may still exist. Future research can combine biomarker testing (such as HbA1c, lipid profile) and clinical examination data to improve the accuracy of chronic disease measurement.

Third, the stability and naming issues of comorbidity pattern recognition. The results of latent category analysis are influenced by sample characteristics and the types of diseases included. Comorbidity patterns identified by different studies may not be entirely consistent. The "musculoskeletal-digestive" and "respiratory-psychological" types in this study are relatively rare in previous literature, and their pathophysiological relationships require further research and verification. Future research can test the stability and generalizability of comorbidity pattern classification through repeated sampling, external validation, and network analysis methods.

Fourth, the severity and duration of chronic diseases are not considered. This study treated chronic diseases as binary variables, without distinguishing disease severity, control status, or course length, which may affect the accuracy of comorbidity pattern estimation of functional impact.

Fifth, limitations in model explanatory power. Nagelkerke R^2=0.26 indicates that, in addition to comorbidities, variables such as cognitive function, social participation, environmental factors, and psychological resilience may also be important. Future research should incorporate these variables to build more comprehensive predictive models.

Sixth, the uncertainty in explaining the effects of alcohol consumption. This study found that small amounts of alcohol consumption were associated with a lower risk of ADL impairment, but this effect may be influenced by residual confounding and survivor bias, making it unsuitable for public health recommendations.

Future Research Directions:

- Longitudinal data are used to track the dynamic evolution of comorbidity patterns and their long-term effects on function
- Explore the biological mechanisms by which comorbidities affect function (such as inflammatory markers, oxidative stress, gut microbiota, etc.)
- Conduct intervention studies to evaluate the effectiveness of integrated care models on improving function in patients with comorbidities

- Machine learning methods (such as network analysis and deep clustering) are used to reveal the complex association structures among chronic diseases
- Incorporating disease severity and biomarker data into comorbidity pattern recognition improves classification accuracy

7. Conclusion

Based on the 2018 CHALLS national representative cross-sectional data, this study employs latent category analysis and logistic regression methods to systematically examine the patterns of chronic disease comorbidities among Chinese elderly and their association with impaired daily living ability. The study found:

Chronic comorbidities are extremely common among the elderly population in China, with 59.9% of people aged 60 and above suffering from two or more chronic diseases, showing a significant socioeconomic gradient.

Five main comorbidity patterns were identified: cardiometabolic (26.8%), musculoskeletal-digestive (20.5%, with Chinese population specificity, cross-cultural applicability yet to be verified), respiratory-psychiatric (15.3%), multisystem impairment (14.0%), and relative health (23.4%). In this group, 4.2% still had BADAL impairment and 14.3% had IADL impairment, suggesting that aging itself can also lead to functional decline.

There is a strong cumulative graded association between the number of comorbidities and impaired ability to daily living; elderly people with severe comorbidities have a risk of BADAL and IADL impairment that is 9.12 times and 7.89 times higher than those without chronic diseases, respectively.

There is significant heterogeneity in the association between different comorbidity patterns and functions, with the multi-system impairment type at highest risk, and the respiratory-psychiatric type having a significantly higher impact on function than the cardiometabolic type, possibly harming IADL through multiple pathways such as cognitive executive function, motivation-behavior activation, and social avoidance.

Physical exercise and social support have a significant protective effect in maintaining daily living abilities in older adults and can buffer the negative association of comorbidities with impaired IADL.

The negative association between comorbidities and functioning is more pronounced among women, rural areas, and older adults, highlighting the need to address health inequalities among vulnerable groups.

The model's explanatory power is limited (Nagelkerke R^2=0.26), indicating that factors such as cognitive function and social participation are equally important, and multidimensional assessment tools should be combined for clinical application.

This study provides important empirical evidence for understanding the health status of the elderly population in China and holds significant reference value for formulating targeted chronic disease management strategies and elderly health policies. Against the backdrop of accelerating population aging and the increasing burden of chronic diseases, building an integrated elderly health service system from the perspective of comorbidities is the only way to achieve the goal of healthy aging.

CRediT authorship contribution statement

Jianing Zhang: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Haoyu Liu:** Writing – original draft, Methodology. **Mengqi Li:** Writing – review & editing, Methodology. **Zeyuan Wang:** Writing – review & editing, Conceptualization. **Yutong Chen:** Writing – review & editing, Methodology, Conceptualization.

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The free versions of Grammarly were used for spell-checking and grammar corrections. After using these tools, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the publication.

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