Postprint of a Study on the Association Between Multimorbidity and Activities of Daily Living Impairment in Older Adults

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Abstract

With the acceleration of population aging, the number of elderly individuals with chronic disease multimorbidity and impaired Activities of Daily Living (ADL) is continuously increasing, imposing a heavy healthcare burden on society. Chronic disease multimorbidity is highly correlated with ADL impairment, yet its specific mechanisms of action and combined effects have not been fully elucidated.

This study aims to analyze the current status of chronic disease multimorbidity among elderly individuals in China, explore the association between different multimorbidity combinations and ADL, and provide scientific evidence for chronic disease management and functional maintenance in the elderly.

This study utilized data from the 2018 China Health and Retirement Longitudinal Study, with elderly individuals aged 60 years and above as the study population, to compare ADL impairment across different characteristics. The Apriori algorithm was employed for association rule analysis to identify major multimorbidity combinations, and binary Logistic regression models were used to evaluate the impact of these multimorbidity combinations on ADL impairment.

This study included a total of 10,999 elderly individuals, with a prevalence of chronic disease multimorbidity of 64.91%. ADL impairment was present in 3,819 individuals (34.72%), Basic Activities of Daily Living (BADL) impairment in 1,149 individuals (10.45%), and Instrumental Activities of Daily Living (IADL) impairment in 3,662 individuals (33.29%). Comparisons of ADL and IADL impairment incidence among elderly individuals with different genders, ages, education levels, marital statuses, residence types, and presence or absence of chronic disease multimorbidity showed statistically significant differences

(P<0.05). Comparisons of BADL impairment incidence among elderly individuals with different genders, ages, education levels, marital statuses, and presence or absence of chronic disease multimorbidity also showed statistically significant differences (P<0.05). A total of 8 association rules were identified through the Apriori algorithm, with the highest support rule being "dyslipidemia and hypertension" (support=8.237%), the highest confidence rule being "dyslipidemia, diabetes or elevated blood glucose and hypertension"(confidence=78.707%), and the highest lift rule being "asthma and chronic lung disease"(lift=4.188). Hypertension appeared most frequently in these multimorbidity combinations. After controlling for confounding factors, binary Logistic regression analysis revealed that the multimorbidity combination of "stroke and hypertension," the combination of "asthma and chronic lung disease," and the combination of "kidney disease, stomach or digestive disease and arthritis or rheumatism" all had significant effects on ADL, BADL, and IADL impairment (P<0.05). Among these, the "stroke and hypertension" combination had the most significant effect on BADL impairment risk, with the risk of having one grade more severe BADL impairment being 4.480 times higher (95%CI=3.754~5.347) than in those without this multimorbidity combination.

Hypertension holds an important central position in multimorbidity among the elderly population and is highly associated with multiple chronic diseases. Various multimorbidity combinations significantly increase the risk of ADL impairment, particularly the "stroke and hypertension" combination. The healthcare system should focus on elderly populations with multimorbidity, develop effective long-term care policies tailored to different multimorbidity combinations, reduce disability risk and delay functional decline, and improve the quality of life for elderly individuals.

Full Text

Study on the Association Between Multiple Chronic Conditions and Impaired Activities of Daily Living in the Elderly

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Abstract

Background: With the acceleration of population aging, there has been a continuous increase in the number of elderly individuals suffering from multiple chronic conditions and impaired activities of daily living (ADL), imposing a substantial healthcare burden on society. While multiple chronic conditions are highly associated with impairment in ADL, the specific mechanisms and combinatorial effects have not been fully elucidated. **Objective:** This study aims to analyze the current status of multiple chronic conditions among the elderly in China and explore the association between different comorbidity combinations and ADL, thereby providing scientific evidence for chronic disease management and functional maintenance in older adults. **Methods:** Utilizing data from the 2018 China Health and Retirement Longitudinal Study (CHARLS), this study focused on individuals aged 60 years and older to compare the prevalence of impaired ADL across demographic subgroups. The Apriori algorithm was employed to perform association rules analysis to identify primary comorbidity combinations. Binary logistic regression models were used to assess the impact of these comorbidity combinations on ADL impairment. **Results:** The study included 10,999 elderly participants, and the prevalence of multiple chronic conditions was 64.91%. 3,819 individuals (34.72%) exhibited ADL impairment, 1,149 (10.45%) demonstrated basic activities of daily living (BADL) impairment, and 3,662 (33.29%) showed instrumental activities of daily living (IADL) impairment. Statistically significant differences ($P<0.05$) in ADL and IADL impairment rates were observed across gender, age, education level, marital status, type of residence, and the presence of multiple chronic conditions. Similarly, BADL impairment rates significantly varied by gender, age, education level, marital status, and the presence of multiple chronic conditions ($P<0.05$). The Apriori algorithm identified 8 association rules, with the highest support rule being "dyslipidemia and hypertension" (support=8.237%), the highest confidence rule being "dyslipidemia, diabetes or high blood sugar and hypertension" (confidence=78.707%), and the highest lift rule being "asthma and chronic pulmonary diseases" (lift=4.188). Hypertension exhibited the highest frequency across all comorbidity combinations. Adjusted binary logistic regression revealed that multiple comorbidity combinations– "stroke and hypertension," "asthma and chronic pulmonary diseases," and "kidney disease, stomach or other digestive diseases, and arthritis or rheumatism" –significantly impacted ADL, BADL, and IADL impairment ($P<0.05$). Notably, the "stroke and hypertension" combination posed the highest risk for BADL impairment; the risk of being one level more severely impaired in BADL for individuals with this comorbidity combination is 4.480 times higher than that of the population without this comorbidity combination (OR=4.480, 95%CI=3.754-5.347). **Conclusion:** Hypertension serves as a central hub in elderly comorbidity networks, demonstrating strong associations with multiple chronic conditions. Multiple comorbidity combinations significantly increase the risk of ADL impairment, with the "stroke and hypertension" combination being the most pronounced. Healthcare systems should prioritize elderly populations with comorbidities, develop effective long-term care policies tailored to different comorbidities, reduce the risk of disability, delay functional decline, and enhance quality of life in elderly population.

[**Key words**] Multiple chronic conditions; Aged; Activities of daily living; Association rules; CHARLS

Introduction

As global population aging accelerates, the number of elderly individuals has increased significantly [1]. Safeguarding the health of older adults represents a crucial component of improving population-wide health outcomes [2]. The phenomenon of multimorbidity, defined as the coexistence of multiple chronic conditions in an individual, is widespread among older adults and has become a major public health concern [3]. Disability refers to impaired or lost physiological functions, restricted daily activities, and reduced self-care ability resulting from various causes—namely, impairment in Activities of Daily Living (ADL) [4]. Compared with their healthy counterparts, disabled elderly individuals experience lower quality of life, which further deteriorates as disability severity increases [5]. Previous research has demonstrated that multimorbidity often adversely affects quality of life and ADL in older adults [6]. However, studies examining the specific effects of different chronic disease combinations on ADL remain relatively scarce. ADL serves as a core indicator for assessing daily functioning and independence in older adults and may be differentially affected by various comorbidity patterns [7]. Therefore, in-depth investigation of the relationship between multimorbidity and ADL is essential for optimizing chronic disease management and developing targeted public health policies to improve quality of life among older adults. This study employs association rule analysis and binary logistic regression analysis to explore the impact of different chronic disease combinations on ADL impairment in older adults, providing scientific evidence for health management in this population.

Methods

1.1 Data Source

This study utilized data from the 2018 China Health and Retirement Longitudinal Study (CHARLS). CHARLS employs a multistage, stratified, probability-proportional-to-size sampling approach to collect high-quality, nationally representative data from households and individuals aged 45 years and older on socioeconomic status, health status, and related domains. The dataset has been widely applied in research on health issues among Chinese older adults [8]. The study was approved by the Peking University Biomedical Ethics Review Committee (approval number: IRB00001052-11015). Our analysis, conducted from August to November 2024, focused on CHARLS 2018 data, selecting participants aged 60 years and older as the study population. After excluding samples with missing information on key variables, we obtained a final sample of 10,999 valid cases.

1.2 Variable Definitions

The 14 chronic conditions selected from CHARLS data include hypertension, dyslipidemia, diabetes or elevated blood glucose, cancer, chronic lung disease, liver disease, heart disease, stroke, kidney disease, stomach or digestive system diseases, emotional and mental health problems, memory-related diseases, arthritis or rheumatism, and asthma. Self-reported disease status was determined based on affirmative responses (“yes” or “no”) to relevant questions in the dataset [9]. Multimorbidity was defined as the simultaneous presence of two or more chronic conditions [10]. Demographic characteristics included gender (male, female), age group (60-64, 65-69, 70-75, $ $75 years), education level (primary school or below, middle/high school, college or above), marital status (married, unmarried), and residence type (urban center, urban-rural integration, rural area, special region). ADL was categorized into Basic Activities of Daily Living (BADL) and Instrumental Activities of Daily Living (IADL). BADL comprises six activities: dressing, bathing, eating, getting out of bed, toileting, and continence control. IADL includes six activities: household chores, cooking, shopping, making phone calls, managing medications, and financial management. Each activity was scored from “no difficulty” to “unable to perform” ; a score $ $2 on any item indicated impairment in that activity. BADL or IADL impairment was defined as having $ $1 impaired item within the respective category, while ADL impairment was defined as impairment in either BADL or IADL [11-12].

1.3 Statistical Analysis

All statistical analyses were performed using R software version 4.4.0. Categorical data were presented as relative frequencies, with between-group comparisons conducted using chi-square tests. Association rule analysis was performed using the arules package for data mining with the Apriori algorithm, and association rules were visualized using the arulesViz package. The Apriori algorithm evaluates rules using three key metrics: support, confidence, and lift [13]. **Support** measures P(AB), the probability of A and B co-occurring in the sample database, reflecting the co-occurrence frequency of A and B. **Confidence** measures P(B|A), the conditional probability of B occurring given A, reflecting the conditional association between A and B. **Lift** measures P(B|A)/P(B), the ratio of the conditional probability of B given A to the unconditional probability of B, indicating how much more likely B is to occur in the presence of A compared with its baseline probability [14]. A lift value >1 indicates a positive correlation between A and B. For rule selection, we set minimum support at 4%, minimum confidence at 70%, and minimum lift at 1 to identify the most significant strong association rules [15-16]. The antecedent and consequent of each association rule were treated as a comorbidity combination and converted into a binary variable, with individuals lacking the complete combination coded as 0 and those possessing all diseases in the combination coded as 1. Binary logistic regression models were used to analyze the impact of these comorbidity

combinations on ADL impairment. Statistical significance was set at P<0.05.

Results

2.1 Participant Characteristics

The study included 10,999 older adults aged 60 years and above, comprising 5,375 males (48.87%) and 5,624 females (51.13%). The mean age was (69.4$±$7.2) years. The majority had primary school education or below (8,283, 75.31%), were married (8,203, 74.58%), and resided in rural areas (8,068, 73.35%). A total of 7,140 participants (64.91%) had multimorbidity. ADL impairment was present in 3,819 individuals (34.72%), BADL impairment in 1,149 (10.45%), and IADL impairment in 3,662 (33.29%).

2.2 Prevalence of ADL Impairment by Participant Characteristics

Statistically significant differences in ADL and IADL impairment rates were observed across gender, age, education level, marital status, residence type, and presence of multimorbidity (all P<0.05). Similarly, BADL impairment rates differed significantly by gender, age, education level, marital status, and presence of multimorbidity (P<0.05). Detailed results are presented in Table 1 .

2.3 Association Rules for Multimorbidity

Apriori algorithm analysis revealed the associations and strength of relationships among chronic conditions. With minimum support set at 4% and minimum confidence at 70%, eight association rules were identified. The rule with highest support was “dyslipidemia, heart disease, and hypertension” (support=8.237%), indicating frequent co-occurrence of these three conditions. The rule with highest confidence was “dyslipidemia, diabetes or elevated blood glucose, and hypertension”(confidence=78.707%), suggesting a high probability of hypertension among individuals with dyslipidemia and diabetes. The rule with highest lift was “asthma and chronic lung disease” (lift=4.188), indicating a substantially increased risk of chronic lung disease among asthma patients. Specifically, 906 participants had coexisting dyslipidemia, heart disease, and hypertension; 804 had stroke and hypertension; and 706 had dyslipidemia, diabetes or elevated blood glucose, and hypertension (see Table 2). Network diagram analysis of association rules revealed that hypertension occupied a central position, appearing in six of the eight rules, demonstrating its frequent co-occurrence with other chronic conditions. Additionally, Rule 1 (“asthma and chronic lung disease”) showed the deepest coloration in the visualization. See Figure 1 [Figure 1: see original paper].

2.4 Association Between Comorbidity Combinations and ADL Impairment

The logistic regression analysis included all 10,999 participants. The presence of ADL, BADL, and IADL impairment served as dependent variables (coded: 0=no, 1=yes), while the eight comorbidity combinations were independent variables (coded: 0=absent, 1=present). Covariates included gender (1=male, 2=female), age group (1=60-64, 2=65-69, 3=70-74, 4=$ $75 years), education level (1=primary or below, 2=middle/high school, 3=college or above), marital status (1=married, 2=unmarried), and residence type (1=urban center, 2=urban-rural integration, 3=rural area, 4=special region). Binary logistic regression models showed that the comorbidity combinations of "stroke and hypertension,""asthma and chronic lung disease," and "kidney disease, stomach or digestive system diseases, and arthritis or rheumatism" significantly impacted ADL, BADL, and IADL impairment (all $P<0.05$). Notably, the "stroke and hypertension" combination exhibited the most pronounced effect on BADL impairment risk, with affected individuals having 4.480 times higher odds of more severe BADL impairment compared with those without this combination (95%CI=3.754-5.347). Detailed results are presented in Table 3 .

Discussion

This study found a multimorbidity prevalence of 64.91% among the elderly population, substantially higher than previous reports. A meta-analysis of multimorbidity prevalence among Chinese mainland residents from 1998-2019 reported a rate of 36.3% [17]. This discrepancy may stem from multiple factors, including China' s rising elderly population proportion, widespread unhealthy lifestyles, uneven distribution of medical resources, and socioeconomic influences. Multimorbidity represents not merely a biological manifestation of aging but rather results from synergistic interactions among chronic inflammatory states, socioeconomic status, mental health, and lifestyle factors [18]. These combined influences may accelerate the clustering effect of chronic diseases, further exacerbating health deterioration in older adults.

Association rule analysis revealed not only high co-occurrence frequencies among chronic conditions but also strong associations between certain disease pairs, as evidenced by high lift and confidence values. The strong association between asthma and chronic lung disease suggests that elderly asthma patients face significantly elevated risk of developing chronic lung disease, likely sharing common pathophysiological mechanisms such as airway inflammatory responses and impaired respiratory function [19]. Furthermore, hypertension occupied a central position in the comorbidity network, consistent with existing epidemiological research [20]. As a risk factor for cardiovascular and metabolic diseases, hypertension frequently coexists with other conditions [21-22]. The strong association between hypertension and dyslipidemia may reflect the cumulative impact of shared lifestyle risk factors such as unhealthy diet and physical inactivity [23]. The close links between hypertension and heart disease or stroke

further underscore the necessity of comprehensive cardiovascular risk management. Additionally, diabetes patients often exhibit metabolic disturbances that increase the probability of developing dyslipidemia and hypertension, warranting enhanced monitoring and intervention for lipids and blood pressure to reduce complication risks [24].

Multimorbidity correlates with ADL impairment, with different comorbidity patterns potentially exerting varying degrees of impact [7]. Griffith et al. [25] emphasized the significant effects of combined physical and mental chronic conditions on ADL, noting these effects differ by age and gender. Ghazali et al. [26] identified ADL impairment as a correlate of multimorbidity in their study of disease prevalence and associated factors among Malaysian older adults. Our findings further validate the differential impacts of various chronic disease combinations on ADL impairment, particularly the "stroke and hypertension" combination. Extensive research has confirmed that both stroke and hypertension independently impair physical function, while their combination exerts particularly pronounced effects. Stroke damages the central nervous system, causing limb weakness, balance disorders, and other functional deficits that increase dependence on others for daily activities [27]. Additionally, stroke may affect cognitive functions including memory, attention, and executive function, directly impacting ADL [28]. Stroke patients may also experience mood disturbances such as depression, frustration, and feelings of defeat, which further compound ADL impairment [29]. Hypertension, as a major risk factor for stroke, not only increases stroke incidence but may also exacerbate burden on the nervous system and other organs through vascular stiffening and occlusion, thereby affecting post-stroke recovery [30]. Therefore, clinical management of elderly patients with both stroke and hypertension should employ dual intervention strategies: intensive post-stroke rehabilitation combined with effective blood pressure control. Adequate rehabilitation resources and appropriate blood pressure management can help reduce ADL impairment risk and improve self-care capacity and quality of life [31].

Additionally, the comorbidity combinations of "asthma and chronic lung disease" and "kidney disease, stomach or digestive system diseases, and arthritis or rheumatism" significantly increased ADL impairment risk. The coexistence of asthma and chronic lung disease may further compromise physical activity capacity in older adults by exacerbating respiratory inflammation and limiting pulmonary function [32]. Meanwhile, the combination of kidney disease, stomach or digestive system diseases, and arthritis or rheumatism may affect ADL through mechanisms involving heightened chronic inflammatory responses, metabolic dysfunction, and restricted joint mobility.

Against the backdrop of accelerated population aging in China, the public health challenges of multimorbidity and ADL impairment among older adults demand comprehensive strategies. First, we recommend incorporating multimorbidity screening into routine elderly health examinations, integrating assessments of blood glucose, lipids, blood pressure, and pulmonary function to enable early

identification and management of multimorbid patients, avoiding treatment conflicts and missed diagnoses stemming from single-disease perspectives. Second, community-based health promotion and chronic disease management programs for older adults should incorporate functional assessments, such as the Short Physical Performance Battery including chair stands and balance tests, to evaluate lower extremity strength and balance for developing targeted rehabilitation plans to prevent falls and functional decline. Additionally, healthcare resources should be integrated to construct comprehensive multimorbidity management models, strengthen chronic disease management and health promotion, facilitate collaborative consultations across specialties, and provide one-stop, precision medical services for older adults while establishing chronic disease archives. Furthermore, public health resource allocation should be optimized with greater investment in elderly chronic disease care, establishment of dedicated research funding, cultivation of geriatric, general practice, and rehabilitation nursing professionals, and improvement of the tiered healthcare system to achieve efficient resource utilization across all levels of medical institutions.

This study utilized association rule analysis to reveal the impact of chronic disease combinations on ADL impairment among Chinese older adults, providing data support for chronic disease management. However, several limitations should be noted. First, chronic disease data relied primarily on self-reported medical histories, which may introduce information bias. Older adults may omit certain conditions due to memory decline, and limited healthcare resources in rural areas may result in lower disease awareness and underestimated multimorbidity rates. Second, the cross-sectional design precludes causal inference. Future research should employ longitudinal designs to further explore causal relationships between multimorbidity and ADL.

In conclusion, against the context of actively addressing population aging, in-depth exploration of the relationship between multimorbidity and ADL among older adults is particularly important. This study identified multiple comorbidity combinations through association rule analysis and revealed their significant associations with ADL impairment. The combinations of "stroke and hypertension," "asthma and chronic lung disease," and "kidney disease, stomach or digestive system diseases, and arthritis or rheumatism" exhibited the most pronounced effects on ADL impairment risk. Chronic disease management should enhance multimorbidity screening, establish comprehensive management models, improve home and community-based elderly care services, optimize medical resource allocation, reduce ADL impairment risk attributable to multimorbidity, delay functional decline, and safeguard quality of life for older adults.

Author Contributions: CHENG Zhuozhuo drafted the manuscript and collected and organized data; ZHANG Rui and HU Jiao performed statistical analysis; PAN Xuanda and XU Haofeng prepared tables and figures; HUANG Junting and LIANG Zijing conceptualized the study and designed the research protocol; YAN Ping revised the final version and takes responsibility for the manuscript.

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