

## RESEARCH ARTICLE

# Association of multimorbidity patterns with motoric cognitive risk syndrome among older adults: Evidence from a China longitudinal study

Feiyang Xiong<sup>1,2</sup> | Yizhong Wang<sup>3</sup> | Jun Zhu<sup>4</sup> | Shixue Li<sup>1,2</sup> | Qiangdong Guan<sup>4</sup> | Zhengyue Jing<sup>4,5</sup>

<sup>1</sup>Centre for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China

<sup>2</sup>NHC Key Lab of Health Economics and Policy Research (Shandong University), Jinan, China

<sup>3</sup>Yangzhou University, Yangzhou, China

<sup>4</sup>School of Public Health, Nanjing Medical University, Nanjing, China

<sup>5</sup>School of Health Policy and Management, Nanjing Medical University, Nanjing, China

## Correspondence

Qiangdong Guan and Zhengyue Jing, Nanjing Medical University, No. 101 Longmian Road, Nanjing 211166, China.  
Email: [gqd@njmu.edu.cn](mailto:gqd@njmu.edu.cn) and [jingzhengyue@njmu.edu.cn](mailto:jingzhengyue@njmu.edu.cn)

## Funding information

National Natural Science Foundation of China, Grant/Award Number: 72304151; The Excellent Innovation Team of the Philosophy and Social Sciences in the Universities and Colleges of Jiangsu Province "The Public Health Policy and Management Innovation Research Team"; Philosophy and Social Science Research Foundation for University of Jiangsu Province, Grant/Award Number: 2022SJYB0296; "Science and Technology Climbing Project" Scientific Research Innovation Project

## Abstract

**Objectives:** Motoric cognitive risk syndrome (MCR), a pre-dementia syndrome, is characterized by slow gait and subjective cognitive complaints among older adults. This study assessed the relationship between multimorbidity, its patterns, and MCR. **Methods:** Data for this study were obtained from three waves (2011, 2013, and 2015) of the China Health and Retirement Longitudinal Study. Participants who were aged 60 years and older and had complete data at baseline as well as complete data about MCR at follow-up were selected. Patients without MCR at baseline were selected for further analyses. Longitudinal associations between multimorbidity, its patterns, and MCR were examined using a Cox proportional hazards model. Multimorbidity patterns were classified using latent class analysis.

**Results:** A total of 4923 respondents were included at baseline, 43.47% of whom had multimorbidity. Additionally, the prevalence of MCR at baseline was 12.61%. After adjusting for covariates, multimorbidity was positively associated with MCR (hazard ratio [HR] = 1.33, 95% confidence interval [CI] = 1.06–1.68). A higher number of multimorbidity was also significantly associated with an increased risk of developing MCR (HR = 1.10, 95% CI = 1.02–1.19). Three multimorbidity patterns were selected: relatively healthy pattern, respiratory pattern, and cardiovascular pattern. Older adults with the cardiovascular pattern were 1.57 times more likely to develop MCR than those with the relatively healthy pattern (HR = 1.57, 95% CI = 1.16–2.13). There was no significant difference between the relatively healthy pattern and the respiratory pattern (HR = 1.31, 95% CI = 0.91–1.92).

**Conclusions:** MCR is highly prevalent among older Chinese adults. MCR may be exacerbated by multimorbidity. For older adults with multimorbidity (especially cardiovascular multimorbidity), attention should be paid to MCR to achieve early detection, diagnosis, and treatment.

## KEYWORDS

cardiovascular multimorbidity, cognitive complaints, motoric cognitive risk syndrome, multimorbidity

### Key points

- Multimorbidity was associated with motoric cognitive risk syndrome.
- The association between different multimorbidity patterns and motoric cognitive risk syndrome varies and cardiovascular multimorbidity deserves more attention.
- Multimorbidity in the elderly should be managed categorically.

## 1 | INTRODUCTION

Motoric cognitive risk syndrome (MCR), which is considered a pre-dementia syndrome, is characterized by slow gait and subjective cognitive complaints among older adults.<sup>1</sup> MCR has been reported to be associated with an increased risk of adverse health outcomes such as dementia, disability, falls, frailty, and all-cause mortality.<sup>1</sup> A multicountry study based on 22 cohorts from 17 countries found that the pooled prevalence of MCR was 9.7%.<sup>2</sup> However, the proportion of vulnerable persons identified by the MCR was 19.6% in China.<sup>3</sup> China has the largest number of dementia patients, accounting for approximately 25% of all dementia patients in the world.<sup>4</sup>

China is facing a tsunami of aging; according to China's seventh national population census, the share of the population aged above 60 and 65 years has increased 18.70% and 13.5%, respectively.<sup>5</sup> By 2050, 365 million people are expected to be over 65 years old, accounting for 26.1% of China's total population.<sup>6</sup> Dementia is one of the leading causes of disability among older people globally, including China.<sup>4</sup> With the increasing elderly population in China, the number of patients with dementia is also expected to increase. In addition, the prevalence of dementia increases with age. China is expected to have nearly half of the world's population with dementia by 2050.<sup>7</sup> Given the lack of effective treatment for dementia, MCR has been considered an effective indicator for preventive treatment or research on dementia, and has been shown to predict incident dementia.<sup>7,8</sup>

Many studies have reported the risk factors associated with MCR. Hypertension, diabetes, and coronary heart disease are the most commonly reported risk factors.<sup>7,9,10</sup> Factors such as stroke, arthritis, and depression have been reported to increase the risk of MCR.<sup>2,11</sup> Most studies have focused on the effect of a specific disease on MCR in older adults. However, multimorbidity is common in older adults. A study based in high-income countries found that the overall prevalence of multimorbidity was 66.1% among older adults (aged  $\geq 65$  years).<sup>12</sup> A nationally representative study in China reported an estimated multimorbidity prevalence of approximately 50% among older adults.<sup>13</sup> Multimorbidity (defined as the presence of two or more chronic diseases) is unavoidable in the older adult population. The effect of multimorbidity on health is evident. In addition, the health impacts of multimorbidity patterns have received increasing attention.

To the best of our knowledge, only a few studies have reported the impact of multimorbidity and its patterns on MCR. This article explored the relationship between multimorbidity, its patterns, and

MCR among older adults using data from a longitudinal study in China.

## 2 | METHODS

### 2.1 | Study design and participants

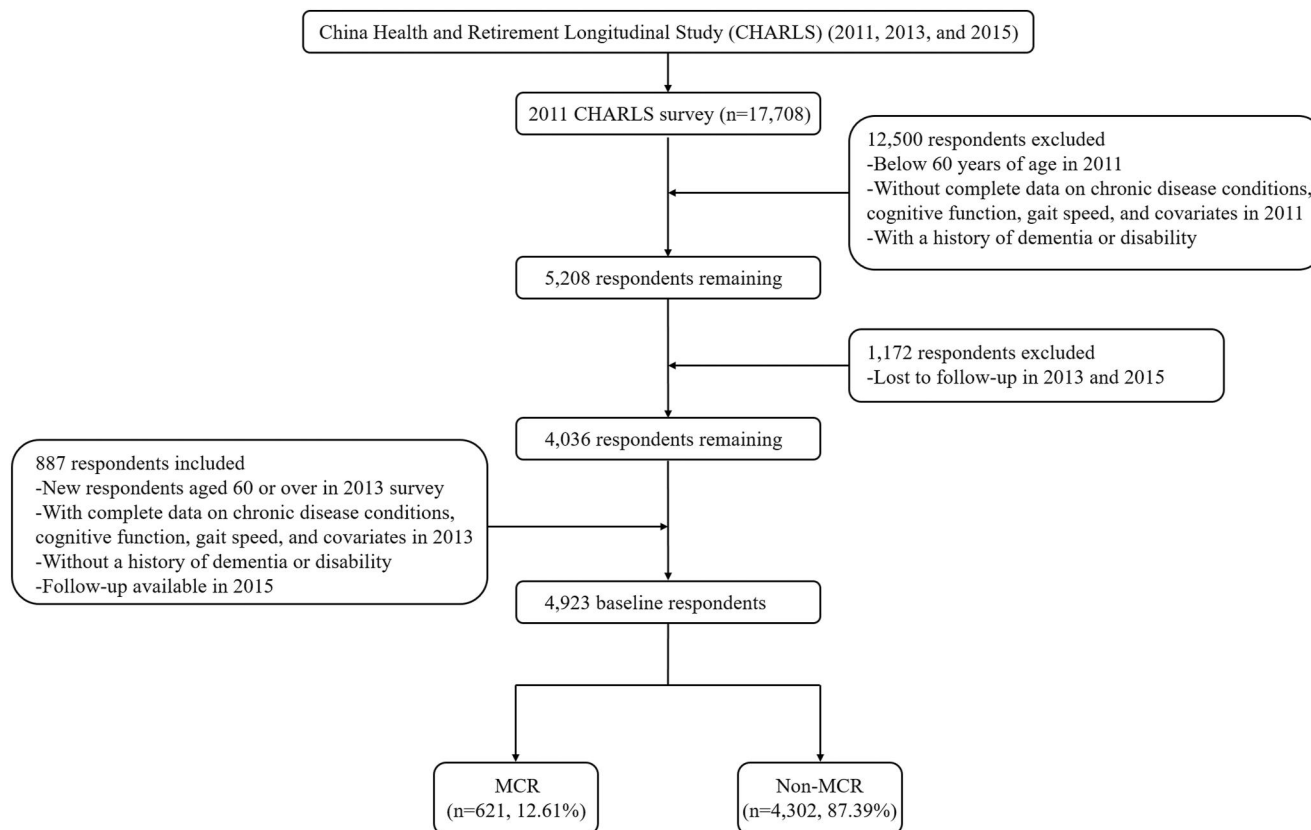
The data for this study originated from three waves (2011, 2013, and 2015) of the China Health and Retirement Longitudinal Study (CHARLS). CHARLS is an ongoing, nationally representative, longitudinal cohort study of middle-aged and older adults in China. CHARLS collects information on middle-aged and older adults in 150 counties and districts nationwide, including basic demographics, household information, health status, health-care, employment, and household economics. Over 17,000 respondents were interviewed in the 2011 survey. These individuals were followed up every 2–3 years through face-to-face computer-assisted personal interviews. More details about the design, recruitment strategy, and sampling approaches of CHARLS have been previously described.<sup>14</sup>

This study included participants aged 60 years and older who had complete data on chronic disease conditions, cognitive function, gait speed, and covariates at baseline, as well as complete data on cognitive function and gait speed at follow-up. Those with a history of dementia or disabilities were also excluded. Dementia status was assessed by the question "Have you been diagnosed with memory-related disease (such as Alzheimer, brain atrophy, Parkinson) by a doctor?" If the answer was "Yes" this was considered as a history of dementia. Disability status was assessed by question "Do you have physical disabilities?" If the answer was "Yes" this was considered as a history of disability. A flowchart of the data selection is shown in Figure 1. Finally, 4923 respondents were included in this study and 4302 respondents without MCR at baseline were selected for further analysis. All participants provided written informed consent. Ethical approval for data collection from human subjects was obtained from local Institutional Review Board.

### 2.2 | Measures and definitions

#### 2.2.1 | MCR

As previously described, MCR was defined as the presence of cognitive complaints and slow gait speed without dementia or impaired mobility. In this study, cognitive complaints were assessed



**FIGURE 1** The flowchart for inclusion of respondents.

through respondents' self-reports: "How would you rate your memory at present?" If the answer was "Fair" or "Poor" this was considered as having cognitive complaints. Gait speed was objectively measured as the average time taken to walk along a straight 2.5 m course twice in an open space approximately 4 m long without a carpet. Slow gait speed was defined as 1.0 standard deviation below the mean values of gait speed, adjusted for sex and age. The specific values of slow gait for different groups are listed in Table S1.

## 2.2.2 | Multimorbidity and its patterns

Multimorbidity was defined as the presence of two or more chronic disease conditions.<sup>15</sup> Chronic disease conditions were investigated by responding to the following question: "Have you been diagnosed with (conditions listed below, read one by one) by a doctor? 1. Hypertension; 2. Dyslipidemia (elevation of low-density lipoprotein, triglycerides (TGs), and total cholesterol, or a low-high density lipoprotein level); 3. Diabetes or high blood sugar levels; 4. Cancer or malignant tumors (excluding minor skin cancers); 5. Chronic lung diseases such as chronic bronchitis and emphysema (excluding tumors or cancer); 6. Liver disease (except fatty liver, tumors, and cancer); 7. Heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems; 8. Stroke; 9. Kidney disease (except for tumors or cancer); 10. Stomach or other digestive

diseases (except for tumors or cancer); 11. Emotional, nervous, or psychiatric problems; 12. Arthritis or rheumatism; 13. Asthma." The number of chronic disease conditions was counted to identify respondents with multimorbidity. The chronic disease conditions of the respondents at baseline were used to classify different multimorbidity patterns using latent class analysis (LCA).<sup>16</sup>

## 2.2.3 | Covariates

The following covariates were included in the analyses: age, sex, drinking (never, occasionally, and often), smoking (yes or no), hukou (household registration system in China) (agriculture, non-agriculture, unified residence, and not have), education (no formal education, middle school and below, and high school and above), marital status (single, and non-single), and savings (have and no).

## 2.3 | Statistical analysis

Descriptive analyses were used to describe the MCR, multimorbidity, and general characteristics of the older adults. Longitudinal associations between multimorbidity, its patterns, and MCR were examined using a Cox proportional hazards model. LCA is a useful tool for identifying groups or subtypes of multivariate categorical data. One

**TABLE 1** General characteristics of Chinese older participants at baseline.

	Total	With MCR	Without MCR
Participants (N/%)	4923 (100.00)	621 (12.61)	4302 (87.39)
Gender (N/%)			
Male	2476 (50.29)	292 (47.02)	2184 (50.77)
Female	2447 (49.71)	329 (52.98)	2118 (49.23)
Age (N ± SD)	66.54 ± 5.98	67.39 ± 5.96	66.42 ± 5.98
Drinking (N/%)			
Never	3326 (67.56)	455 (73.27)	2871 (66.74)
Occasionally	327 (6.64)	42 (6.76)	285 (6.62)
Often	1270 (25.80)	124 (19.97)	1146 (26.64)
Smoking (N/%)			
Yes	2117 (43.00)	253 (40.74)	1864 (43.33)
No	2806 (57.00)	368 (59.26)	2438 (56.67)
Hukou (N/%)			
Agriculture	3961 (80.46)	509 (81.96)	3452 (80.24)
Non-agriculture	921 (18.71)	111 (17.87)	810 (18.83)
Unified residence	40 (0.81)	1 (0.16)	39 (0.91)
Not have	1 (0.02)	0 (0.00)	1 (0.02)
Education (N/%)			
No formal education	1716 (34.86)	248 (39.94)	1468 (34.12)
Middle school and below	2939 (59.70)	352 (56.68)	2587 (60.13)
High school and above	268 (5.44)	21 (3.38)	247 (5.74)
Marital status (N/%)			
Single	852 (17.31)	134 (21.58)	718 (16.69)
Non-single	4071 (82.69)	487 (78.42)	3584 (83.31)
Savings (N/%)			
Have	925 (18.79)	77 (12.40)	848 (19.71)
No	3998 (81.21)	544 (87.60)	3454 (80.29)
Cognitive complaints (N/%)			
Yes	4125 (83.79)	621 (100.00)	3504 (81.45)
No	798 (16.21)	0 (0.00)	798 (18.55)
Slow gait speed (N/%)			
Yes	722 (14.67)	621 (100.00)	101 (2.35)
No	4201 (85.33)	0 (0.00)	4201 (97.65)
Number of diseases (N/%)			
0	1288 (26.16)	143 (23.03)	1145 (26.62)
1	1495 (30.37)	185 (29.79)	1310 (30.45)
2	1068 (21.69)	129 (20.77)	939 (21.83)
3	586 (11.90)	78 (12.56)	508 (11.81)

**TABLE 1** (Continued)

	Total	With MCR	Without MCR
4	283 (5.75)	55 (8.86)	228 (5.30)
≥ 5	203 (4.12)	31 (4.99)	172 (4.00)
Multimorbidity (N/%)			
No	2783 (56.53)	328 (52.82)	2455 (57.07)
Yes	2140 (43.47)	293 (47.18)	1847 (42.93)

to eight classification models were examined to select the best-fit solution on the basis of the evaluation of various model-fit statistics. Stata version 19.0 and Mplus version 7.0 were used for data analysis. The level of statistical significance was set at  $p < 0.05$ .

### 3 | RESULTS

The characteristics of Chinese older participants at baseline included from the CHARLS are shown in Table 1. A total of 4923 respondents were included in this study at baseline, of whom 50.29% were male, 25.80% often drank, 43.00% smoked, 81.21% had no savings, 83.79% had cognitive complaints, 14.67% had slow gait speed, and 43.47% had multimorbidity. A total of 621 respondents (12.61%) at baseline had MCR, of whom 47.02% were male, 19.97% often drank, 40.74% smoked, 87.60% had no savings, and 47.18% had multimorbidity. At the same time, 4302 respondents (87.39%) at baseline were without MCR, of whom 50.77% were male, 26.64% often drank, 43.33% smoked, 80.29% had no savings, and 42.93% had multimorbidity.

#### 3.1 | Association between multimorbidity and MCR in older adults

Associations between multimorbidity and MCR are shown in Table 2. Adjusted for age, sex, drinking, smoking, hukou, education, marital status, and savings, multimorbidity was positively associated with MCR ( $HR = 1.33$ , 95% CI = 1.06–1.68,  $p = 0.015$ ) in older adults. In addition to this, a higher number of multimorbidity was also significantly associated with an increased risk of developing MCR ( $HR = 1.10$ , 95% CI = 1.02–1.19,  $p = 0.012$ ) after adjustment, as shown in Table S2.

#### 3.2 | Association between multimorbidity patterns and MCR in older adults

Three multimorbidity classification patterns were selected according to the fitting statistical parameters of the various models, as shown in Table S3. The three multimorbidity patterns were defined as relatively healthy pattern, respiratory pattern, and cardiovascular pattern. The proportions of the sample were 76.62%, 8.83%, and

**TABLE 2** Association between multimorbidity and MCR in Chinese older adults.

Characteristics	Hazard ratio (95% CI)	p value
Multimorbidity		
No	1.00	
Yes	1.33 (1.06–1.68)	0.015
Age	1.06 (1.04–1.08)	<0.001
Gender		
Male	1.00	
Female	0.83 (0.60–1.16)	0.268
Drinking		
Never	1.00	
Occasionally	1.30 (0.83–2.03)	0.257
Often	0.73 (0.53–1.00)	0.052
Smoking		
Yes	1.00	
No	1.07 (0.79–1.46)	0.649
Hukou		
Agriculture	1.00	
Non-agriculture	0.91 (0.65–1.28)	0.596
Unified residence	0.50 (0.07–3.58)	0.491
Not have	-	-
Education (N/%)		
No formal education	1.00	
Middle school and below	0.78 (0.60–1.03)	0.076
High school and above	0.56 (0.28–1.13)	0.106
Marital status		
Single	1.00	
Non-single	1.34 (0.97–1.85)	0.074
Savings		
Have	1.00	
No	1.66 (1.15–2.40)	0.007

14.55% for the relatively healthy, respiratory, and cardiovascular pattern, respectively. The prevalence of each disease in each pattern is shown in Figure 2. In the relatively healthy pattern, the prevalence of each disease was relatively low; in the respiratory pattern, the prevalence of lung disease was the highest at 60.7%; and in the cardiovascular pattern, the diseases with relatively high prevalence were hypertension, dyslipidemia, and heart attack, at 74.2%, 39.9%, and 41.0%, respectively. The associations between multimorbidity patterns and MCR are presented in Table 3. Adjusted for age, sex, drinking, smoking, hukou, education, marital status, and deposit, older adults with the cardiovascular pattern were 1.57 times more likely to develop MCR compared to those with the relatively healthy pattern (HR = 1.57, 95% CI = 1.16–2.13,  $p = 0.004$ ). There was no

significant difference between the relatively healthy and respiratory pattern (HR = 1.31, 95% CI = 0.91–1.92,  $p = 0.149$ ).

## 4 | DISCUSSION

In this study, more than 12% of older adults had MCR. An earlier study reported that the pooled prevalence of MCR in multiple countries was no greater than 10%.<sup>2</sup> Another 2019 study reported an MCR prevalence of approximately 8.0% in Europe, 7.0% in the United States, and 6.3% in Japan.<sup>17</sup> Several recent studies have reported that the prevalence of MCR is more than 12% in China.<sup>18,19</sup> China has become one of the countries with a high prevalence of MCR. In theory, the MCR is designed to capture early signals of cognitive complaints or functional decline that occur years before the end of life.<sup>3</sup> Within 2 years of MCR diagnosis, the mortality risk was prominent and comparable to the risk of moderate-to-severe cognitive loss and pre-dementia.<sup>20–22</sup> MCR has also been shown in numerous studies to be a good predictor of dementia and is superior to slow gait speed alone or cognitive complaints alone.<sup>2,23</sup>

The financial strain and burden of dementia on society and families cannot be overstated. However, there are currently no efficient medicines or methods for the treatment of dementia. Therefore, early identification of and intervention for dementia have become top priorities. Interestingly, MCR has received increasing attention as a well-known pre-dementia syndrome. Many factors affect MCR, and multimorbidity is receiving increasing attention as a common problem among older adults. In this study, older adults with multimorbidity had a 33% increased risk of developing MCR compared with those without multimorbidity. Few studies have directly reported the relationship between multimorbidity and MCR. A multi-ethnic study in western China also found that multimorbidity was a positively associated risk factor for MCR in middle-aged and older adults.<sup>24</sup> Another Mexican Health and Aging Study 2012–2015 expounded that MCR in older adults was associated with multimorbidity.<sup>10</sup> However, a study on community-dwelling older adults did not find a significant association between multimorbidity and MCR. A significantly higher prevalence of multimorbidity was found in older adults with slow gait alone, and the number of chronic diseases was significantly associated with slow gait.<sup>25</sup> Additionally, multimorbidity can accelerate cognitive decline in individuals with underlying dementia.<sup>26</sup> Interestingly, multimorbidity is particularly relevant to older adults, and the number of morbidities and prevalence of multimorbidity increase substantially with age.<sup>27</sup> In this study, the prevalence of multimorbidity in older adults was more than 40%. Multimorbidity has been shown to increase the risk of functional decline, decrease quality of life, increase healthcare use, and increase mortality.<sup>28</sup> A higher number of multimorbidity was also significantly associated with an increased risk of developing MCR, suggesting that chronic diseases may have a cumulative effect on the development of MCR.

The impact of the number of diseases an older adult has is well known. It has been shown that as the number of non-communicable

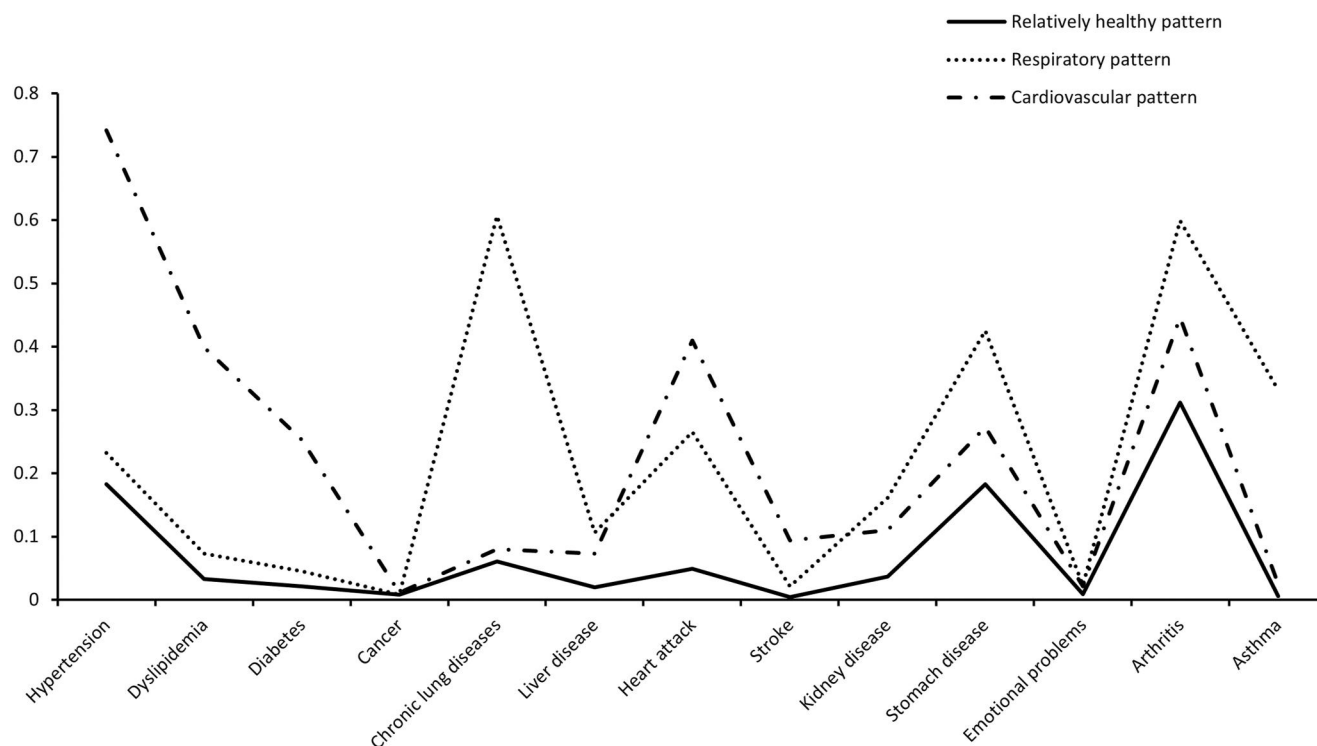


FIGURE 2 Prevalence of each disease in three multimorbidity patterns.

diseases increased, the health-related quality of life of older adults deteriorated.<sup>29</sup> Disease patterns in older adults are worthy of attention.<sup>30</sup> Different multimorbidity patterns have been found to have different effects on self-rated health, catastrophic health expenditures, risk of frailty, and 5-year mortality in older adults.<sup>31–34</sup> In this study, multimorbidity was divided into three patterns: relatively healthy pattern, respiratory pattern, and cardiovascular pattern. Older adults with the cardiovascular pattern were found to have a 57% higher risk of MCR than those with the relatively healthy pattern. Previous studies have also demonstrated that cardiovascular diseases such as diabetes mellitus, hypertension, and stroke can significantly increase the risk of developing MCR in older adults.<sup>9,35,36</sup> Interestingly, a 12-year follow-up cohort study of older adults found that comorbid diabetes and heart disease doubled the risk of developing cognitive impairment-no dementia and dementia.<sup>37</sup> Another longitudinal study on cognitive aging conducted at the University of North Texas Health Science Center demonstrated that comorbid cardiovascular risk factors increased the degree of cognitive deficits in many areas.<sup>38</sup> In addition, a 9-year Swiss cohort study reported that the rate of decline in older adults with cardiovascular multimorbidity was significantly higher at walking speed.<sup>39</sup> Gait and cognitive performance are closely associated with cardiovascular multimorbidity. The association between cardiovascular multimorbidity and MCR cannot be ignored and warrants further research.

However, its pathogenesis remains unclear. Because MCR combines cognitive and gait conditions, it has been proposed that the brain regions that control both of these conditions are associated with MCR. The pathological basis of MCR has been reported to be

associated with white matter hyperintensity, frontal lacunar infarcts, and gray matter atrophy in the pre-motor and pre-frontal cortex.<sup>20,36</sup> Chronic conditions of multiple diseases (especially cardiovascular diseases) have been confirmed to be related to all these pathologies, and the accumulation of chronic disease conditions may exacerbate them.<sup>20,40</sup> Additionally, inflammatory responses have been reported to be the pathological basis of MCR.<sup>20,41,42</sup> Derangements in pro-inflammatory cytokines in older adults have been linked to multimorbidity.<sup>41,43,44</sup>

MCR recovery is also gained increasing attention. Physical activity and executive function are considered the two main directions for recovery from MCR. Exercise and an energetic lifestyle can improve the health of older adults by reducing hypertension, peripheral artery disease, and abnormal cerebral blood flow.<sup>20,45</sup> Additionally, physical activity normalizes blood glucose levels, thereby improving memory function. Executive functions involve a range of cognitive operations, including acquisition, storage, interpretation, and understanding, together with information from the primary somatosensory areas in the ventral dorsal brain region, which has a key influence on gait and mobility.<sup>46</sup> Moreover, some cognitive enhancers have been shown to improve memory loss and dementia as well as gait, motor dysfunction, and falls.<sup>47,48</sup>

This study has several limitations. First, the main variables of this study, such as cognitive complaint and multimorbidity, were assessed by relying on participants' self-reports, which may have led to recall bias. Second, although some covariates were considered in the analysis of the association between multimorbidity, its patterns, and MCR, other confounding factors may have been missed. Finally, a



**TABLE 3** Association between multimorbidity patterns and MCR in Chinese older adults.

Characteristics	Hazard ratio (95% CI)	p value
Multimorbidity pattern		
Relatively healthy pattern	1.00	
Respiratory pattern	1.31 (0.91–1.92)	0.149
Cardiovascular pattern	1.57 (1.16–2.13)	0.004
Age	1.06 (1.04–1.08)	<0.001
Gender		
Male	1.00	
Female	0.83 (0.60–1.16)	0.269
Drinking		
Never	1.00	
Occasionally	1.30 (0.83–2.04)	0.247
Often	0.73 (0.53–0.99)	0.046
Smoking		
Yes	1.00	
No	1.06 (0.78–1.44)	0.702
Hukou		
Agriculture	1.00	
Non-agriculture	0.88 (0.62–1.24)	0.451
Unified residence	0.49 (0.07–3.48)	0.473
Not have	-	-
Education (N/%)		
No formal education	1.00	
Middle school and below	0.78 (0.60–1.02)	0.071
High school and above	0.54 (0.27–1.10)	0.091
Marital status		
Single	1.00	
Non-single	1.34 (0.97–1.85)	0.074
Savings		
Have	1.00	
No	1.66 (1.15–2.40)	0.007

selection bias may have existed in the analysis of the association between multimorbidity patterns and MCR, given that individuals who did not complete the survey in all three waves were excluded.

## 5 | CONCLUSION

With China facing an aging tsunami, the burden of dementia and related diseases is escalating. MCR, a pre-dementia syndrome, is highly prevalent in older Chinese adults. MCR may be exacerbated by multimorbidity. For older adults with multimorbidity (especially

cardiovascular multimorbidity), attention should be paid to achieve early detection, diagnosis, and treatment of MCR. Further longitudinal studies are needed to explore the risk factors for MCR and develop effective interventions.

## ACKNOWLEDGMENTS

We would like to thank all participants, researchers and staff of China Health and Retirement Longitudinal Study for their contributions to this important study. This work was supported by the Philosophy and Social Science Research Foundation for University of Jiangsu Province (No. 2022SJYB0296); National Natural Science Foundation of China (No. 72304151); "Science and Technology Climbing Project" Scientific Research Innovation Project; and The Excellent Innovation Team of the Philosophy and Social Sciences in the Universities and Colleges of Jiangsu Province "The Public Health Policy and Management Innovation Research Team."

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data are publicly available on the China Health and Retirement Longitudinal Study website.

## REFERENCES

- Bai A, Xu W, Lin Z. Prevalence and correlates of motoric cognitive risk syndrome in Chinese community-dwelling older adults. *Front Aging*. 2022;3:895138. <https://doi.org/10.3389/fragi.2022.895138>
- Vergheze J, Annweiler C, Ayers E, et al. Motoric cognitive risk syndrome: multicountry prevalence and dementia risk. *Neurology*. 2014;83(8):718–726. <https://doi.org/10.1212/wnl.0000000000000717>
- Cao X, Chen C, Zhang J, et al. Aging metrics incorporating cognitive and physical function capture mortality risk: results from two prospective cohort studies. *BMC Geriatr*. 2022;22(1):378. <https://doi.org/10.1186/s12877-022-02913-y>
- Jia L, Quan M, Fu Y, et al. Dementia in China: epidemiology, clinical management, and research advances. *Lancet Neurol*. 2020;19(1):81–92. [https://doi.org/10.1016/s1474-4422\(19\)30290-x](https://doi.org/10.1016/s1474-4422(19)30290-x)
- Tu WJ, Zeng X, Liu Q. Aging tsunami coming: the main finding from China's seventh national population census. *Aging Clin Exp Res*. 2022;34(5):1159–1163. <https://doi.org/10.1007/s40520-021-02017-4>
- Fang EF, Xie C, Schenkel JA, et al. A research agenda for ageing in China in the 21st century (2nd edition): focusing on basic and translational research, long-term care, policy and social networks. *Ageing Res Rev*. 2020;64:101174. <https://doi.org/10.1016/j.arr.2020.101174>
- Chhetri JK, Han C, Dan X, Ma L, Chan P. Motoric cognitive risk syndrome in a Chinese older adult population: prevalence and associated factors. *J Am Med Dir Assoc*. 2020;21(1):136–137. <https://doi.org/10.1016/j.jamda.2019.08.007>
- Chhetri JK, Chan P, Vellas B, Cesari M. Motoric cognitive risk syndrome: predictor of dementia and age-related negative outcomes. *Front Med*. 2017;4:166. <https://doi.org/10.3389/fmed.2017.00166>
- Beauchet O, Sekhon H, Barden J, et al. Association of motoric cognitive risk syndrome with cardiovascular disease and risk factors: results from an original study and meta-analysis. *J Alzheimers Dis*. 2018;64(3):875–887. <https://doi.org/10.3233/jad-180203>

10. Aguilar-Navarro SG, Mimenza-Alvarado AJ, Aguilar-Esquivel JE, Yeverino-Castro SG, Juarez-Cedillo T, Mejia-Arango S. Motoric cognitive risk syndrome: prevalence and risk of cognitive impairment in a population studied in the Mexican health and aging study 2012-2015. *J Nutr Health Aging*. 2019;23(3):227-231. <https://doi.org/10.1007/s12603-019-1160-7>
11. Doi T, Verghese J, Shimada H, et al. Motoric cognitive risk syndrome: prevalence and risk factors in Japanese seniors. *J Am Med Dir Assoc*. 2015;16(12):1103.e21-1103.e25. <https://doi.org/10.1016/j.jamda.2015.09.003>
12. Ofori-Asenso R, Chin KL, Curtis AJ, Zomer E, Zoungas S, Liew D. Recent patterns of multimorbidity among older adults in high-income countries. *Popul Health Manag*. 2019;22(2):127-137. <https://doi.org/10.1089/pop.2018.0069>
13. Guo X, Zhao B, Chen T, Hao B, Yang T, Xu H. Multimorbidity in the elderly in China based on the China health and retirement longitudinal study. *PLoS One*. 2021;16(8):e0255908. <https://doi.org/10.1371/journal.pone.0255908>
14. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G. Cohort profile: the China health and retirement longitudinal study (CHARLS). *Int J Epidemiol*. 2014;43(1):61-68. <https://doi.org/10.1093/ije/dys203>
15. Wang Z, Zeng Z. Effects of multimorbidity patterns and socioeconomic status on catastrophic health expenditure of widowed older adults in China. *Front Public Health*. 2023;11:1188248. <https://doi.org/10.3389/fpubh.2023.1188248>
16. Zhang Q, Han X, Zhao X, Wang Y. Multimorbidity patterns and associated factors in older Chinese: results from the China health and retirement longitudinal study. *BMC Geriatr*. 2022;22(1):470. <https://doi.org/10.1186/s12877-022-03154-9>
17. Maggio M, Lauretani F. Prevalence, incidence, and clinical impact of cognitive-motoric risk syndrome in Europe, USA, and Japan: facts and numbers update 2019. *J Cachexia Sarcopenia Muscle*. 2019;10(5):953-955. <https://doi.org/10.1002/jcsm.12476>
18. Zhang L, Feng BL, Wang CY, et al. Prevalence and factors associated with motoric cognitive risk syndrome in community-dwelling older Chinese: a cross-sectional study. *Eur J Neurol*. 2020;27(7):1137-1145. <https://doi.org/10.1111/ene.14266>
19. Bai A, Bai W, Ju H, Xu W, Lin Z. Motoric cognitive risk syndrome as a predictor of incident disability: a 7 year follow-up study. *Front Aging Neurosci*. 2022;14:972843. <https://doi.org/10.3389/fnagi.2022.972843>
20. Xiang K, Liu Y, Sun L. Motoric cognitive risk syndrome: symptoms, pathology, diagnosis, and recovery. *Front Aging Neurosci*. 2021;13:728799. <https://doi.org/10.3389/fnagi.2021.728799>
21. Wilson RS, Aggarwal NT, Barnes LL, Bienias JL, Mendes de Leon CF, Evans DA. Biracial population study of mortality in mild cognitive impairment and Alzheimer disease. *Arch Neurol*. 2009;66(6):767-772. <https://doi.org/10.1001/archneurol.2009.80>
22. Park JE, Lee JY, Suh GH, Kim BS, Cho MJ. Mortality rates and predictors in community-dwelling elderly individuals with cognitive impairment: an eight-year follow-up after initial assessment. *Int Psychogeriatr*. 2014;26(8):1295-1304. <https://doi.org/10.1017/s1041610214000556>
23. Semba RD, Tian Q, Carlson MC, Xue QL, Ferrucci L. Motoric cognitive risk syndrome: integration of two early harbingers of dementia in older adults. *Ageing Res Rev*. 2020;58:101022. <https://doi.org/10.1016/j.arr.2020.101022>
24. Sun X, Harris KE, Hou L, et al. The prevalence and associated factors of motoric cognitive risk syndrome in multiple ethnic middle-aged to older adults in west China: a cross-sectional study. *Eur J Neurol*. 2022;29(5):1354-1365. <https://doi.org/10.1111/ene.15255>
25. Merchant RA, Goh J, Chan YH, Lim JY, Vellas B. Slow gait, subjective cognitive decline and motoric cognitive RISK syndrome: prevalence and associated factors in community dwelling older adults. *J Nutr Health Aging*. 2021;25(1):48-56. <https://doi.org/10.1007/s12603-020-1525-y>
26. Melis RJ, Marengoni A, Rizzuto D, et al. The influence of multimorbidity on clinical progression of dementia in a population-based cohort. *PLoS One*. 2013;8(12):e84014. <https://doi.org/10.1371/journal.pone.0084014>
27. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet*. 2012;380(9836):37-43. [https://doi.org/10.1016/s0140-6736\(12\)60240-2](https://doi.org/10.1016/s0140-6736(12)60240-2)
28. Yarnall AJ, Sayer AA, Clegg A, Rockwood K, Parker S, Hindle JV. New horizons in multimorbidity in older adults. *Age Ageing*. 2017;46(6):882-888. <https://doi.org/10.1093/ageing/afx150>
29. Liu J, Yu W, Zhou J, Yang Y, Chen S, Wu S. Relationship between the number of noncommunicable diseases and health-related quality of life in Chinese older adults: a cross-sectional survey. *Int J Environ Res Publ Health*. 2020;17(14):5150. <https://doi.org/10.3390/ijerph17145150>
30. Chen Y, Shi L, Zheng X, et al. Patterns and determinants of multimorbidity in older adults: study in health-ecological perspective. *Int J Environ Res Publ Health*. 2022;19(24):16756. <https://doi.org/10.3390/ijerph192416756>
31. Zhai X, Zhang Q, Li X, Zhao X. Association between multimorbidity patterns and catastrophic health expenditure among Chinese older adults living alone. *Arch Gerontol Geriatr*. 2023;106:104892. <https://doi.org/10.1016/j.archger.2022.104892>
32. Honda Y, Nakamura M, Aoki T, Ojima T. Multimorbidity patterns and the relation to self-rated health among older Japanese people: a nationwide cross-sectional study. *BMJ Open*. 2022;12(9):e063729. <https://doi.org/10.1136/bmjopen-2022-063729>
33. Vetrano DL, Damiano C, Tazzeo C, et al. Multimorbidity patterns and 5-year mortality in institutionalized older adults. *J Am Med Dir Assoc*. 2022;23(8):1389-1395. e1384. <https://doi.org/10.1016/j.jamda.2022.01.067>
34. Tazzeo C, Rizzuto D, Calderon-Larranaga A, et al. Multimorbidity patterns and risk of frailty in older community-dwelling adults: a population-based cohort study. *Age Ageing*. 2021;50(6):2183-2191. <https://doi.org/10.1093/ageing/afab138>
35. Verghese J, Ayers E, Barzilai N, et al. Motoric cognitive risk syndrome: multicenter incidence study. *Neurology*. 2014;83(24):2278-2284. <https://doi.org/10.1212/wnl.0000000000001084>
36. Meiner Z, Ayers E, Verghese J. Motoric cognitive risk syndrome: a risk factor for cognitive impairment and dementia in different populations. *Ann Geriatr Med Res*. 2020;24(1):3-14. <https://doi.org/10.4235/agmr.20.0001>
37. Dove A, Shang Y, Xu W, et al. The impact of diabetes on cognitive impairment and its progression to dementia. *Alzheim Dement*. 2021;17(11):1769-1778. <https://doi.org/10.1002/alz.12482>
38. Vintimilla R, Balasubramanian K, Hall J, Johnson L, O'Bryant S. Cardiovascular risk factors, cognitive dysfunction, and mild cognitive impairment. *Dement Geriatr Cogn Dis Extra*. 2020;10(3):154-162. <https://doi.org/10.1159/000511103>
39. Vetrano DL, Rizzuto D, Calderon-Larranaga A, et al. Trajectories of functional decline in older adults with neuropsychiatric and cardiovascular multimorbidity: a Swedish cohort study. *PLoS Med*. 2018;15(3):e1002503. <https://doi.org/10.1371/journal.pmed.1002503>
40. Lau H, Mat Ludin AF, Shahar S, Badrasawi M, Clark BC. Factors associated with motoric cognitive risk syndrome among low-income older adults in Malaysia. *BMC Publ Health*. 2019;19(Suppl 4):462. <https://doi.org/10.1186/s12889-019-6869-z>
41. Groeger JL, Ayers E, Barzilai N, et al. Inflammatory biomarkers and motoric cognitive risk syndrome: multicohort survey. *Cereb Circ Cogn Behav*. 2022;3:100151. <https://doi.org/10.1016/j.cccb.2022.100151>



42. Sathyan S, Barzilai N, Atzmon G, Milman S, Ayers E, Verghese J. Association of anti-inflammatory cytokine IL10 polymorphisms with motoric cognitive risk syndrome in an Ashkenazi Jewish population. *Neurobiol Aging*. 2017;58:238.e1-238.e8. <https://doi.org/10.1016/j.neurobiolaging.2017.06.006>
43. Boudoulas KD, Triposkiadis F, Gumina R, Addison D, Iliescu C, Boudoulas H. Cardiovascular disease, cancer, and multimorbidity interactions: clinical implications. *Cardiology*. 2022;147(2):196-206. <https://doi.org/10.1159/000521680>
44. Viasus D, Simonetti AF, Estupinan-Bohorquez AF, Carratala J. Effects of age and comorbidities on serum levels of inflammatory markers in community-acquired pneumonia. *Eur J Clin Invest*. 2021;51(6):e13480. <https://doi.org/10.1111/eci.13480>
45. Cavalcante BR, Germano-Soares AH, Gerage AM, et al. Association between physical activity and walking capacity with cognitive function in peripheral artery disease patients. *Eur J Vasc Endovasc Surg*. 2018;55(5):672-678. <https://doi.org/10.1016/j.ejvs.2018.02.010>
46. Demnitz N, Zsoldos E, Mahmood A, et al. Associations between mobility, cognition, and brain structure in healthy older adults. *Front Aging Neurosci*. 2017;9:155. <https://doi.org/10.3389/fnagi.2017.00155>
47. Tripathi PN, Srivastava P, Sharma P, et al. Biphenyl-3-oxo-1,2,4-triazine linked piperazine derivatives as potential cholinesterase

inhibitors with anti-oxidant property to improve the learning and memory. *Bioorg Chem*. 2019;85:82-96. <https://doi.org/10.1016/j.bioorg.2018.12.017>

48. Beauchet O, Launay CP, Allali G, Annweiler C. Changes in gait variability with anti-dementia drugs: a systematic review and meta-analysis. *CNS Drugs*. 2014;28(6):513-518. <https://doi.org/10.1007/s40263-014-0170-6>

## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**How to cite this article:** Xiong F, Wang Y, Zhu J, Li S, Guan Q, Jing Z. Association of multimorbidity patterns with motoric cognitive risk syndrome among older adults: evidence from a China longitudinal study. *Int J Geriatr Psychiatry*. 2023;e6021. <https://doi.org/10.1002/gps.6021>