

Trajectories of depressive symptoms and chronic disease multimorbidity among middle-aged and older Chinese adults: A group-based trajectory modeling study

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Abstract

Background

The co-occurrence of depressive symptoms and chronic diseases among middle-aged and older adults is increasingly prevalent, yet their longitudinal co-developmental patterns have rarely been examined jointly.

Objective

To identify distinct depressive symptom trajectories among middle-aged and older Chinese adults and examine prevalence patterns of chronic disease comorbidity and associated factors across trajectory groups.

Method

Using four waves of China Health and Retirement Longitudinal Study (CHARLS) data (2011–2018), 6,636 participants aged ≥ 45 years at baseline who completed at least two follow-up assessments were included. Group-based trajectory modeling (GBTM) was applied to CES-D10 scores. Optimal model selection was based on BIC values, average posterior probabilities, minimum group proportions, and clinical interpretability. Multivariable logistic regression identified factors associated with trajectory group membership.

Result

Three stable trajectories were identified: low-depressive-symptom (41.88%, $n = 2,778$), moderate-depressive-symptom (47.68%, $n = 3,191$), and high-depressive-symptom (10.44%, $n = 667$) groups, all exhibiting stable trajectories over the 7-year follow-up period. Prevalence rates of all 14 chronic diseases showed a monotonically increasing gradient from the low to high group (all $P < 0.05$, except Parkinson's disease), with arthritis (from 22.4% to 55.5%), lung disease (from 2.6% to 10.0%), and osteoporosis (from 2.8% to 10.2%) demonstrating the steepest prevalence gradients. Female sex, older age, lower education, and unmarried status all increased progressively with trajectory severity.

Conclusion

Depressive symptom trajectories in Chinese middle-aged and older adults are heterogeneous but stable. Chronic disease comorbidity burden shows a full-spectrum gradient association with depression severity. Integrated physical–mental screening and care should be prioritized for individuals with chronic pain, respiratory disease, and multiple comorbidities.

1. Introduction

The global burden of disease attributed to mental health conditions has reached critical proportions, with recent WHO reports estimating that over 1.1 billion people worldwide live with psychiatric morbidity. Depression is one of the most prevalent psychiatric disorders worldwide, affecting individuals across all age groups(1, 2). Its main symptoms are depressed emotions, declining interest, slowed thinking, sleep and eating disorders, and even suicidal thoughts in severe cases(3–5). Mental disorders accounted for 654.8 million estimated cases in 1990 and 970.1 million cases in 2019, corresponding to an increase of 48.1% between 1990 and 2019 (6). Depressive disorders emerged as a major contributor to the global disability burden across all populations. The 2016 Global Burden of Disease Study report stated that over 34 million disability-adjusted life years (DALYs) across all ages were attributed to depression(7). According to the 2021 Global Burden of Disease Study (GBD), non-communicable diseases (NCDs), depressive disorders caused 56.3 million years lived with disability (YLDs) in 2021, the age-standardized Disability-Adjusted Life Years (DALYs) rate for depression increased by 16.4% between 2010 and 2021, indicating a continuing rise in its disease burden(8). The World Health Organization (WHO) estimates that approximately 350 million people worldwide are affected by depression, and this number continues to climb. It is projected that by 2030, depression will become the leading cause of the global disease burden(9).

Meanwhile, global population aging is accelerating as life expectancy increases and fertility rates decline. The highest projected life expectancy beyond 90 years(10). The number of people aged 60 years and older is projected to more than double, from 901 million in 2015 to over 2.1 billion by 2050(11). With the acceleration of population aging, the problem of “aging before health care” has become increasingly prominent. There is a great impact on social and economic development, healthcare delivery and disease epidemic patterns(12). Depression is one of the common mental health problems in older adults. The World Health Organization reported that depression affects about 7% of older people worldwide(13). According to data from the China Health and Retirement Longitudinal Study 2020 (CHARLS), 34.1% of these individuals report experiencing depressive symptoms(14). It not only seriously impairs an individual's quality of life and social functioning, but is also closely associated with all-cause mortality, cognitive decline, and disability progression, suicide increasing(15). Affecting the quality of life of millions of older adults and brings long-term medical and care burdens to families and society, causing huge pressure(16).

Alongside the rising burden of depression, chronic diseases pose a major challenge for global public health, accounting for approximately 41 million deaths annually and representing 74% of all deaths worldwide(17). More than 60% of patients present with multiple chronic conditions simultaneously(18). For example, Cardiovascular disease (CVD) is highly prevalent and commonly co-occurs with chronic liver disease, chronic kidney disease, and diabetes in middle-aged and older adults.

The relationship between depression and chronic physical illness is bidirectional and complex. On the one hand, patients with depression are more prone to develop various chronic physical diseases(19),

which is related to their unhealthy lifestyles (lack of physical activity, smoking, poor treatment compliance) as well as neurobiological mechanisms such as hypothalamic-pituitary-adrenal axis dysfunction and chronic inflammation(20). On the other hand, patients with chronic diseases have a significantly increased risk of depression due to long-term stress such as pain, functional limitations, and loss of social roles(21, 22).The participants with chronic diseases were at higher risk of depression, and the risk was directly proportional to the number of chronic diseases(23).Patients with depression often present with various metabolic disturbances and have a significantly higher risk of cardiovascular diseases, type 2 diabetes, obesity, and dyslipidemia compared to the general population(24).The two often coexist simultaneously, forming a vicious cycle of "depression-somatocomorbidity".Some studies have already provided preliminary evidence that the mechanistic pathways responsible for the comorbidity between chronic illness and depression are multifactorial, complex and bidirectional, since they involve biological, psychological, socioeconomic and biobehavioral mechanistic systems(25).

However, most of the existing studies on depression and comorbidity of chronic diseases in middle-aged and older adults are cross-sectional designs, which can only reveal the correlation between the two at a certain time point. It is almost impossible to capture its dynamic change pattern over time(19).Meanwhile a few longitudinal studies have focused on the overall changing trend of depressive symptoms, they usually use linear mixed models to estimate the changes in the population mean, masking the significant heterogeneity of development patterns among individuals(23).

Therefore, the aim of this study is: (1) To identify the development trajectory of depressive symptoms among middle-aged and older adults in China; (2) Compare the distribution differences and demographic characteristics of comorbidity of 14 chronic diseases among different trajectory groups.

2. Material and Methods

2.1 Data sources and study populations

Data for this study were obtained from the China Health and Retirement Longitudinal Study (CHARLS). CHARLS is a nationally representative longitudinal cohort study of Chinese adults aged 45 years and older. A baseline survey was conducted in 2011, using multi-stage stratified cluster sampling, covering 28 provinces, 150 counties/districts, and 450 villages/communities across the country. Three rounds of follow-up were carried out in 2013, 2015, and 2018(26). The CHARLS study has been approved by the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015), and all participants have signed written informed consent forms. The inclusion criteria for this study are: (1) Baseline age $\geq$ 45 years; (2) Participated in at least two waves of depressive symptom assessment (in 2011, 2013, 2015, and 2018); (3) The baseline demographic information (age, gender, education, marital status) and chronic disease data are complete. A total of 6,636 research subjects were ultimately included.

2.2 Assessment of depressive symptoms

Depressive symptoms were measured using the Center for Epidemiological Investigation Depression Scale Short Version (CES-D10). The scale comprises 10 items, including eight items assessing negative affect and two items assessing positive affect. Each item is scored on a scale of 0 to 3 points (positive items are scored in reverse), with a total score range of 0 to 30 points. The higher the score, the more severe the depressive symptoms(27, 28). CES-D10 has good reliability and validity in the middle-aged and older adults in China. A score of ≥ 12 has been commonly used as the cut-off for clinically significant depressive symptoms in prior studies(29).

2.3 Chronic disease assessment

Chronic diseases can be self-reported by asking the following question: "Has any doctor told you that you have any of the following diseases?" This study included 14 common chronic physical diseases: (1) arthritis; (2) Angina pectoris (3) Asthma; (4) Cancer; (5) Alzheimer's disease and related dementias; (6) Diabetes (7) Hypercholesterolemia; (8) Heart disease; (9) Hypertension; (10) Heart attack; (11) Heart murmur; (12) Lung disease; (13) Memory-related diseases; (14) Osteoporosis. Each disease is treated as a binary variable of "yes" or "no"(30).

2.4 Covariate

- Demographic and behavioral covariates were extracted from the CHARLS baseline questionnaire, included age(younger than 65 years and 65 years or older), gender(male or female), education(high school or below or above high school.), marital status(married including cohabiting or unmarried including separated, divorced, and widowed), drinking status(yes or no), smoking status(yes or no). Existing research demonstrates that these variables might be associated with depression(31–33)

2.5 Statistical analysis

Data analysis was conducted using StataMP 17.0 software. In statistical descriptions, continuous variables are expressed as Mean $\pm$ standard deviation (Mean $\pm$ SD), and categorical variables are expressed as frequency (percentage). GBTM was applied to identify developmental trajectories of depressive symptoms based on CES-D10 scores. Since the CES-D10 score can be regarded as a continuous variable with an approximate normal distribution, the truncated normal model (censored normal model) was selected for trajectory fitting in this study(34). The fitting process starts with 2 groups and gradually increases the number of groups to 5. Each group begins with a higher-order function (cubic function), and if not significant, it is reduced to a quadratic or linear function. The selection of the optimal model is based on the following criteria: (1) The Bayesian Information Criterion (BIC) value is relatively small; (2) The average posterior probability (AvePP) is greater than 0.70; (3) The proportion of each group of samples should be $\geq 5\%$ to ensure clinical significance and statistical robustness; (4) The trajectory has reasonable clinical interpretability(34).

Inter-group comparison: After determining the best trajectory model, the chi-square test (χ^2 test) was used to compare the differences in baseline demographic characteristics, health behaviors, and the prevalence of 14 chronic diseases among different trajectory groups. Parkinson's disease was tested

using Fisher's exact test. All statistical tests were two-sided tests. A P value < 0.05 was defined as statistically significant. Recognizing the conceptual asymmetry between Chinese and international SMI discourse, a context-specific operationalization strategy was adopted rather than imposing a single definition across both databases.

3. Results

3.1 Identification of the Development Trajectory of Depressive Symptoms

Models with two to five trajectory groups were estimated across multiple functional forms. Based on a comprehensive consideration of BIC values, average posterior probabilities (AvePP), group proportions, and clinical interpretability, the three-group solution was selected as the optimal model (BIC = -40534.09)(Fig. 1). Goodness-of-fit statistics for all candidate models are presented in Table 1. The three-group model yielded AvePP values ranging from 0.87 to 0.90, all substantially exceeding the accepted threshold of 0.70. Group proportions of 41.88%, 47.68%, and 10.44% were each above the 5% minimum required for statistical robustness and clinical meaningfulness. Although the four-group model produced a marginally lower BIC (-40384.86), the fourth group accounted for only 2.6% of the sample, falling below the 5% threshold and indicating insufficient clinical discriminability and statistical reliability. The five-group model yielded a higher BIC than the three-group solution (-40531.25 vs. -40534.09) with an imbalanced distribution of group proportions, and was therefore excluded. Accordingly, the three-group model was retained as the final solution.

Table 1
Goodness-of-fit statistics of group-based trajectory analysis.

Number of groups	Trajectory shape (0 = zero order, 1 = linear, 2 = quadratic)	BIC for total number of observations	Group proportion (%)	Average posterior probabilities
2	3 3	-41430.43	69.92/30.08	0.94/0.91
3	3 3 3	-40534.09	41.88/47.68/10.44	0.89/0.87/0.90
4	3 3 3 3	-40384.86	35.18/47.84/14.32/2.66	0.87/0.86/0.83/0.88
3	3 3 2	-40531.25	41.91/47.68/10.42	0.89/0.87/0.90

Based on CES-D score levels and trajectory patterns across the four survey waves, three groups were identified and named as follows. The low-depressive-symptom group comprised 2,778 participants (41.88%), whose CES-D scores remained near zero throughout the observation period (range: 0.12–0.22), forming a stable trajectory close to the baseline axis. The moderate-depressive-symptom group was the largest subgroup, comprising 3,191 participants (47.68%), with CES-D scores consistently at a moderate level (range: 1.43–1.62) and minimal fluctuation across all waves. The high-depressive-symptom group

comprised 667 participants (10.44%), whose CES-D scores remained substantially elevated throughout (range: 4.62–5.00), markedly exceeding those of the other two groups. As shown in Table 2, none of the three groups exhibited a significant upward or downward trend from 2011 to 2018, presenting a stable pattern of parallel differentiation across the observation period.

Table 2
Mean CES-D Scores by Depressive Symptom Trajectory Group Across Survey Waves

Time	Low Depressive Symptoms(Low)	Moderate depressive Symptoms (Middle)	High depressive Symptom (High)
2011, average	0.22	1.52	4.83
2013, average	0.21	1.62	5.00
2015, average	0.12	1.43	4.71
2018, average	0.21	1.53	4.62

3.2 Comparison of Baseline Characteristics of Different Trajectory Groups

Table 3 presents the baseline demographic characteristics, health behaviors and distribution of 14 chronic diseases of 6,636 research subjects grouped by three trajectories. Except for Parkinson's disease ($P = 0.769$), all variables showed statistically significant differences among the three groups ($P < 0.05$).

Table 3
Patient demographics and baseline characteristics

Characteristic	**trajGroup_label**			p-value ²
	low N = 2,778	middle N = 3,191	high N = 667	
Age, n (%)				< 0.001
< 65	1,645 (59.2%)	1,737 (54.4%)	379 (56.8%)	
≥ 65	1,133 (40.8%)	1,454 (45.6%)	288 (43.2%)	
Gender, n (%)				< 0.001
man	1,520 (54.7%)	1,208 (37.9%)	210 (31.5%)	
woman	1,258 (45.3%)	1,983 (62.1%)	457 (68.5%)	
Education, n (%)				< 0.001
High school and below	1,401 (50.4%)	2,009 (63.0%)	487 (73.0%)	
Above high school	1,377 (49.6%)	1,182 (37.0%)	180 (27.0%)	
Smoke, n (%)				< 0.001
No	1,180 (42.5%)	1,289 (40.4%)	217 (32.5%)	
Yes	1,598 (57.5%)	1,902 (59.6%)	450 (67.5%)	
Drink, n (%)				< 0.001
No	158 (5.7%)	299 (9.4%)	109 (16.3%)	
Yes	2,620 (94.3%)	2,892 (90.6%)	558 (83.7%)	
Marital status, n (%)				< 0.001
married	2,248 (80.9%)	2,246 (70.4%)	349 (52.3%)	
non-married	530 (19.1%)	945 (29.6%)	318 (47.7%)	
1Pearson's Chi-squared test; Fisher's exact test				

Characteristic	**trajGroup_label**			p-value ²
	low	middle	high	
	N = 2,778	N = 3,191	N = 667	
r4arthrew4_r_ever_had_arthritis_label, n (%)				< 0.001
no	2,157 (77.6%)	2,010 (63.0%)	297 (44.5%)	
yes	621 (22.4%)	1,181 (37.0%)	370 (55.5%)	
r4anginew4_r_ever_had_angina_label, n (%)				< 0.001
no	2,676 (96.3%)	2,973 (93.2%)	593 (88.9%)	
yes	102 (3.7%)	218 (6.8%)	74 (11.1%)	
r4asthmaew4_r_ever_had_asthma_label, n (%)				< 0.001
no	2,511 (90.4%)	2,779 (87.1%)	542 (81.3%)	
yes	267 (9.6%)	412 (12.9%)	125 (18.7%)	
r4cancrew4_r_ever_had_cancer_label, n (%)				0.017
no	2,598 (93.5%)	2,929 (91.8%)	608 (91.2%)	
yes	180 (6.5%)	262 (8.2%)	59 (8.8%)	
r4demenew4_r_ever_had_dementia_label, n (%)				0.002
no	2,776 (99.9%)	3,184 (99.8%)	661 (99.1%)	
yes	2 (0.1%)	7 (0.2%)	6 (0.9%)	
r4diabew4_r_ever_had_diabetes_label, n (%)				< 0.001
no	2,605 (93.8%)	2,937 (92.0%)	579 (86.8%)	
yes	173 (6.2%)	254 (8.0%)	88 (13.2%)	
r4hcholew4_r_ever_had_high_chole_label, n (%)				< 0.001
no	2,038 (73.4%)	2,198 (68.9%)	407 (61.0%)	
1Pearson's Chi-squared test; Fisher's exact test				

Characteristic	**trajGroup_label**			p-value ²
	low N = 2,778	middle N = 3,191	high N = 667	
yes	740 (26.6%)	993 (31.1%)	260 (39.0%)	
r4heartew4_r_ever_had_heart_prob_label, n (%)				< 0.001
no	2,478 (89.2%)	2,725 (85.4%)	541 (81.1%)	
yes	300 (10.8%)	466 (14.6%)	126 (18.9%)	
r4hibpew4_r_ever_had_high_blood_label, n (%)				< 0.001
no	1,888 (68.0%)	1,940 (60.8%)	369 (55.3%)	
yes	890 (32.0%)	1,251 (39.2%)	298 (44.7%)	
r4hrtattew4_r_ever_had_heart_att_label, n (%)				< 0.001
no	2,729 (98.2%)	3,047 (95.5%)	631 (94.6%)	
yes	49 (1.8%)	144 (4.5%)	36 (5.4%)	
r4hrtmrew4_r_ever_had_heart_murm_label, n (%)				0.004
no	2,676 (96.3%)	3,068 (96.1%)	624 (93.6%)	
yes	102 (3.7%)	123 (3.9%)	43 (6.4%)	
r4lungew4_r_ever_had_lung_diseas_label, n (%)				< 0.001
no	2,706 (97.4%)	3,051 (95.6%)	600 (90.0%)	
yes	72 (2.6%)	140 (4.4%)	67 (10.0%)	
r4memryew4_r_ever_had_memory_pro_label, n (%)				0.002
no	2,776 (99.9%)	3,184 (99.8%)	661 (99.1%)	
yes	2 (0.1%)	7 (0.2%)	6 (0.9%)	
1Pearson's Chi-squared test; Fisher's exact test				

Characteristic	**trajGroup_label**			p-value ²
	low	middle	high	
	N = 2,778	N = 3,191	N = 667	
r4osteoew4_r_ever_had_osteoporos_label, n (%)				< 0.001
no	2,701 (97.2%)	3,018 (94.6%)	599 (89.8%)	
yes	77 (2.8%)	173 (5.4%)	68 (10.2%)	
r4parkinew4_r_ever_had_parkinson_label, n (%)				0.769
no	2,770 (99.7%)	3,179 (99.6%)	666 (99.9%)	
yes	8 (0.3%)	12 (0.4%)	1 (0.1%)	
1Pearson's Chi-squared test; Fisher's exact test				

3.2.1 Demographic characteristics

Across trajectory groups, the proportion of participants aged ≥ 65 years increased progressively from 40.8% (low) to 45.6% (moderate) and 43.2% (high). The proportion of females rose markedly from 45.3% to 62.1% and 68.5%. Higher educational attainment (above high school) declined from 49.6% to 37.0% and 27.0%, while the proportion of unmarried individuals increased from 19.1% to 29.6% and 47.7%. Regarding health behaviours, current smoking prevalence increased from 57.5% (low) to 59.6% (moderate) and 67.5% (high), whereas current alcohol use declined from 94.3% to 90.6% and 83.7% across the three groups.

3.2.2 Comorbidity Distribution of Chronic Diseases

All 14 chronic diseases showed a monotonically increasing prevalence gradient from the low- to high-depression group. Among musculoskeletal conditions, arthritis demonstrated the steepest gradient (22.4%, 37.0%, and 55.5%, respectively), followed by osteoporosis (2.8%, 5.4%, and 10.2%). Cardiovascular and metabolic diseases followed the same pattern, including hypertension (32.0%, 39.2%, and 44.7%), diabetes (6.2%, 8.0%, and 13.2%), and angina pectoris (3.7%, 6.8%, and 11.1%). Respiratory conditions also increased progressively, with lung disease rising nearly fourfold (2.6%, 4.4%, and 10.0%) and asthma from 9.6% to 18.7%. Cancer (6.5% to 8.8%, $P = 0.017$) and dementia (0.1% to 0.9%) showed more modest but statistically significant gradients.

4. Discussion

Based on the four-wave longitudinal data of CHARLS from 2011 to 2018, which is representative of the country, this study used GBTM to identify three heterogeneous development trajectories of depressive symptoms in middle-aged and elderly people in China, and systematically compared the comorbidity distribution patterns of 14 chronic diseases among different trajectory groups.

4.1 The heterogeneity and stability of depressive symptom trajectories

This study found that the development of depressive symptoms in middle-aged and elderly people can be divided into three highly stable trajectories - the low depression group (41.88%), the moderate depression group (47.68%), and the high depression group (10.44%). All three maintained a steady state in a "set point" manner during the 7-year observation period, and no significant crossover or trend changes were observed. This finding coincides with the study by You et al. on the disabled middle-aged and elderly population in China(35), which study also identified stable low-depression groups and high-depression groups. 52.75% of the disabled population had a CES-D score of less than 12 points throughout the entire process, while 12.23% had a score of ≥ 12 points throughout the entire process, and both groups remained highly constant. In the study by He et al. on the subjective well-being trajectory of the elderly in Ma'an Shan(36), 73.2% belonged to the "high-score stable group", while 5.2% and 14.7% respectively showed dynamic changes of improvement or deterioration. However, the length also confirmed that "stability" is a common feature of the mental health trajectory of the elderly. In Zhang et al.'s study on BMI and cognitive trajectory(37), 55.37% also presented the "stable functional group", which also forms a cross-outcome echo with our conclusion. This stability across time scales and research outcomes has raised a core question: Is there indeed a "set point" for mental health in middle and old age that is difficult to shift once formed? Previous longitudinal studies have indicated that the emotional regulation ability of the elderly increases with age ("Social emotional choice Theory"), with less attention paid to negative stimuli and more emphasis placed on positive experiences(38). This may explain why most middle-aged and elderly people can maintain a stable neutral or positive psychological state. However, 10.44% of the high-depression group did not seem to enjoy this "age advantage", possibly due to their "set point" being severely psychosocial trauma, chronic pain and functional loss accumulated in their early years. In addition, the weakening of traditional family structures and the increasing number of "empty-nest" elderly may exacerbate psychological vulnerability in later life(39).

4.2 The full-spectrum gradient of chronic disease comorbidities: from specific associations to systemic load

The most innovative finding of this study is that all 14 chronic diseases showed a monotonically increasing gradient without exception from the low-depression group to the high-depression group. This "full-spectrum comorbidity burden" feature carries at least three layers of important information.

First, the relationship between depression and chronic diseases is not a simple "one-to-one" disease combination, but rather a cross-system, cumulative overall physical burden effect. Previous studies have

mostly focused on the bidirectional association between depression and specific diseases (such as depression-diabetes(40), depression-coronary heart disease(41, 42), depression-coronary asthma(43)and proposed the pathophysiological mechanisms respectively in the literature of each disease. This study placed 14 common chronic diseases in the same analytical framework and found that their association directions with the depression trajectory were completely consistent and the gradients were highly synchronized. This phenomenon suggests that depression is not "induced" by a specific disease, but is driven by the total multimorbidity burden. You et al. 's research on disabled elderly people(35) also found that having chronic diseases (yes/no) is a risk factor for a high depression trajectory. However, as this paper simplified chronic diseases to binary classification aggregation variables, it failed to present the detailed gradient profiling revealed in this study.It is notable that unhealthy lifestyle (low diet quality, smoking, excessive alcohol consumption, lack of exercise,insomnia) are associated with depressive symptoms in older adults may potentially disturb the hypothalamic-pituitary-adrenal axis, increase cortisol, and cause low-grade systemic inflammation and oxidative stress(44, 45)

Second, the disease groups with the strongest discrimination - pain, respiratory and skeletal degenerative diseases - are the key to understanding the mechanism of chronic depression. The prevalence of arthritis has sharply risen from 22.4% to 55.5%, making it the most common comorbidity among individuals in the high depression group, without any exception. Lung diseases from 2.6% to 10.0%(approximately a fourfold difference) and osteoporosis from 2.8% to 10.2%(approximately a fourfold difference) also showed a strong gradient. What are the common features of these three diseases? The answer is persistent physical pain, limited movement and breathing difficulties. The classic review by Bair et al.(21, 22, 46)confirmed this point.

4.3 The gradient of demographic factors: The cumulative effect of social disadvantages

In terms of gender, the proportion of women in the high-depression group was as high as 68.5%, which was 1.5 times that of the low-depression group (45.3%). This is consistent with the evidence on the risk of depression among elderly women(19)Which found that the depression incidence rate in women was twice as high as that in men (68.4% vs. 31.6%). You et al. also found(35) that 66.93% of patients with high depression were female, almost completely corresponding to this study. He et al.(36) also found in their study in Ma 'anshan that being unmarried, having a low level of education, and being female are important predictors of being unmarried, empty-nest, and lonely. The gender inequality that women endure throughout their life (low control over resources and high economic vulnerability after the death of a spouse), the homogeneity of social roles, and the endogenous emotional instability driven by hormones, etc., jointly construct an cumulative path leading to a high depression trajectory in old age(47).

The gradient of non-married status is even more shocking - from 19.1% to 47.7%, with a difference of nearly 30 percentage points. In China, spouses are the most important source of emotional attachment

and instrumental support for the elderly. The death of a spouse not only represents the loss of love but also implies the disintegration of the daily mutual assistance structure. Fan Wensan(35) also found that "lack of care" is a high-risk factor for depression.

4.4 Clinical and Public Health Implications

These findings support the implementation of tiered, precision-oriented prevention strategies within community and primary healthcare settings. For high-risk individuals, including those with arthritis, lung disease, or osteoporosis combined with female sex, unmarried status, or low educational attainment, routine depression screening using the PHQ-2 can be integrated into chronic disease follow-up visits, such as at the time of antihypertensive or hypoglycaemic medication prescriptions. For the moderate-depression group (47.68%), community-based psychoeducation, peer support programmes, and chronic disease self-management training represent effective secondary prevention approaches. For individuals with comorbid chronic pain and depression, cognitive behavioural therapy combined with multimodal analgesia encompassing physical therapy, structured exercise, and psychoeducation has demonstrated synergistic efficacy in randomised controlled trials(21, 48)and warrants broader clinical implementation.

5. Conclusions

Three heterogeneous yet stable depressive symptom trajectories were identified among middle-aged and older adults in China: low (41.88%), moderate (47.68%), and high (10.44%). All 14 chronic diseases demonstrated a monotonically increasing comorbidity gradient across trajectory groups, with arthritis, lung disease, and osteoporosis showing the strongest discrimination. Social disadvantages including female sex, older age, lower education, and unmarried status accumulated progressively with trajectory severity. These findings suggest that depression and chronic disease comorbidity in older adults should not be viewed as isolated disease combinations, but rather managed as a cumulative physical-mental syndrome. Integrated screening and early intervention are warranted for individuals with chronic pain, respiratory conditions, and multiple comorbidities.

Abbreviations

GBTM

Group-Based Trajectory Modeling

CHARLS

China Health and Retirement Longitudinal Study

WHO

World Health Organization

DALYs

Disability-Adjusted Life Years

GBD

Global Burden of Disease Study

NCDs
Non-Communicable Diseases
YLDs
Years Lived with Disability
CVD
Cardiovascular Disease
Mean $\pm$ SD
Mean $\pm$ standard deviation
BIC
Bayesian Information Criterion
AvePP
average posterior probability

Declarations

Conflicts of Interest:

The authors have no potential conflicts of interest to disclose.

Ethics approval and consent to participate:

The China Health and Retirement Longitudinal Study (CHARLS) was approved by the Biomedical Ethics Review Committee of Peking University (approval number: IRB00001052-11015). All participants provided written informed consent prior to data collection. This study is a secondary analysis of de-identified, publicly available CHARLS data. As the data used in this study contain no personal identifying information, no additional ethical approval was required for this specific analysis. All procedures were conducted in accordance with the Declaration of Helsinki.

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Author Contribution

Siqi Wang: Investigation, Formal analysis, Writing – original draft Lichao, Yang: Methodology, Data curation, Software, Validation, Visualization Jianqiu Xiao: Investigation, Writing editing Wei Tian: Conceptualization, Resources, Supervision Writing – review & editing

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References

1. Berardi C, Antonini M, Jordan Z, et al. 00-Barriers and facilitators to the implementation of digital technologies in mental health systems: a qualitative systematic review to inform a policy framework. *BMC Health Serv Res*. 2024;24(1):243.
2. Liu J, Liu Y, Ma W, et al. 01-Temporal and spatial trend analysis of all-cause depression burden based on Global Burden of Disease (GBD) 2019 study. *Sci Rep*. 2024;14(1):12346.
3. Luo Y, Zhang S, Zheng R, et al. 02-Effects of depression on heart rate variability in elderly patients with stable coronary artery disease. *J Evidence-Based Med*. 2018;11(4):242–5.
4. Seligman F, Nemeroff CB. 03-The interface of depression and cardiovascular disease: therapeutic implications. *Ann N Y Acad Sci*. 2015;1345(1):25–35.
5. Xu DR, Gao X, Zhao LB, et al. 04-Association between triglyceride and depression: a systematic review and meta-analysis. Islam MdR, editor. *PLoS ONE*. 2024;19(10):e0311625.
6. 05-Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of disease study 2019. *Lancet Psychiatry*. 2022;9(2):137–50.
7. Hay SI, Abajobir AA, Abate KH et al. 06-Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the global burden of disease study 2016. *Lancet*. 2017 Sept;390(10100):1260–344.
8. Ferrari AJ, Santomauro DF, Aali A, et al. 07-Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the global burden of disease study 2021. *Lancet*. 2024;403(10440):2133–61.
9. Zhang J, He J, Hu J, et al. 08-Exploring the role of gut microbiota in depression: pathogenesis and therapeutic insights. *Asian J Psychiatry*. 2025;105:104411.
10. Kontis V, Bennett JE, Mathers CD, et al. 09-Future life expectancy in 35 industrialised countries: projections with a bayesian model ensemble. *Lancet*. 2017;389(10076):1323–35.
11. Liu X, Song F, Liu F, et al. 10-Multiple chronic conditions among older adults in China: differences in socio-demographic characteristics. *Heliyon*. 2022;8(10):e11129.
12. Wang H, Abbas KM, Abbasifard M, et al. 11-Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950–2019: a comprehensive demographic analysis for the global burden of disease study 2019. *Lancet*. 2020;396(10258):1160–203.

13. 12-Mental health. of older adults [Internet]. [cited 2026 June 14]. Available from: <https://www.who.int/news-room/fact-sheets/detail/mental-health-of-older-adults>
14. Xu Y, Yang J, Gao J, et al. 13-Decomposing socioeconomic inequalities in depressive symptoms among the elderly in China. *BMC Public Health*. 2016;16(1):1214.
15. Fernandez-Rodrigues V, Sanchez-Carro Y, Lagunas LN, et al. 14-Risk factors for suicidal behaviour in late-life depression: A systematic review. *WJP*. 2022;12(1):187–203.
16. Oyon J, Serra-Prat M, Ferrer M, et al. 15-Psychosocial factors associated with frailty in the community-dwelling aged population with depression. A cross-sectional study. *Aten Primaria*. 2021;53(5):102048.
17. Quiambao A, Malekpour MR, Golestani A, et al. 16-World health organization's guidance for tracking non-communicable diseases towards sustainable development goals 3.4: an initiative for facility-based monitoring. *eClinicalMedicine*. 2025 July;85:103304.
18. Spiers G, Matthews FE, Moffatt S, et al. 17-Impact of social care supply on healthcare utilisation by older adults: a systematic review and meta-analysis. *Age Ageing*. 2019;48(1):57–66.
19. Zheng Y, Zhang C, Liu Y. 18-Risk prediction models of depression in older adults with chronic diseases. *J Affect Disord*. 2024;359:182–8.
20. Pariante CM, Lightman SL. 19-The HPA axis in major depression: classical theories and new developments. *Trends Neurosci*. 2008 Sept;31(9):464–8.
21. Bair MJ, Robinson RL, Katon W, et al. 20-Depression and pain comorbidity: a literature review. *Arch Intern Med*. 2003;163(20):2433.
22. Ai F, Li E, Dong A, et al. 21-Association between disability and cognitive function in older chinese people: a moderated mediation of social relationships and depressive symptoms. *Front Public Health*. 2024;12:1354877.
23. Zhou P, Wang S, Yan Y et al. 22-Association between chronic diseases and depression in the middle-aged and older adult chinese population—a seven-year follow-up study based on CHARLS. *Front Public Health* 2023 July 20;11:1176669.
24. Li Y, Du X, Shi S, et al. 23-Trends in prevalence and multimorbidity of metabolic, cardiovascular, and chronic kidney diseases among US adults with depression from 2005 to 2020. *J Affect Disord*. 2025;372:262–8.
25. Dantzer R, Capuron L, editors. 24-Inflammation-associated depression: evidence, mechanisms and implications [Internet]. Vol. 31. Cham: Springer International Publishing; 2017 [cited 2026 May 28]. Available from: <http://link.springer.com/10.1007/978-3-319-51152-8>
26. Zhao Y, Hu Y, Smith JP, et al. 25-Cohort profile: the China health and retirement longitudinal study (CHARLS). *Int J Epidemiol*. 2014;43(1):61–8.
27. Cheng ST, Chan ACM, Fung HH. 26-Factorial structure of a short version of the center for epidemiologic studies depression scale. *Int J Geriatr Psychiatry*. 2006;21(4):333–6.

28. Radloff LS. 27-The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977 June;1(3):385–401.
29. Chen H, Mui AC. 28-Factorial validity of the center for epidemiologic studies depression scale short form in older population in China. *Int Psychogeriatr.* 2014;26(1):49–57.
30. Pang Y, Jiang Y, Sa N et al. 29-Association between loneliness trajectories and chronic diseases as well as chronic comorbidities among middle - aged and elderly chinese: based on the group - based trajectory modeling method. *Sci Rep.* 2026;1–28.
31. He M, Ma J, Ren Z, et al. 30-Association between activities of daily living disability and depression symptoms of middle-aged and older chinese adults and their spouses: a community based study. *J Affect Disord.* 2019;242:135–42.
32. Yunming L, Changsheng C, Haibo T, et al. 31-Prevalence and risk factors for depression in older people in xi'an China: a community-based study. *Int J Geriatr Psychiatry.* 2012;27(1):31–9.
33. Wang Y, Jiang G, Wang L, et al. 32-Association of the depressive scores, depressive symptoms, and conversion patterns of depressive symptoms with the risk of new-onset chronic diseases and multimorbidity in the middle-aged and elderly chinese population. *eClinicalMedicine.* 2022;52:101603.
34. Liu ZH, Chen CZ, Gao C et al. 33-Prevalence and correlates of depressive symptoms among Chinese patients with cataracts treated in tertiary general hospitals. *PeerJ* 2020 June 16;8:e9397.
35. You R, Li W, Ni L, et al. 34-Study on the trajectory of depression among middle-aged and elderly disabled people in China: based on group-based trajectory model. *SSM - Popul HEALTH.* 2023;24:101510.
36. He Yke, Li T, fei, Liang Y et al. ting,. 35-Influencing factors of subjective well-being trajectory based on the group-based trajectory modeling (GBTM): Results from a healthy aging cohort study in Ma'anshan. *Geriatric Nursing.* 2025;61:177–84.
37. Zhang W, Chen Y, Chen N. 36-Body mass index and trajectories of the cognition among Chinese middle and old-aged adults. *BMC Geriatr.* 2022;22(1):613.
38. Carstensen LL, Isaacowitz DM, Charles ST. 37-A theory of socioemotional selectivity.:1–17.
39. Li D, Zhang D, jun, Shao Jjin, et al. 38-A meta-analysis of the prevalence of depressive symptoms in chinese older adults. *Arch Gerontol Geriatr.* 2014;58(1):1–9.
40. Bo A, Pouwer F, Juul L, et al. 39-Prevalence and correlates of diabetes distress, perceived stress and depressive symptoms among adults with early-onset type 2 diabetes: cross-sectional survey results from the danish DD2 study. *Diabet Med.* 2020;37(10):1679–87.
41. Lichtman JH, Froelicher ES, Blumenthal JA, et al. 40-Depression as a risk factor for poor prognosis among patients with acute coronary syndrome: systematic review and recommendations: a scientific statement from the American heart association. *Circulation.* 2014;129(12):1350–69.
42. Penninx BWJH. 41-Depression and cardiovascular disease: Epidemiological evidence on their linking mechanisms. *Neurosci Biobehav Rev.* 2017;74:277–86.

43. Akula M, Kulikova A, Khan DA, et al. 42-The relationship between asthma and depression in a community-based sample. *J Asthma*. 2018;55(12):1271–7.
44. Goh CMJ, Abdin E, Jeyagurunathan A, et al. 43-Exploring singapore’s consumption of local fish, vegetables and fruits, meat and problematic alcohol use as risk factors of depression and subsyndromal depression in older adults. *BMC Geriatr*. 2019;19(1):161–9.
45. Gomes AP, Oliveira Bierhals I, Gonçalves Soares AL, et al. 44-Interrelationship between diet quality and depressive symptoms in elderly. *J Nutr health aging*. 2018;22(3):387–92.
46. Mejareh ZN, Abdollahi B, Hoseinipalangi Z, et al. 45-Global, regional, and national prevalence of depression among cancer patients: A systematic review and meta-analysis. *Indian J Psychiatry*. 2021;63(6):527–35.
47. Pasciuto T, Moro F, Zace D, et al. 46-Socio-psychological distress, violence, and food insecurity in women undergoing gynecological examinations: insights from a cross-sectional study of an italian tertiary clinic. *AJOG Glob Rep*. 2025;5(3):100546.
48. Kroenke K, Bair MJ, Damush TM, et al. 47-Optimized antidepressant therapy and pain self-management in primary care patients with depression and musculoskeletal pain: a randomized controlled trial. *JAMA*. 2009;301(20):2099.

Figures

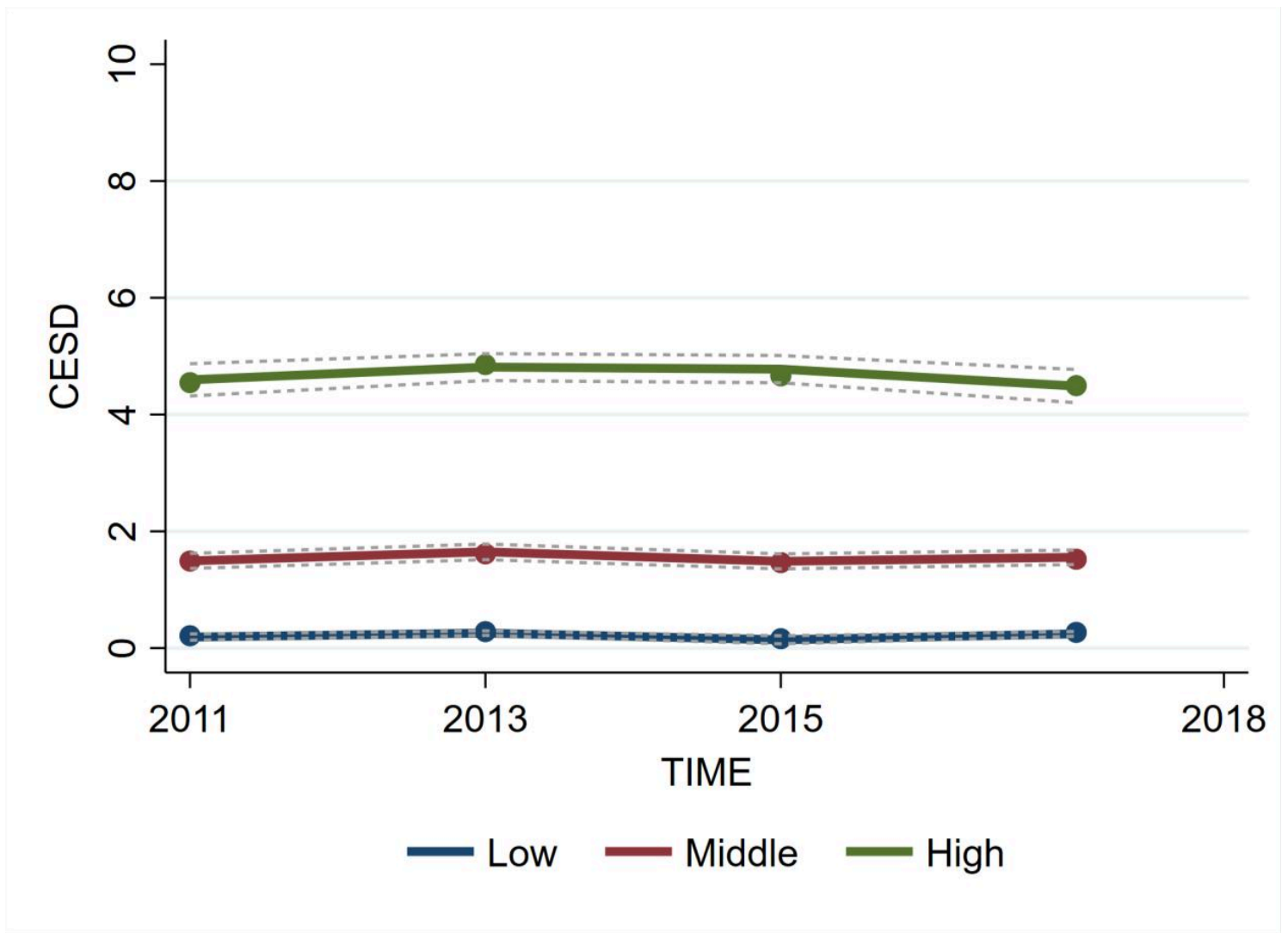


Figure 1

Change track of depressive symptoms of the middle-aged and older adults