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ARTICLE

Social Engagement and Depressive Symptom Trajectories in Older Adults with Arthritis: A 9-Year Longitudinal Study

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ABSTRACT: Background: Depression is highly prevalent among older adults with chronic diseases such as arthritis or rheumatism. However, little is known about the longitudinal patterns of their depressive symptoms or the role social engagement plays in shaping these trajectories. This study aimed to identify distinct trajectories of depressive symptoms among older Chinese adults with arthritis or rheumatism and examine the association between baseline social engagement and these trajectories. **Methods**: Utilizing five waves of data from the China Health and Retirement Longitudinal Study (CHARLS) spanning from 2011 to 2020, our analysis included a final sample of 2022 adults aged 60 and above diagnosed with arthritis or rheumatism. We employed group-based trajectory modeling to classify the trajectories of depressive symptoms based on the 10-item Center for Epidemiologic Studies Depression Scale (CESD-10) scores. Subsequently, we utilized multinomial logistic regression to evaluate the relationship between baseline social engagement and trajectory membership, while adjusting for sociodemographic and health-related covariates. **Results**: Three depressive symptom trajectories were identified: persistently high (n = 558, 27.6%), moderate fluctuating (n = 981, 48.5%), and consistently low (n = 483, 23.9%). Higher baseline social engagement was significantly associated with reduced odds of belonging to the persistently high group (OR = 0.82, 95% CI: 0.69–0.97) and the moderate fluctuating group (OR = 0.87, 95% CI: 0.75–0.99) when compared to the consistently low group. Sensitivity analyses confirmed these findings were robust. The persistently high group had a greater proportion of females, rural residents, and individuals with lower education and living standards. **Conclusion**: Distinct depressive symptom trajectories exist among older adults with arthritis or rheumatism. Social engagement is associated with a lower risk of following adverse long-term depression outcomes. Promoting social engagement should be integrated into mental health and chronic disease management strategies for this population.

KEYWORDS: Depressive symptoms; older population; rheumatoid; social engagement; longitudinal studies

1 Introduction

Depression represents a primary global cause of disability and a critical public health challenge, particularly as the population aged 65 and above continues to grow [1–4]. In China, the burden is especially pronounced, with over 20% of older adults experiencing depressive symptoms—a rate often exceeding those

reported in many developed nations [5–7]. This high prevalence is significantly driven by the presence of chronic conditions; specifically, Chinese older adults with chronic diseases exhibit depression rates exceeding 30% [8]. Arthritis or rheumatism, in particular, serves as a major risk factor, as it is frequently accompanied by chronic pain, physical limitations, and social isolation, which exacerbate the severity and persistence of psychological distress [9]. Given that depression is the most common comorbidity in this population, with prevalence rates reaching as high as 48% [10,11], identifying the longitudinal patterns and protective factors for these individuals is essential for promoting healthy aging.

Recently, research on depression among older adults-especially those with chronic diseases-has predominantly relied on cross-sectional analyses, examining depressive symptoms at a single time point. However, depressive symptoms in later life are not static; they often follow diverse and evolving patterns, or "trajectories", which reflect the heterogeneity of mental health experiences as people age. Depression trajectories are defined as the longitudinal course of depressive symptoms within individuals or subgroups, identified through repeated measures and advanced statistical modeling methods such as group-based trajectory modeling (GBTM) or latent class mixed models (LCMM) [12,13]. These methods allow researchers to classify older adults into distinct subgroups with differing clinical implications. Studying these trajectories is crucial because they reveal temporal variations in symptom progression that cross-sectional studies miss. For example, some older adults maintain stable high symptoms, while others experience gradual increases, each pattern linked to different risks of mortality, dementia, and disability [12,14]. Even persistent subthreshold symptoms predict adverse outcomes like cognitive decline and chronic illness [12]. Moreover, trajectory analyses clarify how sociodemographic factors and health behaviors influence long-term depression courses, enabling identification of high-risk groups for targeted intervention. By mapping depressive trajectories, researchers can better predict outcomes and tailor prevention strategies to alter symptom courses, ultimately improving mental health care for older adults.

Notably, existing research on depressive symptom trajectories in older adults has largely focused on risk factors such as early-life adversity, socioeconomic disadvantage, social isolation, and chronic disease burden that contribute to worsening depression [15–18]. Longitudinal and epidemiological studies highlight that these factors interact complexly to shape the course of depressive symptoms over time. For example, early-life socioeconomic disadvantage and family conflict increase the risk of adverse mental health outcomes in adulthood by setting in motion chains of disadvantage that affect occupational status, income, and living conditions, which in turn expose individuals to chronic stressors linked to depression [19]. In contrast, relatively few studies have examined protective factors that might reduce the onset or persistence of depressive symptoms over time. Understanding these protective factors is crucial for a comprehensive view of late-life depression and for developing interventions that not only reduce risk but also enhance resilience and mental well-being.

Social engagement is recognized as a key protective factor for mental and cognitive health in older adults [20,21], defined by active participation in social activities, community involvement, and maintaining relationships with family, friends, and broader social networks. It provides emotional and practical support, fosters a sense of purpose, offers cognitive stimulation, and buffers stress. Additionally, social engagement promotes healthier behaviors and better access to healthcare, further supporting psychological resilience [22,23]. However, few longitudinal studies have explored how social engagement influences the long-term course and variability of depressive symptoms, particularly among older adults with chronic conditions such as arthritis or rheumatism. Addressing this gap is essential to fully understand the protective role of social engagement and to inform targeted interventions for this vulnerable population.

To address this knowledge gap, the primary objective of this study is to identify distinct trajectories of depressive symptoms among older adults with arthritis or rheumatism using longitudinal data from the China Health and Retirement Longitudinal Study (CHARLS). A secondary objective is to examine the association between baseline social engagement and subsequent depression trajectories, while adjusting for relevant sociodemographic covariates such as age, gender, education, marital status, residence, and living standard.

2 Methods

2.1 Participants and Data Collection Procedure

This study utilizes data from the CHARLS, a nationally representative longitudinal survey of middle-aged and older adults in China [24]. The baseline survey was conducted in 2011 (Wave 1), followed by subsequent waves in 2013 (Wave 2), 2015 (Wave 3), 2018 (Wave 4), and 2020 (Wave 5). CHARLS encompasses 150 county-level units and 450 village-level units, targeting approximately 10,000 households and 17,000 individuals. During the sampling process, CHARLS employed a multi-stage sampling method, incorporating Probability Proportional to Size (PPS) sampling techniques at both the county and village levels. A structured questionnaire was utilized to collect data on health status and other relevant information through face-to-face interviews. The response rate at baseline was approximately 80.5%, with overall follow-up rates exceeding 86.0%. Previous studies have provided detailed information, which is available on the CHARLS website [24]. The CHARLS received ethical approval from the Institutional Review Board of Peking University. The protocol of the main household survey was approved under IRB00001052-11015. During fieldwork, each respondent who agreed to participate was asked to provide written informed consent. The present study is a secondary analysis of de-identified, publicly available CHARLS data and involved no additional data collection.

Among 7656 participants aged 60 years and older, individuals who met all of the following criteria were included: (1) participants aged ≥60 years in 2011; (2) participants with a diagnosed rheumatic condition; (3) participants with available data on depressive symptoms and social engagement; (4) participants with missing covariate data not exceeding 20%; and (5) participants with depressive symptoms data collected in at least two waves. Ultimately, a total of 2022 individuals met the eligibility criteria for subsequent analysis. A detailed flowchart illustrating participant inclusion and analysis in this study is presented in Fig. 1.

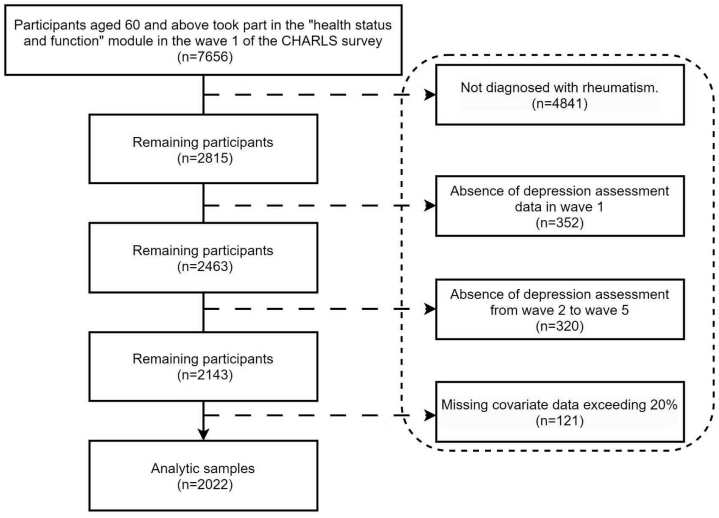

Figure 1: Flow chart of sample selection and the exclusion criteria.

2.2 Measurements

2.2.1 Identification of Rheumatic Conditions

Participants were identified using the 2011 baseline CHARLS questionnaire. Specifically, respondents were asked (item DA007, variable da007): "Have you ever been told by a doctor that you have arthritis or rheumatism?" Responses of "Yes" were coded as 1 and "No" as 0. As this item captures a broad category of joint and rheumatic conditions and does not allow subtype differentiation at baseline (e.g., rheumatoid arthritis vs. osteoarthritis or gout), we consistently used the term "arthritis or rheumatism" throughout the manuscript to accurately reflect the CHARLS measure.

2.2.2 Depressive Symptoms

The 10-item Center for Epidemiologic Studies Depression Scale (CESD-10) [25] was used to assess participants' depressive symptoms at baseline (2011) and in subsequent follow-ups (2013, 2015, 2018, and 2020). The CESD-10 consists of 10 items, where participants rate the frequency of symptoms experienced during the past week on a 4-point Likert scale: 0 (rarely or none of the time), 1 (some or a little of the time), 2 (occasionally or a moderate amount of time), and 3 (most or all of the time). Specifically, two positive emotion items ("I felt hopeful about the future" and "I was happy") were reverse-scored before summation. The total score ranges from 0 to 30, with higher scores reflecting greater symptom severity. For the GBTM, we utilized the continuous total scores as the primary input to capture fine-grained longitudinal variations in mental health status. While continuous scores were used for modeling, the commonly used threshold of CESD-10 $\geq$10 was used only as a reference to aid interpretation of symptom severity across trajectory groups; this threshold was not used to derive trajectory membership. Mild to moderate depression is indicated by scores of 10–15, and severe depression by scores of 16 or higher. The scale demonstrates strong internal consistency (Cronbach's α ranging from 0.70 to 0.90), as well as adequate sensitivity (71.4% to 84.6%) and specificity (72.6% to 95.0%) in screening for depressive symptoms [26]. Additionally, it has been thoroughly validated in the Chinese older adult population, confirming its reliability and validity. The Cronbach's α coefficients were 0.78 (Wave 1), 0.68 (Wave 2), 0.72 (Wave 3), 0.81 (Wave 4), and 0.80 (Wave 5), indicating good internal consistency.

2.2.3 Social Engagement

Based on the previous studies [27–29], Social engagement was measured using the Social Activities module in CHARLS (Module K: Social activities and government assistance), which includes 11 activity items (SC011_1–SC011_11). Respondents were asked whether they had participated in each activity during the past month, including: (1) interacting with friends; (2) playing Mahjong, chess, or cards; (3) providing unpaid help to family, friends, or neighbors not living with the respondent; (4) attending sports, social, or other clubs; (5) participating in community-related organizations; (6) engaging in voluntary or charity work; (7) caring for a sick or disabled adult; (8) attending educational or training courses; (9) stock investment; (10) using the Internet; and (11) other activities. Response options for each item were originally binary (1 = yes, 2 = no) and were recoded for this study as 1 = participated and 0 = did not participate. Consistent with prior CHARLS-based studies [27–29], we constructed a social engagement index by summing the number of endorsed activities, yielding a total score ranging from 0 to 11, with higher scores indicating greater breadth of social participation. This continuous index was used as the primary exposure in the main analyses.

2.2.4 Covariates

Baseline covariates included sociodemographic characteristics, health status, and social support factors. Sociodemographic variables consisted of age, gender (male/female), residence (urban/rural), marital status (married/partnered or divorced/widowed/living alone), and education level (junior high school and below vs. above).

Health and functional status were assessed via self-rated health (ranging from 1 = "poor" to 5 = "excellent") and Activities of Daily Living (ADL). ADL was measured across six essential tasks: bathing, dressing, toileting, transferring, continence, and feeding. Each task was dichotomized (1 = completely independent, 0 = dependent), and a composite score was utilized to reflect functional impairment.

Indicators of social and economic support included living standards (self-rated from 1 = "poor" to 5 = "very high"), living arrangements (binary: living with any children vs. not), and financial support from children (the total value of cash and in-kind transfers received from all children in the past year).

2.3 Statistical Analysis

2.3.1 Preliminary Analysis

We conducted preliminary analyses to evaluate potential bias and measurement comparability across waves. Attrition analyses were performed to compare baseline characteristics between participants who completed all five waves and those with missing data in at least one wave. Additionally, longitudinal measurement invariance of the CESD-10 was tested to ensure that depressive symptom scores remained comparable across the nine-year study period.

2.3.2 Trajectory Identification

GBTM was applied to characterize heterogeneous longitudinal trajectories of depressive symptoms [30]. To determine the optimal number of trajectory groups, models were fitted, ranging from one to four group trajectories. Depressive symptoms recorded in 2011 (Wave 1), 2013 (Wave 2), 2015 (Wave 3), 2018 (Wave 4), and 2020 (Wave 5) were used to estimate these trajectories. The criteria for the best-fitting trajectory model are as follows [31]: (1) the absolute Bayesian Information Criterion (BIC) value should be close to 0; (2) class-specific Average Posterior Probabilities (AvePP) $\geq$0.70 indicating acceptable classification certainty; (3) a minimum class size $\geq$5% of the total sample, and (4) interpretability of the identified trajectories. Polynomial functions of time (linear, quadratic, or cubic) were specified to capture the shape of symptom change, and class-specific functional forms were allowed as appropriate.

2.3.3 Association and Sensitivity Analyses

Baseline characteristics of the study sample were presented as means and standard deviations for continuous variables, and as frequencies and percentages for categorical variables. Comparisons across trajectory groups were conducted using analysis of variance (ANOVA) and Chi-square tests. Pearson correlations examined the associations between baseline social engagement (T1) and depressive symptoms across all waves (T1–T5). Multinomial logistic regression models were employed to assess the association between social engagement and trajectory membership, adjusting for potential confounders. Furthermore, sensitivity analyses were conducted using alternative scoring methods for social engagement (binary and frequency-based) to evaluate the robustness of our findings.

All GBTM models were estimated in R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria) using the 'gbmt' package (version 0.1.4), utilizing the Expectation-Maximization (EM) algorithm

to robustly handle unbalanced panels and missing data. Multinomial logistic regression and descriptive analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Statistical significance was determined at a two-tailed p-value of less than 0.05.

3 Results

3.1 Preliminary Analysis

3.1.1 Attrition Analysis

We conducted attrition analyses by comparing participants who completed all five waves (n = 782) with those who had missing data in at least one wave (n = 1240). At baseline, completers were younger (64.81 ± 4.12 vs. 68.27 ± 6.11 years, $p < 0.001$), more likely to be female (42.87% vs. 35.41%, $\chi^2 = 11.68$, $p < 0.001$), and more likely to be married/partnered (41.67% vs. 27.61%, $\chi^2 = 28.27$, $p < 0.001$). No significant differences were observed in ADL, financial support from children, living standards, education level, or residence (all ps > 0.05). Overall, attrition appeared to be associated primarily with age and related demographic characteristics; however, residual attrition bias cannot be fully excluded (see Table 1).

Table 1: Attrition analysis: baseline differences between completers and non-completers.

Covariates	Completers	Non-Completers	t/χ^2	p-Value
Age, mean ± SD	64.81 ± 4.12	68.27 ± 6.11	−13.9	<0.001
ADL, mean ± SD	4.45 ± 2.29	4.52 ± 2.09	−0.65	0.52
Financial support from children, mean ± SD	4.96 ± 3.81	5.15 ± 3.76	−1.10	0.27
Living standards, mean ± SD	2.45 ± 0.74	2.39 ± 0.79	1.65	0.10
Gender, n (%)			11.68	<0.001
Female	379 (42.87%)	505 (57.13%)		
Male	403 (35.41%)	735 (64.59%)		
Marital status, n (%)			28.27	<0.001
Divorced/living alone	119 (27.61%)	312 (72.39%)		
Married/partnered	663 (41.67%)	928 (58.33%)		
Education level, n (%)			2.52	0.11
Junior high school or below	749 (38.35%)	1204 (61.65%)		
High school or above	33 (47.83%)	36 (52.17%)		
Location of residence, n (%)			0.87	0.91
Rural	641 (38.59%)	1020 (61.41%)		
Urban	141 (39.06%)	220 (60.94%)		
Living with any children, n (%)			0.31	0.32
Yes	23 (32.86%)	47 (67.14%)		
No	759 (38.88%)	1193 (61.12%)		

Note: Based on Independent samples t-tests for continuous variables and chi-square tests (χ^2) for categorical variables. SD, standard deviation; ADL, Activities of Daily Living.

3.1.2 Longitudinal Measurement Invariance

Longitudinal measurement invariance of the depressive symptom measure was supported across all five waves (see Table 2). The configural model demonstrated acceptable fit, establishing a consistent factor structure over time. Progression to the metric model (constraining factor loadings) and the scalar model (constraining item intercepts) did not result in a meaningful decrement in fit. Specifically, the changes in CFI and RMSEA across these nested models remained well within recommended thresholds (ΔCFI ≤ 0.010; ΔRMSEA ≤ 0.015). These results confirm that the CESD-10 scale measures the same construct across time, allowing longitudinal changes to be interpreted as true shifts in depressive symptoms.

Table 2: Fit indices for longitudinal measurement invariance of the CESD-10.

Model	χ^2	CFI	TLI	RMSEA	SRMR	ΔCFI	ΔRMSEA
Config	3044.390	0.897	0.885	0.041	0.045		
Metric	3125.435	0.895	0.887	0.040	0.049	0.002	0.001
Scalar	3336.896	0.887	0.883	0.040	0.051	0.008	0.001

Note: CFI, Comparative Fit Index; TLI, Tucker-Lewis Index; RMSEA, Root Mean Square Error of Approximation; SRMR, Standardized Root Mean Square Residual.

3.1.3 Baseline Characteristics

The average age of participants was 66.94 years (SD = 5.68) at the baseline in Wave 1. In terms of gender, females made up 56.28% (n = 1138) while males were 43.72% (n = 884) of the sample. Regarding education, 95.59% (n = 1953) had completed junior high school or lower, whereas 3.41% (n = 69) had obtained senior high school or higher qualifications. The majority of participants (82.15%) resided in rural areas, and 78.68% were married or partnered.

3.2 Identified Trajectories of Depressive Symptoms

In the group-based trajectory models, we compared candidate solutions (1–4 classes) using the BIC, AvePP (higher values indicate greater classification certainty), and minimum class size. As shown in Table 3, the quadratic three-class solution achieved the lowest BIC (BIC = 61,906.47) while maintaining adequate class proportions (27.60%, 48.52%, and 23.89%) and good classification quality (AvePP = 0.89–0.91 across classes). Solutions with cubic terms produced a negligible class (~0.1%) and were therefore not retained, and the quadratic four-class solution showed a higher BIC (BIC = 61,937.40) and a smaller fourth class with lower AvePP (0.78). Accordingly, we selected the three-class model as the final solution. In the final model, trajectory functional forms were allowed to differ by class ("1–2–2"), indicating that Class 1 was modeled as linear (first-order), whereas Classes 2 and 3 were modeled as quadratic (second-order).

Table 3: Goodness-of-fit statistics of group-based trajectory analysis.

Order	Group Number	BIC	Group Proportion (%)				AvePP			
			1	2	3	4	1	2	3	4
3	1	64,511.00	100				100			
	2	62,249.18	48.81	51.19			95.30	94.98		
	3	62,286.66	48.91	50.98	0.10		95.28	95.03	100	
	4	61,958.89	27.34	48.76	23.79	0.10	91.54	89.66	89.67	100
2	1	64,515.36	1				100			
	2	62,255.86	48.81	51.19			95.30	94.92		
	3	61,906.47	27.60	48.52	23.89		91.18	89.71	89.67	
	4	61,937.40	27.10	47.03	17.85	8.01	90.66	90.10	89.05	77.51

Note: "Order" denotes the polynomial order of the time term used in the model (1 = linear, 2 = quadratic, 3 = cubic). "1–2–2" indicates class-specific polynomial orders for the selected three-class solution. BIC, Bayesian Information Criterion, AvePP, Average posterior probabilities.

Fig. 2 illustrates the distribution of older adults across the three identified trajectories of depressive symptoms, with the parameter estimates of the trajectory curves for the resulting model presented in Supplementary Table S1. Consequently, three distinct trajectories of depressive symptoms were delineated: the persistently high group (n = 558, 27.60%), characterized by consistently high depressive symptom scores with minor fluctuations; the moderate fluctuating group (n = 981, 48.52%), exhibiting moderate

symptom levels with a U-shaped pattern-initially decreasing and then increasing; and the consistently low group (n = 483, 23.89%), defined by stable, low depressive symptom scores with minimal variation. The chosen model thus captures three distinct patterns of CESD-10 score changes within the target population, accurately reflecting the stable high, moderate fluctuating, and consistently low trajectories observed across all time points.

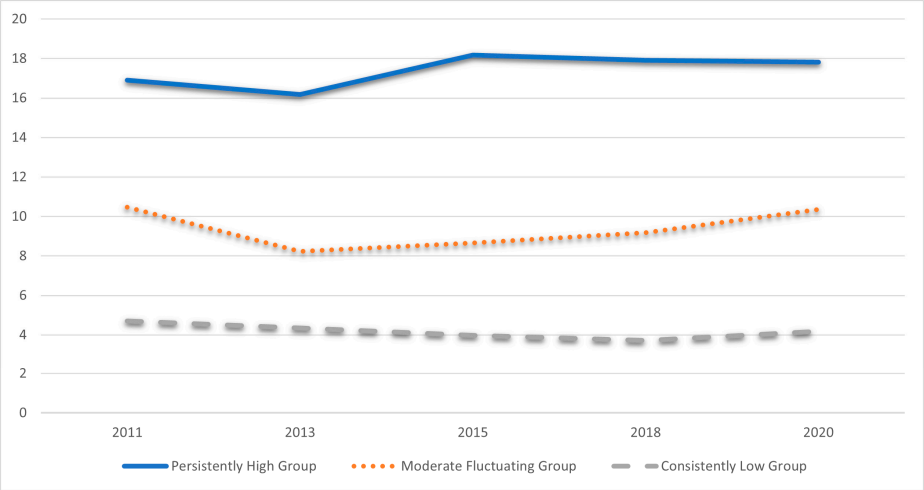

Figure 2: Trajectories of depressive symptoms among older adults with arthritis or rheumatism. Three CESD-10 measurements were obtained in 2011 (Wave 1), 2013 (Wave 2), 2015 (Wave 3), 2018 (Wave 4), and 2020 (Wave 5) and were used to fit trajectories.

3.3 Baseline Characteristics of Trajectory Groups

Supplementary Table S2 presents the mean CESD-10 scores and the prevalence of depression across five time points for the three depressive symptom trajectory groups. The Moderate Fluctuating Group consistently showed high CESD-10 scores (16.17–18.17) and high depression prevalence (85.97%–93.10%) across all five time points. The Persistently Moderate Group maintained moderate CESD-10 scores (8.24–10.48) with intermediate depression prevalence (34.51%–58.00%). The Consistently Low Group had stable low CESD-10 scores (3.72–4.71) and very low depression prevalence (1.24%–4.97%) throughout the study period. Overall, these findings indicate distinct and stable patterns of depressive symptoms and depression prevalence among the three trajectory groups over time.

The baseline characteristics and univariate analyses of older adults with arthritis or rheumatism, stratified by the three depressive symptom trajectory groups, are presented in Table 4. Statistically significant differences ($p < 0.05$) were observed among the subgroups with respect to age, gender, marital status, education level, location of residence, ADL, and living standards. Specifically, participants in the consistently low group were older, had a higher proportion of individuals with education above junior high school, were more likely to reside in urban areas, and reported the highest living standards. In contrast, the persistently high group comprised a greater proportion of females, rural residents, individuals with lower educational attainment, and reported the lowest living standards. The moderate fluctuation exhibited intermediate characteristics across these variables.

Table 4: Baseline characteristics by depressive symptom trajectories.

Variables	Baseline Characteristics	Trajectory Subgroups			F/χ^2	p-Value	LSD
		Persistently High Group	Moderate Fluctuating Group	Consistently Low Group			
Age, mean ± SD	66.94 ± 5.68	66.43 ± 5.14	66.84 ± 5.69	67.71 ± 6.14	6.89	0.001	G3 > G1/G2
ADL, mean ± SD	4.49 ± 2.17	4.58 ± 1.85	4.56 ± 2.13	4.25 ± 2.55	4.08	0.017	G1/G2 > G3
Financial support from children, mean ± SD	5.08 ± 3.78	5.07 ± 3.77	5.13 ± 3.76	4.99 ± 3.83	0.22	0.803	
Living standards, mean ± SD	2.41 ± 0.77	2.15 ± 0.81	2.43 ± 0.74	2.67 ± 0.69	61.26	<0.001	G1 < G2 < G3
Gender, *n* (%)							
Female	884 (43.72%)	167 (18.89%)	462 (52.26%)	255 (28.85%)	63.84	<0.001	
Male	1138 (56.28%)	391 (34.36%)	519 (45.61%)	228 (20.04%)			
Marital status, *n* (%)							
Divorced/living alone	1591 (78.68%)	144 (33.41%)	198 (45.94%)	89 (20.65%)	9.86	0.007	
Married/partnered	431 (21.32%)	414 (26.02%)	783 (49.21%)	394 (24.76%)			
Education level, *n* (%)							
Junior high school or below	1953 (95.59%)	550 (28.16%)	955 (48.90%)	448 (22.94%)	29.90	<0.001	
High school or above	69 (3.41%)	8 (11.59%)	26 (37.68%)	35 (50.72%)			
Location of residence, *n* (%)							
Rural	1661 (82.15%)	513 (30.89%)	810 (48.77%)	338 (20.35%)	85.33	<0.001	
Urban	361 (17.85%)	45 (12.47%)	171 (47.37%)	145 (40.17%)			
Living with any children, *n* (%)							
Yes	70 (3.46%)	21 (30.00%)	36 (51.43%)	13 (18.57%)	1.14	0.567	
No	1952 (96.54%)	537 (27.51%)	945 (48.41%)	470 (24.08%)			

Note: G1 = Persistently high group; G2 = Moderate fluctuating group; G3 = Consistently low group. ADL, Activities of Daily Living; LSD, Least Significant Difference.

3.4 Association between Social Engagement and Symptom Trajectories

As illustrated in the correlation heatmap (see Fig. 3), social engagement was negatively correlated with depressive symptoms across all survey waves (correlation coefficients ranging from −0.08 to −0.12). This suggests that higher social engagement is associated with lower levels of depressive symptoms among older adults with arthritis or rheumatism.

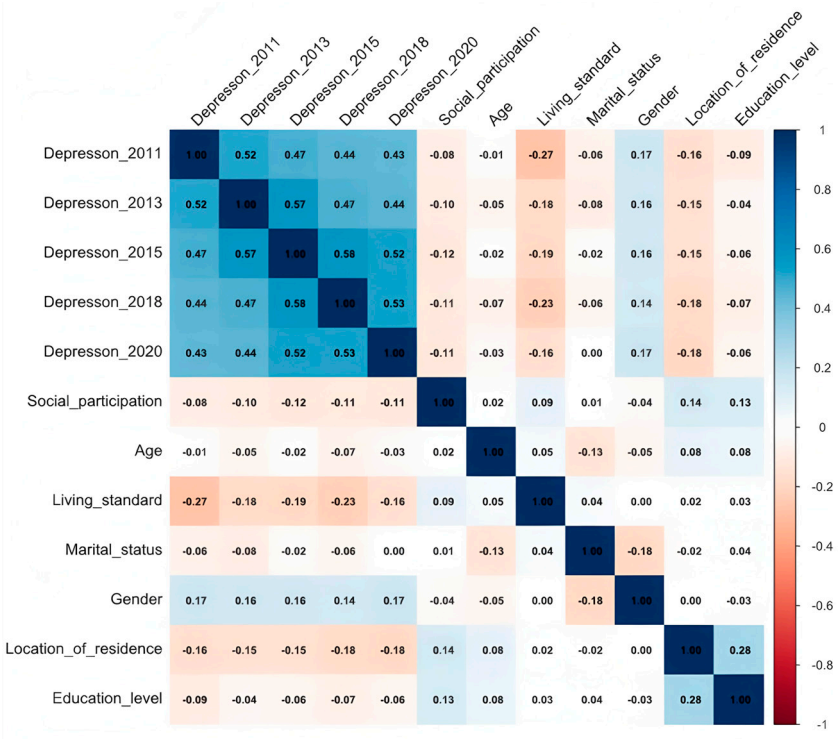

Figure 3: Association between social engagement and trajectories of depressive symptoms.

Multinomial logistic regression was performed to further examine the association between social engagement and depressive symptom trajectories, adjusting for potential confounders (see Table 5). Results indicated that higher social engagement was significantly associated with a lower likelihood of being in the persistently high group (OR = 0.82, 95% CI: 0.69–0.97, $p = 0.019$) and the moderate fluctuating group (OR = 0.86, 95% CI: 0.75–0.99, $p = 0.040$), compared to the consistently low group. In other words, greater social engagement reduced the risk of following less favorable depressive symptom trajectories.

Table 5: Multinomial logistic regression of social engagement and depressive symptom trajectories.

Variable	G1 vs. G3, OR (95%CI)	*p*-Value	G2 vs. G3, OR (95%CI)	*p*-Value
Social engagement	0.82 (0.69, 0.97)	0.019	0.86 (0.75, 0.99)	0.040
Covariates				
Age	0.96 (0.94, 0.99)	0.001	0.98 (0.96, 0.99)	0.025
ADL	1.05 (0.99, 1.11)	0.127	1.06 (1.01, 1.12)	0.014
Financial support from children	0.99 (0.96, 1.03	0.649	1.01 (0.98, 1.04)	0.768
Living standards	0.41 (0.34, 0.49)	<0.001	0.66 (0.56, 0.77)	<0.001
Marital status				
Married/partnered	Reference		Reference	
Divorced/living alone	0.31 (0.93, 1.84)	0.125	1.10 (0.81, 1.49)	0.541

Table 5: *Cont.*

Variable	G1 vs. G3, OR (95%CI)	*p*-Value	G2 vs. G3, OR (95%CI)	*p*-Value
Gender				
Female	Reference		Reference	
Male	0.38 (0.29, 0.50)	<0.001	0.82 (0.65, 1.04)	0.105
Location of residence				
Urban	Reference		Reference	
Rural	4.27 (2.88, 6.33)	<0.001	1.77 (1.34, 2.34)	<0.001
Education level				
High school or above	Reference		Reference	
Junior high school or below	1.62 (0.68, 3.85)	0.279	1.66 (0.95, 2.91)	0.076
Living with any children				
Yes	Reference		Reference	
No	0.89 (0.42, 1.89)	0.756	0.77 (0.40, 1.48)	0.431

Note: G1 = Persistently high group; G2 = Moderate fluctuating group; G3 = Consistently low group. ADL, Activities of Daily Living.

3.5 Sensitivity Analyses

In this study, the robustness of the model results was tested by adjusting the scoring methods for the independent variable. According to previous research, there are two alternative scoring approaches for the social engagement variable in CHARLS [27,29]: (1) Binary scoring, where a score of 1 indicates participation in at least one social activity and 0 indicates no participation in any social activities; (2) Frequency scoring, where the frequencies of participation in each type of social activity are summed: 0 indicates no participation, 1 indicates "not regularly", 2 indicates "almost every week" and 3 indicates "almost daily".

Supplementary Table S3 presents the results of multinomial logistic regression examining the association between binary social engagement (participation in at least one social activity vs. none) and depressive symptom trajectories. The findings indicate that, compared to the consistently low group, higher social engagement (any participation) is significantly associated with lower odds of being in both the persistently high (OR = 0.76, 95% CI: 0.58–0.95, $p = 0.045$) and moderate fluctuating (OR = 0.81, 95% CI: 0.64–0.98, $p = 0.047$) depressive symptom groups. These associations remain significant after adjusting for age, living standards, marital status, gender, residence, and education.

Supplementary Table S4 presents the results of multinomial logistic regression examining the association between the frequency of social engagement (summed participation frequency across activity types) and depressive symptom trajectories among older adults with rheumatism. The results show that a higher frequency of social engagement is significantly associated with lower odds of being in both the persistently high and moderate fluctuating depressive symptom groups compared to the consistently low group. Additionally, older age, higher living standards, male gender, urban residence, and higher education were associated with lower risks of adverse depressive symptom trajectories. Conversely, rural residence and female gender were associated with higher risks. Marital status was not significantly associated with trajectory group membership.

4 Discussion

4.1 Principal Findings

In this nationwide prospective cohort study of Chinese adults aged 60 years and above, the present study used a GBTM approach to identify three distinct trajectory patterns for Chinese older adults with arthritis or rheumatism: the persistently high group characterized by consistently severe depressive symptoms, the

moderate fluctuating group with moderate symptoms exhibiting a U-shaped pattern over time, and the consistently low group maintaining stable low symptom levels. These trajectories reflect heterogeneous patterns of depression progression in this population. Importantly, higher baseline social engagement was associated with a lower likelihood of belonging to the adverse persistently high and moderate fluctuating trajectories, independent of sociodemographic-related factors. This finding suggests that social engagement may represent a potentially beneficial psychosocial correlate of long-term mental health among older adults living with chronic conditions.

Three subgroups of depression trajectories were identified in this study: the “consistently low group”, the “moderate fluctuating group”, and the “persistently high group”. In our sample of older adults with arthritis or rheumatism, 23.9% were categorized into the consistently low group, characterized by consistently low CESD-10 scores across all survey waves and a depression prevalence not exceeding 5%, indicating relatively stable and low levels of depressive symptoms. The moderate fluctuating group comprised 48.5% of participants, with CESD-10 scores demonstrating a U-shaped pattern over time and the prevalence of depression ranging from 34.5% to 58.0%, reflecting moderate but variable depressive symptom levels. The persistently high group accounted for 27.6% of the sample, with both mean CESD-10 scores and depression prevalence remaining high throughout the study period (mean scores above 16 and prevalence above 86%), suggesting severe and persistent clinical symptoms of depression. Consistent with previous studies using LCMM [31], our findings highlight that both the initial severity and persistence of mental health symptoms are important predictors of future mental health risk. Therefore, it is recommended that particular attention be given to individuals in the moderate fluctuating and persistently high groups when designing prevention and intervention strategies, as these subgroups demonstrate elevated risks of poor functional outcomes and mortality comparable to findings in multinational arthritis or rheumatism cohorts [32]. Early screening and targeted interventions are crucial to improving depressive outcomes, with a focus on identifying and addressing the factors influencing these distinct trajectories. These results provide valuable evidence to inform the development of depression screening and intervention programs tailored to older adults with arthritis or rheumatism in China, ultimately supporting more precise and effective mental health care for this vulnerable population.

The analysis of baseline characteristics across the three depressive symptom trajectory groups revealed significant sociodemographic differences. Participants in the consistently low symptom group were more likely to have attained education beyond junior high school, predominantly urban residents, and reported higher living standards. In contrast, the persistently high symptom group was characterized by a higher proportion of females, rural dwellers, individuals with lower educational attainment, and poorer living standards. The moderate fluctuating group exhibited intermediate profiles on these variables. These findings suggest that socioeconomic and demographic factors play a crucial role in shaping the longitudinal course of depressive symptoms among older adults with arthritis or rheumatism. This pattern aligns with existing literature emphasizing the influence of social determinants on late-life depression trajectories [33–35]. For instance, prior studies have consistently found that older women are at greater risk of persistent or severe depressive symptoms, potentially due to biological vulnerabilities, social role expectations, and differential exposure to stressors [36]. Similarly, rural residency and lower educational attainment have been linked to higher depression prevalence [37] and poorer mental health outcomes, likely reflecting disparities in healthcare access, social support, and economic resources. The association of higher education and urban residence with more favorable depression trajectories corroborates findings from Chinese and international cohorts, which highlight the protective effects of socioeconomic advantage and better infrastructure [37,38]. Overall, these results reinforce the importance of considering sociodemographic heterogeneity when

assessing depression risk and designing interventions. Targeted strategies addressing the needs of socially disadvantaged groups-particularly rural women with limited education and economic means-are essential to mitigate persistent depressive symptoms and promote mental well-being among older adults with chronic conditions like arthritis or rheumatism.

There is a significant negative association between baseline social engagement and the likelihood of belonging to adverse depressive symptom trajectories among older adults with arthritis or rheumatism. Specifically, higher levels of social engagement were associated with reduced odds of being in the persistently high and moderate fluctuating groups compared to the consistently low group. This finding underscores the protective role of social engagement in mitigating the severity and persistence of depressive symptoms in this vulnerable population.

Social engagement may is hypothesized to support mental health benefits through multiple pathways, including providing emotional support, enhancing cognitive stimulation, fostering a sense of purpose and belonging, and promoting healthier lifestyle behaviors. Moreover, social networks can facilitate access to healthcare resources and reduce feelings of isolation, which are critical factors in managing chronic illness and associated psychological distress [39]. Our findings align with prior studies conducted in diverse populations, including older adults in China and other countries, which have similarly reported that greater social engagement or social integration is associated with lower levels of depressive symptoms [40,41]. Importantly, by focusing on longitudinal trajectories rather than cross-sectional symptom levels, our study provides evidence that social engagement is related to more favorable long-term symptom patterns. For example, previous longitudinal research in Hong Kong reported that higher social engagement was associated with lower depressive symptoms over time [42], although causal inference remains limited in observational designs.

Notably, reverse causality cannot be fully ruled out. Depressive symptoms may reduce motivation, energy, and willingness to participate in social activities, leading to lower social engagement (i.e., depression → social withdrawal). Although social engagement was measured at baseline and depressive symptoms were tracked longitudinally, the observational nature of this study precludes causal conclusions. Future studies using repeated measures of social engagement, cross-lagged or time-varying models, or intervention designs will be valuable to clarify the directionality and potential causal mechanisms underlying these associations.

Sensitivity analyses using both binary and frequency scoring methods for social engagement consistently demonstrated that greater social engagement was associated with lower odds of belonging to the persistently high and moderate fluctuating depressive symptom trajectories, compared to the consistently low group. These associations remained significant after adjusting for sociodemographic and health-related factors. The robustness of these findings across different operationalizations of the social engagement variable indicates that the protective effect of social engagement on depression trajectories in older adults with rheumatism is stable and not dependent on the specific scoring method used.

4.2 Clinical and Practical Implications

This study highlights social engagement as a key protective factor against persistent depressive symptoms in older adults with arthritis or rheumatism, emphasizing its importance in clinical practice. Integrating social engagement promotion into routine care-through community programs, peer support, and group activities-can help reduce depression and improve quality of life. Early screening for depressive symptoms and social isolation should be standard in managing older adults with chronic diseases, enabling timely, targeted interventions.

Community-based interventions that encourage social engagement, physical activity, and cognitive stimulation have demonstrated effectiveness in reducing depressive symptoms among the olde adults [43]. Programs such as group exercise classes, volunteer opportunities, peer support groups, and community centers can foster meaningful social connections, enhance emotional support, and mitigate feelings of isolation-key contributors to depression. Moreover, combining social engagement with cognitive-behavioral therapy (CBT) and health education may yield synergistic benefits by addressing both psychosocial and cognitive risk factors. Tailoring these interventions to the specific needs and cultural contexts of older adults with arthritis or rheumatism, especially those in rural areas or with lower socioeconomic status, can improve accessibility and adherence.

The findings also emphasize the importance of early screening for depressive symptoms and social isolation in clinical settings. Healthcare providers should routinely assess social engagement levels alongside physical health indicators in older adults with chronic conditions to identify those at risk of adverse depression trajectories. Interdisciplinary approaches involving mental health professionals, social workers, and community organizations can facilitate comprehensive care that addresses both medical and social determinants of health.

4.3 Limitations and Future Research Directions

This study has several limitations. First, it relies on secondary data from the CHARLS database rather than primary data collection. While CHARLS provides a large, nationally representative longitudinal dataset, the use of existing data limits control over variable selection and measurement precision, and some potentially relevant factors related to social engagement or depressive symptoms may not be fully captured. Although we utilized self-rated health and socioeconomic indicators as robust proxies for overall health status, the potential for residual confounding from unmeasured clinical variables cannot be entirely ruled out. Second, arthritis/rheumatism was identified using self-reported physician diagnosis rather than clinical examinations or biomarkers. While this approach is commonly used in large epidemiological surveys such as CHARLS, it may introduce misclassification across rheumatic subtypes. Such misclassification is likely non-differential and may attenuate the observed associations (bias toward the null), suggesting that the protective effects of social engagement could be conservative. Future studies using clinical records, imaging, or serological markers are needed to validate diagnoses and refine subtype-specific associations. Third, depressive symptoms and social engagement were self-reported, which may introduce recall or reporting biases. Furthermore, while the longitudinal design establishes temporal precedence, the observational nature of this study restricts definitive causal inference. We acknowledge the possibility of reverse causality, where initial depressive symptoms might lead to social withdrawal.

Future research should address these limitations by conducting primary data collection specifically designed to capture detailed psychosocial variables and by employing experimental or intervention designs to establish causal relationships between social engagement and depression trajectories. Investigating which specific types or dimensions of social engagement are most protective, along with exploring moderators such as gender, socioeconomic status, and urban-rural residence, will enable more effective tailoring of interventions. Furthermore, integrating biological, psychological, and social factors within a life-course framework could enhance our understanding of the development of depression in older adults with chronic diseases. Expanding research to encompass diverse populations and cultural settings will improve the generalizability of findings and support the design of culturally relevant interventions.

5 Conclusions

This study identified three distinct depressive symptom trajectories among older adults with arthritis or rheumatism and demonstrated that higher social engagement is associated with more favorable depression outcomes. Social engagement emerged as a key protective factor against persistent and worsening depressive symptoms, independent of other risk factors. These findings highlight the importance of promoting social engagement in clinical and public health interventions to improve mental health and quality of life in this vulnerable population. Future research should explore causal pathways and develop targeted, culturally appropriate strategies to enhance social engagement and reduce depression among older adults with chronic illnesses.

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Availability of Data and Materials: The data that support the findings of this study are openly available in [China Health and Retirement Longitudinal Survey] at [https://charls.pku.edu.cn/].

Ethics Approval: The China Health and Retirement Longitudinal Study (CHARLS) received ethical approval from the Institutional Review Board of Peking University. The protocol of the main household survey was approved under IRB00001052-11015. During fieldwork, each respondent who agreed to participate was asked to provide written informed consent. The present study is a secondary analysis of de-identified, publicly available CHARLS data and involved no additional data collection.

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