BMC Public Health

RESEARCH

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Impact of social, familial and personal factors on depressive symptoms in middle-aged and older adults from the national CHARLS cohort

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Abstract

Background This study aimed to evaluate whether social, familial and personal factors can predict incident and prevalent depressive symptoms in Chinese adults aged ≥ 45 years using data from the China Health and Retirement Longitudinal Study (CHARLS).

Methods Study subjects without depressive symptoms from CHARLS at baseline were enrolled. Depressive symptoms were defined by the 10-item Center for Epidemiologic Studies Depression Scale. Statistical adjustment, subgroup exploration and unmeasured confounding assessment were undertaken to derive reliable estimates.

Results 1681 (27.04%) of 6215 subjects who had no depressive symptoms in 2011, suffered one or more depressive symptoms in 2018. Multivariate analyses showed that number of grandchildren (odds ratio [95% confidence interval]: 1.06 [1.02, 1.10]), social activity score (0.95 [0.91, 0.98]), instrumental activities of daily living (IADL) (1.35 [1.11, 1.65]) and number of comorbidities (1.16 [1.10, 1.22]) were independently and significantly associated with the presence of incident depressive symptoms. Further categorization revealed significance for social activity score (odds ratio [95% confidence interval]: 0.78 [0.69, 0.89] and 0.71 [0.53, 0.95] for 1–5 and > 5 vs. 0), IADL (1.35 [1.11, 1.65] for yes vs. no) and number of comorbidities (1.38 [1.20, 1.58], 1.44 [1.16, 1.81] and 2.42 [1.54, 3.80] for 1–2, 3–4 and > 4 vs. 0) associated with incident depressive symptoms. Restricting analysis to wave IV data in 2018 observed significant association of number of grandchildren, social activity score, IADL and number of comorbidities with prevalent depressive symptoms.

Conclusions The present study findings support the marked contribution of social activity score, IADL and number of comorbidities to incident and prevalent depressive symptoms in Chinese middle-aged and older adults.

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Keywords Cohort study, Incident depressive symptoms, Middle-aged and elder adults, Prevalent depressive symptoms, Risk factor

Introduction

Depression as a serious mental illness is highly prevalent worldwide [1]. A global estimated 5% of adults suffered from depression, and this number was approximately 30% among elders [2–4]. With the intensification of aging process, the prevalence of depression will continue to grow around the world [5]. In China, the number of older adults over 65 and 80 years of year is projected to reach 400 million and 150 million by 2050, respectively [6, 7]. Such ageing population structure will inevitably boost future mental health burden. As the second leading cause of years lived with disability, depression often impairs quality of life, enhances suicide risk and shortens life expectancy [8, 9]. To curb these unexpected consequences, action is urgently needed to identify individuals susceptible to depression or with undiagnosed depression and implement imperative measures to prevent or delay its onset or progression.

The possible causes underlying the pathogenesis of depression are multifaceted [10]. Growing evidence supports the involvement of social, familial and personal factors in the development of depressive symptoms [10, 11]. From social aspects, depression can significantly weaken sense of pleasure and desire to communication, and ultimately loss opportunities to participate in society [12, 13]. Less social connection is recognized as a risk factor for depressive symptoms [14]. From familial aspects, the rapid industrialization and urbanization of China has shrunk family structure and weakened family functions during the past 3 decades, which shook the traditional 'filial piety' idea and reduced the protection of geriatric depression [15]. From personal aspects, multiple comorbidity and its resultant physical activity disorders are commonly seen among older adults [16] who often experience different degrees of depression [17, 18]. At present, investigations on depressive symptoms in China mainly focus on the association with one or only a few factors [19–21], and evidence on the implication of social, familial and personal abnormalities in depressive symptoms was mainly from cross-sectional studies [11, 22, 23]. To comprehensively decipher the underlying causes of depression, a working hypothesis was developed in this article, postulating that abnormalities from social, familial and personal have potential influences on depressive symptoms from both a cross-sectional and longitudinal perspective.

To test this hypothesis and yield more information for future research, this study analyzed the longitudinal data from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative survey, to evaluate whether social, familial and personal factors can predict incident and prevalent depressive symptoms in Chines adults aged ≥ 45 years.

Methods

Study subjects

This study used data from the CHARLS [24]. In brief, CHARLS is a nationally representative longitudinal survey hosted by the Institute of Social Science Survey, Peking University. The CHARLS is conducted according to stringent quality control policies.

The baseline wave on adults aged ≥ 45 years was conducted in 2011 and sampled 17,708 residents from 150 counties across 28 provinces in mainland China (wave I). All study subjects have been followed up every 2 to 3 years using a probability-proportional-to-size method to assess social, economic and health situations on ageing (wave II in 2013, wave III in 2015 and wave IV in 2018). For each around of surveys, face-to-face interviews were conducted by trained interviewers via computer-assisted personal interviewing (CAPI).

Subject-level data were drawn from CHARLS 2011 baseline and 3 consecutive waves, including 17,705 respondents. A total of 6,215 subjects aged ≥ 45 years without depressive symptoms in wave I and with complete data on depression scores in wave IV were eligible for inclusion. The selection process of study subjects is presented in Fig. 1.

Definition of depression symptoms

Depressive symptoms were defined by the 10-item Center for Epidemiological Studies Depression Scale (CESD-10) that has been widely employed to screen depression in elders [25]. There is robust evidence for good validity and reliability of CESD-10 [26, 27]. Specifically, CESD-10 is composed of 10 items, and each item uses a 4-point scale, ranging from 0 to 3. Negative symptoms are assigned as 0, 1, 2 and 3 in turn, and positive symptoms have the opposite assignment. The scores 0, 1, 2 and 3 correspond to "rarely or none of the time (< 1 day)", "some or a little of the time (1–2 days)", "occasionally or a moderate amount of the time (3–4 days)" and "most or all of the time (5–7 days)", respectively. The sum of the CESD-10 scores ranges from 0 to 30, with higher values indicating more severe depressive symptoms. The total score at 10 was set as a cut-off point for depressive symptomatology [25].

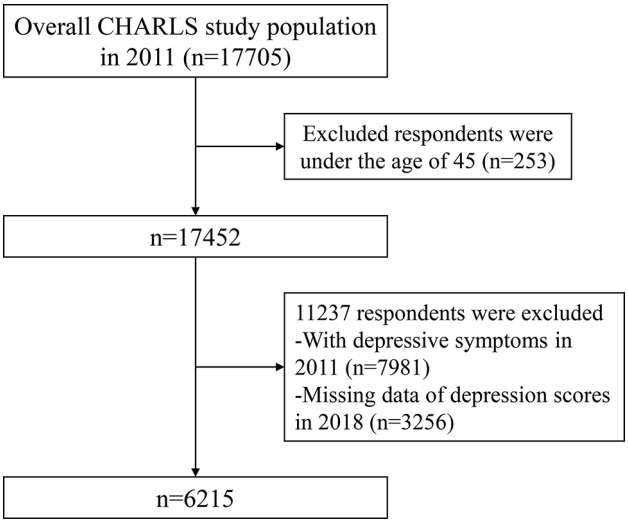

Fig. 1 Flow diagram for the selection process of study subjects. *Abbreviations* CHARLS, China Health and Retirement Longitudinal Study

Social factors

According to the CHARLS instructions, 11 types and frequencies of social activities were used to measure social participation [28], with reliability coefficient (alpha) at 0.72. Frequency of social events in the last month was assigned as 1, 2 and 3 in turn, and the scores 1, 2 and 3 correspond to "not regularly", "almost every week" and "almost daily", respectively. The total scores ranged from 0 to 33, and social participation was the sum of frequencies of all social activities. This sum equals to 0 in the case of nonattendance to any social activities.

Familial factors

Familial factors were assessed based on the following five aspects: number of children [29], number of grandchildren [30], caring for grandchildren [31], offspring's financial support [32] and contact with offspring [33]. Number of children referred to total number of living and dead children, including biological, adopted, fostered and stepchildren. Number of grandchildren totaled the number of sons and daughters of all children. Caring for grandchildren was measured by two questions: [1] Did you spend any time taking care of your grandchildren last year? It took the value of 1 if caregiving was provided and 0 otherwise; [2] How many weeks and how many hours per week did you spend last year taking care of this child's children? Intensity of grandchildren care per week was measured by categorical variables based on previous studies: none (0 h), low intensity (1–14 h), moderate intensity (15–39 h) and high intensity (≥40 h) [34, 35]. Three categories of grandchild-care frequencies were identified: never, not regularly (≤half a year: 1–26 weeks) and regularly (≥half a year: ≥26 weeks) [36]. Evaluation of grandchildren care was calculated as the product of intensity and frequencies of grandchildren care. Intergenerational support from children included both economic and emotional support, that is, offspring's financial support and contact with offspring. Offspring's financial support was measured by the sum of all children's money including cash and in-kind in the past year. Considering the existence of extreme values, this variable was logarithm-transformed. Contact with offspring was measured according to the question "How often do you communicate with children you do not live with?" Ten options of this question were divided into five options, that is, "hardly", "seldom", "almost monthly", "almost weekly" and "almost every day", ranging from 1 to 5. Contact with offspring totaled the frequencies of contact with each child.

Personal factors

Personal factors of all subjects included number of chronic diseases, activities of daily living (ADL) [37] and instrumental activity of daily living (IADL) [38]. According to the CHARLS instructions, ADL were assessed by reporting difficulty in dressing, bathing, eating, getting into or out of bed, going to the toilet, and controlling urination and defecation. Difficulty in any item was recorded as 1, and 0 otherwise. For IADL, each subject was asked whether he or she had difficulty in doing household chores, preparing hot meals, shopping, managing money and taking medications, and similarly binary IADL was created. Number of comorbidities was recorded by the number of following chronic diseases: hypertension, dyslipidemia, diabetes or high blood sugar, cancer or malignant tumor, chronic lung diseases, liver diseases, heart problems, stroke, kidney diseases, stomach or other digestive diseases, psychiatric problem, memory-related disease, arthritis or rheumatism and asthma. For each disease, it was recorded as 1 in the case of presence, and 0 otherwise. The total number of comorbidities was obtained by adding these 14 diseases.

Confounding factors

Socio-demographic factors [39], cigarette smoking [40], alcohol drinking [41], sleeping time [42] and body mass index (BMI) [43] were considered as confounding factors. Socio-demographic factors included age, sex, household (agriculture, non-agriculture), education (primary school or below, junior high school and college or above), marital status (married, divorced, widowed and single) and migration experience (whether an individual had left their place of residence for six months or more at least once since birth). Cigarette smoking and alcohol drinking were determined based on two questions: "Have you ever cigarette smoking or alcohol drinking?" and "Do you still have the habit or have you totally quit?" Smoking and drinking were grouped into 3 categorical variables (never smoking or drinking, quit smoking or drinking

and still smoking or drinking). Sleeping time per day was divided into "<5 h", "5–6 h", "6–7 h", "7–8 h", "8-9 h" and ">9 h". BMI was calculated by body weight (kg) divided by height squared (m^2), using the standards of the WHO to define overweight and obesity [44]. BMI was categorized as non-overweight (<25 kg/m^2), overweight (25–30 kg/m^2) and obesity (≥30 kg/m^2).

Statistical analyses

Data analyses were conducted using the STATA software Release 16.0 (Stata Corp, College Station, TX, USA) and R coding platform (version 3.5.2). Continuous variables are expressed as mean (standard deviation) if there is no validation from normal distributions and as median (interquartile range) otherwise. Categorical variables are expressed as count (percent). All variable assignments were presented in Supplementary Table 1. Between-group comparisons of variables were performed using the t test, χ^2 test, or rank-sum test, where appropriate. The analytical procedure for social, familial and personal factors at baseline (2011, wave I) associated with depressive symptoms in 2018 (wave IV) consisted of two steps. First, actual scores to quantify the magnitude of depression were treated as the independent outcome in generalized linear models to regress social, familial and personal factors individually before and after adjusting for age, sex, household, education, marital status, cigarette smoking, alcohol drinking, sleep time and BMI. Effect-sizes are expressed as unstandardized coefficient with 95% confidence interval (CI). Second, after binarizing depressive symptoms, Logistic regression analyses were carried out to assess the independent impact of individual social, familial and personal factors on either continuous or categorical scales with and without confounding adjustment. Effect-sizes are expressed as odds ratio (OR) with 95% CI. Besides statistical adjustment, stratified analyses were performed for the association of baseline social, familial and personal factors with depressive symptoms according to the categories of each confounding factor. To investigate the interaction between depressive symptoms and survey waves, generalized additive mixed models were constructed using baseline data at baseline (wave I) and 3 follow-up waves (II-IV). In the first sensitivity analysis, the association of social, familial and personal factors at baseline (wave I) with depressive symptoms in 2018 were assessed on either continuous or categorical scales. Differential probabilities in predicting depressive symptoms were estimated for social activity and number of comorbidities according to age, sex, BMI, marital status, education and physical activity, respectively. In the second sensitivity analysis, E-value was adopted to assess the potential impact of unmeasured confounding, with the higher E-values indicating the stronger the unmeasured confounders that are needed to interpret the observed association [45, 46].

Results

Baseline sample characteristics

Of 6,215 subjects without any hint of depressive symptoms in 2011, 1,681 (27.04%) were recorded to suffer one or more depressive symptoms in 2018. Table 1 showed the baseline sample characteristics of study subjects. Age distributions were comparable between subjects with and without depressive symptoms. Men were overrepresented in subjects without vs. with depressive symptoms ($P<0.001$).

Association with incident depressive symptoms

Shown in Table 2 was the association of social, familial and personal factors with depression scores on a continuous scale. After adjusting for all confounders, number of grandchildren (β, 95% CI: 0.27, 0.19 to 0.35), contact with offspring (β, 95% CI: 0.06, 0.01 to 0.12), offspring's financial support (β, 95% CI: 0.67, 0.20 to 1.13), ADL (β, 95% CI: 1.39, 0.70 to 2.08), IADL (β, 95% CI: 1.31, 0.76 to 1.85) and number of comorbidities (β, 95% CI: 0.50, 0.37 to 0.64) were positively and significantly associated with depression scores, whereas for social activity score (β, 95% CI: -0.19, -0.27 to -0.11), the association was negative and significant.

After treating depression scores as a binary outcome, the association was statistically significant for number of grandchildren (OR, 95% CI: 1.06, 1.02 to 1.10), social activity score (0.95, 0.91 to 0.98), IADL (1.35, 1.11 to 1.65) and number of comorbidities (1.16, 1.10 to 1.22) on continuous scales (Table 3). By contrast, categorization of social, familial and personal factors only confirmed the association of social activity score, IADL and number of comorbidities with the presence of incident depressive symptoms, and marginal significance was seen for number of grandchildren. For instance, there was a significant dose-dependent increase in the odds of incident depressive symptoms, with the increasing number of comorbidities (1.38, 1.20 to 1.58 for 1–2 comorbidities, 1.44, 1.16 to 1.81 for 3–4 comorbidities and 2.42, 1.54 to 3.80 for >4 comorbidities) after full adjustment.

Stratified association with incident depressive symptoms

After linear and Logistic regression analyses, 3 significant factors, including social activity score, IADL and number of comorbidities were teased out as independent predictors for incident depressive symptoms. To further improve confounding control, stratified analyses were performed according to the categories of confounders adjusted in model 3 (Supplementary Table 2).

By age and sex, social activity score was a significant predictor for incident depressive symptoms in elders

Table 1 Baseline sample characteristics of Chinese participants from CHARLS according to the presence of incident depressive symptoms in 2018

Characteristics	Incident depressive symptoms		*p*
	Absence	Presence	
Sample size, N	4,534	1,681	
Age (years), N (%)			0.164
45–59	2,746 (60.6)	1,068 (63.6)	
60–74	1,627 (35.9)	562 (33.4)	
≥ 75	161 (3.5)	51 (3.0)	
Sex, N (%)			< 0.001
Men	2,384 (56.4)	682 (43.1)	
Women	1,840 (43.6)	902 (56.9)	
Ethnicity, N (%)			0.762
Han	4,223 (93.1)	1,562 (92.9)	
Minorities	311 (6.9)	119 (7.1)	
Household, N (%)			< 0.001
Agriculture	3,345 (73.8)	1,387 (82.6)	
Non-agriculture	1,188 (26.2)	293 (17.4)	
Education, N (%)			< 0.001
Primary school or below	2,430 (53.6)	1,099 (65.4)	
Junior high school	1,949 (43.0)	557 (33.2)	
College or above	154 (3.4)	24 (1.4)	
Marital status, N (%)			0.020
Married	4,234 (93.4)	1,554 (92.4)	
Divorced	30 (0.7)	11 (0.7)	
Widowed	255 (5.6)	100 (5.9)	
Single	15 (0.3)	16 (1)	
Migration, N (%)			
No	2,826 (0.67)	1,068 (0.68)	0.426
Yes	1,386 (0.33)	498 (0.32)	
Social activity score, median (IQR)	1.0 (0.0, 3.0)	0.0 (0.0, 3.0)	< 0.001
Number of children, median (IQR)	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	0.140
Number of grandchildren, median (IQR)	2.0 (1.0, 4.0)	3.00 (1.0, 5.0)	< 0.001
Contact with offspring, median (IQR)	6.0 (4.0, 10.0)	6.00 (4.0, 10.0)	0.149
Offspring's financial support (RMB), median (IQR)	2,000 (800, 4,500)	1,500 (600, 3,900)	< 0.001
Grandparent care, median (IQR)	0.0 (0.0, 4.0)	0.0 (0.0, 3.0)	0.188
Cigarette smoking, N (%)			< 0.001
Never smoking	2,561 (56.5)	1,077 (64.1)	
Quit smoking	402 (8.9)	116 (6.9)	
Still smoking	1,571 (34.6)	488 (29)	
Alcohol drinking, N (%)			0.201
Never drinking	2,475 (81)	1,045 (82.5)	
Quit drinking	286 (9.4)	121 (9.6)	
Still drinking	294 (9.6)	100 (7.9)	
Sleep status, median (IQR)	4.0 (3.0, 5.0)	3.0 (2.0, 5.0)	< 0.001
Nap time, median (IQR)	1.0 (1.0, 5.0)	1.0 (1.0, 5.0)	< 0.001
ADL, N (%)			0.038
No	1,959 (88.3)	874 (85.7)	
Yes	260 (11.7)	146 (14.3)	
IADL, N (%)			< 0.001
No	4,135 (91.4)	1,468 (87.5)	
Yes	389 (8.6)	210 (12.5)	
Life satisfaction, N (%)			< 0.001
Extremely satisfied	102 (2.4)	24 (1.6)	
Very satisfied	1,105 (25.8)	302 (19.7)	

Table 1 (continued)

Characteristics	Incident depressive symptoms		*p*
	Absence	Presence	
Somewhat satisfied	2,783 (65.1)	1,028 (67.1)	
Not very satisfied	267 (6.2)	169 (11)	
Not satisfied at all	18 (0.4)	10 (0.7)	
Physical activity, N (%)			< 0.001
None	311 (6.9)	179 (10.7)	
Light	1,332 (29.4)	555 (33.1)	
Moderate	1,499 (33.1)	473 (28.2)	
Heavy	1,390 (30.7)	471 (28.1)	
BMI, N (%)			0.258
Not overweight or obese	2,480 (64.5)	960 (64.9)	
Overweight	1,152 (29.9)	422 (28.5)	
Obesity	215 (5.6)	98 (6.6)	
Number of comorbidities, median (IQR)	1 (0, 2)	1 (0, 2)	< 0.001

Abbreviations IQR, interquartile range; ADL, activity of daily living; IADL, instrumental activities of daily living; BMI, body mass index. The p values were calculated by the rank-sum test or the χ^2 test, where appropriate

Table 2 Social, familial and personal factors associated with depression scores of Chinese participants from CHARLS in 2018

Variables	Unstandardized β coefficient (95% confidence interval)		
	Model 1	Model 2	Model 3
Number of children	2.94 (2.80, 3.08)**	0.01 (-0.21, 0.24)	-0.01 (-0.25, 0.23)
Number of grandchildren	1.29 (1.23, 1.36)**	0.26 (0.17, 0.36)**	0.27 (0.19, 0.35)**
Grandparents care	1.44 (1.32, 1.57)**	0.01 (-0.10, 0.13)	-0.06 (-0.19, 0.06)
Contact with offspring	0.67 (0.64, 0.70)**	0.08 (0.02, 0.13)**	0.06 (0.01, 0.12)*
Offspring's financial support	2.10 (1.99, 2.21)**	1.21 (0.88, 1.53)**	0.67 (0.20, 1.13)**
Social activity score	1.43 (1.36, 1.51)**	-0.18 (-0.25, -0.11)**	-0.19 (-0.27, -0.11)**
ADL	8.55 (7.66, 9.45)**	1.44 (0.79, 2.09)**	1.39 (0.70, 2.08)**
IADL	8.28 (7.60, 8.97)**	1.53 (1.02, 2.05)**	1.31 (0.76, 1.85)**
Number of comorbidities	3.09 (2.97, 3.20)**	0.55 (0.42, 0.67)**	0.50 (0.37, 0.64)**

Abbreviations ADL, activity of daily living; IADL, instrumental activities of daily living

In model 1, no confounder was adjusted; in model 2, age, sex, household, education and marital status were adjusted; in model 3, cigarette smoking, alcohol drinking, sleeping time and body mass index were additionally adjusted. **$p<0.01$; *$p<0.05$

(OR, 95% CI: 0.92, 0.87 to 0.98) and women (0.94, 0.90 to 0.98), but not in youngers and men. Similarly, for IADL, the significantly increased risk was noted in elders (1.88, 1.42 to 2.48) and women (1.53, 1.18 to 1.98), as well as in subjects with non-overweight (1.38, 1.08 to 1.76), primary school or below (1.48, 1.18 to 1.86) and moderate (1.46, 1.02 to 2.09) or heavy (1.77, 1.23 to 2.54) physical activity. Number of comorbidities was a risk-conferring factor in subjects without obesity (OR, 95% CI: 1.22, 1.13 to 1.30 for non-overweight and 1.12, 1.03 to 1.23 for overweight), below college education (1.17, 1.09 to 1.24 for primary school or below, and 1.15, 1.05 to 1.26 for junior high school) and having light to heavy physical activity (1.17, 1.06 to 1.29, 1.16, 1.06 to 1.27 and 1.15, 1.04 to 1.26, respectively).

In addition, estimated probabilities for incident depressive symptoms conferred by continuous social activity score (Supplementary Fig. 1) and number of comorbidities (Supplementary Fig. 2) were displayed according to confounder categories.

Chronological changes of significant factors

Figure 2 provided the chronological changes of 3 significant factors at baseline (wave I) and 3 follow-up waves (II-IV) by the presence of depressive symptoms. Changes for social activity score and number of comorbidities were synchronous from 2011 to 2018 between subjects with and without depressive symptoms. Contrastingly, for IADL, changes were stabilized for subjects without depressive symptoms, whereas for those with depressive symptoms, IADL was increased sharply with ageing.

Interaction between depressive symptoms and survey waves

In Supplementary Tables 3, 3 factors were significantly associated with depressive symptoms and survey waves, with the exception of IADL with wave II. For the interaction between depressive symptoms and survey waves, significance was seen for IADL across all interaction items, and for number of comorbidities only depressive symptoms-wave III interaction.

Sensitivity analyses

Besides incidence of depressive symptoms, prevalence of depressive symptoms was also evaluated by using data

Table 3 Social, familial and personal factors associated with incident depressive symptoms of Chinese participants from CHARLS in 2018

Variables	Odds ratio (95% confidence interval)		
	Model 1	Model 2	Model 3
Variables on a continuous scale			
Number of grandchildren	0.85 (0.83, 0.87)**	1.06 (1.02, 1.09)**	1.06 (1.02, 1.10)**
Contact with offspring	0.91 (0.90, 0.92)**	1.01 (0.99, 1.03)**	1.01 (0.99, 1.04)
Social activity score	0.73 (0.72, 0.75)**	0.95 (0.92, 0.98)**	0.95 (0.91, 0.98)**
Offspring's financial support	0.75 (0.72, 0.78)**	0.80 (0.67, 0.95)*	0.82 (0.66, 1.00)
ADL	0.56 (0.46, 0.69)**	1.27 (1.01, 1.58)*	1.25 (0.99, 1.59)
IADL	0.54 (0.46, 0.64)**	1.38 (1.14, 1.67)**	1.35 (1.11, 1.65)**
Number of comorbidities	0.70 (0.67, 0.73)**	1.16 (1.11, 1.22)**	1.16 (1.10, 1.22)**
Variables on a categorical scale			
Number of grandchildren			
0	Ref.	Ref.	Ref.
1–5	0.37 (0.34, 0.41)**	1.05 (0.80, 1.39)	1.09 (0.79, 1.51)
> 5	0.45 (0.37, 0.54)**	1.36 (0.94, 1.97)	1.47 (0.98, 2.23)
Social activity score			
0	Ref.	Ref.	Ref.
1–5	0.32 (0.30, 0.35)**	0.76 (0.67, 0.85)**	0.78 (0.69, 0.89)**
> 5	0.27 (0.21, 0.34)**	0.76 (0.59, 0.99)*	0.71 (0.53, 0.95)*
IADL			
No	Ref.	Ref.	Ref.
Yes	0.54 (0.46, 0.64)**	1.38 (1.14, 1.66)**	1.35 (1.11, 1.65)**
Number of comorbidities			
0	Ref.	Ref.	Ref.
1–2	0.41 (0.38, 0.44)**	1.36 (1.20, 1.55)**	1.38 (1.20, 1.58)**
3–4	0.42 (0.36, 0.50)**	1.47 (1.20, 1.81)**	1.44 (1.16, 1.81)**
> 4	0.77 (0.52, 1.14)	2.64 (1.73, 4.04)**	2.42 (1.54, 3.80)**

Abbreviations ADL, activity of daily living; IADL, instrumental activities of daily living; Ref., reference group

In model 1, no confounder was adjusted; in model 2, age, sex, household, education and marital status were adjusted; in model 3, cigarette smoking, alcohol drinking, sleeping time and body mass index were additionally adjusted. **$p<0.01$; *$p<0.05$

from wave IV in 2018 (Supplementary Table 4). Linear regression analyses identified all, except contact with offspring, factors in significant and independent association with prevalent depressive symptoms. Further Logistic regression analyses confirmed the association for number of grandchildren, social activity score, IADL and number of comorbidities, which reinforced the results associated with prevalent depressive symptoms.

Unmeasured confounding assessment

Although a wide panel of confounding factors were adjusted, the possibility of unmeasured confounding cannot be fully excluded. To address this possibility, E-values were computed for 3 significant factors (Supplementary Table 5). In detail, E-values ranged from 1.52 to 1.66 for social activity score (1–5 and >5 vs. 0), was 1.60 for IADL disorder (yes vs. no) and ranged from 1.63 to 2.49 for number of comorbidities (1–2, 3–4 and >4 vs. 0). These E-values were larger than the effect-sizes in corresponding Logistic regression analyses, indicating that unmeasured confounders, if exist, must have much larger effects than the exposure variables studied to explain away reported association.

Discussion

Using a nationally representative sample of Chinese middle-aged and older adults, this study aimed to test the hypothesis that social, familial and personal factors can predict incident and prevalent depressive symptoms. The key findings of this longitudinal study are the identification of social activity score, IADL and number of comorbidities that can independently predict the significant risk of incident depressive symptoms. Moreover, this cross-sectional analyses of CHARLS wave IV dataset confirmed the association of the 3 factors with prevalent depressive symptoms. Furthermore, prediction capability of social activity score and IADL for depressive symptoms was more evident in older women, and that of number of comorbidities was greatly impacted by obesity, education and physical activity. To our knowledge, this is thus far the first study that has comprehensively and longitudinally unraveled the possible causes of depression symptoms in Chinese adults aged ≥ 45 years from the perspective of social, familial and personal dimensions.

Facing the intensification of global ageing, depression is becoming a major public health burden. As projected by the World Health Organization (WHO), depression ranks as the leading cause of disability worldwide [47]. In fact, depression is preventable and treatable, and its clinical diagnosis is usually hinged upon neuroimaging [48]. In the healthcare settings, it is anticipated that population screening and case-finding in high-risk subjects are considered beneficial for early identification of depressive patients, timely management of depressive symptoms

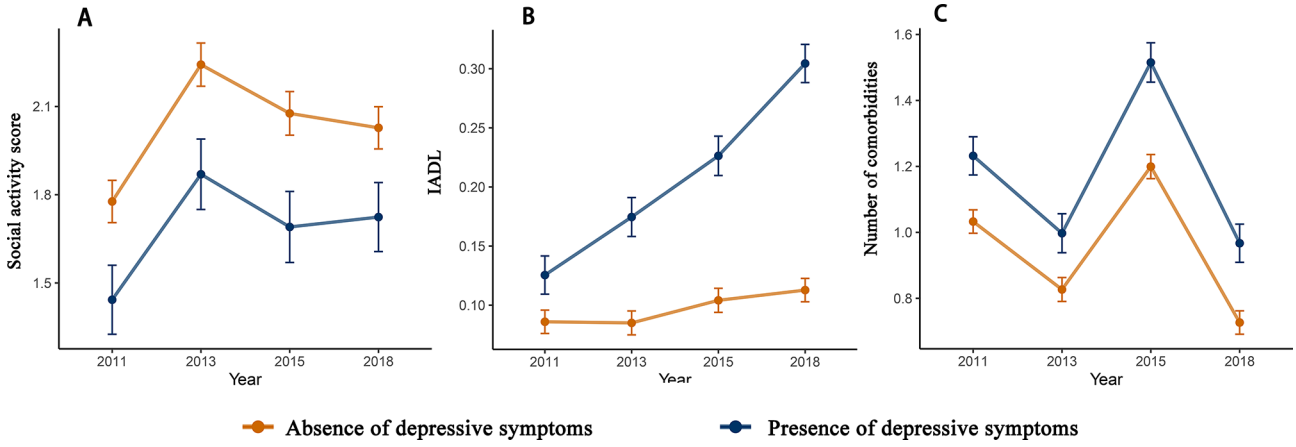

Fig. 2 Chronological changes of social activity score, IADL and number of comorbidities according to the absence (orange solid line) and presence (blue solid line) of depressive symptoms from 2011 to 2018. *Abbreviations* IADL, instrumental activities of daily living

and great improvement in quality of life. Currently, the pathogenesis of depression is not fully understood, and a comprehensive understanding of its risk profiles is critical. The causes of depression are extremely complex, with multiple factors implicated [10]. To shed some light on this issue, attempts were made to seek the causes of depressive symptoms from social, familial and personal dimensions in Chinese middle-aged and older adults.

It is worth noting that in this study, low social activity scores, high IADL scores and large numbers of comorbidities were found to be associated with the significantly elevated risk of both incident and prevalent depressive symptoms, and importantly this association was independent of confounding factors. Social participation has been widely evaluated as a risk factor or a mediator of depressive symptoms in the literature. Epidemiologic evidence revealed that different types of social participation exerted divergent effects on depression in elders [49], with lower frequencies of social interaction paralleling higher risk of depression [23, 50]. Additionally, social participation also served as a mediator for the impact of the WeChat usage on depression in middle-aged and older adults [51]. Clinical evidence indicated the negative correlation between social interaction frequencies and circulating interleukin (IL-6) and C-reactive protein (CRP) concentrations in depressive patients [52]. Whether inflammatory biomarkers can mediate the association between social activity and depressive symptoms is beyond the scope of this longitudinal study, and future studies that address the biological implications of social activity in the development of depression are warranted.

Besides, the present study findings supported the involvement of IADL and number of comorbidities in predisposition to depressive symptoms, consistent with the results of prior studies [10, 53]. For instance, IADL disability onset was found to be 1.05 times more likely to have depressive symptoms in US Chinese elders [53], and in this study, per score increment in IADL was associated with approximately 40% increased risk of incident depressive symptoms, especially among older women. In addition, it is widely recognized that aging put people at greater risk for a wide panel of chronic disorders. Some pathological changes, including arteriosclerosis, inflammation and immune responses, can compromise the functions of amygdala and hippocampus, and hence boost the susceptibility to depression [54], in line with the findings of this study that number of comorbidities was deemed as a significant predictor for incident depressive symptoms. For practical reasons, more attention should be attached to older patients with IADL disability or comorbidities in population screenings.

In addition, the current research results did not support the impact of intergenerational support, such as contact with offspring, offspring's financial support and grandparents care on incident depressive symptoms, and other studies also failed to confirm this impact [15, 55]. It is possible that generational responsibility has reduced the protection of geriatric depression.

Limitations

Besides the clear strengths of this present study, including long follow-up, large sample size and sufficient causal inference, some limitations should be acknowledged. First, considering the limitations of CESD-10 in defining depression, depressive symptoms (CESD-10 scores of 10 and over) was adopted when assessing the impact of social, familial and personal factors. Second, recall bias is inevitable in the process of cohort surveys. Third, the results in this article are based on Chinese, and further verification is needed to extrapolate the findings of this study to other countries.

Conclusions

Findings from this study support the marked contribution of social activity score, IADL and number of comorbidities to incident and prevalent depressive symptoms in Chinese middle-aged and older adults. Given the rapid growth of older populations in China and other countries, there is an urgent need to identify those at high risk for depressive symptoms in an attempt to reduce associated individual and social economic burden. For practical reasons, in light of the present study findings, fostering social connections and promoting independent daily living can significantly lighten this burden, and enable more effective interventions for older individuals who are susceptible to depression.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-20159-8.

Supplementary Material 1

Acknowledgements
The authors thank the China Center for Economic Research, National School of Development at Peking University for their hard work and unselfish sharing of survey data.

Author contributions
C.L., J.W. and W.N. designed the study. X.Z. and W.N. contributed to data cleaning. X.Z., Z.G., Z.Z. and W.N. performed the statistical analysis. X.Z. and M.X. written first draft. C.L., J.W. and W.N. are the study guarantors. The final manuscript was contributed by all authors.

Funding
This research received no external funding.

Data availability
The data will not be shared without permission of all authors. Please contact W.N. if required.

Declarations

Ethics approval and consent to participate
The performance of CHARLS was approved by the Institutional Review Board of Peking University (No. IRB00001052-11015), in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all subjects and/or their legal guardian(s).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 28 January 2024 / Accepted: 23 September 2024
Published online: 30 September 2024

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