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The association between changes in health behaviors and depressive symptoms among Chinese older adults: A national cross-sectional study

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Abstract

Background: Depressive symptoms are common in older adults. However, few studies have assessed changes in health behaviors during the pandemic and gender differences among Chinese older adults.

Objective: To examine the association of changes in health behaviors with depressive symptoms among Chinese older adults during the pandemic, and gender differences. Methods: The data were obtained from the 2020 China Health and Retirement Longitudinal Study, which included 7,947 older adults. Binary logistic regression examined associations between changes in health behaviors and depressive symptoms, and subgroup analyses assessed gender differences in effects of physical activity, smoking, and alcohol consumption changes on depressive symptoms.

Results: The prevalence of depressive symptoms among older adults in China was 39.37% during the COVID-19 pandemic in 2020. Female (odds ratio [OR] = 1.790, 95% CI: 1.578–2.031), unmarried (OR = 1.438, 95% CI: 1.266–1.634), rural residency (OR = 1.479, 95% CI: 1.321–1.657), and two or more chronic diseases (OR = 1.472, 95% CI: 1.253–1.729) were associated with higher odds of depressive symptoms. Decreased intense activities (OR=1.301, 95% CI: 1.133–1.493) and decreased smoking (OR = 1.500, 95% CI: 1.183–1.903) were associated with higher odds of depressive symptoms. Subgroup analyses revealed a significant interaction between gender and changes in alcohol consumption on depressive symptoms.

Conclusion: The study found that decreased intense activities and decreased smoking were associated with higher odds of depressive symptoms. Health administrators

should develop policies based on the relationship between changes in health behaviors and depressive symptoms among older adults of different genders.

Keywords: Depressive symptoms; Older adults; Health behaviors; Smoking; Physical activities; Drinking

1. Introduction

The phenomenon of population aging is emerging as a global trend, representing an inevitable outcome of economic and societal advancement. The World Health Organization estimates that from 2015 to 2050, the global percentage of individuals aged 60 and above will nearly double, rising from approximately 12% to 22%.[1] Notably, China is facing a difficult demographic aging situation, with the proportion of the population aged 60 and above reaching 18.70% in 2020.[2] Depressive symptoms are common in older adults.[3] These symptoms may be difficult to treat and are associated with a decrease in quality of life and an increased risk of suicide.[4,5] Long-term or recurrent episodes of depressive symptoms pose challenges in managing elderly patients.

Depressive symptoms have been shown to be associated with life experience, quality of sleep, lower socio-economic status, and health conditions such as chronic diseases.[6-8] Lifestyle factors, such as physical inactivity, may serve as potential targets for strategies aimed at addressing depressive symptoms.[9] A systematic review found that physical activity was associated with better mental health and lower odds of depressive symptoms.[10] A large-scale population cohort study in Norway found that any level of physical activity intensity was associated with lower odds of depressive symptoms, and that the odds of depressive symptoms were 12% lower among individuals who exercised for at least one hour per week.[11] However, some research has also revealed that only moderate-intensity and high-intensity physical activity may be associated with benefits.[12,13] Despite the varying results of prospective studies, the notion that physical exercise is one of the most effective ways of addressing depressive symptoms is widely acknowledged. Numerous literature reviews have concluded that physical exercise is moderately associated with alleviation of depressive symptoms.[10,14-17]

Smoking and drinking are significant predictors of depressive symptoms.[18-21] Existing literature provides evidence that both smoking cessation and alcohol abstinence are associated with reductions in depressive symptoms over time.[22-26] A study has found that smoking abstinence is associated with improvements in depressive symptoms as compared to any level of sustained or reduced use.[27] Reductions in depressive symptoms appeared to be greater for those who achieved abstinence compared to a reduction in smoking.[23] A large-scale prospective six-year cohort study found that moderate alcohol consumption was not associated with fewer depressive symptoms in cross-sectional analysis, but a reduction in alcohol consumption was associated with an improvement in depressive symptoms over time.[25] The results of a Chinese study showed a negative association between smoking, drinking, and depressive symptoms, but no evidence was found of higher odds or persistence of depressive symptoms among high-frequency drinkers or heavy smokers.[28]

Although prior work has extensively investigated the associations between physical activity, smoking, or alcohol consumption and depressive symptoms, few studies have examined reported changes in these behaviors during the pandemic and gender differences among older adults. The stress-coping model posits that when individuals encounter external stressors, they engage in cognitive appraisal and coping responses to manage the demands of the stressful situation, which in turn influence mental health outcomes.[29] Under this framework, the COVID-19 pandemic served as a significant external stressor that disrupted daily routines and led to changes in health behaviors among older adults. These behavioral changes may have implications for mental health outcomes. Therefore, the main objective of this study is to investigate the relationship between changes in physical activity, smoking, and alcohol consumption and depressive symptoms among older adults aged 60 and above in China, using data collected during this special period, and to explore whether this relationship existed in the male and female groups.

2. Methods

2.1. Data source

The China Health and Retirement Longitudinal Study (CHARLS) is a large-scale, interdisciplinary survey carried out by the China Social Science Survey Center of Peking University.[30] It aimed to collect a high-quality, nationally representative sample of Chinese residents aged 45 and older to serve the needs of scientific research on older adults. CHARLS adopted a multi-stage stratified

probability sampling proportional to size (PPS). The data used in this study were obtained from the CHARLS 2020 wave (fieldwork conducted from July 2021 to March 2022), which included questions on changes in physical activity, smoking, and alcohol consumption. According to the purpose of the current study, participants aged 60 years and older were selected for analysis, and those who had emotional and mental problems, or missing data on depressive symptoms or any of the covariates, were excluded. A total of 7,947 valid subjects were screened (Figure 1). This study obtained authorization for data use from the CHARLS project team and was approved by the Ethics Review Committee of Peking University (No. IRB00001052-11015).[30] All participants provided signed informed consent forms.

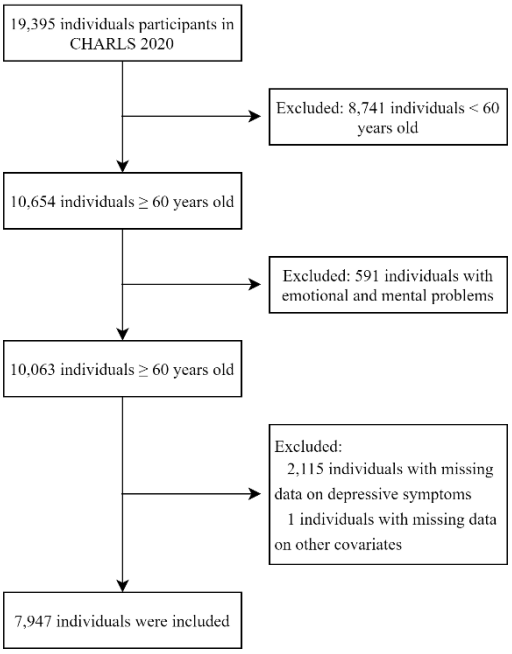


Figure 1. Flowchart of the study population from China Health and Retirement Longitudinal Study (CHARLS)

2.2. Depressive symptoms

The Center for Epidemiological Studies Depression Scale (CES-D-10) was used to measure depressive symptoms. CES-D-10 has high reliability and validity in accurately assessing depressive symptoms in middle-aged and older adults.[31] Previous research has established that CES-D-10 has a Cronbach's alpha of 0.79 in Chinese adults.[32] The simplified scale comprises 10 questions, and the total score was calculated by summing up the individual responses. The scoring range was from 0 to 30 points. A higher score reflects a higher level of depressive symptoms. A score of 10 and below was considered no depressive symptoms and assigned a value of 0; a score above 10 was considered to have depressive symptoms and assigned a value of 1.

2.3. Independent variable

The core independent variables were changes in health behaviors due to the COVID-19 pandemic, including changes in intense activities, moderate activities, light activities, smoking, and alcohol consumption. Changes in intense activities refer to changes in the time spent on intense physical activities per day compared to the time before the pandemic. Intense activities refer to those that are highly physically demanding and can cause shortness of breath, including carrying heavy loads, digging, farming, aerobic exercise, fast cycling, cycling with cargo, and intense indoor activities. Changes in moderate activities refer to changes in the time spent on moderate physical activities per day compared to the time before the pandemic. Moderate activities include lifting light objects, mopping floors, cycling at a regular speed, and brisk walking. Changes in light activities such as walking or strolling refer to changes in time spent on daily light physical activities compared with the time before the pandemic. Changes in smoking refer to changes in the amount of smoking compared to the time before the pandemic. Changes in alcohol consumption refer to changes in the amount of alcohol consumed compared to the time before the pandemic. Responses for changes in physical activities, including intense, moderate, and light activities, were coded as 1 for unchanged, 2 for increased, and 3 for decreased. For smoking and alcohol consumption, the coding was 1 for unchanged, 2 for increased, 3 for decreased, and 4 for never, which referred to participants who reported no smoking or drinking at all.

2.4. General demographic information

Control variables included socio-demographic variables and health-status variables. Socio-demographic variables included gender (male and female), age (60–69 years, 70–79 years, ≥80 years), marital status (married and unmarried), educational level (illiterate/semiliterate, primary school, junior high school, and senior high school or above), and residence (urban and rural). The married group included participants who were married and living with their spouse, those who were married but temporarily not living with their spouse due to work or other reasons, and those who were separated. The unmarried group included participants who were divorced, widowed, or never married. Health status variables included self-reported health (good, bad, and fair) and chronic disease (0, 1, and ≥2). Chronic disease refers to whether an individual suffers

from one or more of the 14 common chronic diseases included in CHARLS 2020. These 14 common chronic diseases include: hypertension, dyslipidemia, diabetes or hyperglycemia, malignant tumors, chronic lung diseases, liver diseases, heart diseases, stroke, kidney diseases, gastric or digestive system diseases, Parkinson's disease, arthritis or rheumatism, asthma, and memory-related diseases.

2.5. Statistical analysis

We used frequency (*n*), percentage (%), and mean (standard deviation [SD]) to show the socio-demographic and depressive symptom-related characteristics of older adults. Using the chi-squared test, we compared categorical factors associated with depressive symptoms among older adults. Dummy variables were set for the categorical variables with more than two groups. In multivariate analysis, binary logistic regression was performed to examine the factors associated with depressive symptoms. The odds ratio (OR), 95% confidence interval (95% CI), and *p*-value were reported. To test the robustness of the results, we repeated the logistic regression models using alternative CES-D-10 cutoffs of 8 and 12 to define depressive symptoms, based on previous studies.[31,33] To examine whether the associations between behavioral changes and depressive symptoms differed by gender, we tested the interaction between gender and each behavioral change variable using likelihood ratio tests. We then conducted gender-stratified subgroup analyses using logistic regression models to explore the direction and magnitude of the associations within each gender. All statistical analyses were conducted using STATA 16.0 (StataCorp LLC, United States of America). The significance level for statistics was set at two-sided $p < 0.05$.

3. Results

3.1. Basic characteristics of the participants

The characteristics of the participants are shown in Table 1. More than half of older adults were aged 60–69 years (66.21%), with an average age of 67.96 years. Slightly more than half of the participants were male (50.82%); most were married (80.11%) and living in rural areas (64.78%). There were 48.79% older adults who were illiterate/semiliterate, and the proportion of those with senior high school or above was the lowest. In addition, 51.09% of participants considered their health fair. More than half of older adults suffered from two or more chronic diseases (64.92%).

Table 1. Basic characteristics of older adults (*N* = 7,947)

Variables	*n*	%
Gender		
Male	4,039	50.82
Female	3,908	49.18
Age (years)		
60–69	5,262	66.21
70–79	2,265	28.50
≥80	420	5.29
Marital status		
Married	6,366	80.11
Unmarried	1,581	19.89
Educational level		
Illiterate/semiliterate	3,877	48.79
Primary school	1,769	22.26
Junior school	1,416	17.82
Senior high school or above	885	11.14
Residence		
Urban	2,799	35.22
Rural	5,148	64.78
Self-reported health		
Good	1,801	22.66
Fair	4,060	51.09
Bad	2,086	26.25
Chronic disease		
0	1,110	13.97
1	1,678	21.11
≥2	5,159	64.92

3.2. Depressive symptoms and changes in physical activities, smoking, and alcohol consumption in older adults

Table 2 shows depressive symptoms and changes in physical activities, smoking, and alcohol consumption in older adults. Among the 7,947 participants included in the analysis, 39.37% of them suffered from depressive symptoms. Specifically, 47.95% of female older adults and

31.07% of male older adults had depressive symptoms. Meanwhile, 24.49% of older adults reduced intense activity, and the proportion of those with no change was the highest (74.57%); 3.27% increased moderate activity, and almost half reduced light activity (44.48%). In addition, 5.68% of older adults reduced smoking, and 2.09% increased smoking. For alcohol consumption, 8.18% of older adults reduced alcohol consumption and 0.99% increased consumption. Among participants who reported increased alcohol consumption, 69 (87.34%) were male, and 10 (12.66%) were female.

3.3. Depressive symptoms by basic characteristics and behavioral changes of older adults

Table 3 shows the prevalence of depressive symptoms and basic characteristics disparities in older adults. In general, 47.95% of females suffered from depressive symptoms, and gender was associated with the presence of depressive symptoms ($p < 0.05$). Age was associated with depressive symptom status ($p < 0.05$), and the proportion of depressive symptoms among the older adults aged 70–79 years was the highest (41.72%). Compared with urban older adults, the prevalence rate of depressive symptoms among rural

Table 2. Depressive symptoms and changes in physical activities, smoking, and alcohol consumption in older adults (N = 7,947)

Variables	*n* (%)	Gender		p
		Male (*n* [%])	Female (*n* [%])	
Depressive symptoms				<0.001
No	4,818 (60.63)	2,784 (57.78)	2,034 (42.22)	
Yes	3,129 (39.37)	1,255 (40.11)	1,874 (59.89)	
Intense activities				<0.001
Unchanged	5,926 (74.57)	2,917 (49.22)	3,009 (50.78)	
Increase	75 (0.94)	45 (60.00)	30 (40.00)	
Decrease	1,946 (24.49)	1,077 (55.34)	869 (44.66)	
Moderate activities				<0.001
Unchanged	5,848 (73.59)	2,871 (49.09)	2,977 (50.91)	
Increase	260 (3.27)	117 (45.00)	143 (55.00)	
Decrease	1,839 (23.14)	1,051 (57.15)	788 (42.85)	
Light activities				<0.001
Unchanged	4,245 (53.42)	2,199 (51.80)	2,046 (48.20)	
Increase	167 (2.10)	110 (65.87)	57 (34.13)	
Decrease	3,535 (44.48)	1,730 (48.94)	1,805 (51.06)	
Smoking				<0.001
Unchanged	1,832 (23.05)	1,618 (88.32)	214 (11.68)	
Increase	166 (2.09)	142 (85.54)	24 (14.46)	
Decrease	451 (5.68)	409 (90.69)	42 (9.31)	
Never	5,498 (69.18)	1,870 (34.01)	3,628 (65.99)	
Alcohol consumption				<0.001
Unchanged	2,000 (25.17)	1,556 (77.80)	444 (22.20)	
Increase	79 (0.99)	69 (87.34)	10 (12.66)	
Decrease	650 (8.18)	523 (80.46)	127 (19.54)	
Never	5,218 (65.66)	1,891 (36.24)	3,327 (63.76)	

older adults was higher (44.19%), and residence was associated with the presence of depressive symptoms ($p < 0.05$). Meanwhile, 44.93% of patients with two or more chronic diseases suffered from depressive symptoms.

The prevalence of depressive symptoms was highest among those with increased moderate activity (46.15%), while it was lowest among those with decreased activity (37.30%). Smokers who decreased their habit exhibited the highest depressive symptom rate of 42.57%, and the lowest rate of 32.91% among those who did not change their smoking status. The prevalence of depressive symptoms was highest among individuals who abstained from alcohol (43.25%), while individuals who increased alcohol consumption had the lowest rate of 26.58%.

3.4. Factors associated with depressive symptoms using logistic regression

Table 4 showed the results of logistic regression for depressive symptoms. The results showed that female (OR = 1.790, 95% CI: 1.578–2.031), unmarried (OR = 1.438, 95% CI: 1.266–1.634), educational levels of primary school, junior high school, and senior high school or above (OR = 0.742, 95% CI: 0.652–0.845; OR = 0.641, 95% CI: 0.554–0.742; OR = 0.468, 95% CI: 0.386–0.567, respectively), rural residency (OR = 1.479, 95% CI: 1.321–1.657), decreased intense activities (OR = 1.301, 95 %CI: 1.133–1.493), decreased light activities (OR = 0.870, 95% CI: 0.775–0.977), decreased smoking (OR = 1.500, 95% CI: 1.183–1.903), self-reported health as fair and bad (OR =

Table 3. Depressive symptoms by the characteristics of older adults (N = 7,947)

Variables	Depressive symptoms		χ^2	p
	No (n [%])	Yes (n [%])		
Gender			237.110	<0.001
Male	2,784 (68.93)	1,255 (31.07)		
Female	2,034 (52.05)	1,874 (47.95)		
Age (years)			7.532	0.023
60–69	3,235 (61.48)	2,027 (38.52)		
70–79	1,320 (58.28)	945 (41.72)		
≥80	263 (62.62)	157 (37.38)		
Marital status			77.947	<0.001
Married	4,013 (63.04)	2,353 (36.96)		
Unmarried	805 (50.92)	776 (49.08)		
Educational level			279.377	<0.001
Illiterate/semiliterate	2,021 (52.13)	1,856 (47.87)		
Primary school	1,123 (63.48)	646 (36.52)		
Junior school	987 (69.70)	429 (30.30)		
Senior high school or above	687 (77.63)	198 (22.37)		
Residence			142.171	<0.001
Urban	1,945 (69.49)	854 (30.51)		
Rural	2,873 (55.81)	2,275 (44.19)		

(*Cont'd...*)

Table 3. (*Continued*)

Variables	Depressive symptoms		χ^2	*p*
	No (*n* [%])	Yes (*n* [%])		
Self-reported health			791.194	<0.001
Good	1,465 (81.34)	336 (18.66)		
Fair	2,565 (63.18)	1,495 (36.82)		
Bad	788 (37.78)	1,298 (62.22)		
Chronic disease			200.269	<0.001
0	827 (74.50)	283 (25.50)		
1	1,150 (68.53)	528 (31.47)		
≥2	2,841 (55.07)	2,318 (44.93)		
Intense activities			4.507	0.105
Unchanged	3,625 (61.17)	2,301 (38.83)		
Increase	39 (52.00)	36 (48.00)		
Decrease	1,154 (59.30)	792 (40.70)		
Moderate activities			8.610	0.014
Unchanged	3,525 (60.28)	2,323 (39.72)		
Increase	140 (53.85)	120 (46.15)		
Decrease	1,153 (62.70)	686 (37.30)		
Light activities			6.804	0.033
Unchanged	2,517 (59.29)	1,728 (40.71)		
Increase	103 (61.68)	64 (38.32)		
Decrease	2,198 (62.18)	1,337 (37.82)		
Smoking			45.930	<0.001
Unchanged	1,229 (67.09)	603 (32.91)		
Increase	110 (66.27)	56 (33.73)		
Decrease	259 (57.43)	192 (42.57)		
Never	3,220 (58.57)	2,278 (41.43)		
Alcohol consumption			99.700	<0.001
Unchanged	1,376 (68.80)	624 (31.20)		
Increase	58 (73.42)	21 (26.58)		
Decrease	423 (65.08)	227 (34.92)		
Never	2,961(56.75)	2,257(43.25)		

Table 4. Factors associated with depressive symptoms using logistic regression (*N* = 7,947)

Variables	OR	95% CI	
Gender (ref. = male)			
Female	1.790***	1.578	2.031
Age (years) (ref. = 60–69)			
70–79	1.034	0.924	1.158
≥80	0.842	0.669	1.061
Marital status (ref. = married)			
Unmarried	1.438***	1.266	1.634
Educational level (ref. = illiterate)			
Primary school	0.742***	0.652	0.845
Junior school	0.641***	0.554	0.742
Senior high school	0.468***	0.386	0.567
Residence (ref. = urban)			
Rural	1.479***	1.321	1.657
Intense activities (ref. = unchanged)			
Increase	1.545	0.929	2.570
Decrease	1.301***	1.133	1.493
Moderate activities (ref. = unchanged)			
Increase	1.339	1.004	1.785
Decrease	0.964	0.834	1.114
Light activities (ref. = unchanged)			
Increase	0.834	0.580	1.200
Decrease	0.870*	0.775	0.977
Smoking (ref. = unchanged)			
Increase	0.910	0.630	1.315
Decrease	1.500**	1.183	1.903
Never	0.918	0.797	1.058
Alcohol consumption (ref. = unchanged)			
Increase	0.833	0.475	1.458
Decrease	1.057	0.855	1.306
Never	1.101	0.966	1.254
Self-reported health (ref. = good)			
Fair	2.444***	2.121	2.816
Bad	6.142***	5.232	7.211
Chronic disease (ref. = 0)			
1	1.081	0.901	1.296
≥2	1.472***	1.253	1.729

Notes:. Illiterate: Illiterate/semiliterate. Senior high school: Senior high school or above. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Abbreviations: OR: Odds ratio; Ref.: Reference category.

2.444, 95%-CI: 2.121–2.816; OR = 6.142, 95% CI: 5.232–7.211, respectively), and two or more chronic diseases (OR = 1.472, 95% CI: 1.253–1.729) were associated with the presence of depressive symptoms.

3.5. Sensitivity analysis of the association between changes in health behaviors and depressive symptoms

To test the robustness of our findings, we repeated the logistic regression models using alternative CES-D-10 cutoffs of 8 (Model 1) and 12 (Model 2) to define depressive symptoms (Table 5). The results were generally consistent with the main analysis using a cutoff of 10.

Specifically, older adults who reported a decrease in intense activities had higher odds of depressive symptoms in both Models 1 (OR = 1.314, 95% CI: 1.147–1.504) and 2 (OR = 1.322, 95% CI: 1.142–1.529). A decrease in light activities was associated with lower odds of depressive symptoms in both models (Model 1: OR = 0.879, 95% CI: 0.785–0.984; Model 2: OR = 0.863, 95% CI: 0.764–0.976). In addition, a decrease in smoking remained associated with higher odds of depressive symptoms (Model 1: OR = 1.464, 95% CI: 1.159–1.848; Model 2: OR = 1.505, 95% CI: 1.170–1.937). No significant associations were observed for alcohol consumption across the alternative cutoffs.

3.6. Subgroup analysis of the association between changes in physical activity, smoking, and alcohol consumption and depressive symptoms

Table 6 presents the results of interaction tests and subgroup analyses by gender. The interaction was statistically significant only for alcohol consumption (p = 0.002), but not for intense activities, moderate activities, light activities, or smoking (p > 0.05). For alcohol consumption, the interaction indicates that the association differed by gender. Among female older adults, decreased

Table 5. Sensitivity analysis of the association between changes in health behaviors and depressive symptoms using alternative CES-D-10 cutoffs (*N* = 7,947)

Variables	Model 1			Model 2		
	OR	95% CI		OR	95% CI	
Intense activities (ref. = unchanged)						
Increase	1.306	0.785	2.173	1.407	0.829	2.389
Decrease	1.314***	1.147	1.504	1.322***	1.142	1.529
Moderate activities (ref. = unchanged)						
Increase	1.242	0.933	1.654	1.354*	1.004	1.826
Decrease	0.946	0.822	1.088	0.958	0.821	1.118
Light activities (ref. = unchanged)						
Increase	0.800	0.563	1.137	0.797	0.541	1.175
Decrease	0.879*	0.785	0.984	0.863*	0.764	0.976
Smoking (ref. = unchanged)						
Increase	1.072	0.756	1.519	0.991	0.669	1.469
Decrease	1.464**	1.159	1.848	1.505**	1.170	1.937
Never	0.892	0.779	1.021	0.911	0.782	1.062
Alcohol consumption (ref. = unchanged)						
Increase	1.047	0.631	1.737	0.582	0.297	1.142
Decrease	1.086	0.888	1.328	1.016	0.806	1.279
Never	1.064	0.939	1.206	1.136	0.986	1.307

Notes: Both Models 1 and 2 controlled for age, marital status, educational level, residence, self-reported health, and chronic disease. *p < 0.05; **p < 0.01; ***p < 0.001.

Abbreviations: OR: Odds ratio; Ref.: Reference category.

Table 6. Subgroup analysis of the association between changes in physical activity, smoking, and alcohol consumption and depressive symptoms (*N* = 7,947)

Variables	OR	95% CI		*p* interaction
Intense activities				
Gender				0.795
Male (ref. = unchanged)				
Increase	1.424	0.723	2.807	
Decrease	1.194	0.976	1.460	
Female (ref. = unchanged)				
Increase	1.741	0.787	3.850	
Decrease	1.395***	1.151	1.691	
Moderate activities				
Gender				0.619
Male (ref. = unchanged)				
Increase	1.297	0.830	2.025	
Decrease	1.077	0.874	1.327	
Female (ref. = unchanged)				
Increase	1.339	0.912	1.968	
Decrease	0.863	0.705	1.057	
Light activities				
Gender				0.969
Male (ref. = unchanged)				
Increase	0.858	0.539	1.364	
Decrease	0.850	0.716	1.011	
Female (ref. = unchanged)				
Increase	0.815	0.449	1.478	
Decrease	0.893	0.763	1.044	
Smoking				
Gender				0.537
Male (ref. = unchanged)				
Increase	0.933	0.623	1.397	
Decrease	1.621***	1.256	2.091	
Never	0.902	0.767	1.061	

(*Cont'd...*)

Table 6. (*Continued*)

Variables	OR	95% CI		*p* interaction
Female (ref. = unchanged)				
Increase	0.705	0.284	1.749	
Decrease	0.908	0.439	1.878	
Never	0.898	0.660	1.221	
Alcohol consumption				
Gender				0.002
Male (ref. = unchanged)				
Increase	1.184	0.664	2.108	
Decrease	0.919	0.718	1.176	
Never	1.085	0.922	1.276	
Female (ref. = unchanged)				
Increase	0.069*	0.008	0.579	
Decrease	1.632*	1.054	2.526	
Never	1.136	0.908	1.420	

Notes: Adjusted variables included age, marital status, educational level, residence, self-reported health, and chronic disease. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Abbreviations: OR: Odds ratio; Ref.: Reference category.

alcohol consumption was associated with higher odds of depressive symptoms (OR = 1.632, 95% CI: 1.054–2.526), while increased consumption was associated with lower odds (OR = 0.069, 95% CI: 0.008–0.579). However, the latter estimate was based on only 10 women and should be interpreted with caution. Among male older adults, no significant associations were observed for changes in alcohol consumption. For intense activities, the subgroup analysis by gender showed that decreased intense activities were associated with higher odds of depressive symptoms among female older adults (OR = 1.395, 95% CI: 1.151–1.691). Similarly, for smoking, the subgroup analysis by gender showed that increased smoking was associated with higher odds among male older adults (OR = 1.621, 95% CI: 1.256–2.091).

4. Discussion

The prevalence of depressive symptoms among older adults in China was 39.37% in 2020, indicating a substantial burden of depressive symptoms. Our results were consistent with most of the prior studies that the prevalence of depressive symptoms among the Chinese population aged 60 and above ranged from 24.10% to 50.64%.[34-39] Several studies also found that the prevalence of depressive symptoms among the elderly in China showed an increasing trend.[34,40] From the perspective of the stress-coping model, external stressors trigger coping responses, and the COVID-19 pandemic can be regarded as a major stressor, disrupting daily life and promoting changes in the health behavior of older adults.[29,41] This study found that due to the COVID-19 pandemic, nearly a quarter of older adults had a decrease in intense and moderate activities, over 40% had a decrease in light activities, and the proportions of older adults who reduced smoking and alcohol consumption were 5.63% and 7.96%, respectively. In other studies,[42-45] reductions in various levels of physical activity, as well as decreases in smoking and alcohol consumption, were also observed.

Older adults who decreased intense activities had higher odds of depressive symptoms compared with those with no changes, especially among older women. Some studies

found that a higher level of physical activity was associated with fewer depressive symptoms among older adults.[46] A cohort study indicated that regular physical activity was associated with lower depressive symptoms among individuals with a higher level of activity.[47] However, in this study, no evidence was found to support an association between the increase in intense activities and depressive symptoms. From the perspective of the stress-coping model, the reduction in intense activities among older adults during the pandemic can be interpreted not simply as a behavioral choice, but largely as a passive behavioral restriction imposed by external policies. Intense activities often provide daily structure, social engagement, and a sense of accomplishment, all of which serve as important coping resources, and their loss may be associated with reduced capacity to manage pandemic-related stress and greater vulnerability to depressive symptoms.

During the pandemic, smokers who reduced their smoking had higher odds of depressive symptoms, and this association was mainly observed among older men. Tobacco is an easily accessible psychoactive drug, and smoking is often used as a means of mood regulation.[48] Disruptions to daily routines may also be associated with mental health problems.[49] One potential interpretation is that smokers may use tobacco as a means of mood regulation, and the reduced availability of tobacco during pandemic restrictions could have disrupted this habitual coping pattern. Within the stress-coping framework, such reduction in smoking among older men may be interpreted as the loss of a previously available coping resource, and may be associated with greater vulnerability to depressive symptoms. Our finding was contrary to the observation in other countries that participants with more smoking reduction had significantly fewer depressive symptoms.[27] The complicated relationship between depressive symptoms and tobacco dependence, as well as cultural differences, may be the reasons for the different research results. A study found that current drinkers had lower odds of depressive symptoms compared to never drinkers or former drinkers.[28] Among female older adults, decreased alcohol consumption was associated with higher odds of depressive symptoms, while increased consumption appeared to be associated with lower odds. However, given the extremely small number of women who reported increased alcohol consumption, this latter finding should be interpreted with caution. These results suggest that the association between changes in alcohol consumption and depressive symptoms may differ between older men and women, though this requires confirmation in larger studies.

The present study showed that female older adults had higher odds of depressive symptoms compared to male older adults. Across nationally representative surveys of older adults in China, female older adults consistently report a higher prevalence of depressive symptoms than male older adults.[6,50-52] Several factors may account for this difference. Biologically, sex differences in hormonal regulation, inflammatory responses, and neuroendocrine function may be associated with greater vulnerability among women.[53,54] Fluctuations in estrogen and progesterone across the life course, particularly during menopause, may influence mood regulation and stress reactivity. Women also tend to show stronger inflammatory and immune responses, which have been linked to depressive symptoms in later life. In addition, sex differences in brain regions involved in emotion processing and stress regulation may partly underlie the higher prevalence among women. Psychologically, women may be more likely to ruminate and to express emotional distress. During the pandemic, due to home isolation, women may also be more likely to seek help and to report symptoms when facing difficulties, which may be associated with higher observed prevalence. At the same time, men may underreport emotional problems because traditional Chinese norms of masculinity discourage emotional expression, which may be associated with an underestimation of depressive symptoms among men. Socially, gender roles and expectations may also limit women's access to education, employment, and financial resources across the life course, accumulating disadvantages that persist into older age.

In our study, unmarried older adults had higher odds of depressive symptoms compared to married ones. Several studies found that marital status was an important predictor of depressive symptoms, with unmarried elderly individuals showing a higher risk of depressive symptoms in those studies.[34,39,55] A spouse can provide emotional support, companionship, and a sense of belonging, which may buffer the impact of stress and loneliness. The unmarried group in our study included participants who were divorced, widowed, or never married. Widowed older adults may experience acute grief and loss of daily companionship, whereas divorced older adults may face ongoing conflict. Older adults who are unmarried may also face stronger social stigma and weaker traditional family support.

This study found that the higher the level of education, the lower the odds of depressive symptoms, similar to previous studies.[56-58] Individuals with lower educational attainment tend to exhibit weaker cognitive and emotional management skills, which may be associated with greater difficulty in effectively coping with stress, anxiety, irritability, and other depressive factors, and

with higher odds of depressive symptoms. Education is also closely linked to socio-economic resources such as income, occupation, and financial security, which may be associated with lower exposure to material hardship and related stress. Education represents people's ability to access and use health information.[58] The COVID-19 pandemic created a rapidly changing and sometimes conflicting information environment. Older adults with higher education may have been better able to access, understand, and evaluate health information, adopt protective behaviors, and manage uncertainty. In contrast, those with lower education may have had greater difficulty in obtaining reliable information, may have been more vulnerable to misinformation, and may have experienced more fear and uncertainty, all of which may be associated with higher odds of depressive symptoms.

Older adults with poorer self-reported health had higher odds of depressive symptoms. Previous research has shown that depressive symptoms in older adults were associated with functional disability.[39,59,60] A longitudinal study found that dysfunction was associated with higher odds of depressive symptoms, especially the impairment of instrumental activities of daily living.[61] Similar to previous reports, having chronic diseases was strongly associated with depressive symptoms.[56] The prevalence of depressive symptoms among older adults in rural areas was higher compared to urban areas. The survey on the urban-rural differences in depressive symptoms among Chinese older adults indicated that the difference in depressive symptoms could be accounted for by area of residence.[62] In recent years, despite the widespread implementation of policies focused on rural development in China, which have promoted the development of rural areas, the socio-economic gap between urban and rural areas remains prominent. The imbalance in urban and rural development in China may be associated with significant differences in living environments, living conditions, and the fulfillment of needs among urban and rural residents, which might be related to differences in mental health. Limited mental health resources and weak professional support in rural areas may also pose challenges to the prevention, diagnosis, and treatment of depressive symptoms.

This study has several limitations. First, the analyses were based on a cross-sectional study design, and therefore the results cannot be used to infer the causal relationship between changes in physical activity, smoking, and alcohol consumption and depressive symptoms among older adults. Reverse causality, where depressive symptoms are associated with behavioral changes, remains a plausible alternative explanation. Second, although CES-D-10 has been widely used in the epidemiological investigation of depressive symptoms, there may still be some differences between it and the real diagnosis of depression, and it does not represent the population of individuals finally diagnosed with depression. Third, we could not control for several unmeasured confounders, such as social support, loneliness, and pre-pandemic mental health status, which may have influenced the observed associations. Fourth, given that the data were collected during the COVID-19 pandemic, the specific external circumstances may have influenced the observed associations. Therefore, caution is needed when extrapolating these findings to non-pandemic periods, and future studies in more stable settings are warranted to confirm our results. Additionally, we lacked quantitative pre-pandemic baseline measures of physical activity, smoking, and alcohol consumption, which prevented us from distinguishing whether a reported decrease had different implications for participants with high versus low initial levels. Moreover, some questions in this study were self-reported, which may have introduced recall bias. Lastly, excluding participants with emotional and mental problems may have excluded individuals most relevant to depressive symptoms and could have led to an underestimation of the observed prevalence. This potential selection bias should be considered when interpreting our findings.

5. Conclusion

This study provides evidence of the association between changes in physical activity, smoking, and alcohol consumption and depressive symptoms among Chinese older adults. Decreases in intense activities and smoking were associated with higher odds of depressive symptoms. Among elderly men, smoking reduction was associated with higher odds of depressive symptoms, whereas among elderly women, decreased alcohol consumption was associated with higher odds. It is advisable to encourage older adults to maintain appropriate levels of physical activity, though the optimal intensity may vary across individuals and warrants further investigation. Health administrators should develop policies based on the association between changes in health behaviors and depressive symptoms among older adults of different genders to provide a scientific basis for identifying and supporting groups with higher odds of depressive symptoms.

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Conflict of interest

The authors declare that they do not have any conflicts of interest.

Author contributions

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Ethics approval and consent to participate

Not applicable. This study is a secondary analysis using the public database of the CHARLS study. The CHARLS study was approved by the Ethics Review Committee of Peking University (No. IRB00001052-11015). The data were obtained with authorization from the CHARLS project team.

Consent for publication

Not applicable.

Availability of data

The CHARLS study data are publicly available and are open to researchers all over the world. The CHARLS dataset is accessible at http://charls.pku.edu.cn/

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