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ORIGINAL RESEARCH

The Impact of Falls on Depressive Symptoms in Middle-Aged and Older Chinese Adults: Mediating Effects of Pain

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Purpose: Based on the biopsychosocial integrated model and the diathesis-stress model, we investigate whether fall experiences prospectively exacerbate depressive symptoms among middle-aged and elderly individuals in China, while also examining whether pain serves as a key somatic pathway.

Patients and Methods: A total of 10963 participants aged 45+ were obtained from the China Health and Retirement Longitudinal Study (CHARLS). Depressive symptoms were assessed using the 10-item Center for Epidemiological Studies Depression Scale (CESD-10). Falls and pain were assessed by self-report. The causal effect of falls on depressive symptoms was assessed using the Difference-in-Differences (DID) method. Subsample regression analyses and Chow tests were employed to explore heterogeneity in the effect of falls on depressive symptoms across demographic groups. The Karlson, Holm, and Breen (KHB) method was applied to examine the mediating effect of pain.

Results: DID analysis indicated that falls were associated with a 0.030 increase in depressive symptoms ($P<0.01$, 95% CI= 0.008–0.052). Heterogeneity analyses showed that the negative impact of falls on depressive symptoms is more pronounced among urban residents and men. Pain significantly mediated the relationship between falls and depressive symptoms, with an effect size of 0.144 ($P<0.001$, 95% CI=0.127–0.160), accounting for 26.6% of the total effect.

Conclusion: Falls exert a significant causal impact on depressive symptoms among middle-aged and older adults in China. The impact was stronger among urban residents and men and pain partly mediated this effect. This research contributes to cross-cultural understanding of psychological reactions triggered by falls and highlights the necessity of developing prevention and pain management strategies for vulnerable populations.

Keywords: falls, depressive symptoms, pain, mediation effect, CHALRS

Introduction

Depression is a common mental illness worldwide,[1] affecting more than one-third of the older population.[2] In China, the rapid aging of the population has led to a rising prevalence of depressive symptoms among middle-aged and older adults (aged≥45 years), ranging from 24.1% to 34.1%.[3,4] Studies have shown that depressive symptoms are significantly associated with cognitive decline,[5] cardiovascular disease,[6] pain,[7] and functional disability.[8] Given the high prevalence and potentially severe consequences of depressive symptoms, it is crucial to explore the contributing factors and underlying mechanisms to support effective prevention.

Falls are a common occurrence among middle-aged and older adults and have been identified as a potential risk factor for the onset and exacerbation of depressive symptoms.[9] Previous studies employing linear and logistic regression models have

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confirmed a significant association between falls and depressive symptoms.[10] However, the precision of causal estimates remains limited due to potential endogeneity and selection bias. To address these limitations, the combination of Propensity Score Matching (PSM) and Difference-in-Differences (DID) methods has been proposed as a robust analytical approach.[11,12]

Despite a growing body of literature examining the relationship between depression and falls,[13,14] much of this research has emphasized the role of depressive symptoms as a predictor of falls, rather than exploring falls as a determinant of depression. Multiple meta-analyses and prospective studies have identified depression as a recognized major risk factor for falls.[15–18] However, few studies rigorously employ causal inference methods to empirically test falls as an inducer of depressive symptoms. Although several longitudinal and cross-sectional studies in different populations have indicated that falls may increase the risk of subsequent depressive symptoms,[19,20] there remains a lack of representative data from China, particularly among middle-aged individuals. This further underscores the necessity of using longitudinal data from Chinese middle-aged and elderly populations alongside causal inference methods in this study. Moreover, it is unclear whether the mental health impact of falls differs across demographic groups such as sex and urban-rural residence. Understanding such subgroup differences is particularly important in the context of China's rapidly aging population and widening urban–rural health disparities, underscoring the need for heterogeneity analyses to identify vulnerable subpopulations. Therefore, this study aims to investigate (1) the causal relationship between falls and depressive symptoms among middle-aged and older adults in China, with a particular focus on (2) the heterogeneity of this relationship across demographic subgroups.

Emerging evidence suggests that psychosocial factors may mediate the association between falls and depressive symptoms. Sociodemographic variables, such as marital status, living arrangement,[21,22] and social participation,[23] have been identified as moderating or mediating factors. Psychological resources, such as mental resilience[24] and self-efficacy[9] may buffer the emotional impact of falls. However, comparatively less attention has been given to physiological pathways, particularly the role of pain.

Pain is a common and often long-lasting consequence of falls. Chronic pain affects more than 30% of the global population[25] and is strongly associated with both falls and depression. Individuals with chronic pain are significantly more likely to experience falls[26] and are at an elevated risk of developing depressive symptoms. Furthermore, pain may act as both a consequence and a predictor in the reciprocal relationship between falls and depression.[27,28] According to the diathesis-stress model, psychological disorders are caused by adverse emotions (including distress and depressive mood) resulting from the interaction between environmental stressors (such as falls) and individual susceptibility (including physiological responses such as pain).[29](Figure S1) Thus, (3) pain may constitute a key mediating factor linking falls to depressive symptoms.

Materials and Methods

Study Design and Participants

In this study, data were obtained from the CHARLS, a nationally representative cohort study launched in 2011. CHARLS employed a multi-stage probability sampling method to recruit individuals aged 45 years and older, with subsequent data collection in four waves: 2013, 2015, 2018, and 2020. Details of information and study design about CHARLS were documented in previous research.[30] This study used data from the 2013, 2015, and 2018 waves.

In 2013, a total of 18605 participants participated. Several exclusion criteria were applied. (1) age<45 (n=274), (2) lost to follow-up in 2015 (n=2350) and 2018 (n=1978), (3) participants with missing data on both falls and depressive symptoms during 2013–2018 (n=120), (4) participants with missing data on falls during 2013–2018 (n=33), and (5) participants with missing data on depressive symptoms during 2013–2018 (n=2887). After applying these exclusions, 10963 participants remained, resulting in a combined panel dataset of 32889 observations (Figure S2).

Assessment of Falls

Fall events were identified using the CHARLS questionnaire item: "Have you fallen since the last interview?" Based on participants' self-reported answers, a binary variable was constructed to indicate the occurrence of a fall (1=fall occurred; 0=no fall).[31]

Assessment of Depressive Symptoms

Depressive symptoms were measured using the 10-item Center for Epidemiological Studies Depression Scale(CESD-10), which has been extensively validated as a reliable and valid instrument for measuring depressive symptoms.[32] According to the standard scoring criteria, responses were coded from 0 to 3, corresponding to the frequency categories: "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)". Two positive items were reverse-coded, and total scores ranged from 0–30. Higher scores reflected more severe depressive symptoms.[33] In line with previous research, a cutoff score of ≥10 was classified as having depressive symptoms; otherwise, no.[34,35]

Assessment of Pain

A self-report questionnaire was administered by the trained CHARLS interviewer to gather information on pain. The interviewer asked the respondents, "Do you often experience any pain in your body?". If the participant answered "yes", the respondent was defined as having incident pain.[36,37]

Covariates

The following criteria were considered in this study. (1) sociodemographic characteristics: age (45–59 years and ≥60 years), sex (men and women), education level (<9 years and ≥9 years), marital status (married and unmarried [including separated, divorced, widowed, never married, and cohabitated]), and residence (urban and rural). (2) health behaviors: smoking (smokers, nonsmokers [including quit and never smoked]), alcohol consumption (drinkers [drinking more than once a month and less than once a month], nondrinkers). Social activity was assessed by asking participants whether they had participated in specific activities in the past month, such as participation in a community-based organization. Social activity was categorized as no (none) and yes (≥1 social activities). (3) Physical health status: Chronic disease status was assessed based on self-reported diagnoses of chronic conditions, including hypertension, dyslipidemia, diabetes, cancer, chronic lung disease, liver disease, heart problems, stroke, kidney disease, digestive disease, emotional or psychiatric problems, memory-related disease, arthritis or rheumatism, and asthma. Participants were classified as having no chronic disease (none) or at least one chronic disease (≥1 chronic conditions). And (4) Subjective well-being indicators: Life satisfaction was self-reported and categorized as satisfied (completely satisfied, very satisfied, somewhat satisfied) and not satisfied (not very satisfied, not at all satisfied). Self-rated health was also self-reported and categorized as good (very good, good, fair) and poor (poor, very poor).

Statistical Analysis

Participants were divided into the falling group and non-falling group according to whether they self-reported falls between 2013 and 2018. The control variables were described with frequency (percentage) for categorical variables. Comparison of differences among the falling group and non-falling group was examined by the χ^2-test.

The DID analysis relies on the parallel trend assumption, which posits that prior to the fall event, there were no significant differences in depressive symptoms between the treatment and control groups, and their trends were consistent. Therefore, we conducted a parallel trends test before performing the DID analysis.[38] We used a quasi-experimental study design, which was an effective way to learn about causal relationships between falls and depressive symptoms. The DID model demonstrates greater applicability and effectively mitigates endogeneity issues arising from omitted variables and reverse selection bias.[39] The impact of falls on depressive symptoms was systematically assessed by comparing the differences in relevant indicators between the treatment group and the control group before and after the fall.

Therefore, the DID model in this study was constructed as follows: In equation (1). DS_{it} represents the depressive symptoms status of individual i in year t. $Treat_i \times Time_t$ is the core explanatory variable. $Treat_i$=1 if the individual is in the "treatment group" affected by falls; $Treat_i$=0 if the individual is in the "control group" not affected by falls.$Time_t$=0 represents the period before the fall occurred (and 1 otherwise). β_1 represents the corresponding regression coefficients. β_0 is the intercept term, γ_i represents the individual fixed effect, and θ_t represents the time fixed effect. ε_{it} represents the random disturbance term.

$$DS_{it} = \beta_0 + \beta_1 Treat_i \times Time_t + \beta_2 \sum Z_{it} + \gamma_i + \theta_t + \varepsilon_{it} \quad (1)$$

This study employed the PSM-DID method for a robustness test to match the samples with similar characteristics in the treatment group and the control group, so as to form an appropriate control to reduce the estimation bias caused by the selection problem.[40] All the covariates were included as confounding variables in the matching process to estimate the propensity scores. Subsequently, the nearest neighbor matching method was used for matching. After identifying individuals in the control group with similar characteristics to those in the treatment group, the DID model was applied.

Given that the impact of falls on depressive symptoms may vary across different middle-aged and older adult populations. Therefore, we conducted a heterogeneity analysis based on sex and residence. This study conducted subsample regression analyses and Chow tests to analyze differences in the effects of falls on depressive symptoms among middle-aged and older adults of different sex, and residence (rural and urban).

To explore the potential mechanisms underlying the impact of falls on depressive symptoms, this study used the Karlson, Holm, and Breen (KHB) method to examine the mediating role of pain.[41] This method extends the decomposition nature of linear models to nonlinear probability models and is commonly used for mediating analysis of binary outcome variables.[42] Specifically, the KHB method was used to estimate the total effect of falls on depressive symptoms, as well as the direct effect, excluding the effect of pain and the indirect effect mediated by pain.

The sensitivity analysis of the DID results was confirmed in order to verify that there were no other confounding factors affecting the results. We conducted a placebo trial in which the treatment group was randomly assigned from the original data. The DID coefficient for this newly created treatment group was then re-estimated at different time points. In addition, to verify the reliability of the mediated effects results, we conducted sensitivity analyses using repeated KHB analyses for different samples: (1) multiple interpolation to interpolate the information on falls in the non-responders and lost participants during the follow-up process; (2) excluded participants who had depressive symptoms in 2013 and 2015 (3) limited the participants to those who did not experience pain in 2013; (3) grouped the participants according to their age (45–59 years and ≥60 years) stratification for subgroup analysis.

All statistical analyses were conducted using STATA (version MP18). Two-tailed $P<0.05$ was set as the threshold for statistical significance.

Results

Sample Characteristics

This study included 10963 participants. Among them, 1677 (15.30%), 1850 (16.87%), and 2135 (19.47%) reported falls in 2013, 2015, and 2018, respectively, with an average detection rate of 17.22%. Regarding depressive symptoms, 3380 participants (30.83%), 3635 participants (33.16%), and 5073 participants (46.27%) reported depressive symptoms in 2013, 2015, and 2018, respectively, with an average detection rate of 36.75% (Table S1).

Compared to the non-falling group, participants in the falling group were more likely to be older, women, unmarried, rural resident, nonsmokers, nondrinkers, have lower levels of education (<9 years). They were also more likely to have chronic disease, be dissatisfied with their lives, report poor self-rated health, experience pain and depressive symptoms (Table 1).

Table 1 Comparison of Sample Characteristics Between Falling and Non-Falling Groups

Characteristics	Full Sample (n=32889)	Falling Group (n=12153)	Non-Falling Group (n=20736)	P-value[b]
Age[a]				<0.001
45-59 years	14693 (44.9)	4844 (40.1)	10,752 (52.2)	
≥60 years	18001 (55.1)	7249 (59.9)	9849 (47.8)	
Sex[a]				<0.001
Men	15981 (48.6)	5258 (43.3)	10,723 (51.7)	
Women	16907 (51.4)	6895 (56.7)	10,012 (48.3)	

(*Continued*)

Table 1 (Continued).

Characteristics	Full Sample (n=32889)	Falling Group (n=12153)	Non-Falling Group (n=20736)	P-value[b]
Education level[a]				<0.001
≥9 years	11521 (35.0)	3725 (30.7)	7796 (37.6)	
<9 years	21364 (65.0)	8428 (69.3)	12,936 (62.4)	
Marital status				<0.001
Married	27296 (83.0)	9697 (79.8)	17,599 (84.9)	
Unmarried	5593 (17.0)	2456 (20.2)	3137 (15.1)	
Residence[a]				<0.001
Urban	7392 (23.7)	2487 (21.5)	4905 (24.9)	
Rural	23839 (76.3)	9069 (78.5)	14,770 (75.1)	
Smoking[a]				<0.001
Smokers	11261 (34.2)	3876 (31.9)	7385 (35.6)	
Nonsmokers	21623 (65.8)	8275 (68.1)	13,348 (64.4)	
Alcohol consumption[a]				<0.001
Drinkers	11616 (35.3)	4252 (35.0)	7364 (35.5)	
Nondrinkers	21257 (64.7)	7892 (65.0)	13,365 (64.5)	
Chronic disease status[a]				<0.001
Yes	19413 (59.8)	7800 (65.0)	11,613 (56.8)	
No	13027 (40.2)	4198 (35.0)	8829 (43.2)	
Social activity				0.980
Yes	18202 (55.3)	6727 (55.4)	11,475 (55.3)	
No	14687 (44.7)	5426 (44.6)	9261 (44.7)	
Life satisfaction[a]				<0.001
Satisfied	29030 (89.6)	10,241 (85.8)	18,789 (91.8)	
Not satisfied	3371 (10.4)	1700 (14.2)	1671 (8.2)	
Self-rated health[a]				<0.001
Good	7644 (23.5)	1995 (16.6)	5649 (27.5)	
Poor	24873 (76.5)	10,003 (83.4)	14,870 (72.5)	
Pain[a]				<0.001
Yes	13838 (42.1)	6394 (52.6)	7444 (35.9)	
No	19042 (57.9)	5754 (47.4)	13,288 (64.1)	
Depressive symptoms				<0.001
Yes	12088 (36.8)	5672 (46.7)	6416 (30.9)	
No	20801 (63.2)	6481 (53.3)	14,320 (69.1)	

Notes: [a]Missing data: 144 for age, 1 for sex, 4 for education level, 1658 for marital status, 5 for smoking, 16 for alcohol consumption, 449 for chronic disease status, 488 for life satisfaction, 372 for self-related health, and 9 for pain. [b]Categorical variables were represented using Number (%); The differences in characteristics between the falling group and the non-falling group were based on χ^2-test.

DID Estimates

The test results (Figure 1) indicated that the periods before the falls were not statistically significant, confirming that there was no significant difference in depressive symptoms between the treatment and control groups. At the same time, in the periods after falling, the estimates of depressive symptoms rose significantly. This suggests that falls may significantly contribute to depressive symptoms. Table 2 shows the estimated effects of falls on depressive symptoms in middle-aged and older adults. In Model 1, without any control variables or fixed effects, falls were found to increase depressive symptoms (coefficient=0.181, Model 1, $P<0.001$). Pain increases the likelihood of developing depressive symptoms by 18.1%. Model 2 incorporates control variables and fixed effects as specified in Equation (1), and still shows a significant association between falls and increased depressive symptoms (coefficient=0.030, Model 2, $P<0.01$). Pain increases the likelihood of developing depressive symptoms by 3%. These results indicated that falls are a key risk factor for depressive symptoms.

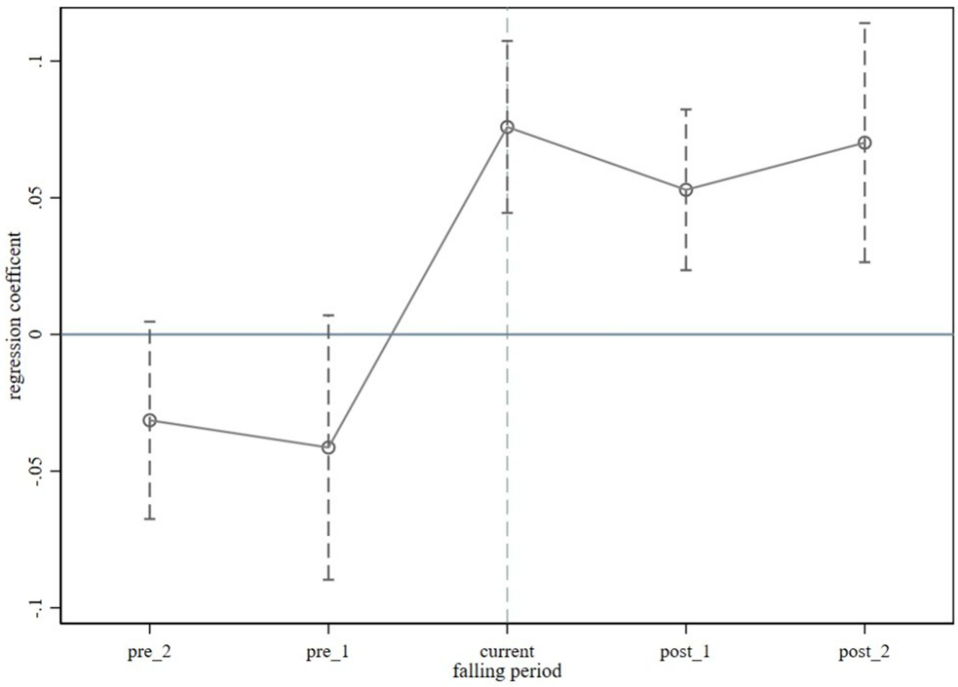

Figure 1 Result of the depressive symptoms parallel trend test.

PSM-DID Estimates

To avoid confounding bias that may result from non-random selection, we used the PSM-DID method to test the robustness of the DID estimate. To ensure the estimation quality, a balance test for the matching results was conducted (Figure S3). The test results indicated that the percentage of standardized bias across most covariates was reduced to within 10% (with values below 20% generally considered indicative of a good match).[43] Moreover, for all observed samples, the propensity scores of both the treatment and control groups fell within the common support range. Consequently, the propensity score matching results in this study were considered ideal. The results showed that the DID coefficient remained significant whether the propensity score was matched or not and whether the control variable and fixed effects was incorporated or not (Table 2).

Heterogeneity Analysis

The results indicated that falls had a significant impact on depressive symptoms among middle-aged and older adults in urban areas (coefficient=0.064, $P<0.05$) and men (coefficient=0.043, $P<0.01$) while it had no significant effect on

Table 2 Impact of Falls on Depressive Symptoms by the DID and PSM-DID Method

Variables	Model 1[b]	Model 2[b]	Model 3[b]	Model 4[b]
	Depressive symptoms	Depressive symptoms	Depressive symptoms	Depressive symptoms
$Treat_i \times Time_t$	0.181***(0.006)	0.030**(0.011)	0.173***(0.006)	0.029*(0.012)
Control variables[a]	NO	YES	NO	YES
Time-fixed effect	NO	YES	NO	YES
Individual fixed effect	NO	YES	NO	YES
Pseudo R^2	0.027	0.605	0.597	0.208
Constant	0.320***(0.003)	0.517***(0.107)	0.314***(0.003)	0.476***(0.122)
N	32889	30,063	28,852	28,387

Notes: Clustered standard errors were in brackets. [a]Control variables include: Age, sex, education level, marital status, residence, smoking, alcohol consumption, chronic disease status, social activity, life satisfaction, self-rated health, pain. [b]Model 1 and Model 2 are the DID regression results, and Model 3 and Model 4 are the PSM-DID results. *$P<0.05$, **$P<0.01$, ***$P<0.001$.

Table 3 DID Estimates of Falls on Depressive Symptoms Between Different Groups of Participants

Variables	Depressive Symptoms	Depressive Symptoms	Depressive Symptoms	Depressive Symptoms
	Rural	Urban	Men	Women
$Treat_i \times Time_t$	0.016(0.013)	0.064*(0.025)	0.043**(0.016)	0.019(0.015)
Control variables[a]	YES	YES	YES	YES
Time-fixed effect	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES
Pseudo R^2	0.603	0.633	0.582	0.606
Constant	0.586***(0.121)	0.687*(0.279)	0.412***(0.037)	0.519***(0.039)
N	22273	5935	14,552	15455
Coefficient difference p-value [b]	<0.001		<0.001	

Notes: Clustered standard errors were in brackets. [a]Control variables include: Age, sex, education level, marital status, residence, smoking, alcohol consumption, chronic disease status, social activity, life satisfaction, self-rated health, pain. [b]Coefficient difference p-value calculated from estimates of Chow test. *P<0.05, **P<0.01, ***P<0.001.

Table 4 The Mediating Effect of Pain Between Falls and Depressive Symptoms

	β	SE	95% CI	P-value	Percentage[a]
Direct effect	0.396	0.035	(0.327, 0.464)	<0.001	73.4%
Indirect effect	0.144	0.008	(0.127, 0.160)	<0.001	26.6%
Total effect	0.539	0.035	(0.471, 0.607)	<0.001	100.00%

Notes: [a]Contribution (%) to the total effect.
Abbreviations: β, regression coefficient; SE, standard error; CI, confidence interval.

middle-aged and older adults in rural areas or women middle-aged and older adults. The between-group differences of different groups passed the Chow test (P<0.001) (Table 3). This indicates that compared to rural areas and females, middle-aged and elderly individuals in urban areas and males are more likely to develop depressive symptoms following a fall.

Intermediary Mechanism

The results of the mediating effect analysis (Table 4) revealed that pain played a significant mediating role between falls and depressive symptoms, with an indirect effect coefficient of 0.144 and an indirect effect accounting for 26.6%. These findings suggested that falls contribute to depressive symptoms by increasing the experience of pain.

Sensitivity Analysis

A placebo test was performed (Figure S4) by running 5000 simulations of random assignment and comparing the distribution of these estimates to the baseline estimates. The results showed that the distribution of estimates from the random assignments was strongly centered around zero, suggesting the significant effect of falls on depressive symptoms was not driven by unobserved factors, but represented a genuine causal effect, thus passing the placebo test. The results of repeated KHB analyses for different samples were consistent with the primary analysis, verifying the reliability of the mediated effects results (Table S2).

Discussion

Among the 10963 participants included in the study, the average detection rate of falls across the three waves (2013, 2015, and 2018) was 17.22%, while the detection rate of depressive symptoms was 36.75%. These findings are consistent with previous studies reporting the detection rate of falls and depressive symptoms in middle-aged and older Chinese adults.[4,44–46] The current study further demonstrates that falls increase the risk of depressive symptoms among middle-aged and older adults, with a stronger effect observed in urban residents and men. Pain was also identified as a partial

mediator in this relationship. These findings underscore the importance of developing targeted interventions that address subgroup disparities in the mental health consequences of falls.

This study conducted a causal inference analysis of the relationship between falls and depressive symptoms and found that falls increase the probability of developing depressive symptoms. These findings not only support previous research indicating a positive correlation between falls and depressive symptoms,[22] but also address the limitation of prior studies that did not explicitly establish a causal relationship.[13,21] For example, a cross-sectional study of Korean Americans residing in government-subsidized senior housing in the Los Angeles area found that falls have a direct impact on depressive symptoms.[9] Similarly, data from the Irish longitudinal study on ageing indicated that falls increase the likelihood of depressive symptoms.[47] In fact, we believe that falls leading to depressive symptoms can be explained by an overarching theoretical model: the biopsychosocial integrated model.[48] The emergence of depressive symptoms is interrelated through physiological factors such as pain, psychological factors like fear and helplessness, and social factors including social isolation and low social engagement. In addition, falls and the resulting injuries may lead to functional limitations,[49] the loss of independence can reduce their sense of self-efficacy in performing daily tasks[9] and undermine their sense of control over life, both of which may contribute to depressive symptoms.[50] Moreover, fallers who fear falling again may exhibit excessive vigilance and activity avoidance behaviors, often leading to reduced social participation, heightened social isolation, and intensified somatic symptoms, thereby further increasing the risk of depression.[51,52]

Additionally, heterogeneity analysis revealed that the negative impact of falls on depressive symptoms is more pronounced for urban residents and men. Previous studies have confirmed that urbanization adversely affects mental health, primarily due to overcrowding, limited green spaces and open areas, as well as factors like pollution and traffic noise—all of which constitute built environments detrimental to mental well-being.[53] Compared with individuals in rural areas, urban residents often experience a faster pace of life and more distant interpersonal relationships. As a result, they are more prone to social withdrawal and reduced social participation following a fall,[54] which increases the risk of developing depressive symptoms. According to social role theory,[55] women are often perceived as bearing care-oriented roles such as childcare and caregiving, while men predominantly engage in dominant occupations. These social roles influence gender-specific behaviors. From the perspective of traditional Chinese gender roles, men are typically expected to bear more economic and familial responsibilities.[56] A fall-related decline in physical function can temporarily hinder their ability to fulfill these obligations, leading to feelings of guilt and frustration. Furthermore, compared to women, older men tend to internalize emotional distress[57] and have fewer avenues for emotional expression, making it more difficult for them to process negative emotions after a fall, and these emotions can accumulate over time, increasing the likelihood of depression.

This study also revealed the underlying mechanisms through which falls influence depressive symptoms from a physiological perspective, thereby addressing the limitations of previous research that primarily focused on social-psychological factors.[9,23,24] Although physical functional limitations have been suggested as a somatic mediator linking falls to depressive symptoms in older adults,[21] the underlying mechanisms remain unclear. To the best of our knowledge, this is the first study to propose pain as an alternative somatic mediator in this association, specifically among middle-aged and older adults in China. The pathway linking falls to depressive symptoms through pain may be understood from two key perspectives. From a neurobiological perspective, chronic pain resulting from falls can lead to structural and functional remodeling of brain regions involved in pain modulation, such as the periaqueductal gray in the midbrain and the locus coeruleus.[58] These changes can lead to imbalances in emotional regulation by affecting the secretion of neurotransmitters like norepinephrine and serotonin,[59] which play critical roles in mood regulation. From a stress response perspective, the diathesis-stress model posits that the onset of mental disorders is caused by the combined effects of an individual's constitutional factors and environmental stressors.[29] In this study, falls—being sudden and impactful life events—are conceptualized as key environmental stressors that interact with physiological vulnerabilities in individuals. Age-related physiological vulnerabilities—such as osteoporosis, diminished muscle strength and delayed wound healing, often lead to the persistent occurrence of pain after falls. This ongoing pain not only causes suffering, but also trigger negative emotional reactions, which can strain relationships with family and friends, thereby reducing social support. The erosion of social support, in turn, may further undermine psychological resilience,[60] ultimately increasing the risk of developing depressive symptoms.

Strengths and Limitations

This study has several notable strengths. First, it utilizes a nationally representative, large-sample survey to examine the causal relationship between falls and depressive symptoms, enhancing the generalizability of the findings. Second, it innovatively identifies the mediating role of pain in this relationship, contributing to a more nuanced understanding of the underlying mechanism. However, several limitations should be considered. First, the use of self-reported measures for falls, pain, and depressive symptoms may introduce recall bias. Additionally, we did not provide quantitative descriptions of pain intensity, duration, or location, making it impossible to distinguish the differential effects of various pain characteristics on depressive symptoms. Future research should account for these factors. Second, non-response and attrition during the follow-up period may have led to selection bias. Nevertheless, sensitivity analyses and multiple imputation techniques were employed to mitigate this concern. Third, although key covariates were adjusted for, the possibility of residual confounding cannot be entirely excluded. Particular attention should be paid to the economic losses incurred following physical injury. We regret that we were unable to control for this confounding factor. Furthermore, future research directions may consider focusing on this factor.

Conclusion

This study found that falls significantly increase the likelihood of developing depressive symptoms. Moreover, pain was identified as a key mediating factor in this pathway. The adverse effects of falls on depressive symptoms are more pronounced among urban residents and men. These findings underscore the necessity of developing specialized strategies for preventing falls and managing physical symptoms such as pain among middle-aged and older adults, with particular attention to urban residents and male populations.

Abbreviations

CHARLS, China Health and Retirement Longitudinal Study; CESD-10, 10-item Center for Epidemiological Studies Depression Scale; DID, Difference-in-Differences; KHB, The Karlson, Holm, and Breen; PSM, Propensity Score Matching.

Data Sharing Statement

The data supporting this study's findings are available from the CHARLS website: https://charls.pku.edu.cn/html.

Ethics Approval and Informed Consent

CHARLS was approved by the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015). All participants provided written informed consent to participate in the study. The research methods employed in this study adhered to the guidelines outlined in the Declaration of Helsinki, ensuring that ethical considerations were followed. According to Article 32, Paragraphs 1 and 2 of the "Measures for Ethical Review of Life Sciences and Medical Research Involving Human Subjects" issued by China on February 18, 2023: (1) Research utilizing publicly available data obtained legally, or data generated through observation without interfering with public activities; (2) Research conducted using anonymized information data, may be exempted from ethical review. This study meets the above criteria.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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