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From starvation to depression: unveiling the link between the great famine and late-life depression

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Abstract

Background The Great Famine in China from 1959 to 1961 is recognized as one of the most severe social and public health disasters of the 20th century, with profound long-term impacts on the health of survivors, particularly on their mental health. Early-life malnutrition and psychological trauma are considered to contribute to a range of health issues in adulthood, including depression.

Objective This study aims to explore how the experience of the Chinese Great Famine from 1959 to 1961 affects the risk of depressive symptoms among the elderly. Using a mechanism analysis, the study investigates the roles of social support, socioeconomic status, and intergenerational support in this process.

Methods Using micro-level individual data from the China Health and Retirement Longitudinal Survey (CHARLS), combined with province-level excess mortality data, this study employs a cohort-based difference-in-differences model to identify the causal effects of the famine experience on depression levels among the elderly.

Results The study reveals that experiencing the Great Famine significantly increases the risk of depression among the elderly. This effect is more pronounced among rural residents, those who experienced the famine during adolescence, and in regions less influenced by Confucian culture. The mechanism analysis indicates that diminished social support, lower socioeconomic status, and insufficient intergenerational support are the primary pathways through which the famine experience influences depression levels in the elderly.

Conclusions The experience of the Great Famine has exerted a long-term and profound impact on the mental health of the elderly in China, particularly in terms of depression. The findings provide new perspectives on understanding the long-term effects of major historical events on health and offer important empirical evidence for the development of mental health intervention policies for the elderly.

Keywords Great famine, Depression, Social support, Socioeconomic status, Intergenerational support

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Introduction

The Great Chinese Famine of 1959–1961 was one of the most severe social and public health disasters of the 20th century, leaving a profound and lasting impact on the long-term health of those who experienced it. Extensive research has demonstrated that early-life malnutrition and psychological trauma can have enduring effects on health in adulthood, particularly in the context of economic transitions [1, 2]. As China gradually transitions into an aging society, investigating the mechanisms underlying mental health issues among the elderly, particularly the onset of depression, holds significant academic value and practical relevance. Depression has become a critical factor affecting the quality of life in older adults. Exploring the long-term impact of this historical event on the incidence of depression among the elderly not only enhances our understanding of the far-reaching health consequences of major social upheavals but also provides empirical evidence for the formulation of public health policies targeting the elderly population.

Existing literature has explored the impact of the Great Famine on adult health from various perspectives. For example, Chen and Zhou (2007) [1] found that the experience of the famine significantly increased the risk of chronic diseases in adulthood, while Li et al. (2018) [3] revealed a link between early-life malnutrition and the risk of depression in later life. However, current research primarily focuses on the direct effects of the famine on physical health, lacking a systematic examination of its impact on mental health, particularly the mechanisms underlying the onset of depression. Moreover, previous studies often overlook the heterogeneous effects of the Great Famine across different cultural and urban-rural backgrounds, as well as the mediating roles of social support, socioeconomic status, and intergenerational support in this process.

This paper aims to address the research gaps mentioned above by systematically analyzing how the experience of the Great Chinese Famine influences the risk of developing depression among the elderly through multiple pathways. The innovation of this study lies not only in identifying the causal relationship between the famine experience and the risk of depression but also in thoroughly exploring the underlying mechanisms, particularly the heterogeneous effects across different socioeconomic backgrounds and urban-rural populations. The findings of this study will provide new perspectives on understanding the long-term health impacts of major historical events and offer empirical support for policymakers.

This study utilizes micro-level individual data from the China Health and Retirement Longitudinal Survey (CHARLS), combined with province-level excess mortality data, and employs a cohort-based

difference-in-differences model to rigorously identify the long-term health impacts of the Great Famine. This approach effectively controls for province-level fixed effects and time fixed effects, enabling a more precise identification of the causal effects of the famine experience on the risk of depression among the elderly.

The structure of this paper is as follows: Section 2 introduces the historical background of the Great Famine and its profound socioeconomic impacts, along with a detailed literature review. Section 3 develops the theoretical framework and proposes testable hypotheses. Section 4 outlines the research design, including data sources, econometric models, and variable definitions. Section 5 presents the empirical results, including baseline regression results, mechanism tests, and heterogeneity analyses. Section 6 concludes with policy recommendations and a discussion of the study's limitations.

Background and literature review

Background of the great famine

The Great Chinese Famine (1959–1961) is one of the most devastating disasters in the history of the People's Republic of China, resulting in the unnatural deaths of millions and having far-reaching socioeconomic impacts. The background of the famine can be traced back to the “Great Leap Forward” period, during which the Chinese government implemented extremely radical agricultural and industrial policies aimed at rapidly increasing agricultural output and achieving rapid industrial development to close the gap with Western countries. During this period, the People's Commune system was fully implemented, leading to the collectivization of agricultural production. However, as farmers lost their autonomy, their motivation to produce was severely diminished, resulting in a sharp decline in agricultural productivity. Additionally, local governments commonly exaggerated grain production figures, leading the central government to overestimate grain reserves and implement excessive grain requisitions nationwide, further depleting the food reserves available to farmers. Moreover, from 1959 to 1961, several regions in China experienced severe natural disasters, such as droughts and floods, which further weakened the already fragile agricultural system and became one of the key triggers of the famine [1].

In practice, the famine led to widespread food shortages, with many rural areas suffering from severe famine widespread malnutrition, and massive mortality events. It is estimated that the famine caused between 15 million and 30 million deaths, mostly in rural areas. Beyond the direct mortality, the famine had severe long-term health consequences for survivors, particularly those who were children during the famine. These individuals face higher risks of chronic diseases in adulthood and often exhibit

lower body weight and height, consequences that have been widely documented in academic research [2, 4].

The consequences of the famine extended beyond population reduction and health problems, deeply affecting China's social structure and economic development. Rural social order was severely disrupted, agricultural productivity declined, and the poverty gap between rural and urban areas widened. The harsh lessons of the Great Famine prompted the Chinese government to make significant adjustments to agricultural policy in the following years, gradually dismantling the People's Commune system and implementing policies that allowed farmers to retain a portion of their production, laying the foundation for later economic reforms [5].

Overall, the Great Chinese Famine was the result of multiple factors, including policy failures, natural disasters, and the lack of transparency in local government reporting. It led to widespread hunger and death and had lasting impacts on Chinese society. This event remains a crucial case study for scholars and policymakers reflecting on history and discussing policies.

Literature Review

The Great Chinese Famine of 1959–1961, one of the most severe social and public health disasters of the 20th century, has had profound and lasting impacts on the long-term health of those who experienced it. Existing research has explored the complex effects of famine exposure on psychological health, physical health, socioeconomic status, and intergenerational outcomes, revealing its enduring impacts at both the individual and societal levels.

(1) Psychological Health Impacts

Numerous studies have examined the association between famine exposure and mental health in adulthood. Early-life exposure to the Great Famine significantly increased the risk of depression in old age. Research indicates that individuals who experienced the famine during fetal development or childhood are more likely to exhibit depressive symptoms in later life, with this relationship being particularly pronounced among women [3, 6, 7]. Furthermore, those who were adolescents during the famine, facing significant social upheaval during a critical developmental stage, are also more prone to mental health problems in adulthood [8, 9]. Qiao et al. (2022) [10] highlighted the bidirectional relationship between famine exposure, depression, and multimorbidity, suggesting that the famine may exacerbate these conditions.

(2) Physical Health Impacts

The negative impact of famine exposure on physical health in old age has been widely documented. Studies have shown that early-life famine exposure significantly increases the risk of physical dysfunction and chronic diseases in old age. Famine exposure during infancy and preschool years is significantly associated with physical dysfunction, sarcopenia, and chronic diseases (such as diabetes and hyperglycemia) in old age [11–14]. Additionally, research has revealed associations between famine exposure and adult bone health issues, such as osteoporosis [15].

(3) Intergenerational Impacts

The intergenerational effects of famine exposure have increasingly become a focus of research. Studies have shown that individuals whose parents experienced famine during fetal development exhibit significantly impaired cognitive function and mental health [16]. Furthermore, famine exposure may affect offspring health through epigenetic mechanisms, increasing the risk of metabolic syndrome [17]. Early-life famine exposure is also associated with changes in DNA methylation levels and higher cholesterol levels in adulthood [18] and may influence depression through mechanisms such as leukocyte telomere length [19].

(4) The Moderating Role of Socioeconomic Status

Research has found that socioeconomic status (SES) plays a crucial role in moderating the health effects of famine exposure. Individuals with low SES are more vulnerable to the negative impacts of famine, particularly in terms of mental health [20, 21]. Famine exposure significantly affects educational attainment, income levels, and labor market performance in adulthood, which in turn reduces life satisfaction and increases the risk of chronic diseases [1, 22]. SES also plays a key role in moderating the relationship between famine exposure and adult health problems, such as hyperuricemia [15].

(5) Epigenetic Mechanisms and Other Health Impacts

Research on epigenetic mechanisms has indicated that early exposure to famine is associated with changes in DNA methylation levels, which may have long-term effects on adult health by influencing factors such as IGF2 gene methylation and leukocyte telomere length [18, 19]. Additionally, famine exposure has been significantly linked to an increased risk of metabolic syndrome in adulthood. Furthermore, studies have found a significant correlation between early malnutrition and various

adult health issues, such as Type 2 diabetes and schizophrenia [23].

(6) Cognitive Function and Aging

The long-term effects of famine exposure on cognitive function have also been a focus of research. Individuals exposed to famine during early life tend to exhibit significant cognitive decline in middle and old age, particularly among those from lower socioeconomic backgrounds [24, 25]. While education may mitigate some of the negative impacts of famine on cognitive function, the long-term damage remains evident [26].

While existing research has explored the impact of famine exposure on adult physical and mental health from various perspectives—particularly in terms of the increased risks of depression, chronic disease, and changes in socioeconomic status—several limitations persist. For instance, most studies rely on cross-sectional data analysis, lacking rigorous identification of causal relationships. Moreover, these studies have often failed to fully elucidate the mechanisms through which famine experiences influence long-term mental health, particularly through pathways involving social support, economic hardship, and intergenerational relationships. Additionally, existing literature often overlooks the heterogeneity of famine exposure, neglecting to investigate how urban-rural disparities, cultural backgrounds, and developmental stages differentially moderate depression levels among the elderly.

To address these research gaps, this study utilizes longitudinal data from the CHARLS and employs a difference-in-differences model to rigorously identify the causal effects of the Great Famine on depression among the elderly. Through mechanism testing and heterogeneity analysis, this research further dissects the mediating roles of social support, socioeconomic status, and intergenerational support. This study not only deepens our understanding of the complex relationship between famine exposure and mental health but also provides empirical evidence to inform future policy-making.

Theoretical hypotheses

Social support

The Great Chinese Famine of 1959–1961 had profound impacts not only on material conditions but also on the social structure, particularly the social support networks of the elderly. Research has shown that the famine led to family fragmentation, the weakening of social bonds, and the disintegration of traditional support networks, placing the elderly at greater risk of social isolation in their later years. This trend is particularly pronounced against the backdrop of accelerated urbanization and changing family structures, where traditional family support

functions have gradually weakened, and reliance on offspring for support has increasingly collapsed, especially among those who experienced the famine. Zhao et al. (2020) [27] found that social support levels among China's elderly population have significantly declined over the past few decades, exacerbated by growing economic inequality and reduced social connectivity. Other studies have also indicated that famine experiences contributed to the shrinking of social networks and the lack of social support for the elderly [28, 29]. These changes have made elderly famine survivors more susceptible to social isolation, increasing their risk of lacking social support in later life.

The absence of social support networks is a significant factor influencing depression among the elderly. Research indicates that older adults with weaker social support networks tend to exhibit more severe depressive symptoms. Social support provides not only emotional comfort but also practical assistance in daily life, such as caregiving and financial support, all of which are crucial for the psychological well-being of the elderly. Chou and Chi (2003) [30] found a significant correlation between social support levels and depressive symptoms among the elderly, particularly when support from family members is lacking, leading to a higher risk of depression. Moreover, Chen et al. (2019) [31] also pointed out that a lack of social support is significantly associated with increased depressive symptoms among the elderly, as the absence of social support deprives them of a buffer mechanism to cope with life stressors, thereby exacerbating depressive symptoms. These studies suggest that the weakening of social support networks is not only a consequence of the famine but also a key mechanism underlying the worsening of depressive symptoms among the elderly. Based on the above, the following hypothesis is proposed:

Hypothesis 1 The experience of the Great Famine increases depression levels among the elderly by reducing their social support.

Socioeconomic status

During the Great Famine, widespread food shortages and economic collapse deprived many individuals of opportunities for education and career development in their youth. This early-life economic instability often resulted in lower socioeconomic status and long-term financial stress in adulthood. Research has shown that those who experienced the famine tend to have lower income levels and fewer economic resources in later life, with this decline in socioeconomic status closely linked to the extreme poverty experienced during the famine period. For example, Case and Paxson (2010) [32] found that early-life malnutrition and poverty significantly limited individuals' educational opportunities and career

advancement, leading to lower income and economic hardship in adulthood. This economic hardship further exacerbates financial stress, leaving these individuals more vulnerable to financial pressures in old age [1].

Low socioeconomic status and financial stress are widely recognized as important social and economic risk factors for depression. Financial stress not only directly increases psychological burden but also leads to a lack of social support and insufficient access to health resources, further heightening the risk of depression. Guan et al. (2022) [33] identified a significant positive correlation between financial difficulties and depression, with prolonged financial stress leading to feelings of helplessness and anxiety, thereby increasing the likelihood of depression. Additionally, Gallo and Matthews (2003) [34] demonstrated that elderly individuals with low socioeconomic status often lack effective coping mechanisms when faced with life events, further exacerbating the occurrence of depressive symptoms. Therefore, it can be inferred that the long-term economic hardship and financial stress resulting from famine exposure constitute a crucial mechanism for increasing the risk of depression among the elderly. Based on this, the following hypothesis is proposed:

Hypothesis 2 The experience of the Great Famine increases depression levels among the elderly by lowering their socioeconomic status.

Intergenerational support

The Great Famine profoundly impacted family structure and the stability of social support networks, particularly by reducing intergenerational support. Due to high mortality rates and declining birth rates during this period, family sizes shrank significantly, directly weakening the ability of the elderly to receive intergenerational support. Intergenerational support includes not only material assistance, such as financial aid and caregiving but also emotional solace and psychological dependency. This support is especially crucial for the elderly, as it alleviates their daily burdens and provides emotional security. However, research has found that changes in family structure caused by the famine significantly reduced the likelihood of elderly individuals receiving stable support. The reduction in family members, especially the number of children, concentrated the burden of caregiving on a few family members, thereby diminishing the continuity and quality of support [35].

The reduction in intergenerational support directly affects the psychological health of the elderly, particularly in the emergence and exacerbation of depressive symptoms. Studies indicate that adequate intergenerational support, especially in economic and emotional dimensions, can effectively improve the psychological

well-being of the elderly and reduce the incidence of depression. However, when intergenerational support diminishes, elderly individuals often experience higher levels of loneliness and decreased life satisfaction, significantly increasing the risk of depression [36]. Moreover, the weakening of support networks deprives the elderly of necessary psychological and emotional support when facing life stressors, leading to further deterioration of their mental health and exerting a lasting and profound impact on their psychological well-being [37]. Based on this, the following hypothesis is proposed:

Hypothesis 3 The experience of the Great Famine increases depression levels among the elderly by reducing intergenerational support.

Empirical design

Data sources

The micro-level individual data for this study primarily comes from the China Health and Retirement Longitudinal Survey (CHARLS). CHARLS is a large-scale interdisciplinary survey project conducted by the National School of Development at Peking University, in collaboration with the China Social Science Survey Center and the Communist Youth League Committee at Peking University. The survey aims to collect data on middle-aged and elderly Chinese individuals and households aged 45 and above. CHARLS employs a Probabilities Proportional to Size (PPS) sampling method, with a multi-stage sampling process from county to village/residence, household, and individual levels. The baseline national survey was conducted in 2011, covering 150 counties (districts) and 450 villages (residences) across the country, including visits to 10,257 households and 17,708 individuals, thereby providing a comprehensive reflection of China's middle-aged and elderly population. The CHARLS questionnaire includes information on individual demographics, family structure, employment and retirement, health status, and health behaviors. Since 2011, national surveys have been conducted every two years, resulting in five waves of data spanning ten years, including surveys conducted in 2011, 2013, 2015, 2018, and 2020. To date, CHARLS is the most authoritative and largest representative database for studying the health of elderly individuals in China.

The mortality data during the Great Famine is entirely sourced from the Compilation of Statistical Materials on New China's 55 Years. The provincial-level control variables data are obtained from the provincial statistical yearbooks and the official website of the National Bureau of Statistics.

The data-cleaning process is as follows: (1) First, the data from the five survey waves were merged into a panel dataset, resulting in a total of 96,616 observations. (2) After excluding samples with individuals younger than

45 years old, 94,813 observations remained. (3) Further excluding observations with missing dependent variables reduced the dataset to 79,320 observations. (4) After excluding samples with missing values for the key explanatory variables, 78,244 observations remained. (5) Finally, after excluding observations with missing control variables, the final dataset comprised 54,614 observations.

Econometric specification

Drawing on the approach used by Chen and Zhou (2007) [1], the following cohort difference-in-differences model is constructed:

$$\text{Depress}_{ipt} = \beta_0 + \beta_1 \text{EDR}_p \times I(\text{Birth} \leq 1961) + X'_{ipt}\theta + \delta_p + \gamma_t + \varepsilon_{ipt} \quad (1)$$

In this study, *Depress* represents the level of depression among the elderly and serves as the dependent variable; *i* represents the individual, *p* denotes the province, and *t* indicates time. *EDR* represents the excess death rate at the provincial level, used to measure the varying levels of exposure to the Great Famine across different provinces. $I(\text{Birth} \leq 1961)$ is a dummy variable for birth cohorts, where individuals born before 1961 are assigned to the treatment group (value=1), while others constitute the control group (value=0). The interaction term $\text{EDR}_p \times I(\text{Birth} \leq 1961)$ captures the exogenous shock of experiencing the Great Famine. $X'_{ipt}\theta$ refers to a set of individual-level and provincial-level control variables. δ_p represents provincial fixed effects to account for unobserved province-level shocks, and γ_t denotes time fixed effects to control for unobserved shocks across different years. ε_{ipt} is the error term. The coefficient of interest β_1 , reflects the causal effect of the Great Famine experience on depression levels among the elderly, which is the core focus of this study.

Definition of variables

Dependent variable (Depression level) The widely used 10-item Center for Epidemiologic Studies Depression Scale (CESD-10) is employed to measure the depression level of the elderly. Each item is rated on a 4-point scale, ranging from 1 to 4, with items 5 and 8 being reverse-scored. The sum of these 10 items constitutes the Elderly Depression Scale score, with higher scores indicating a higher risk of depression. To mitigate the impact of extreme values and facilitate the interpretation of results, the total depression score is logarithmized, resulting in the dependent variable *Depress* used in this study.

Key independent variable (great famine) It is represented by the product of the provincial excess mortality rate and the birth cohort dummy variable $\text{EDR}_p \times I(\text{Birth} \leq 1961)$.

The calculation of *EDR* follows the method used by Chen and Zhou (2007) [1], where the excess death rate is derived by subtracting the average death rate from 1956 to 1958 from the death rate in 1960. The actual death rate in 1960 is used as the baseline for calculating the excess death rate because 1960 was the most severe year of the famine, with nationwide grain production reaching its lowest point and mortality rates peaking. This allows for a precise assessment of the extremity of the famine and its impact on population health. The average death rate from 1956 to 1958 is selected as the baseline because these years represent a relatively stable period before the famine, providing a benchmark that reflects mortality rates in normal years. By making this comparison, the scale of excess mortality during the famine can be accurately quantified, offering robust data support for further analysis.

Control variables Referring to Zhu (2023) [38], Li and Luo (2024) [39], Zhang et al. (2023) [40], Yang et al. (2022) [41], the individual-level control variables are as follows: Gender, Household registration (HR), marital status (MS), education, self-rated health (SH), medical insurance (MI), personal income (PI), smoking status (SS), alcohol consumption (AC). This paper also introduces provincial-level variables to control the impact of regional economic and health development: Gross Domestic Product (GDP), Local Government Health Expenditure (LGHE), Number of Healthcare Institutions (NHI), Number of Healthcare Personnel (NHP), Number of Hospital Beds (NHB).

Descriptive statistics

Table 1 below is the variable definition and descriptive statistics of this paper: the mean value of *Depress* is 2.86 and the standard deviation is 0.336, showing good variation information; the mean value of $\text{EDR} \times I(\text{Birth} \leq 1961)$ is 9.859; the mean value of *EDR* is 15.004 and the standard deviation is 15.05, indicating that the excess mortality rate varies greatly among regions; the mean value of $I(\text{Birth} \leq 1961)$ is 0.661, indicating that 66.1% of the samples experienced the Great Famine; other variables are not described in detail. We also constructed population density distribution maps based on different birth cohorts and provided detailed descriptive statistics for the core variables. Please refer to Appendix A and Appendix B for specifics.

Results and discussion

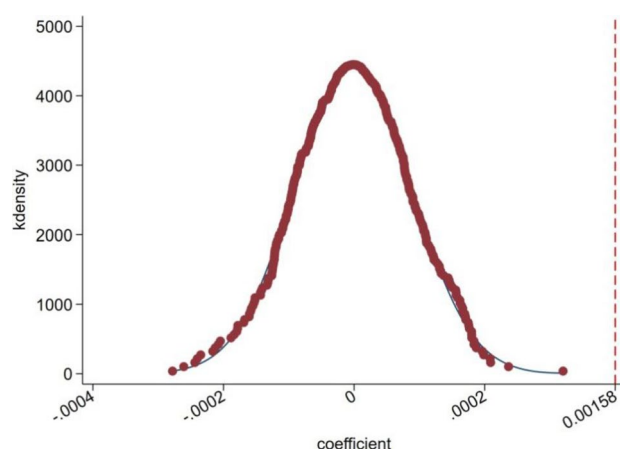
Placebo examination

When employing a difference-in-differences (DID) model, it is essential to satisfy the parallel trends assumption. The placebo test is a crucial method for verifying this assumption. The primary objective of this test is to ensure that the estimated treatment effect genuinely

Table 1 Variable definition and description

Variable	Obs	Mean	Std. Dev.	Description
Depress	54,614	2.86	0.336	Measured by the CESD-10 scale, the total score is log-transformed
EDR × I(Birth ≤ 1961)	54,614	9.859	14.112	The Great Famine
EDR	54,614	15.004	15.05	Excess death rate, calculation method as described above
I(Birth ≤ 1961)	54,614	0.661	0.474	Cohort dummy variable, calculation method as described above
Gender	54,614	0.303	0.46	Gender, male = 1, female = 0
HR	54,614	0.486	0.5	Rural household registration = 1, others = 0
MS	54,614	0.871	0.335	Married = 1, others = 0
SH	54,614	2.804	0.934	Self-rated health: Very poor = 1, poor = 2, fair = 3, good = 4, very good = 5, excellent = 6
MI	54,614	0.948	0.222	Medical insurance = 1, others = 0
SS	54,614	1.823	0.381	Smoking status: Smoker = 1, Non-smoker = 0
AC	54,614	2.542	0.79	Alcohol consumption in the past month: More than once = 1, less than once = 2, no alcohol = 3
GDP	54,614	10.134	0.704	Gross Domestic Product
LGHE	54,614	495.609	290.002	Local Government Health Expenditure
NHI	54,614	46499.347	22798.229	Number of Healthcare Institutions
NHP	54,614	48.927	23.409	Number of Healthcare Personnel
NHB	54,614	32.151	15.647	Number of Hospital Beds

Note: Compiled by the author

**Fig. 1** Placebo examination

reflects a causal relationship, rather than being a spurious effect resulting from model misspecification, random noise, or specific data characteristics.

To conduct the placebo test, we randomly assigned individuals to placebo treatment and control groups and repeated the simulated regressions 500 times. This process yielded 500 estimates of placebo treatment effects. If the distribution of these placebo effects is centered around zero and does not exhibit systematic deviations, it indicates that the model effectively identifies the true causal effect, rather than mistakenly attributing the influence of other factors to the treatment effect. This also implies that there are no inherent systematic differences between the treatment and control groups, thereby satisfying the parallel trends assumption.

As illustrated in Fig. 1, the 500 placebo regression coefficients are concentrated around zero and are distinctly separate from the actual estimated coefficient (represented by the red dashed line). This finding confirms that the baseline results are indeed driven by the experience of the Great Famine, rather than by other unobserved factors.

In addition, we followed the approach of Chen and Zhou (2007) to conduct a parallel trend test: using the cohort born from 1963 to 1967 as a subsample, with 1967 as the control group and other years as treatment groups for regression analysis. The coefficients were not statistically significant, supporting the parallel trends hypothesis. Specific results can be found in Appendix D.

Baseline results and robustness checks

Next, we employ the econometric model (1) to rigorously identify the causal relationship between exposure to the Great Famine and depression among the elderly. The specific results are presented in Table 2:

Column (1) reports the baseline regression results. The coefficient of the interaction term. $EDR \times I(\text{Birth} \leq 1961)$ is 0.00158, which is statistically significant at the 1% level, indicating that experiencing the Great Famine significantly increased the level of depression among the elderly by 0.158%. Column (2) addresses the robustness of the baseline results by transforming the dependent variable, depression level, into a binary variable based on the median and conducting a logit regression. The results indicate that the odds ratio for $EDR \times I(\text{Birth} \leq 1961)$ is 1.017, which is statistically significant at the 1% level. This finding suggests that individuals who experienced

Table 2 Basic regression and robust tests

Variables	Depress				
	Baseline	Logit	Rural	Variables changed	Excluding UMD
	(1)	(2)	(3)	(4)	(5)
EDR×I(Birth≤1961)	0.00158*** (0.000138)	1.017*** (0.00109)	0.00138*** (0.000186)	0.00220*** (0.000138)	0.00139*** (0.000184)
Controls	Y	Y	Y	Y	Y
Pro FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Robust	Y	Y	Y	Y	Y
Observations	54,614	62,272	26,528	54,614	33,994
R-squared	0.152	-----	0.207	0.158	0.156

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Pro FE represents province fixed effects; Year FE represents time fixed effects; Robust represents the use of robust standard errors; Controls represents a series of control variables at the individual level and the province level. UMD: Up to the Mountains and Down to the Countryside

Table 3 Mechanism testing

Variables	Social Support		Socioeconomic Status		Intergenerational Support	
	Family Care	Social Activity	Education Level	Wage	Material support	Spiritual support
	(1)	(2)	(3)	(4)	(5)	(6)
EDR×I(Birth ≤ 1961)	-0.0831** (0.0421)	-0.00641*** (0.000450)	-0.0389*** (0.00134)	0.946*** (0.00178)	-0.00573*** (0.00197)	-0.0116** (0.00473)
Controls	Y	Y	Y	Y	Y	Y
Pro FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Robust	Y	Y	Y	Y	Y	Y
Observations	62,272	41,621	62,272	89,761	30,647	25,360
R-squared	0.021	0.198	0.316	-----	0.062	0.132

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Province FE represents province fixed effects; Year FE represents year fixed effects; Robust indicates the use of robust standard errors; Controls represent a series of individual-level and province-level control variables

the Great Famine face a higher risk of depression. Column (3) considers the potential impact of widespread panic and population outflow caused by the famine during 1959–1961, which might have attenuated the effect of famine exposure on depression. Following the approach of Chen and Zhou (2007) [1], we exclude samples with population mobility to minimize bias from selective migration. The regression results show that the coefficient of $EDR \times I(\text{Birth} \leq 1961)$ is 0.00138, still significant at the 1% level, indicating that famine exposure increased depression levels among the elderly by 0.138%. The slight decrease in the coefficient aligns with expectations.

Column (4) employs an alternative measure of famine severity based on the method proposed by Shi (2011) [42], using abnormal death rates to gauge the impact of the famine across provinces. Specifically, abnormal death rates are calculated as the difference between actual mortality rates and estimated normal mortality rates, with the latter derived using finite differences from mortality rates in the five years before and after the famine for each province (or municipality). The results show that the coefficient of $EDR \times I(\text{Birth} \leq 1961)$ is 0.00220, statistically significant at the 1% level, indicating that experiencing the Great Famine increased depression levels among the

elderly by 0.220%, further confirming the robustness of the results.

Column (5) excludes individuals who participated in the “Up to the Mountains and Down to the Countryside” movement, as previous studies have shown that early experiences in this movement significantly affect depression levels in old age [43, 44]. The re-estimated regression results show that the coefficient of $EDR \times I(\text{Birth} \leq 1961)$ is 0.00139, significant at the 1% level, indicating that famine exposure increased depression levels among the elderly by 0.139%. This finding further supports the robustness of our results.

Additionally, we conducted other robustness checks, such as expanding the treatment group to include cohorts born in 1962 and earlier, as well as incorporating EDR and birth date variables, all of which remained robust. The results are presented in Columns (1) and (3) of Appendix C.

Mechanism test

This section will test the three theoretical mechanism hypotheses proposed in the previous article. The specific results are shown in Table 3 below.

(1) Social Support.

In examining social support, this study uses two indicators: the time spent on caregiving by family members [45] and the frequency of participation in social activities by the elderly [46]. For caregiving time, we calculated the total monthly caregiving hours (hours/month) provided by parents, spouses, children, and grandchildren over the past month. The regression results are shown in column (1): the coefficient of the interaction term $EDR_p \times I(\text{Birth} \leq 1961)$ is -0.0831, which is statistically significant at the 5% level, indicating that the experience of the Great Famine significantly reduced the time spent on family caregiving.

Regarding the frequency of participation in social activities, we measured it by summing up the number of activities such as “interacting with friends, attending community or recreational events, assisting solitary individuals, participating in clubs, volunteering or engaging in charitable activities, caring for sick or disabled people, using the internet, and investing in stocks”. The regression results are shown in column (2): the coefficient of the interaction term $EDR_p \times I(\text{Birth} \leq 1961)$ is -0.00641, which is statistically significant at the 1% level, indicating that the experience of the Great Famine significantly decreased the frequency of elderly participation in social activities. In summary, the experience of the Great Famine indeed significantly reduced social support for the elderly, confirming Hypothesis 1.

(2) Socioeconomic Status.

To assess socioeconomic status, this study employs two indicators: education level [47, 48] and wage income [49, 50]. Education level is measured according to Zhu and He (2021)'s [51] approach: less than elementary school=0, elementary school=6, middle school=9, high school/technical school=12, associate degree=15, bachelor's degree=16, master's degree=19, and doctoral degree=22. The regression results are shown in column (3): the coefficient of the interaction term $EDR \times I(\text{Birth} \leq 1961)$ is -0.0389, which is statistically significant at the 1% level, indicating that the experience of the Great Famine significantly lowered the education level of the elderly.

For wage income, it is measured by whether the individual received wages or bonuses in the past year, coded as 1 for receiving and 0 for not receiving. Given that the dependent variable is binary, a Logit regression was used. The results are presented in column (4): the odds ratio of the interaction term $EDR \times I(\text{Birth} \leq 1961)$ is 0.946, which is statistically significant at the 1% level. Due to the challenges in interpreting this result using relative risk, we calculated the average marginal effect from the Logit

model, which is -0.0055 and statistically significant at the 1% level. This indicates that experiencing the Great Famine reduces the likelihood of receiving a wage by 0.55%. In summary, the experience of the Great Famine significantly reduced the socioeconomic status of the elderly, confirming Hypothesis 2. We also re-regressed using the logarithm of the number of wages or bonuses received, and found that the results remained robust. Please refer to Column (2) in Appendix C for details.

(3) Intergenerational Support.

Intergenerational support is assessed using two indicators: material support and emotional support. Material support is measured by the total amount of material goods and cash received from children over the past year. The regression results are shown in column (5): the coefficient of the interaction term $EDR_p \times I(\text{Birth} \leq 1961)$ is -0.00573, which is statistically significant at the 1% level, indicating that the experience of the Great Famine significantly reduced the material support provided by children to the elderly.

Emotional support is measured by the total frequency of contact with all children through phone calls, messages, WeChat, mail, or email. The regression results are shown in column (6): the coefficient of the interaction term $EDR_p \times I(\text{Birth} \leq 1961)$ is -0.0116, which is statistically significant at the 5% level, indicating that the experience of the Great Famine significantly reduced the emotional support provided by children to the elderly. In conclusion, the experience of the Great Famine indeed significantly reduced intergenerational support for the elderly, confirming Hypothesis 3.

Heterogeneity analysis

(1) Household Registration Type

Urban-rural differences are a key factor when examining the long-term psychological health impacts of the Chinese Great Famine on the elderly. Chen and Zhou (2007) [1] revealed that the famine had different effects on urban and rural populations, showing that the impact on urban residents' height was significantly weaker, as they were less affected by the famine during that time. This result contrasts sharply with findings related to rural populations. Due to limited mobility, rural residents were often forced to live in resource-scarce environments, leading to more severe damage to their health and psychological well-being. In contrast, urban residents, with better living conditions and higher social mobility, were able to access relatively adequate medical resources and social support, which helped mitigate the negative effects of the famine to some extent. Fan and Qian (2015) [22]

further supported this view, noting that the long-term effects of the famine on middle-aged health were more significant in rural areas, especially for individuals born into rural families. Hence, it is expected that the famine experience has a more pronounced impact on depression among the elderly in rural areas. The results of the subgroup regression based on household registration (hukou) are presented in columns (1)-(2) of Table 4: the coefficient of $EDR_p \times I(Birth \leq 1961)$ is significantly higher for the rural sample than for the urban sample ($0.00237 > 0.00157$), which is consistent with expectations.

(2)Growth Period

Adolescence is a critical period for psychological and physical development, and experiences during this stage can have long-term impacts on mental health. Zhang (2002) [52] pointed out that adolescence is a key stage for individuals to understand and interpret the world, form lasting memories, and shape personality. Major societal upheavals like the Great Famine during this period could result in long-lasting negative effects on mental health in adulthood. Developmental psychology further emphasizes that adolescents are highly sensitive to environmental changes and lack mature strategies to cope with significant societal disruptions. Consequently, such experiences may damage the social support systems during adolescence, weaken positive social interactions, and increase the risk of depression in adulthood [19]. Therefore, it is anticipated that the impact of experiencing the famine during adolescence on depression will be greater. Following the approach of Cheng and Zhang (2011) [53], and Lin and Zhou (2019) [54], the sample born between 1943 and 1952 is defined as the adolescent cohort, which is then compared with other cohorts who experienced the famine during different life stages. The subgroup regression results are presented in columns (3)-(4) of

Table 4: the coefficient of $EDR_p \times I(Birth \leq 1961)$ is significantly higher for the adolescent sample compared to other periods ($0.00182 > 0.00142$), which aligns with expectations.

(3)Confucian Culture

Religious beliefs have been shown to buffer the negative impact of life stressors, including major events like the Chinese Great Famine, on psychological health. Religion typically provides individuals with a sense of meaning, belonging, and emotional support, all of which can mitigate the adverse effects of traumatic experiences on mental health. For instance, the stress-buffering hypothesis suggests that religious beliefs, by offering emotional support and social networks, can help individuals cope with life's stresses, thus reducing the incidence of mental health issues. Confucian culture plays a key role in this process. Confucianism emphasizes family, society, and interpersonal relationships, which can strengthen individuals' social support networks and further buffer the negative impact of significant life stressors like the famine on mental health. This suggests that in regions where Confucian culture is stronger, individuals may be able to draw more psychological support from religious beliefs and cultural values, helping them cope better with stress and reducing the incidence of depression [27]. In this paper, the number of Confucian temples is used to measure the strength of Confucian culture in different regions, as these temples symbolize Confucianism. Li and Zhu (2021) [55] noted that the higher the density of Confucian temples in a region, the greater the influence of Confucian culture on the region's cultural and economic development, as well as residents' behavior. Based on the presence or absence of Confucian temples, the sample is divided into regions with strong and weak Confucian cultural influences. The subgroup regression results are presented in columns (5)-(6) of Table 4: the coefficient

Table 4 Heterogeneity regressions

Hukou Status			Growth Period		Confucian Culture	
Variables	Rural	Urban	Adolescence	Other Period	Strong Culture	Weak Culture
	(1)	(2)	(3)	(4)	(5)	(6)
EDRxI(Birth ≤ 1961)	0.00237*** (0.000185)	0.00157*** (0.000203)	0.00182*** (0.000166)	0.00142*** (0.000152)	0.00139*** (0.000198)	0.00175*** (0.000194)
Empirical p-value	0.026**		0.008***		0.022**	
Controls	Y	Y	Y	Y	Y	Y
Pro FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Robust	Y	Y	Y	Y	Y	Y
Observations	26,528	28,086	31,712	43,569	30,586	24,028
R-squared	0.216	0.109	0.153	0.141	0.142	0.165

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; Pro FE represents provincial fixed effects; Year FE represents year fixed effects; Robust represents the use of robust standard errors; Controls include a series of individual-level and provincial-level control variables. The Empirical p-value involves conducting 500 random resampling and then calculating the percentile range in which the true value falls. This approach is used to estimate the statistical significance of the differences between groups

of $EDR_p \times I(Birth \leq 1961)$ is significantly lower in regions with strong Confucian culture compared to regions with weak Confucian culture ($0.00139 < 0.00175$), which is in line with expectations.

Conclusion

This study utilizes longitudinal data from the CHARLS to examine the long-term impact of the 1959–1961 Great Famine on depression among the elderly in China. By constructing a cohort-based difference-in-differences model, the analysis reveals that the experience of the Great Famine is significantly associated with an increased risk of depression among the elderly. This effect is particularly evident among individuals with rural household registration, those who experienced the famine during adolescence, and in regions less influenced by Confucian culture. The analysis further indicates that weakened social support networks, declining socioeconomic status, and diminished intergenerational support are key pathways through which the famine experience impacts depression levels in the elderly. Specifically, famine exposure significantly reduced opportunities for elderly individuals to receive family care and engage in social activities later in life, further exacerbating mental health deterioration.

The findings of this study provide important insights into understanding the long-term health impacts of the Great Famine and informing relevant policy development. First, the research emphasizes the profound effects of major social and historical events on the mental health of individuals in later life, highlighting the need to focus on populations exposed to significant traumatic events when designing mental health interventions for the elderly. Second, the study reveals the critical role of absent social support networks in the development of depressive symptoms among the elderly, suggesting that policymakers should prioritize constructing and maintaining social support systems, particularly in regions that have undergone significant social transformations. Furthermore, the research demonstrates the significant moderating effect of socioeconomic status on mental health, indicating that reducing socioeconomic inequalities and providing broader economic support could help reduce the prevalence of mental health issues.

Although this study reveals a significant association between the experience of the Great Famine and depression among the elderly, it has certain limitations. First, the data is primarily drawn from surviving individuals, which may introduce selection bias, as it does not fully capture the experiences of those who perished during the famine. Second, this study does not account for potential genetic predispositions to mental health disorders or family history of depression, particularly among parents and grandparents. This omission could lead to

an overestimation of the impact of famine exposure on depression, as hereditary factors play a crucial role in mental health outcomes. Future studies should include genetic and familial mental health history to provide a more accurate assessment of the relationship between early life conditions and mental health in later life. Additionally, the findings of this study are primarily based on the Chinese context, and similar research in other countries and cultural settings is necessary for further validation.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-024-20604-8>.

Supplementary Material 1

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Author contributions

G.L. S. B. and L.S.N. wrote the main manuscript text; L.Y. and Y.W.Q. review and edit the manuscript, in charge of the project administration; X.Z.M. prepared Table 1, and 2; L.M.L. prepared Table 3, and 4; Y.M.R. prepared Fig. 1.

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Data availability

The data will be available to other researchers for non-commercial purposes upon request to the corresponding author.

Declarations

Ethics approval and consent to participate

This study has been approved by the Biomedical Ethics Review Committee of Peking University (#IRB 00001052–11015).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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