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Adverse childhood experiences from family and society contribute to increased risk of depressive symptoms and cognitive impairment: a cross-sectional study

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ABSTRACT

Background Family environments can shape children's personalities and social networks, rendering distinguishing adverse childhood experiences (ACEs) from family and society essential, but related evidence remains limited.

Aims This cross-sectional study aimed to investigate the correlations between intrafamilial and social ACEs, their associations with depressive symptoms and cognitive impairment and the (education-moderated) mediating role of social ACEs.

Methods Data for this cross-sectional study were from the China Health and Retirement Longitudinal Study. Nine intrafamilial (0, 1, 2, 3, and 4 or more) and three social (0, 1, and 2 or more) ACEs were identified. Depressive symptoms were assessed using the 10-item Center for Epidemiological Studies Depression Scale. Global cognition, including episodic memory and mental intactness, was calculated as z scores. Binary and ordered logistic regressions, generalised linear models with Gaussian family and identity link, and mediation analysis were used.

Results 13 435 participants aged 59.0 (51.0–66.0) were included. Compared with participants with no intrafamilial ACEs, those with 1, 2, 3, and 4 or more intrafamilial ACEs tended to develop more social ACEs, with odds ratios (ORs) of 1.55 (95% confidence interval (CI): 1.36 to 1.76), 2.36 (95% CI: 2.08 to 2.68), 3.46 (95% CI: 3.02 to 3.96) and 6.10 (95% CI: 5.30 to 7.02), respectively. Both intrafamilial and social ACEs were associated with depressive symptoms (OR >3 for four or more intrafamilial ACEs and two or more social ACEs) and global cognition (β=−0.26 for four or more intrafamilial ACEs and β=−0.29 for two or more social ACEs). Social ACEs mediated the associations of intrafamilial ACEs with depressive symptoms and global cognition by 12.3% and 13.1%, respectively. Furthermore, as education levels increased, the impact of intrafamilial ACEs on depressive symptoms was increasingly mediated through social ACEs, while the mediating role of social ACEs between intrafamilial ACEs and cognitive impairment gradually diminished.

Conclusions Improving children's social environments and elevating general education can prevent later-life depressive symptoms and cognitive impairment attributed to ACEs in China.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Adverse childhood experiences (ACEs), generally classified as deprivation and threat, are known to induce depression and cognitive impairment in later life. According to the ecological systems theory, family environments can influence children's personalities and social networks. Thus, taking a sociological perspective when studying ACEs, for instance, the mediating role of social ACEs among the associations of intrafamilial ACEs with depressive symptoms and cognitive impairment, seems worthy of investigation. Furthermore, exploring whether education modifies the mediating role of social ACEs can provide population evidence for reducing the health burdens attributed to ACEs, but related evidence remains controversial.

WHAT THIS STUDY ADDS

⇒ This study found significant correlations between intrafamilial and social ACEs, as well as their significant associations with depressive symptoms and cognitive impairment. Of all ACEs, parental mental illness, loneliness and unfriendly neighbours exhibited the highest depressive and cognitive risks. Social ACEs mediated more than 10% of the associations of intrafamilial ACEs with depressive symptoms and cognitive impairment. Interestingly, as education levels increased, the impact of intrafamilial ACEs on depressive symptoms and cognitive impairment gradually weakened or even diminished.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Given the high prevalence of ACEs in China, our findings highlight that parents, teachers and community workers should concentrate on preventing children's occurrence of social ACEs and fostering the development of their social abilities while working to reduce ACEs within the family. In addition, the Chinese government should strive to raise the educational levels for all to prevent widespread ACE-induced depressive symptoms and cognitive impairment.

INTRODUCTION

Due to the rapid expansion of the ageing population, mental and memory-related disorders, such as depression and dementia, presently affect 13.3% and 7.0% of the elderly population worldwide and have escalated into significant public health issues.[1 2] Therefore, identifying potential lifelong risk factors for these disorders is essential to alleviate their considerable socioeconomic and medical burdens.

Adverse childhood experiences (ACEs) encompass a broad range of traumatic events children and adolescents may encounter, precipitating subsequent risks of depression and cognitive impairment in their adult lives.[3] Given their distinct effects on neurodevelopment, ACEs are typically categorised as deprivation and threat.[4] Nevertheless, considering the impact of intrafamilial circumstances on the development of children's personalities and social relationships, a sociological perspective becomes indispensable when studying ACEs.[5 6] It helps to comprehensively understand ACEs and facilitates the formulation of efficacious prevention and intervention strategies, particularly in China, where such evidence remains limited.

A previous study has shown that peer bullying during childhood is a mediator between intrafamilial aggression and depression in adulthood, suggesting that children growing up in unfavourable familial environments may experience social adversities in their early years, leading to long-term health issues.[7] However, this study only focused on maltreatment as intrafamilial adversity and peer bullying as social adversity. The associations between broader intrafamilial ACEs, such as emotional neglect and economic hardship, and social ACEs, such as loneliness and neighbourhood environments, have not been extensively investigated thus far. Even though individuals with ACEs are susceptible to developing depression and cognitive impairment,[3] evidence is limited concerning the distinctions between intrafamilial and social ACEs and whether social ACEs mediate the impact of intrafamilial ACEs on health issues. Furthermore, research conducted in the UK has provided evidence suggesting a negative association between ACEs and education. Years of education are a significant component of socioeconomic status and cognitive reserve known to benefit mental health and cognitive function.[8 9] However, a recent study conducted in China has reported no significant moderated effects of education among the association of ACEs with depression and cognitive impairment,[10] leading to controversial findings. Given the gap in older adults' education and the substantial cultural differences between China and Western countries, investigating how education moderates the mediating role of social ACEs between intrafamilial ACEs and health outcomes may help develop targeted interventions to reduce the health hazards of ACEs in older Chinese.

To fill in these research gaps, we used the China Health and Retirement Longitudinal Study (CHARLS) to investigate the associations of intrafamilial and social ACEs with depressive symptoms and cognitive impairment, the mediating role of social ACEs and the education-moderated mediating role of social ACEs in middle-aged and older Chinese.

METHODS

Study population

For this cross-sectional study, we used data from CHARLS, a nationally representative survey that included adults aged 45 years and older from 450 villages and urban communities across 28 provinces in China. The detailed procedures taken by CHARLS have been described elsewhere.[11] After the 2011 baseline survey, there were follow-ups in 2013, 2015 and 2018. In 2014, CHARLS additionally carried out a life history survey to retrospectively record the respondents' life experiences from birth. CHARLS 2014 and 2015 waves were used in this study.

Among 21 095 participants recruited in 2015, those who were aged <45 or with incomplete data on age, gender, residence, education, marital status, smoking history, drinking history and history of chronic diseases (n=1787) and who had incomplete data on ACEs (n=5873) were excluded, leaving 13 435 participants included at baseline (figure 1).

Definition of ACEs

The detailed definitions of ACEs are shown in online supplemental table S1. In CHARLS, ACEs before the age of 17 were assessed using the 2014 Life History Questionnaire. Nine intrafamilial ACEs (emotional neglect, family violence, parental separation or divorce, parental behavioural problem, parental mental illness, parental disability, parental death, physical abuse and economic adversity) and three social ACEs (bullying, loneliness and unfriendly neighbours) were finally identified. All ACEs were dichotomised and summed to obtain intrafamilial ACEs and social ACEs, with values ranging from 0 to 9 and 0 to 3, respectively. Intrafamilial ACEs were then divided into 0, 1, 2, 3, and 4 or more; social ACEs were classified as 0, 1, and 2 or more.

Assessment of depressive symptoms

CHARLS uses the 10-item Center for Epidemiological Studies Depression Scale to measure depressive symptoms.[12] Participants were asked about their feelings for 10 aspects during the last week, such as feeling bothered, having trouble concentrating and feeling depressed, with options including (1) rarely or none of the time (1 day); (2) some or a little of the time (1–2 days); (3) sometimes or a significant amount of the time (3–4 days); and (4) most or all of the time (5–7 days). These four choices were then valued as 0, 1, 2 and 3 in sequence, with a total depressive score ranging from 0 to 30. A higher depressive score indicates more depressive symptoms. Individuals with a depressive score of ≥10 were defined as having depressive symptoms.[13]

Assessment of cognitive function

The cognitive function includes episodic memory and mental intactness (orientation, attention and

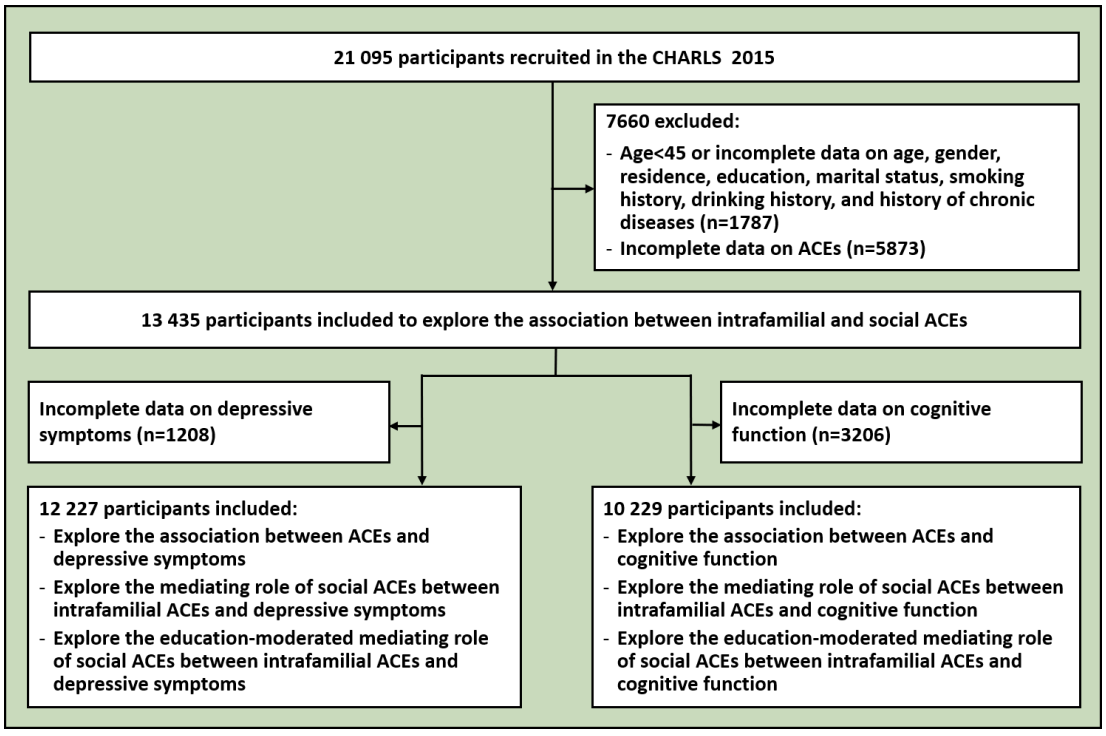

Figure 1 Flowchart and design of the study. ACEs, adverse childhood experiences. CHARLS, China Health and Retirement Longitudinal Study.

visuoconstruction) in CHARLS, with a total cognitive score ranging from 0 to 21.[10] A higher cognitive score indicates better cognitive function. The average of immediate (within 2 min) and delayed (4–10 min later) word recalls using 10 random words was adopted to measure episodic memory (0–10). Orientation was defined by asking about the day, week, month, season and year of the interview (0–5). Attention was determined using five serial subtractions of 7 from 100 (0–5). Visuoconstruction was defined by asking participants to redraw a previously displayed figure (0–1). Global cognition, episodic memory and mental intactness were then calculated as each-5-year-age stratified z scores. All cognitive z scores were further normalised using Blom transformation to fit Gaussian distributions.

Covariates

Information on age, gender, residence, education, marital status, smoking history, drinking history and number of diseases was collected through face-to-face interviews. Residence was classified as rural and urban. Education was divided into primary school or less, middle school, and high school or above. Marital status was classified as married/cohabiting or single. Smoking and drinking history were classified as never or ever. Number of diseases was defined as using self-reported physician diagnoses or using treatments and was divided into 0, 1, and 2 or more.

Statistical analysis

The baseline characteristics of included participants were described as medians and interquartile ranges (IQRs) for continuous variables, given their skewed distribution, and frequency and per cent (%) for categorical variables. To compare characteristics across participants with different numbers of intrafamilial ACEs, differences were assessed by Kruskal-Wallis tests (continuous or ordered categorical variables) and χ^2 tests (binary variables).

Binary logistic regression was used to investigate the association of each and overall intrafamilial ACEs with each social ACE. Ordered logistic regression was further used to investigate the association of each and overall intrafamilial ACEs with overall social ACEs. All models were adjusted for age, gender, residence, smoking history, drinking history and number of diseases.

Furthermore, the fully adjusted associations of intrafamilial and social ACEs with depressive symptoms were investigated using binary logistic regression, while the associations with cognitive function (global cognition, episodic memory and mental intactness) were investigated using generalised linear models with Gaussian family and identity link. Corresponding associations of each ACE with depressive symptoms and cognitive function were investigated using similar models. Gender, residence and marital status-stratified analyses were further conducted.

Before mediation analysis, the correlation between intrafamilial ACEs and social ACEs was examined using Spearman's rank correlation, and the variance inflation factors (VIFs) were also calculated to assess potential collinearity issues. The Spearman's rank correlation was 0.27 (<0.40), and the VIFs for intrafamilial ACEs and social ACEs were 1.10 and 1.09, respectively. Also, the

Table 1 Baseline characteristics of included participants (n=13 435)

Characteristics		Number of intrafamilial ACEs						
		0 (n=2745)	1 (n=3938)	2 (n=3197)	3 (n=1997)	4 or more (n=1558)	χ^2	P value
Age, year		58.0 (51.0–66.0)	59.0 (51.0–66.0)	59.0 (52.0–66.0)	60.0 (52.0–66.0)	59.0 (52.0–66.0)	9.63	0.047
Gender							42.26	<0.001
	Men	1191 (43.4)	1893 (48.1)	1637 (51.2)	1007 (50.4)	775 (49.7)		
	Women	1554 (56.6)	2045 (51.9)	1560 (48.8)	990 (49.6)	783 (50.3)		
Residence							37.67	<0.001
	Rural	1604 (58.4)	2310 (58.7)	2012 (62.9)	1250 (62.6)	1022 (65.6)		
	Urban	1141 (41.6)	1628 (41.3)	1185 (37.1)	747 (37.4)	536 (34.4)		
Education							132.29	<0.001
	Primary school or less	1726 (62.9)	2609 (66.3)	2209 (69.1)	1460 (73.1)	1208 (77.5)		
	Middle school	651 (23.7)	819 (20.8)	671 (21.0)	344 (17.2)	240 (15.4)		
	High school or above	368 (13.4)	510 (13.0)	317 (9.9)	193 (9.7)	110 (7.1)		
Marital status							9.46	0.051
	Married/cohabiting	2446 (89.1)	3505 (89.0)	2821 (88.2)	1733 (86.8)	1361 (87.4)		
	Single	299 (10.9)	433 (11.0)	376 (11.8)	264 (13.2)	197 (12.6)		
Social ACEs							908.22	<0.001
	0	2309 (84.1)	3045 (77.3)	2204 (68.9)	1208 (60.5)	739 (47.4)		
	1	376 (13.7)	730 (18.5)	779 (24.4)	580 (29.0)	535 (34.3)		
	2 or more	60 (2.2)	163 (4.1)	214 (6.7)	209 (10.5)	284 (18.2)		
Smoking history							41.35	<0.001
	Ever	1073 (39.1)	1731 (44.0)	1486 (46.5)	932 (46.7)	703 (45.1)		
	Never	1672 (60.9)	2207 (56.0)	1711 (53.5)	1065 (53.3)	855 (54.9)		
Drinking history							29.74	<0.001
	Ever	890 (32.4)	1402 (35.6)	1220 (38.2)	762 (38.2)	600 (38.5)		
	Never	1855 (67.6)	2536 (64.4)	1977 (61.8)	1235 (61.8)	958 (61.5)		
Number of chronic diseases							150.20	<0.001
	0	937 (34.1)	1247 (31.7)	908 (28.4)	520 (26.0)	365 (23.4)		
	1	800 (29.1)	1121 (28.5)	888 (27.8)	533 (26.7)	349 (22.4)		
	2 or more	1008 (36.7)	1570 (39.9)	1401 (43.8)	944 (47.3)	844 (54.2)		
Depressive symptoms*							435.94	<0.001
	Yes	578 (22.8)	948 (26.3)	930 (32.2)	745 (41.4)	697 (50.0)		
	No	1958 (77.2)	2661 (73.7)	1961 (67.8)	1053 (58.6)	696 (50.0)		

Continued

Table 1 Continued

Characteristics	Number of intrafamilial ACEs					χ^2	P value
	0 (n=2745)	1 (n=3938)	2 (n=3197)	3 (n=1997)	4 or more (n=1558)		
Global cognition*	12.5 (9.5–15.0)	12.0 (9.5–14.5)	12.0 (9.0–14.5)	11.5 (9.0–14.5)	11.5 (8.0–14.0)	60.66	<0.001
Episodic memory*	4.0 (2.5–5.0)	4.0 (2.5–5.0)	3.5 (2.5–5.0)	3.5 (2.5–5.0)	3.5 (2.0–4.5)	36.06	<0.001
Mental intactness*	9.0 (6.0–11.0)	8.0 (6.0–10.0)	8.0 (6.0–10.0)	8.0 (6.0–10.0)	7.0 (6.0–10.0)	51.09	<0.001

Values are presented as n (%) or median (IQR).
*The analytical sample is less than 13 435.
ACEs, adverse childhood experiences; IQR, interquartile range.

VIFs of all other variables were less than 10, suggesting no severe collinearity.

Subsequently, the mediating role of social ACEs in the associations of intrafamilial ACEs with depressive symptoms and cognitive function (global cognition, episodic memory and mental intactness), as well as the education-moderated mediating role of social ACEs in these associations, was explored based on the 'mediation' package in R. For instance, the equations for exploring the mediating role of social ACEs between intrafamilial ACEs and depressive symptoms were as follows:

Model 1: Social ACEs=Intrafamilial ACEs+Covariates (ordered logistic regression)

Model 2: Depressive symptoms=Intrafamilial ACEs+Social ACEs+Covariates (binary logistic regression)

Reporting of this study was done under the Strengthening the Reporting of Observational Studies in Epidemiology guidelines. Analyses were performed using R statistical software V.4.2.3 (R Project for Statistical Computing). All analyses were two-sided, and a p value of <0.05, a 95% confidence interval (CI) of odds ratio (OR) that did not cross 1.00 or a 95% CI of β that did not cross 0 was considered statistically significant.

RESULTS

The baseline characteristics of the included participants are shown in table 1. A total of 6503 (48.4%) men and 6932 (51.6%) women aged 59.0 (51.0–66.0) were included. Those with more intrafamilial ACEs tend to develop more social ACEs, depressive symptoms and cognitive impairment (all p values <0.001).

According to table 2, when compared with those with no intrafamilial ACEs, participants with more overall intrafamilial ACEs tend to develop more overall social ACEs, with ORs of 1.55 (95% CI: 1.36 to 1.76), 2.36 (95% CI: 2.08 to 2.68), 3.46 (95% CI: 3.02 to 3.96) and 6.10 (95% CI: 5.30 to 7.02) for 1, 2, 3, and 4 or more intrafamilial ACEs, respectively.

Both intrafamilial and social ACEs are associated with depressive symptoms, with ORs of 3.23 (95% CI: 2.79 to 3.73) for four or more intrafamilial ACEs and 3.15 (95% CI: 2.71 to 3.67) for two or more social ACEs (online supplemental table S2) when compared with those with no corresponding ACEs. Similarly, both intrafamilial and social ACEs are negatively associated with global cognition (β=−0.26, 95% CI: −0.33 to −0.19 for four or more intrafamilial ACEs and β=−0.29, 95% CI: −0.36 to −0.21 for two or more social ACEs), episodic memory (β=−0.16, 95% CI: −0.23 to −0.09 for four or more intrafamilial ACEs and β=−0.19, 95% CI: −0.27 to −0.11 for two or more social ACEs) and mental intactness (β=−0.26, 95% CI: −0.33 to −0.19 for four or more intrafamilial ACEs and β=−0.27, 95% CI: −0.35 to −0.19 for two or more social ACEs). Online supplemental table S3 suggests that parental mental illness, loneliness and unfriendly neighbours are associated the most with depressive symptoms and cognitive impairment among all ACEs. Furthermore,

Table 2 Associations between intrafamilial ACEs and social ACEs: binary and ordered logistic regressions

Exposure	Outcome			
	Bullying	Loneliness	Unfriendly neighbours	Overall social ACEs
	OR (95% CI)			
Specific intrafamilial ACEs				
Emotional neglect	1.11 (1.01 to 1.23)	1.05 (0.94 to 1.18)	1.22 (1.09 to 1.37)	1.13 (1.04 to 1.22)
Family violence	2.42 (2.20 to 2.68)	1.57 (1.40 to 1.76)	1.40 (1.25 to 1.58)	1.94 (1.79 to 2.11)
Parental separation or divorce	2.46 (1.48 to 4.07)	1.82 (1.01 to 3.29)	1.38 (0.72 to 2.63)	1.81 (1.15 to 2.85
Parental behavioural problem	1.54 (1.25 to 1.91)	1.69 (1.34 to 2.13)	1.28 (0.99 to 1.65)	1.62 (1.36 to 1.93)
Parental mental illness	2.27 (2.00 to 2.57)	2.91 (2.55 to 3.32)	2.32 (2.02 to 2.65)	2.74 (2.48 to 3.04)
Parental disability	1.59 (1.43 to 1.77)	1.75 (1.55 to 1.97)	1.50 (1.32 to 1.69)	1.70 (1.56 to 1.85)
Parental death	1.12 (0.97 to 1.30)	1.85 (1.61 to 2.14)	1.44 (1.24 to 1.68)	1.45 (1.30 to 1.62)
Physical abuse	2.82 (2.55 to 3.10)	1.56 (1.39 to 1.75)	1.43 (1.27 to 1.60)	2.08 (1.92 to 2.25)
Economic adversity	2.09 (1.90 to 2.30)	1.96 (1.76 to 2.19)	2.43 (2.17 to 2.71)	2.28 (2.12 to 2.46)
Overall intrafamilial ACEs				
0	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
1	1.65 (1.37 to 1.98)	1.50 (1.23 to 1.83)	1.43 (1.18 to 1.74)	1.55 (1.36 to 1.76)
2	2.80 (2.34 to 3.35)	1.92 (1.58 to 2.34)	2.00 (1.65 to 2.43)	2.36 (2.08 to 2.68)
3	4.27 (3.55 to 5.14)	2.71 (2.21 to 3.32)	2.60 (2.12 to 3.19)	3.46 (3.02 to 3.96)
4 or more	6.50 (5.39 to 7.83)	4.80 (3.93 to 5.86)	4.06 (3.32 to 4.97)	6.10 (5.30 to 7.02)

Models were adjusted for age, gender, residence, marital status, smoking history, drinking history and number of chronic diseases.
ACEs, adverse childhood experiences; CI, confidence interval; OR, odds ratio.

the associations of intrafamilial and social ACEs with depressive symptoms and cognitive impairment remain significant in sex, residence and marital status-stratified analysis, as shown in online supplemental tables S4–S6.

As shown in figure 2, social ACEs mediate the associations of intrafamilial ACEs with depressive symptoms, global cognition, episodic memory and mental intactness by 12.3%, 13.1%, 9.8% and 15.5%, respectively. However, the mediating role of social ACEs between intrafamilial ACEs and episodic memory was not so robust in stratified analysis. According to the final moderated mediation models in figure 3, significant interactions of intrafamilial ACEs and education towards depressive symptoms and of social ACEs and education towards cognitive impairment were found. Online supplemental table S7 provides additional evidence showing a noteworthy decrease in the direct effects of intrafamilial ACEs on depressive symptoms while an increase in the mediation proportion of social ACEs as the level of education increases. Furthermore, the direct and indirect effects of intrafamilial ACEs and the mediation proportion of social ACEs towards global cognition, episodic memory and mental intactness become non-significant in those with an education level of high school or above (online supplemental table S7).

DISCUSSION

Main findings

In this retrospective study, we found that intrafamilial ACEs may lead to social ACEs and, thus, further facilitate depressive symptoms and cognitive impairment in adulthood. Interestingly, as education levels increased, the impact of intrafamilial ACEs on depressive symptoms was increasingly mediated through social ACEs; however, the mediating role of social ACEs between intrafamilial ACEs and cognitive impairment gradually diminished and became non-significant among older adults with high school or above education levels.

Prior research has consistently demonstrated that ACEs are associated with increased risks of later-life mental disorders.[3 14] Increased chronic inflammation and dysfunctional hypothalamic-pituitary-adrenal axis can be used to interpret the associations between ACEs and depression.[15] As for cognitive impairment, the blockage of neurodevelopment by ACEs may play a role.[16 17] Importantly, we further confirmed that social ACEs mediated the associations of intrafamilial ACEs with both depressive symptoms and cognitive impairment. Family environments have been found to influence children's behaviour and personality development.[18] Previous research has shown that children who grow up in chaotic homes are more likely to cheat in games.[19] Harsh parenting, quite prevalent in China, can also lead to child aggression.[20] Some theories can be used to interpret our findings. According to the ecological systems theory, the family represents the most fundamental microsystem in children's lives and plays a significant role in their development and adaptation.[21] Intrafamilial ACEs, such as family conflict or parental relationship breakdown, can disrupt

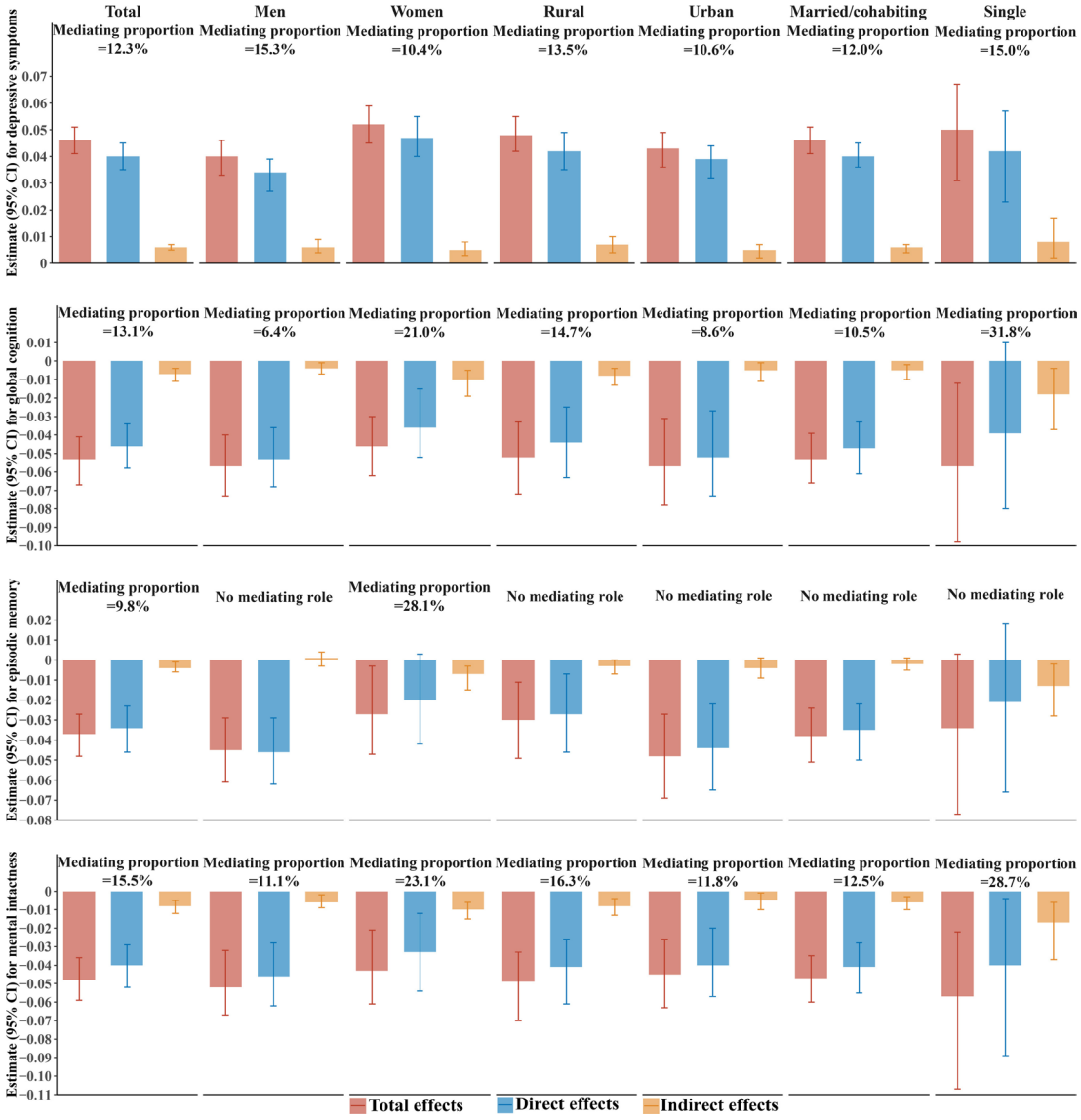

Figure 2 The mediating role of social ACEs in the associations of intrafamilial ACEs with depressive symptoms and cognitive function. Models were adjusted for age, gender, residence, marital status, smoking history, drinking history and number of chronic diseases. ACEs, adverse childhood experiences.

children's microsystems, leading to adverse consequences for their socialisation process, such as feelings of insecurity and unacceptance. Simultaneously, social learning theory emphasises that children acquire behaviours by observing and imitating the adults and peers around them.[22] Hence, intrafamilial ACEs can influence children's ability to develop healthy relationships with peers. For instance, conflict and violence within the family may shape children's perception of violence as an effective means of problem-solving, increasing their likelihood of engaging in aggressive behaviour and encountering conflict within their social environment.

Among all ACEs, parental mental illness, loneliness and unfriendly neighbours are most strongly associated with depressive symptoms and cognitive impairment. According to our findings, parental mental illness may contribute to other intrafamilial ACEs like physical abuse[22] and is associated with social ACEs the most among all intrafamilial ACEs. In addition, to some extent, parental mental illness may indicate a genetic predisposition for children's mental illness.[23] Loneliness during childhood is a relatively direct reflection of children's mental health. Furthermore, living in unfriendly neighbourhoods shows substantial associations with depressive symptoms and cognitive impairment later in life. In unfriendly neighbourhoods, children may experience feelings of isolation and have limited access to emotional support, which can contribute to developing depressive symptoms.[24] Unfriendly neighbourhoods may also provide inadequate opportunities for cognitive stimulation, intellectual engagement or positive social interactions, resulting in children's weaker cognitive foundations and reduced confidence in social interactions.[25]

Interestingly, the adverse impacts of intrafamilial ACEs on depressive symptoms and cognitive impairment gradually diminish with elevated education. Higher levels

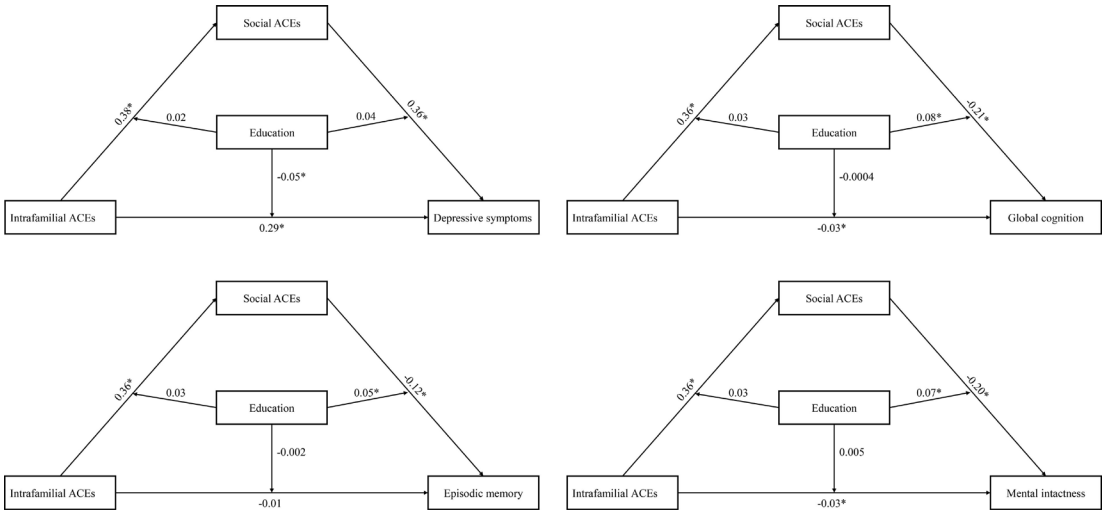

Figure 3 The final moderated mediation models. Models were adjusted for age, gender, residence, marital status, smoking history, drinking history and number of chronic diseases. *p<0.05. ACEs, adverse childhood experiences.

of education generally provide individuals with more resources that can help mitigate the effects of ACEs. For instance, highly educated individuals often have better access to healthcare, mental health services and social support networks,[26] all of which can offer crucial support in coping with the emotional and cognitive challenges attributed to ACEs. Higher education levels are also associated with greater resilience and autonomy.[27] Education equips individuals with knowledge, skills and self-confidence, enabling them to navigate the difficulties posed by ACEs effectively. Additionally, higher education provides opportunities for cognitive stimulation and intellectual growth. These mental skills act as protective factors against the detrimental effects of ACEs on depressive symptoms and cognitive impairment.[28]

In this retrospective study, we comprehensively explored the associations of intrafamilial and social ACEs in China. We indicated for the first time the mediating role of social ACEs in the associations of intrafamilial ACEs with depressive symptoms and cognitive impairment. Our findings highlight the necessity of distinguishing different ACE types via a more sociological perspective. Furthermore, the education-moderated mediation analyses indicate that elevating education levels can reduce ACEs' adverse effects on depressive symptoms and cognitive impairment. The national representativeness and the rigorous procedures of CHARLS ensure the robustness of our conclusions.

Limitations

Our study has several limitations. First, the ACEs data were self-reported, which could lead to recall bias. However, this strategy has been used consistently in most previous studies and seems difficult to avoid. In addition, the study design was retrospective rather than cohort, leaving the causal association less established. Finally, there are racial differences among the effects of ACEs, according to Assari[29] and Assari and Lankarani.[30] However, information on ethnicity in CHARLS is unavailable, rendering its effect modification in this study not explored.

Implications

In addition to resolving conflicts within their families, our study emphasises that interventions for children with intrafamilial ACEs should concentrate on preventing the occurrence of social ACEs and fostering the development of their social abilities. This should be done with the combined efforts of parents, teachers and community workers. Moreover, China should strive to elevate general education levels to prevent and reduce depressive symptoms and cognitive impairment attributed to prevalent ACEs.

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Table S1. Definition of ACEs

		Questionnaire Items	**Answers defined as exposure to the domain**
Intrafamilial	Emotional neglect	How much love and affection did your female guardian give you while you were growing up?	rarely/never
		How much effort did your female guardian put into watching over you?	a little/not at all
	Family violence	Did your parents often quarrel?	often/sometimes
		Did your father/mother ever beat up your mother/father?	often/sometimes
	Parental separation or divorce	Did your biological parents divorce (including a long separation due to emotional problems) before you were 17 years old?	yes
	Parental behavioral problem	During the years you were growing up, did your male/female guardian ever use drugs or gamble, hit other family members after drinking alcohol, often lie, often get into physical fights, get involved in criminal activities like burglary or selling stolen property, or get arrested or sent to prison?	yes
	Parental mental illness	During the years you were growing up, did your male/female guardian show continued signs of sadness or depression that lasted two weeks or more?	yes
		Did your male/female guardian have mental abnormalities when you were young?	yes
	Parental disability	Did your male/female guardian have an extended illness requiring bedrest when you were young?	yes
		Did your male/female guardian have a serious physical deformity when you were young?	yes
	Parental death	Did either of your parents die before you were 17 years old?	yes
	Physical abuse	When you were growing up, did your male/female guardian ever hit you?	often/sometimes
	Economic adversity	When you were a child before the age of 17, how was your family's financial situation compared to the average family in the same community/village at that time?	a lot/somewhat worse off than them
Social	Bullying	When you were a child, how often were you picked on or bullied by children in your neighborhood?	often/sometimes
		When you were a child, how often were you picked on or bullied by children in your school?	often/sometimes
	Loneliness	When you were a child, how often did you feel lonely because you had no friends?	often/sometimes
	Unfriendly neighbors	Was it safe to be out alone at night in the neighborhood where you lived as a child?	not very safe/not safe at all
		Were your childhood neighbors very close-knit?	not very close-knit/not close-knit at all

Notes: ACEs, adverse childhood experiences.

Table S2. Associations of intrafamilial and social ACEs with depressive symptoms and cognitive function: logistic regression and generalized linear model with gaussian family and identity link

ACEs	Depressive symptoms	Global cognition	Episodic memory	Mental intactness
	OR (95% CI)		β (95% CI)	
Intrafamilial ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.22 (1.08-1.38)	-0.06 (-0.11 to -0.01)	0 (-0.06 to 0.05)	-0.09 (-0.14 to -0.03)
2	1.60 (1.41-1.81)	-0.10 (-0.16 to -0.05)	-0.09 (-0.14 to -0.03)	-0.10 (-0.15 to -0.04)
3	2.38 (2.07-2.73)	-0.15 (-0.22 to -0.09)	-0.10 (-0.16 to -0.03)	-0.15 (-0.21 to -0.08)
4 or more	3.23 (2.79-3.73)	-0.26 (-0.33 to -0.19)	-0.16 (-0.23 to -0.09)	-0.26 (-0.33 to -0.19)
Social ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.65 (1.50-1.81)	-0.10 (-0.15 to -0.06)	-0.04 (-0.09 to 0)	-0.12 (-0.16 to -0.07)
2 or more	3.15 (2.71-3.67)	-0.29 (-0.36 to -0.21)	-0.19 (-0.27 to -0.11)	-0.27 (-0.35 to -0.19)

Notes: ACEs, adverse childhood experiences. OR, odds ratio. CI, confidence interval. Models were adjusted for age, gender, residence, marital status, smoking history, drinking history, and number of chronic diseases.

Table S3. Associations of each ACE with depressive symptoms and cognitive function: logistic regression and generalized linear model with gaussian family and identity link

ACEs	Depressive symptoms	Global cognition	Episodic memory	Mental intactness
	OR (95% CI)		β (95% CI)	
Emotional neglect	1.20 (1.10-1.30)	-0.10 (-0.14 to -0.06)	-0.11 (-0.15 to -0.07)	-0.07 (-0.11 to -0.03)
Family violence	1.52 (1.39-1.66)	0.03 (-0.01 to 0.08)	0.03 (-0.01 to 0.08)	0.02 (-0.03 to 0.06)
Parental separation or divorce	1.31 (0.79-2.17)	0.09 (-0.17 to 0.34)	0.07 (-0.19 to 0.34)	0.06 (-0.20 to 0.31)
Parental behavioral problem	1.37 (1.12-1.67)	-0.08 (-0.17 to 0.02)	-0.04 (-0.14 to 0.06)	-0.05 (-0.15 to 0.05)
Parental mental illness	2.58 (2.30-2.90)	-0.23 (-0.29 to -0.17)	-0.14 (-0.20 to -0.08)	-0.22 (-0.27 to -0.16)
Parental disability	1.79 (1.63-1.96)	-0.07 (-0.12 to -0.03)	0.02 (-0.07 to 0.03)	-0.09 (-0.14 to -0.05)
Parental death	1.11 (0.98-1.25)	-0.07 (-0.13 to -0.01)	-0.05 (-0.11 to 0.01)	-0.04 (-0.10 to 0.02)
Physical abuse	1.40 (1.29-1.53)	-0.06 (-0.10 to -0.02)	-0.04 (-0.08 to 0)	-0.08 (-0.12 to -0.04)
Economic adversity	1.62 (1.49-1.76)	-0.16 (-0.19 to -0.12)	-0.12 (-0.16 to -0.08)	-0.13 (-0.17 to -0.09)
Bullying	1.76 (1.58-1.96)	-0.03 (-0.08 to 0.02)	-0.01 (-0.06 to 0.05)	-0.06 (-0.11 to -0.01)
Loneliness	2.24 (1.99-2.53)	-0.25 (-0.32 to -0.19)	-0.17 (-0.24 to -0.11)	-0.23 (-0.29 to -0.16)
Unfriendly neighbors	1.92 (1.70-2.17)	-0.23 (-0.29 to -0.17)	-0.15 (-0.21 to -0.08)	-0.22 (-0.28 to -0.15)

Notes: ACEs, adverse childhood experiences. OR, odds ratio. CI, confidence interval. Models were adjusted for age, gender, residence, marital status, smoking history, drinking history, and number of chronic diseases.

Table S4. Gender-stratified associations of intrafamilial and social ACEs with depressive symptoms and cognitive function: logistic regression and generalized linear model with gaussian family and identity link

ACEs	Depressive symptoms	Global cognition	Episodic memory	Mental intactness
	OR (95% CI)		β (95% CI)	
			Men	
Intrafamilial ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.32 (1.08-1.61)	-0.09 (-0.17 to -0.02)	-0.02 (-0.10 to 0.06)	-0.12 (-0.19 to -0.04)
2	1.56 (1.27-1.91)	-0.15 (-0.22 to -0.07)	-0.13 (-0.21 to -0.05)	-0.13 (-0.21 to -0.06)
3	2.49 (2.01-3.08)	-0.18 (-0.27 to -0.10)	-0.15 (-0.24 to -0.06)	-0.17 (-0.25 to -0.08)
4 or more	3.54 (2.83-4.42)	-0.27 (-0.36 to -0.18)	-0.17 (-0.26 to -0.07)	-0.28 (-0.38 to -0.19)
Social ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.81 (1.58-2.08)	-0.06 (-0.12 to 0)	0.01 (-0.06 to 0.07)	-0.10 (-0.16 to -0.04)
2 or more	3.81 (3.07-4.73)	-0.22 (-0.32 to -0.12)	-0.13 (-0.24 to -0.02)	-0.20 (-0.30 to -0.10)
			Women	
Intrafamilial ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.16 (1.00-1.36)	-0.03 (-0.11 to 0.05)	0.01 (-0.07 to 0.08)	-0.06 (-0.13 to 0.01)
2	1.65 (1.40-1.94)	-0.05 (-0.14 to 0.03)	-0.05 (-0.13 to 0.03)	-0.06 (-0.14 to 0.02)
3	2.31 (1.93-2.77)	-0.12 (-0.22 to -0.03)	-0.05 (-0.15 to 0.05)	-0.12 (-0.21 to -0.03)
4 or more	2.98 (2.45-3.63)	-0.24 (-0.35 to -0.14)	-0.15 (-0.25 to -0.05)	-0.24 (-0.34 to -0.14)
Social ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.52 (1.34-1.73)	-0.15 (-0.22 to -0.08)	-0.10 (-0.17 to -0.03)	-0.14 (-0.21 to -0.07)
2 or more	2.62 (2.12-3.24)	-0.35 (-0.47 to -0.23)	-0.26 (-0.38 to -0.14)	-0.34 (-0.46 to -0.23)

Notes: ACEs, adverse childhood experiences. OR, odds ratio. CI, confidence interval. Models were adjusted for age, residence, marital status, smoking history, drinking history, and number of chronic diseases.

Table S5. Residence-stratified associations of intrafamilial and social ACEs with depressive symptoms and cognitive function: logistic regression and generalized linear model with gaussian family and identity link

ACEs	Depressive symptoms	Global cognition	Episodic memory	Mental intactness
	OR (95% CI)		β (95% CI)	
			Rural	
Intrafamilial ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.18 (1.01-1.37)	-0.09 (-0.16 to -0.02)	-0.02 (-0.09 to 0.05)	-0.12 (-0.19 to -0.05)
2	1.53 (1.31-1.78)	-0.11 (-0.18 to -0.04)	-0.10 (-0.17 to -0.02)	-0.10 (-0.17 to -0.02)
3	2.50 (2.10-2.97)	-0.14 (-0.23 to -0.06)	-0.06 (-0.14 to 0.03)	-0.16 (-0.25 to -0.08)
4 or more	2.88 (2.41-3.46)	-0.27 (-0.36 to -0.18)	-0.15 (-0.24 to -0.05)	-0.28 (-0.37 to -0.19)
Social ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.68 (1.50-1.89)	-0.13 (-0.19 to -0.07)	-0.05 (-0.12 to 0.01)	-0.13 (-0.19 to -0.07)
2 or more	2.90 (2.41-3.50)	-0.23 (-0.33 to -0.14)	-0.11 (-0.21 to -0.01)	-0.24 (-0.34 to -0.14)
			Urban	
Intrafamilial ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.30 (1.06-1.59)	-0.02 (-0.10 to 0.06)	0.01 (-0.07 to 0.09)	-0.04 (-0.12 to 0.04)
2	1.74 (1.41-2.16)	-0.09 (-0.17 to 0)	-0.07 (-0.16 to 0.02)	-0.10 (-0.18 to -0.01)
3	2.18 (1.73-2.75)	-0.17 (-0.26 to -0.07)	-0.16 (-0.26 to -0.06)	-0.12 (-0.22 to -0.03)
4 or more	4.00 (3.13-5.13)	-0.24 (-0.35 to -0.13)	-0.18 (-0.29 to -0.07)	-0.23 (-0.33 to -0.12)
Social ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.58 (1.35-1.86)	-0.06 (-0.13 to 0.01)	-0.03 (-0.10 to 0.04)	-0.10 (-0.17 to -0.03)
2 or more	3.73 (2.87-4.85)	-0.38 (-0.50 to -0.25)	-0.33 (-0.47 to -0.20)	-0.32 (-0.44 to -0.19)

Notes: ACEs, adverse childhood experiences. OR, odds ratio. CI, confidence interval. Models were adjusted for age, gender, marital status, smoking history, drinking history, and number of chronic diseases.

Table S6. Marital status-stratified associations of intrafamilial and social ACEs with depressive symptoms and cognitive function: logistic regression and generalized linear model with gaussian family and identity link

ACEs	Depressive symptoms	Global cognition	Episodic memory	Mental intactness
	OR (95% CI)		β (95% CI)	
			Married/cohabiting	
Intrafamilial ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.21 (1.07-1.38)	-0.05 (-0.11 to 0)	0 (-0.06 to 0.06)	-0.08 (-0.14 to -0.03)
2	1.59 (1.39-1.82)	-0.08 (-0.14 to -0.02)	-0.08 (-0.14 to -0.02)	-0.08 (-0.13 to -0.02)
3	2.35 (2.03-2.72)	-0.15 (-0.21 to -0.08)	-0.09 (-0.16 to -0.02)	-0.14 (-0.21 to -0.07)
4 or more	3.25 (2.78-3.80)	-0.25 (-0.33 to -0.18)	-0.16 (-0.23 to -0.08)	-0.25 (-0.33 to -0.18)
Social ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.64 (1.49-1.82)	-0.09 (-0.13 to -0.04)	-0.03 (-0.08 to 0.02)	-0.11 (-0.15 to -0.06)
2 or more	3.15 (2.67-3.71)	-0.26 (-0.35 to -0.18)	-0.17 (-0.26 to -0.09)	-0.26 (-0.34 to -0.18)
			Single	
Intrafamilial ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.24 (0.87-1.75)	-0.11 (-0.27 to 0.06)	-0.03 (-0.21 to 0.14)	-0.11 (-0.29 to 0.06)
2	1.63 (1.14-2.33)	-0.24 (-0.41 to -0.06)	-0.12 (-0.30 to 0.06)	-0.28 (-0.46 to -0.10)
3	2.60 (1.77-3.83)	-0.20 (-0.39 to -0.01)	-0.16 (-0.36 to 0.04)	-0.19 (-0.39 to 0)
4 or more	3.08 (2.02-4.69)	-0.29 (-0.50 to -0.08)	-0.15 (-0.37 to 0.07)	-0.31 (-0.52 to -0.09)
Social ACEs				
0	1.00 (Reference)	0 (Reference)	0 (Reference)	0 (Reference)
1	1.65 (1.25-2.17)	-0.21 (-0.35 to -0.07)	-0.15 (-0.29 to -0.01)	-0.22 (-0.36 to -0.08)
2 or more	3.23 (2.14-4.89)	-0.44 (-0.64 to -0.23)	-0.33 (-0.55 to -0.12)	-0.36 (-0.57 to -0.15)

Notes: ACEs, adverse childhood experiences. OR, odds ratio. CI, confidence interval. Models were adjusted for age, gender, residence, smoking history, drinking history, and number of chronic diseases.

Table S7. The education-moderated mediating role of social ACEs in the associations of intrafamilial ACEs with depressive symptoms and cognitive function

	Depressive symptoms	Global cognition	Episodic memory	Mental intactness
Primary school or less				
Total effects	0.050 (0.045 to 0.055)	-0.035 (-0.045 to -0.027)	-0.023 (-0.037 to -0.011)	-0.036 (-0.049 to -0.023)
Direct effects	0.044 (0.041 to 0.049)	-0.026 (-0.039 to -0.018)	-0.016 (-0.030 to -0.004)	-0.027 (-0.040 to -0.009)
Indirect effects	0.006 (0.005 to 0.007)	-0.009 (-0.013 to -0.008)	-0.006 (-0.008 to -0.004)	-0.009 (-0.014 to -0.007)
Mediating proportion (%) (95% CI)	12.3 (10.0 to 13.9)	25.4 (20.4 to 37.2)	27.9 (16.4 to 66.0)	25.5 (18.4 to 64.9)
Middle school				
Total effects	0.036 (0.033 to 0.042)	-0.029 (-0.044 to -0.015)	-0.020 (-0.037 to -0.017)	-0.027 (-0.041 to -0.013)
Direct effects	0.030 (0.029 to 0.036)	-0.026 (-0.042 to -0.013)	-0.019 (-0.033 to -0.016)	-0.022 (-0.039 to -0.009)
Indirect effects	0.006 (0.004 to 0.007)	-0.003 (-0.006 to 0)	-0.001 (-0.005 to 0)	-0.005 (-0.008 to -0.002)
Mediating proportion (%) (95% CI)	16.1 (11.9 to 16.6)	9.1 (1.9 to 34.3)	-	18.0 (6.2 to 50.7)
High school or above				
Total effects	0.023 (0.013 to 0.031)	-0.023 (-0.049 to 0.008)	-0.018 (-0.044 to 0.015)	-0.017 (-0.050 to 0.002)
Direct effects	0.018 (0.008 to 0.026)	-0.027 (-0.055 to 0.010)	-0.021 (-0.046 to 0.017)	-0.018 (-0.051 to 0.003)
Indirect effects	0.005 (0.004 to 0.007)	0.003 (-0.003 to 0.008)	0.003 (-0.002 to 0.009)	0.001 (-0.004 to 0.006)
Mediating proportion (%) (95% CI)	21.8 (16.9 to 78.5)	-	-	-

Notes: ACEs, adverse childhood experiences. Models were adjusted for age, gender, residence, marital status, smoking history, drinking history, and number of chronic diseases. "-" refers to no mediating role.