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Association between adverse childhood experiences and social integration among older people in Japan: Results from the JAGES study

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HIGHLIGHTS

- Adverse childhood experiences associated with social integration in older adults.
- The association may be influenced by the social/historical context of childhood.
- Psychological neglect may be associated with all types of low social integration.
- Handling adverse childhood experiences may improve social integration in later life.

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ABSTRACT

Social integration, network, and support are beneficial to health. However, there is little evidence of the association between adverse childhood experiences (ACEs) and social integration in later life. This study investigates the association between ACE history and social integration in older people. We used data from the Japan Gerontological Evaluation Study (JAGES) 2013, which conducted a self-reported survey of functionally independent people aged ≥ 65 years from 30 municipalities across Japan and yielded information on ACE history. We conducted a Poisson regression analysis with robust error variances to assess the association between ACE history and social integration, adjusting for sex, age, childhood economic hardship, adult socioeconomic status, health status, living status, and trust in others. The number of respondents with at least one incident of ACE was approximately 36.8%. The prevalence ratios for those who reported a history of ACEs were as follows: housebound 1.495 (95% confidence interval [CI]: 1.19–1.88), small network size 1.146 (95% CI: 1.10–1.19), low network contact 1.059 (95% CI: 1.00–1.059), non-membership sports group 1.038 (95% CI: 1.00–1.07), and non-membership hobby group 1.06 (95% CI: 1.03–1.09). Among older people in Japan, a history of ACEs is inversely associated with social integration. These findings support the life course approach and suggest that adverse events in early life may have an impact on social life in old age. In order to promote healthy aging, it is important to recognize the significant impact of early-life adversities that can extend into later life.

1. Introduction

Social isolation has become a growing concern worldwide, with much evidence that social relationships play an essential role in health and well-being (Berkman & Syme, 1979; Holt-Lunstad et al., 2010; Holt-Lunstad, 2017; House et al., 1988). Social isolation indicates an objective lack of interaction with family, friends, and others, or of becoming closer to that state. Weak social relationships suggest that

individuals have few friendly relationships and contacts within the community. Social isolation is also recognized as one of the social determinants of undermining physical and mental health (Leigh-Hunt et al., 2017) and is linked to health norms and broader dynamic dimensions, such as reduced access to various types of social support, material goods, employment, and cultural capital (Kawachi & Berkman, 2001). In the United Kingdom and Japan, a Minister for Loneliness has been appointed to tackle the challenge of social isolation. Social

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isolation is a predictor of depression and cognitive decline in older adults, making it an urgent public health issue in a rapidly aging population (Barnes et al., 2022).

In recent years, it has been discovered that exposure to inequality in the early life stages (e.g., socioeconomic disadvantage) is an essential determinant of health and well-being in the long term (Fujiwara et al., 2014; Pavea & Latham, 2016). Early inequality may begin with vulnerability in utero and increase due to exposure to environmental factors (negative experiences), such as illness, deprivation, and family distress. For example, childhood disadvantage is associated with numerous diseases, including cardiovascular disease (O'Rand & Hamil-Luker, 2005) and dementia in old age (Radford et al., 2017; Tani et al., 2020). The childhood family environment also influences cognitive ability and educational outcomes, affecting the formation of human capital (Attanasio et al., 2022; Heckman, 2006). Additionally, empirical studies have demonstrated that having a low socioeconomic status (SES) in early childhood affects social relationships such as one's social network in middle and older age (Ashida et al., 2022; Kuh & Cooper, 1992; Van Groenou & Van Tilburg, 2003). However, the mechanisms of low childhood SES that drive social integration in later life remain unclear.

Children with low SES are more likely to have been exposed to adverse childhood experiences (ACEs), such as abuse and neglect (Felitti et al., 1998). Many previous studies suggest that exposure to ACEs can have lasting negative effects on educational outcomes (Pietse, 2015; Romano et al., 2015), social adversity (e.g., low income and contact with services), and health (Gilbert et al., 2009; Irish et al., 2010). Therefore, enhancing awareness of the potential long-term effects of ACEs can be an essential and cost-effective policy to prevent disabilities in the aging population. Social integration, as seen in social ties and networks, is used as a potential mediating pathway in ACEs among the older population. However, little is known on social integration as an independent outcome with ACEs.

According to attachment theory, childhood maltreatment can lead to failure in developing secure attachments and can impair interpersonal and social communication skills (Bowly, 1969). Further, studies in neuroscience have demonstrated that early childhood maltreatment can alter the structure and function of the brain (Teicher and Samson (2013); Teicher et al. (2006); Tomoda et al. (2012)). Previous studies have also shown that the social environment, which includes access to community support, trusted individuals, and social capital, plays an important role in mitigating the effects of childhood maltreatment (Bellis et al., 2017, 2018; Fujiwara, 2022; Isumi et al., 2023). These studies highlight the importance of social connectedness and support in achieving social resilience. For example, Berkman and Syme (1979) demonstrated the positive effects of social connections on health and well-being. However, the specific relationship between ACEs and social connections in later life, particularly among maltreatment survivors, remains largely unexplored. Further research is needed to examine the influence of ACEs on social interactions later in life and to better understand the role of social relationships in mitigating the long-term effects of childhood maltreatment.

To investigate the association between ACEs and social integration among older people, we used data from the Japan Gerontological Evaluation Study (JAGES), which assesses both ACEs and social integration in community-dwelling, independent Japanese adults aged 65 years or older who are not certified for long-term care. Half of the respondents in this study survived World War II during their childhood. As the World War II period is associated with ACEs, including severe poverty and the death of parents, these data provide a unique opportunity to investigate the impact of ACEs on the social relationships of older adults.

2. Materials and methods

2.1. Data

We used data from the JAGES 2013 project, which was designed to investigate the social determinants of health among community-dwelling, functionally independent (not receiving public long-term care insurance) individuals aged 65 and older. These individuals were selected based on the basic resident register provided by the local government. The survey was designed to determine the risk of older adults requiring long-term care; therefore, long-term insurance data were also used to identify and select those who had not already been certified as requiring long-term care. Individuals with visual, hearing, speech, or other impairments were excluded if they were certified by the public long-term care insurance; otherwise, they were included in the survey. The survey was conducted between October 2013 and February 2014 and was sampled from 30 municipalities in 15 of the 47 prefectures in Japan. Within the 30 municipalities, we mailed self-administered questionnaires to randomly selected functionally independent older adults based on official residential registers in 17 large municipalities. In the other 13 relatively small municipalities, we mailed the questionnaires to all eligible residents. The JAGES questionnaire consists of core questions to be completed by all respondents and five modules that are randomly assigned to participants. The core questions consist of physical and functional status (diseases, health behavior, etc.), psychological (depression, well-being), social environment, socioeconomic status, local environment and social participation status. One fifth of recipients were randomly selected to receive an additional survey module asking about ACEs. We received 129,740 responses in total, of which 25,928 included ACEs. We excluded those responses indicating limitations in daily living, such as limitations in walking, bathing, and toileting without assistance ($n = 1,920$). We also excluded those who did not respond to the ACEs series ($n = 2,623$), resulting in a total analytic sample size of 21,385.

2.2. Ethical considerations

The study protocol for the AGES project was approved by the Committee on Research of Human Subjects at [blinded for review]. Regarding the informed consent of the respondents, we only used data from the respondents who voluntarily returned the questionnaires, and we agreed to use the data only for academic purposes.

2.3. Social integration

The social integration variables used in this study are based on the Berkman-Syme Social Network Index (Berkman & Syme, 1979), which includes four dimensions of social relationships and affiliations: community association membership, church group membership, sociability, and marital status. This index has been used in major studies examining the relationship between social involvement and mortality, as well as in social epidemiology and sociological research. In this study, we excluded church membership because of differences in religious beliefs between Japan and the United States. We also included a measure of being "homebound," which refers to physical and social inactivity, which is a serious public health concern (Nicholson, 2012; Cudjoe et al., 2022).

We assessed the social activity variable based on participation in community groups (i.e., sports and hobby groups). We treated respondents who answered "only a few times a year" or "never participate" as non-members. We assessed the homebound variable through the following question: "How often do you go out? This includes going to the neighborhood, farm, or shopping." We considered homebound those who answered that they went out less than once a week. Regarding social network variables, we assessed marital status, frequency of contact with friends and acquaintances, and the number of friends and

Table 1.1
Outcome measure characteristics by number of adverse childhood experiences (ACEs).

	Total (n = 21,385)		0 (n = 13,507)		1 (n = 6,283)		≥2 (n = 1,595)	
	N	%	N	%	n	%	N	%
Homebound								
Homebound	622	2.9	338	2.5	214	3.4	70	4.4
Not homebound	20,525	96.0	13,032	96.5	5,991	95.4	1,502	94.2
Missing	238	1.1	137	1.0	78	1.2	23	1.4
Social network contact								
Low	9,960	46.6	6,168	45.7	2,971	47.3	821	51.5
High	10,547	49.3	6,826	50.5	3,024	48.1	697	43.7
Missing	878	4.1	513	3.8	288	4.6	77	4.8
Social network size								
Small	5,158	24.1	3,057	22.6	1,585	25.2	516	32.4
Large	15,368	71.9	9,941	73.6	4,423	70.4	1,004	63.0
Missing	859	4.0	509	3.8	275	4.4	75	4.7
Participation in sports group or club								
Non-membership	13,606	63.6	8,443	62.5	4,060	64.6	1,103	69.2
Membership	4,782	22.4	3,187	23.6	1,321	21.0	274	17.2
Missing	2,997	14.0	1,877	13.9	902	14.4	218	13.7
Participation in hobby group								
Non-membership	12,167	56.9	7,515	55.6	3,625	57.7	1,027	64.4
Membership	6,460	30.2	4,290	31.8	1,811	28.8	359	22.5
Missing	2,758	12.9	1,702	12.6	847	13.5	209	13.1
Marital status								
Unmarried	5,569	26.0	3,446	25.5	1,637	26.1	486	30.5
Married	15,490	72.4	9,874	73.1	4,546	72.4	1,070	67.1
Missing	326	1.5	187	1.4	100	1.6	39	2.5

acquaintances. We dichotomized marital status into married or widowed, divorced, separated, and never married. We assessed the frequency of contact with friends and acquaintances based on whether it was less than or more than once a week, and the number of friends and acquaintances based on whether it was less than or more than three. We dichotomized all variables as present or absent.

2.4. ACEs

We based the history of ACEs on previous research (Felitti et al., 1998), which was modified to reflect older adults living in Japan (Matsuyama et al., 2016). In the questionnaires, we included the following seven situations of adversity experienced before the age of 18: death of a parent, parental divorce, parental mental illness, domestic violence, physical abuse, psychological neglect, and psychological abuse. The respondents answered either “yes” or “no.” Only a small number of respondents (approximately 1.8%) had experienced three or more ACEs; therefore, we categorized the total number of ACEs into three groups (0, 1, and 2 or more) according to previous studies (Aemmiya et al., 2018; Yanagi et al., 2020).

2.5. Covariates

We considered age, sex, childhood environment, adult SES, socio-demographic factors, current health status, and personality-related social relationships as potential confounders of the association between childhood ACEs and late-life social integration. We divided the age group into 65–69, 70–74, 75–79, 80–84, and ≥ 85 years. We asked the following question to assess the childhood environment: “Did you have any financial hardship before you reached the age of 18?” (yes/no). We assessed adult SES based on educational attainment (less than 9 years, 10–12 years, or more than 13 years), equivalized household income (less than 2 million yen, 2–3.99 million yen, or 4 million yen or higher), and working status (currently working, retired, or never had a job). We also asked questions related to sociodemographic factors, including whether they lived with their children (yes/no). Among health behaviors, we included smoking (never smoked, quit, or smoked) and defined health status based on any disease currently being treated (yes/no). We also included a question related to trust, “Generally speaking, would you say

that people living in your area can be trusted?”, because trust in others is a crucial aspect of social interaction. We categorized the general trust factors into five levels: very, moderately, neutral, slightly, or not at all. We treated missing values as dummy variables.

2.6. Statistical analysis

We used Poisson regression analysis with a robust variance estimator to investigate the association between childhood ACEs and late-life social integration because the incidence was over 10%. In other words, the odds ratios obtained by logistic regression analysis could have overestimated the risk (Zhang & Yu, 1998). To address the correlation of the error terms between clusters at the municipal level, we used a cluster-robust standard error (81 clusters). We performed the analysis in the following order: We adjusted Model 1 for age and sex, Model 2 for childhood economic disadvantage, and Model 3 for adult SES. We adjusted Model 4 for sociodemographic and health-related variables to identify any changes in the association between ACEs and low social integration. We adjusted the final model, Model 5, for social interaction variables, particularly trust in others. In addition, as a sensitivity analysis, we also identified whether the association between ACEs and social integration types differed with the age-cohort effect (“preadolescent” [i.e., under age 75] vs. “post-adolescent” [age 75+] World War II survivors). To identify specific ACEs that may be more tightly associated, we also analyzed the association between each ACE and each type of social integration using Model 5. We performed all statistical analyses using Stata version 15.1 (Stata Corp, College Station, Texas, USA).

3. Results

Tables 1.1 and 1.2 present the characteristics of the population sample considered in this study, listing those with no ACEs at all, those who had one ACE, and those who had two or more ACEs separately. Of the respondents, 46.4% were male and 53.6% were female, and the mean age was 73.4 years (standard deviation 6.00). Regarding adult SES, 38.1% had less than 10 years of education, 42.2% had an income of less than two million yen, and 59.9% were retired. Further, 10% were current smokers, 78.7% were receiving some kind of medical treatment, and 40.1% were living with their children. Regarding trust in others,

Table 1.2
 Characteristics of Older Japanese respondents by number of adverse childhood experiences (ACEs) (n = 21,385).

	Total (n = 21,385)		0 (n = 13,507)		1 (n = 6,283)		≥2 (n = 1,595)	
	N	%	N	%	n	%	N	%
Sex								
Male	9,932	46.4	5,984	44.3	3,061	48.7	887	55.6
Female	11,453	53.6	7,523	55.7	3,222	51.3	708	44.4
Age (years)								
65–69	6,527	30.5	4,329	32.1	1,700	27.1	498	31.2
70–74	6,622	31.0	4,103	30.4	2,010	32.0	509	31.9
75–79	4,600	21.5	2,828	20.9	1,425	22.7	347	21.8
80–84	2,523	11.8	1,550	11.5	816	13.0	157	9.8
≥85	1,113	5.2	697	5.2	332	5.3	84	5.3
Educational attainment (years)								
≤9	8,146	38.1	4,572	33.9	2,730	43.5	844	52.9
10–12	8,287	38.8	5,518	40.9	2,293	36.5	476	29.8
≥13	4,653	21.8	3,238	24.0	1,173	18.7	242	15.2
Other/Missing	299	1.4	179	1.3	87	1.4	33	2.1
Equivalized household income (million yen)								
Low (<2.00)	9,013	42.2	5,351	39.6	2,826	45.0	836	52.4
Middle (2.00–3.99)	7,088	33.1	4,694	34.8	1,996	31.8	398	25.0
High (≥4.00)	1,981	9.3	1,392	10.3	486	7.7	103	6.5
Missing	3,303	15.5	2,070	15.3	975	15.5	258	16.2
Employment status								
Working	5,008	23.4	3,177	23.5	1,420	22.6	411	25.8
Retired	12,817	59.9	8,034	59.5	3,831	61.0	952	59.7
Never had a job	2,360	11.0	1,548	11.5	669	10.7	143	9.0
Missing	1,200	5.6	748	5.5	363	5.8	89	5.6
Smoking status								
Current smoker	2,166	10.1	1,242	9.2	713	11.4	211	13.2
Ex-smoker	3,351	15.7	2,053	15.2	1,010	16.1	288	18.1
Never smoked	15,617	73.0	10,068	74.5	4,482	71.3	1,067	66.9
Missing	251	1.2	144	1.1	78	1.2	29	1.8
Living with children status								
Yes	8,566	40.1	5,510	40.8	2,455	39.1	601	37.7
No	12,065	56.4	7,540	55.8	3,604	57.4	921	57.7
Missing	754	3.5	457	3.4	224	3.6	73	4.6
Disease status; currently in treatment								
Receiving some treatment	16,831	78.7	10,502	77.8	5,024	80.0	1,305	81.8
Not receiving any treatment	3,405	15.9	2,273	16.8	921	14.7	211	13.2
Missing	1,149	5.4	732	5.4	338	5.4	79	5.0
Trust in others								
Very	2,446	11.4	1,624	12.0	679	10.8	143	9.0
Moderately	12,308	57.6	8,070	59.8	3,485	55.5	753	47.2
Neutral	5,448	25.5	3,179	23.5	1,753	27.9	516	32.4
Slightly	646	3.0	318	2.4	210	3.3	118	7.4
Not at all	165	0.8	76	0.6	49	0.8	40	2.5
Missing	372	1.7	240	1.8	107	1.7	25	1.6
Childhood economic disadvantage								
Yes	9,607	44.9	4,996	37.0	3,416	54.4	1,195	74.9
No	11,615	54.3	8,406	62.2	2,818	44.9	391	24.5
Missing	163	0.8	105	0.8	49	0.8	9	0.6

11.4% responded as being very trusting, and 57.6% responded moderately trusting; 44.9% reported that they had experienced childhood economic disadvantage. For ACE history, the distribution of the respondents was as follows: no experience at all: 13,507 respondents (63.1%); one experience: 6283 respondents (29.4%); and two or more experiences: 1595 respondents (7.5%). The prevalence of each ACE is presented in [Appendix A](#). The highest ACE for both sexes was “parent’s death” at 22.5% (men 22.9%; women 22.1%), followed by “psychological neglect” at 11.9% (men 14.3%; women 9.8%) and “psychological abuse” at 5.2% (men 5.9%; women 4.6%).

Regarding the negative aspects of social integration, the lowest was “not a member of a sports group or club” (63.6%), followed by “not a member of a hobby group” (56.9%). Further, 46.4% had low social networks, 24.1% had small social networks, 2.9% were homebound, and 26.0% had never been married.

[Table 2](#) presents the prevalence ratio (PR) of social inclusion by the cumulative number of ACEs, assessed by conducting multiple Poisson regression analyses with robust error variance. Overall, the cumulative number of ACEs was negatively related to the index of various social integration domains. For example, it showed a PR of 1.322 for the

homebound variable of one ACE compared with no ACE (95% confidence interval [CI]=1.12–1.56) and a PR of 1.768 for two or more ACEs (95% CI=1.43–2.19) adjusted for sex and age. Furthermore, in Model 2, which was adjusted for childhood economic hardship, the history of ACEs was still associated with being homebound (PR=1.757, 95% CI=1.42–2.18). In Model 3, we further adjusted for adult SES, and in Model 4, we added health behaviors, disease status, and living with children. In Model 5, we additionally included trust in others, and the relationship for two or more ACEs remained significant after adjusting for possible confounders (PR=1.495, 95% CI=1.19–1.88).

For the analyses stratified by age cohort, the PR for homebound was 1.87 (95% CI=1.30–2.69) for the youngest respondents (65–74 years), but there was no significant association for this for the oldest respondents (75+ years). The full details of the age-cohort analyses are presented in [Appendix B](#). Examining each individual’s ACE and low social integration with the fully adjusted Model 5, we observed that psychological neglect was significantly associated with all of the low social integration types ([Appendix C](#)).

Table 2
Prevalence ratio of the number of adverse childhood experiences (ACEs) and social integration by Poisson regression analysis.

	Model 1			Model 2		Model 3		Model 4		Model 5	
	PR	95%CI		PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI
	Number of ACEs										
Non-membership sports group (N = 18,388)	0	Ref									
	1	1.034***	1.02–1.06	1.031*	1.00–1.06	1.019	1.00–1.04	1.018	1.00–1.04	1.014	0.99–1.04
	2+	1.095***	1.06–1.13	1.086***	1.05–1.12	1.055***	1.03–1.09	1.052***	1.02–1.08	1.038*	1.00–1.07
Non-membership hobby group (N = 18,627)	0	ref									
	1	1.040***	1.02–1.06	1.035**	1.01–1.06	1.018	1.00–1.04	1.017	1.00–1.04	1.012	0.99–1.03
	2+	1.140***	1.11–1.17	1.129***	1.10–1.16	1.083***	1.05–1.11	1.081***	1.05–1.11	1.060***	1.03–1.09
Low social network contact (N = 20,507)	0	Ref									
	1	1.033	1.00–1.07	1.029	1.00–1.06	1.030	1.00–1.06	1.030	1.00–1.06	1.020	0.99–1.05
	2+	1.100***	1.05–1.16	1.092***	1.04–1.15	1.094***	1.04–1.15	1.094***	1.04–1.15	1.059*	1.00–1.12
Small social network size (N = 20,526)	0	Ref									
	1	1.103**	1.03–1.18	1.091**	1.02–1.16	1.071*	1.00–1.14	1.068*	1.00–1.14	1.046	0.98–1.11
	2+	1.385***	1.28–1.50	1.352***	1.25–1.47	1.297***	1.20–1.41	1.292***	1.19–1.40	1.197***	1.10–1.30
Homebound (N = 21,147)	0	ref									
	1	1.322***	1.12–1.56	1.319***	1.12–1.55	1.265**	1.07–1.49	1.248**	1.06–1.47	1.236*	1.05–1.46
	2+	1.768***	1.43–2.19	1.757***	1.42–2.18	1.602***	1.28–2.00	1.573***	1.26–1.97	1.495***	1.19–1.88
Unmarried (N = 21,059)	0	Ref									
	1	1.041	0.98–1.10	1.031	0.97–1.09	1.020	0.96–1.08	1.013	0.96–1.07	1.004	0.95–1.06
	2+	1.376***	1.27–1.50	1.344***	1.24–1.45	1.308***	1.21–1.41	1.298***	1.20–1.40	1.264***	1.17–1.36

Note. PR; prevalence rate ratio, CI; confidence interval; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Model 1: adjusted for age and sex; Model 2: Model 1 + childhood economic hardship; Model 3: Model 2 + adult SES (education, income, and working status); Model 4: Model 3 + health behavior, disease status (currently in treatment), and living status with children; Model 5: Model 4 + trust in others.

4. Discussion

In this study, we examined the association between social integration (multiple social relationship domains) and ACEs using data from healthy community-dwelling older adults. We found that the cumulative number of ACEs was significantly associated with older adults with tenuous social ties compared to those with strong social ties. Childhood economic disadvantage, sociodemographics, health behaviors, and health status attenuated the impact of ACEs on social integration; however, significant associations remained, indicating that there may be lasting effects in old age. Furthermore, of the seven forms of ACE, psychological neglect in childhood was significantly associated with various aspects of low social integration in old age. The results suggest that ACEs may have a long-term impact on social connectedness in old age.

The possible pathways are as follows: ACEs have detrimental effects on childhood cognitive development by altering brain structure and function—individuals with a history of ACEs have been reported to have smaller prefrontal cortex volumes (Teicher et al., 2006, 2016), which process information about emotions and feelings. This may make it difficult for them to develop interpersonal relationships. Alternatively, the trauma caused by ACEs may lower their trust in others (Gobin & Freyd, 2014), which is vital for developing interpersonal relationships. Furthermore, the PR values decrease when adjusted for all mediating factors and for general trust in others. This may be due to a disorder consequent to maltreatment that leads to a poorly formed attachment relationship with the primary caregiver. Bowlby (1969) proposed the attachment theory, which states that childhood relationships with caregivers are related to personality formation and social adaptability.

In addition, we found that ACEs affected social interactions in later life, although the consequences differed across age cohorts. Our sample experienced social and historical events in childhood, such as World War II and the postwar period of rapid economic growth. Age-stratified results demonstrate that the influence differed by cohort. Therefore, differences in the effects of childhood ACEs on social interactions may be explained by the social and historical context of childhood experiences. Several previous studies have examined the association between childhood disadvantage and functional impairment, showing that the impact differed by age cohort (Fujiwara et al., 2014; Murayama et al., 2018). Our findings are consistent with the trends in their results.

This study has some limitations. First, it may have induced recall bias, which is expected from a retrospective assessment of ACEs. However, evidence suggests that severe adversities are more often well-

remembered, and less severe adversities are more likely to be under-reported (Hardt & Rutter, 2004). Thus, this association is likely to be underestimated but less likely to be overestimated. Second, because we used a single self-report questionnaire to assess all the measures, there is a common method bias. A prospective ACE study reported a strong association with subjectively assessed outcomes (Hardt & Rutter, 2004). Compared with the results of the prospective ACE study, our results may have overestimated the association. Third, we used data from the JAGES study, which only included healthy respondents. This suggests that survival bias may have underestimated the association between ACEs and social integration in the older population. Fourth, we cannot deny the possibility of unmeasured confounding because this is a retrospective study. In addition, we did not collect variables on the social networks and support available to them during childhood. Therefore, it is necessary to be careful when interpreting the results. Nevertheless, this study suggests that neglecting maltreatment in childhood may have long-term negative effects. Finally, the data used in this study were collected in 2013, and given the dynamic nature of social and economic factors, circumstances may have changed since then. For example, it is known that PTSD is more likely to be triggered by the crisis caused by a disaster; however, studies have shown that people who have experienced childhood abuse have lower rates of PTSD than those who have not (Inoue et al., 2019). If this is the case, the current situation after the COVID-19 may return different findings. Therefore, further research in this area is essential to fully understand the current situation with more up-to-date evidence. Ongoing research will highlight potential changes and developments in relation to key life events, socioeconomic context, and the likelihood of receiving social assistance, so that policies and interventions remain relevant and effective in addressing social welfare needs.

In sum, using a large Japanese population-based sample, this study found an association between ACEs and social integration in old age. This indicates that addressing ACEs may improve social integration in later life. However, this finding may not be applicable to other generations. Further research is necessary to replicate the association between ACEs and social integration in other settings.

Data statement

This study used data from the Japan Gerontological Evaluation Study (JAGES). The datasets generated and analysed during the current study are not publicly available due to ethical or legal restrictions. However,

they are available upon reasonable request. If you have any queries, please contact the Data Management Committee (e-mail: dataadmin.ml@jages.net).

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Credit author statement

All authors approved the final manuscript as submitted and agree to

Appendices

Appendix A. Prevalence of adverse childhood experiences by sex

	Total (N = 21,385)		Male (n = 9,932)		Female (n = 11,453)	
	N	%	n	%	n	%
Parent's death	4,806	22.5	2,272	22.9	2,534	22.1
Parent's divorce	428	2.0	232	2.3	196	1.7
Parent's mental illness	148	0.7	84	0.9	64	0.6
Domestic violence	769	3.6	423	4.3	346	3.0
Physical abuse	255	1.2	183	1.8	72	0.6
Psychological neglect	2,545	11.9	1,420	14.3	1,125	9.8
Psychological abuse	1,110	5.2	582	5.9	528	4.6

Appendix B. Prevalence ratios of the number of adverse childhood experiences and social integration by Poisson regression analysis by age group

	—	Model 1		Model 2		Model 3		Model 4		Model 5	
		PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI
65-74 years old											
Non-membership sports group or club (N = 11,612)	0	Ref		Ref		ref		ref		ref	
	1	1.043**	1.01-1.07	1.038*	1.01-1.07	1.020	0.99-1.05	1.018	0.99-1.04	1.015	0.99-1.04
	2+	1.114***	1.07-1.16	1.102***	1.06-1.14	1.061***	1.03-1.10	1.056**	1.02-1.09	1.043*	1.00-1.08
Non-membership hobby group (N = 11,720)	0	Ref		Ref		ref		ref		ref	
	1	1.043**	1.01-1.08	1.036*	1.00-1.07	1.016	0.99-1.05	1.015	0.99-1.04	1.010	0.98-1.04
	2+	1.133***	1.09-1.18	1.119***	1.07-1.17	1.069**	1.03-1.11	1.065**	1.02-1.11	1.044*	1.00-1.09
Low Social network contact (N = 12,751)	0	Ref		Ref		ref		ref		ref	
	1	1.032	0.99-1.07	1.027	0.99-1.07	1.024	0.98-1.07	1.025	0.98-1.07	1.017	0.98-1.06
	2+	1.097***	1.04-1.16	1.087**	1.03-1.15	1.091**	1.02-1.14	1.081**	1.02-1.14	1.052	0.99-1.11
Small Social network size (N = 12,754)	0	ref		Ref		ref		ref		ref	
	1	1.096***	1.04-1.15	1.096***	1.04-1.15	1.069**	1.02-1.12	1.066**	1.02-1.12	1.055*	1.01-1.10
	2+	1.260***	1.20-1.32	1.257***	1.20-1.32	1.199***	1.15-1.25	1.191***	1.14-1.25	1.15***	1.10-1.21
Homebound (N = 13,019)	0	ref		Ref		ref		ref		ref	
	1	1.339*	1.01-1.78	1.332	1.00-1.78	1.228	0.92-1.65	1.208	0.90-1.62	1.19	0.88-1.60
	2+	2.398***	1.68-3.42	2.370***	1.67-3.36	2.009***	1.40-2.89	1.953***	1.36-2.80	1.87***	1.30-2.69

(continued on next page)

be accountable for all aspects of the work.

CRedit authorship contribution statement

Toyo Ashida: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Takeo Fujiwara:** Conceptualization, Methodology, Writing – review & editing. **Katsunori Kondo:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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(continued)

	Model 1			Model 2		Model 3		Model 4		Model 5	
	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI	
Unmarried (N = 12,997)	0 ref		Ref		ref		ref		ref		
	1 1.092	0.99–1.20	1.073	0.97–1.18	1.043	0.95–1.14	1.033	0.94–1.13	1.019	0.93–1.12	
	2+ 1.599***	1.42–1.79	1.539***	1.38–1.71	1.447***	1.31–1.60	1.419***	1.28–1.58	1.362***	1.22–1.52	
≥75 years old											
Non-membership sports group or club (N = 6,776)	0 ref		Ref		ref		ref		ref		
	1 1.022	0.99–1.05	1.021	0.99–1.05	1.015	0.98–1.05	1.015	0.98–1.05	1.011	0.98–1.04	
	2+ 1.061*	1.01–1.11	1.059*	1.00–1.11	1.041	0.99–1.09	1.042	0.99–1.10	1.027	0.98–1.08	
Non-membership hobby group (N = 6,907)	0 ref		Ref		ref		ref		ref		
	1 1.035*	1.01–1.07	1.033*	1.00–1.06	1.021	0.99–1.05	1.021	0.99–1.05	1.015	0.99–1.04	
	2+ 1.152***	1.10–1.20	1.146***	1.10–1.20	1.109***	1.06–1.16	1.110***	1.06–1.16	1.089***	1.04–1.14	
Low Social network contact (N = 7,756)	0 ref		Ref		ref		ref		ref		
	1 1.034	0.98–1.09	1.031	0.98–1.09	1.038	0.98–1.09	1.039	0.99–1.09	1.027	0.98–1.08	
	2+ 1.106*	1.00–1.22	1.100	1.00–1.21	1.117*	1.01–1.23	1.118*	1.01–1.24	1.073	0.97–1.19	
Small Social network size (N = 7,772)	0 ref		Ref		ref		ref		ref		
	1 1.066*	1.01–1.12	1.064*	1.13–1.29	1.054*	1.00–1.11	1.052*	1.00–1.11	1.041	0.99–1.09	
	2+ 1.218***	1.14–1.30	1.21***	1.16–1.46	1.174***	1.10–1.25	1.173***	1.09–1.26	1.134***	1.05–1.22	
Homebound (N = 8,128)	0 Ref		Ref		ref		ref		ref		
	1 1.310**	1.08–1.59	1.310**	1.08–1.59	1.281*	1.05–1.56	1.267*	1.04–1.55	1.248*	1.02–1.52	
	2+ 1.386*	1.00–1.90	1.382	1.00–1.92	1.307	0.95–1.81	1.297	0.93–1.81	1.224	0.86–1.74	
Unmarried (N = 8,062)	0 ref		Ref		ref		ref		ref		
	1 1.001	0.95–1.05	0.997	0.95–1.05	0.995	0.95–1.05	0.995	0.95–1.04	0.989	0.94–1.04	
	2+ 1.175**	1.05–1.32	1.165*	1.03–1.31	1.156*	1.03–1.30	1.156*	1.03–1.30	1.139*	1.01–1.28	

Note: ACE = adverse childhood experience, PR = prevalence rate ratio; 95%CI = 95% confidence interval; * p<0.05, ** p<0.01, *** p<0.001

Model 1: adjusted for age and sex

Model 2: Model 1 + childhood economic hardship

Model 3: Model 2 + adult SES (education, income, and working status)

Model 4: Model 3 + health behavior, disease status (currently in treatment), and living status with children

Model 5: Model 4 + trust in others.

Appendix C. Prevalence ratio of each adverse childhood experience and social integration by Poisson regression analysis

	Non-membership sports group or club		Non-membership hobby group		Low Social network contact		Small Social network size		Homebound		Unmarried	
	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI	PR	95%CI
	(N = 18,388)		(N = 18,627)		(N = 20,507)		(N = 20,526)		(N = 21,147)		(N = 21,059)	
Parent's death	1.001	0.98–1.02	1.012	0.98–1.04	1.000	0.97–1.03	1.021	0.99–1.06	1.129	0.95–1.34	1.024	0.97–1.08
Parent's divorce	1.016	0.97–1.07	1.024	0.96–1.09	1.039	0.93–1.16	1.123*	1.02–1.23	1.451	0.96–2.18	1.229**	1.08–1.40
Parent's mental illness	1.083*	1.01–1.17	1.033	0.92–1.15	1.064	0.92–1.23	1.065	0.93–1.22	0.635	0.21–1.88	1.000	0.77–1.30
Domestic violence	1.024	0.98–1.06	1.052*	1.00–1.10	0.999	0.94–1.06	1.064*	1.00–1.12	0.768	0.42–1.39	1.206***	1.07–1.35
Physical abuse	1.005	0.95–1.07	0.999	0.93–1.07	0.983	0.89–1.09	1.004	0.92–1.10	1.598	0.98–2.59	1.275**	1.06–1.53
Psychological neglect	1.041***	1.02–1.06	1.045**	1.01–1.08	1.081***	1.03–1.13	1.146***	1.11–1.18	1.327***	1.12–1.56	1.088***	1.03–1.15
Psychological abuse	1.027	0.99–1.06	1.014	0.97–1.06	1.004	0.95–1.06	1.036	0.99–1.09	1.553**	1.12–2.15	1.154***	1.06–1.25

Note: ACE = adverse childhood experience, PR = prevalence rate ratio; 95%CI = 95% confidence interval; * p < 0.05, ** p < 0.01, *** p < 0.001

Model: adjusted for age and sex + childhood economic hardship + adult SES (education, income, and working status) + health behavior, disease status (currently in treatment) , and living status with children. + trust in others.

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