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Adverse childhood experiences and fruit and vegetable intake among older adults in Japan

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ABSTRACT

Background: Although adverse childhood experiences (ACEs) have been linked to negative health behaviors in adulthood, few studies have investigated if the impact continues until late adulthood. We examined the association between ACEs and fruit and vegetable intake (FVI) among older adults in Japan.
Methods: Data came from the Japan Gerontological Evaluation Study (JAGES), 2013 in which 24,271 individuals aged ≥65 years participated. The number of ACEs was calculated (0, 1 and ≥2) while low FVI was defined as consuming fruit and vegetables less than once a day. A sex-stratified multilevel Poisson regression analysis was used to investigate the association between ACEs and low FVI.
Results: Among men, 35.4% reported at least one ACE while the corresponding figure for women was 30.6%. Compared to those without ACEs, the prevalence ratios for low FVI among those who reported ≥2 ACEs were 1.51 (95% confidence interval [CI] = 1.30–1.75) for women and 1.28 (95% CI = 1.14–1.44) for men after adjusting for age and childhood economic hardship. Although these associations were attenuated after adjusting for socio-demographic and health-related variables, the link between ACEs and low FVI remained statistically significant among women. Of the seven individual forms of ACE, psychological neglect was significantly associated with low FVI (PR = 1.16, 95% CI = 1.03–1.31) among women in the final model.
Conclusions: ACEs are associated with low FVI among older Japanese adults. Our results suggest that the detrimental effect of ACEs on health behavior may stretch across the life course.

1. Introduction

Adverse childhood experiences (ACEs), which include child maltreatment and household dysfunction, have been associated with a wide range of negative physical and mental health outcomes later in life (Felitti et al., 1998; Hughes et al., 2017) including mortality (Brown et al., 2009; Chen, Turiano, Mroczek, & Miller, 2016), cardiovascular diseases (Appleton, Holdsworth, Ryan, & Tracy, 2017; Jakubowski, Cundiff, & Matthews, 2018), cancer (Holman et al., 2016), obesity (Palmisano, Innamorati, & Vanderlinden, 2016), type 2 diabetes (Huang et al., 2015), and depression (Li, D'Arcy, & Meng, 2016). While it is uncertain what underlies the association between ACEs and poorer health in adulthood, several lifestyle factors might act as mediators, e.g., smoking and alcohol consumption (Felitti et al., 1998; Hughes et al., 2017).

There is also some evidence that ACEs might be linked to diet in adulthood (Palmisano et al., 2016). In particular, fruit and vegetable intake (FVI) is an important modifiable lifestyle-related factor of non-communicable diseases which has been shown to be associated with ACEs. Previous studies conducted in the UK among adults aged 18 to 70

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reported for example, that the cumulative number of ACEs was positively associated with low FVI (Bellis, Hughes, Leckenby, Perkins, & Lowey, 2014; Bellis, Lowey, Leckenby, Hughes, & Harrison, 2014). This is important as other research has also shown that FVI may be associated with a reduced risk of the above-mentioned health outcomes in both younger and older adults (Boeing et al., 2012; Lo, Chang, Wahlqvist, Huang, & Lee, 2012; Wang et al., 2014). A recent meta-analysis that used information from 142 articles found that FVI was associated with a reduced risk of all-cause mortality, cancer and cardiovascular diseases (Aune et al., 2017).

In this study, we examined the association between ACEs and FVI among the older adult population in Japan. There are several reasons why this research may be important. First, although previous studies have examined the association between ACEs and negative health outcomes among older adults, there has been comparatively little research in relation to FVI. Second, given the rapid population aging in Japan (Tamiya et al., 2011; United Nations and Department of Economic and Social Affairs, 2015), efforts should be made to identify factors that are associated with non-communicable diseases and potential modifiable risk factors. Third, FVI is low among the older population aged 70 and above in Japan; only one-third of them consume the level of FVI (i.e., 350 g per day of vegetables and 200 g per day of fruit) recommended by the Japanese authorities (Ministry of Health, Labour and Welfare, 2020; Ministry of Agriculture, Forestry and Fisheries, 2019). Given this, an increased understanding of the factors that are associated with low FVI among older adults in Japan may offer a starting point for the design and implementation of measures to address this deficit.

The purpose of this study was to thus investigate the association between ACEs and FVI among older Japanese adults using data from the Japan Gerontological Evaluation Study (JAGES).

2. Methods

2.1. Data and participants

We used data from community-dwelling adults aged 65 years or older living in 31 municipalities across Japan who participated in JAGES, 2013 (Kondo, 2016; Kondo & Rosenberg, 2018). A self-report questionnaire was mailed to 193,694 eligible residents (those who were not receiving public long-term care insurance) during the period between October and December 2013 with 137,736 individuals responding (a response rate of 71.1%). Due to questionnaire size limitations, information on ACEs was randomly collected from one in every five participants (n = 26,229). After excluding respondents needing help for daily living and those who provided no information on this matter (n = 1958), the final analytic sample comprised 24,271 individuals.

The JAGES study protocol was approved by the Ethics Committee on Research of Human Subjects at Nihon Fukushi University (No. 13-14). The survey's aims and methods were explained in the document mailed to participants and informed consent was assumed with the voluntary return of the questionnaire.

2.2. Fruit and vegetable intake

The frequency of FVI was assessed by asking the question "How often did you eat fruit and vegetables over the past month?". This question has been previously used among older adults in Japan (Tani et al., 2015; Yanagi, Hata, Kondo, & Fujiwara, 2018). Response options included: "twice a day or more frequently"; "once a day"; "four to six times a week"; "two or three times a week"; "once a week"; "less than once a week"; and "not at all". Following the lead of previous studies (Atkins et al., 2015; Osler, Godtfredsen, & Prescott, 2008; Sauvaget, Nagano, Allen, & Kodama, 2003), we categorized the participants into two groups, i.e., those who consumed fruit and vegetables "once a day or more frequently" and "less than once a day".

2.3. Adverse childhood experiences

Similar to previous studies (Felitti et al., 1998), participants were asked about whether they had experienced different types of adversity before the age of 18 years old (yes/no). These seven adverse experiences were grouped under two main rubrics: family dysfunction (parent's death, parents' divorce, parental mental illness, domestic violence [DV]) and childhood maltreatment (physical abuse, psychological abuse, psychological neglect). These questions have been used previously in other studies using the JAGES data set (Amemiya et al., 2019; Amemiya, Fujiwara, Murayama, Tani, & Kondo, 2018; Inoue et al., 2019; Isumi et al., 2020; Matsuyama et al., 2016). Following the lead of Amemiya et al. (2018) and given the small number of participants with ≥3 ACE episodes (1.8%), the number of ACEs was summed and categorized into the following groups (i.e., 0; 1; and ≥2).

2.4. Covariates

Information was also collected on socio-demographic factors, the childhood environment and current health status: age (divided into four categories: 65–69; 70–74; 75–79; and 80 and above); sex (male; female); educational attainment (the number of years of schooling: <10 [junior high school or less]; 10–12 [high school]; ≥13 years [attained further education]); longest-held occupation (non-manual [professional, technical or managerial work]; manual [clerical, sales/service, skilled/labor, agriculture/forestry/fishery workers or other]; no occupation); annual equivalized household income (<2.00; 2.00–3.99; ≥4.00 million yen; 1 US dollar = 98.4 yen as of October 1, 2013); marital status (married; widowed; divorced; never married); living arrangement (living alone at home; living with someone at home; other).

Childhood circumstances were assessed with a question that inquired about childhood economic hardship before the age of 18 (yes; no). Regarding health status, experiencing any limitations in higher-level functional capacity was assessed with the Tokyo Metropolitan Institute of Gerontology Index of Competence (no limitations, have some limitations) (Koyano, Shibata, Nakazato, Haga, & Suyama, 1991). Depressive symptoms were assessed with the Japanese version of the Geriatric Depression Scale (GDS-15) (Wada et al., 2005). Participants were categorized into three groups: no depressive symptoms (score 0–4), mild depressive symptoms (score 5–9), and severe depressive symptoms (score 10–15).

2.5. Statistical analyses

We used multiple imputation to account for missing data on ACEs, FVI, education, occupation, income, marital status, living arrangement, functional capacity, depressive symptoms, and childhood economic hardship. The imputation used information on age and sex, which did not have any missing cases. We generated 20 data sets and combined the results using Rubin's rules (Rubin, 1987). After we found that the interaction between sex and ACEs was significant (p = 0.022), a sex-stratified multilevel Poisson regression analysis with a robust variance estimator was used to investigate the association between ACEs and current low FVI. We adjusted for clustering by municipality by incorporating a random intercept at the municipality level (i.e. Level 1: individual participants; Level 2: municipality).

Analyses were performed in the following order. Model 1 investigated the association between ACEs and low FVI while adjusting for age. Model 2 further adjusted for childhood economic hardship. We then adjusted for socio-demographic and health-related variables to see if the association between ACEs and low FVI changed. Specifically, Model 3 included the same variables as in Model 2 while additionally adjusting for indicators of adult socioeconomic status (SES) (i.e., education, longest-held occupation and current equivalized annual

Table 1
Total participant characteristics (n = 24,271), stratified by sex.

	Total (n = 24,271)		Male (n = 11,268)		Female (n = 13,003)		p-Value
Age (year), n (%)							
65–69	7040	29.0	3370	29.9	3670	28.2	0.036
70–74	7370	30.4	3386	30.1	3984	30.6	
75–79	5364	22.1	2464	21.9	2900	22.3	
≥80	4497	18.5	2048	18.2	2449	18.8	
Education (years), n (%)							
<10	9780	40.3	4197	37.3	5583	42.9	<0.001
10–12	9060	37.3	3959	35.1	5101	39.2	
≥13	4991	20.6	2953	26.2	2038	15.7	
Missing	440	1.8	159	1.4	281	2.2	
Longest-held occupation, n (%)							
Non-manual	5179	21.3	3890	34.5	1289	9.9	<0.001
Manual	14,992	61.8	6387	56.7	8605	66.2	
No occupation	1146	4.7	43	0.4	1103	8.5	
Missing	2954	12.2	948	8.4	2006	15.4	
Equivalized annual household income (million yen[a]), n (%)							
Low (<2.00)	10,064	41.5	4756	42.2	5308	40.8	<0.001
Middle (2.00–3.99)	7546	31.1	3909	34.7	3637	28.0	
High (≥4.00)	2081	8.6	1072	9.5	1009	7.8	
Missing	4580	18.9	1531	13.6	3049	23.5	
Marital status, n (%)							
Married	17,293	71.3	9637	85.5	7656	58.9	<0.001
Widowed	4951	20.4	837	7.4	4114	31.6	
Divorced	807	3.3	291	2.6	516	4.0	
Never married	503	2.1	218	1.9	285	2.2	
Missing	717	3.0	285	2.5	432	3.3	
Living arrangement, n (%)							
Alone at home	3270	13.5	924	8.2	2346	18.0	<0.001
With someone at home	19,506	80.4	9703	86.1	9803	75.4	
Other	351	1.5	180	1.6	171	1.3	
Missing	1144	4.7	461	4.1	683	5.3	
Limitations in higher level functional capacity, n (%)							
No limitations	9432	38.9	3533	31.4	5899	45.4	<0.001
Has limitations	13,193	54.4	7083	62.9	6110	47.0	
Missing	1646	6.8	652	5.8	994	7.6	
Depressive symptom (GDS scale/points), n (%)							
No depression (0–4)	15,203	62.6	7303	64.8	7900	60.8	<0.001
Mild depression (5–9)	3827	15.8	1929	17.1	1898	14.6	
Severe depression (10–15)	1143	4.7	588	5.2	555	4.3	
Missing	4098	16.9	1448	12.9	2650	20.4	
Frequency of fruit and vegetable intake, n (%)							
≥1/day	18,872	77.8	8096	71.9	10,776	82.9	<0.001
<1/day	5040	20.8	2995	26.6	2045	15.7	
Missing	359	1.5	177	1.6	182	1.4	
Childhood economic hardship, n (%)							
No	12,185	50.2	4900	43.5	7285	56.0	<0.001
Yes	10,791	44.5	5762	51.1	5029	38.7	
Missing	1295	5.3	606	5.4	689	5.3	
Types of adverse childhood experience, n (%)							
Parent's death	5732	23.6	2668	23.7	3064	23.6	0.26
Parents' divorce	528	2.2	274	2.4	254	2.0	0.030
Parent's mental illness	174	0.7	98	0.9	76	0.6	0.023
Domestic violence	879	3.6	479	4.3	400	3.1	<0.001
Physical abuse	311	1.3	218	1.9	93	0.7	<0.001
Psychological abuse	1254	5.2	638	5.7	616	4.7	<0.001
Psychological neglect	2722	11.2	1498	13.3	1224	9.4	<0.001
Number of childhood adversities, n (%)							
0	13,642	56.2	6048	53.7	7594	58.4	<0.001
1	6356	26.2	3098	27.5	3258	25.1	
≥2	1612	6.6	893	7.9	719	5.5	
Missing	2661	11.0	1229	10.9	1432	11.0	

[a] 1 US dollar = 98.4 yen, as of October 1, 2013.

Table 2
Results of a sex-stratified Poisson regression analysis examining the associations between the number of adverse childhood experiences and low fruit and vegetable intake among older Japanese adults.

	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
Men										
ACEs (ref. none)										
1	1.17	1.08–1.27	1.14	1.06–1.24	1.09	1.01–1.18	1.07	0.99–1.16	1.06	0.97–1.14
≥2	1.34	1.20–1.50	1.28	1.14–1.44	1.17	1.04–1.31	1.10	0.98–1.23	1.04	0.92–1.17
Women										
ACEs (ref. none)										
1	1.18	1.07–1.30	1.14	1.03–1.25	1.08	0.97–1.19	1.05	0.95–1.16	1.04	0.94–1.15
≥2	1.64	1.42–1.89	1.51	1.30–1.75	1.36	1.17–1.58	1.27	1.10–1.48	1.18	1.01–1.37

ACEs: adverse childhood experiences CI: confidence interval; PR: prevalence ratio.
Model 1: adjusted for age.
Model 2: Model 1 + adjusted for childhood economic hardship.
Model 3: Model 2 + adjusted for education, longest occupation, annual equivalized household income.
Model 4: Model 3 + adjusted for marital status, living arrangements, functional limitations.
Model 5: Model 4 + adjusted for depressive symptoms.

household income). Model 4 included the same variables as in Model 3 as well as marital status, living arrangements and the presence of limitations in higher-level functional capacity. The fully adjusted Model 5 included the same variables as in Model 4 with the addition of depressive symptoms. An inspection of the variance inflation factors (VIF) indicated that there was no significant multicollinearity among the variables.

To identify specific types of ACE that might be more strongly associated with low FVI, we also analyzed the association between each individual ACE and FVI using the above-mentioned models. All analyses were performed using Stata ver. 15.0 (Stata Corp, College Station, TX). The results are presented as prevalence ratios (PR) with 95% confidence intervals (CI). Statistical significance was set at $p < 0.05$ (two-tailed).

3. Results

The mean age of the participants was 73.7 (standard deviation [SD] = 6.1) and 53.6% of them were women. Table 1 shows the socio-demographic characteristics of the participants stratified by sex. Among men, 26.6% consumed fruit and vegetables less than once a day, while the corresponding figure for women was 15.7%. Just over 35% of men (35.4%) reported at least one ACE while the figure for women was 30.6%.

Table 2 shows the results of a sex-stratified multilevel Poisson regression analysis which investigated the association between ACEs and low FVI. Among men, having more than one ACE was significantly associated with low FVI in Model 1 (≥2 ACEs: PR = 1.34, 95% CI = 1.20–1.50) and remained statistically significant in Model 2. The inclusion of the socio-demographic and health-related variables attenuated the association, which became non-significant after adjusting for marital status, living arrangements and functional limitations in Model 4. For women, experiencing more than one ACE was significantly associated with low FVI in Model 1 (≥2 ACEs: PR = 1.64, 95% CI = 1.42–1.89). The inclusion of childhood economic hardship (Model 2), adult SES (Model 3), marital status, current living situation and functional limitations (Model 4) and depressive symptoms (Model 5) all attenuated the prevalence ratio although the association remained statistically significant (≥2 ACEs: PR = 1.18, 95% CI = 1.01–1.37 in Model 5).

Table 3 presents the results of a sex-stratified multilevel Poisson regression model that examined the association between each individual ACE item and low FVI. Among men, parental death (PR = 1.12, 95% CI = 1.03–1.21) and psychological neglect (PR = 1.23, 95% CI = 1.12–1.35) were associated with low FVI after adjusting for age and childhood economic hardship (Model 2). Further adjustment by adult SES (Model 3) and marital status, current living situation and functional limitations (Model 4) attenuated these results. Among women, domestic violence (PR = 1.33, 95% CI = 1.07–1.64), physical abuse (PR = 1.57, 95% CI = 1.08–2.27), psychological abuse (PR = 1.22, 95% CI = 1.03–1.46) and psychological neglect (PR = 1.45, 95% CI = 1.29–1.64) were associated with low FVI in Model 2. In the fully adjusted Model 5 only psychological neglect continued to be significantly associated with low FVI.

4. Discussion

This study found that both men and women who experienced ACEs had a significantly increased risk for low FVI in late adulthood compared to those without ACEs, with more pronounced associations observed among women. The association among women, although attenuated, remained statistically significant even after adjusting for childhood economic hardship, adult SES, marital status, current living situation, functional limitations and depressive symptoms. Moreover, our results indicate that psychological neglect in childhood might be especially important in this context. Overall, the findings of this study suggest that ACEs may have a long-lasting effect on health-related behavior that might even stretch into late adulthood.

Our finding that ACEs were linked to an increased risk for low FVI is in line with those reported in previous studies. For example, Bellis, Lowey, et al. (2014) found that among a sample of 1464 participants (age: 18–70 years), those who reported 4 or more ACEs had a 2.10 times higher risk of low FVI, compared to those without ACEs; this finding has been replicated in other studies by the same authors using different datasets (Bellis et al., 2017; Bellis, Hughes, et al., 2014). Our study builds on and extends this previous research that examined the association among participants with a wide age range (18–70 years old), by showing that ACEs are associated with low FVI even when the research is restricted to much older adults; this indicates that ACEs may be important for dietary behavior even in the oldest age groups.

Previous studies have suggested that several mechanisms might link ACEs and poorer health behaviors such as low FVI. For example, research has indicated that ACEs may cause structural and functional changes to the brain (e.g., reduced volume in the prefrontal cortex) that may have a negative, long-lasting effect on executive function (Danese & McEwen, 2012; Kelder, Akker, Geurts, Lindauer, & Overbeek, 2018); in turn, executive dysfunction may result in a less healthy lifestyle as a result, for example, of choosing immediate rewards (e.g., energy dense food) instead of large delayed rewards (e.g. health) (Barlow, Reeves, McKee, Galea, & Stuckler, 2016). Other research has hypothesized that those who experienced ACEs may have lacked childhood role models

Table 3
Results of a sex-stratified Poisson regression analysis examining the associations between individual childhood adversities and low fruit and vegetable intake among older Japanese adults.

	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
Men										
Parent's death	1.15	1.06–1.25	1.12	1.03–1.21	1.07	0.99–1.16	1.06	0.98–1.15	1.05	0.97–1.14
Parents' divorce	1.27	1.04–1.54	1.21	1.00–1.48[a]	1.15	0.94–1.39	1.13	0.93–1.38	1.11	0.91–1.35
Parent's mental illness	1.20	0.86–1.67	1.15	0.82–1.61	1.06	0.76–1.48	1.02	0.73–1.42	1.00	0.72–1.40
Domestic violence	1.17	1.00–1.38[b]	1.12	0.95–1.31	1.09	0.92–1.28	1.06	0.90–1.25	1.02	0.87–1.20
Physical abuse	1.27	1.02–1.58	1.21	0.97–1.51	1.10	0.88–1.37	1.05	0.84–1.31	0.99	0.79–1.24
Psychological abuse	1.14	1.00–1.31[c]	1.10	0.96–1.26	1.06	0.93–1.22	1.02	0.89–1.17	0.97	0.84–1.12
Psychological neglect	1.26	1.15–1.38	1.23	1.12–1.35	1.12	1.02–1.24	1.08	0.98–1.18	1.02	0.93–1.12
Women										
Parent's death	1.13	1.02–1.25	1.08	0.97–1.20	1.04	0.94–1.15	1.04	0.94–1.15	1.03	0.93–1.14
Parents' divorce	1.37	1.06–1.77	1.29	1.00–1.66[d]	1.20	0.93–1.54	1.17	0.90–1.51	1.13	0.87–1.46
Parent's mental illness	1.23	0.77–1.97	1.12	0.70–1.80	1.07	0.67–1.70	1.05	0.66–1.67	1.01	0.63–1.61
Domestic violence	1.44	1.17–1.78	1.33	1.07–1.64	1.24	1.01–1.53	1.16	0.94–1.43	1.10	0.89–1.36
Physical abuse	1.73	1.20–2.50	1.57	1.08–2.27	1.39	0.96–2.02	1.27	0.88–1.84	1.13	0.78–1.65
Psychological abuse	1.31	1.10–1.56	1.22	1.03–1.46	1.18	0.99–1.41	1.12	0.94–1.33	1.03	0.86–1.23
Psychological neglect	1.51	1.34–1.71	1.45	1.29–1.64	1.31	1.16–1.48	1.23	1.09–1.39	1.16	1.03–1.31

CI: confidence interval; PR: prevalence ratio.
Model 1: adjusted for age.
Model 2: Model 1 + adjusted for childhood economic hardship.
Model 3: Model 2 + adjusted for education, longest occupation, annual equivalized household income.
Model 4: Model 3 + adjusted for marital status, living arrangements, functional limitations.
Model 5: Model 4 + adjusted for depressive symptoms.
[a] 95% CI: 0.996–1.478.
[b] 95% CI: 0.996–1.378.
[c] 95% CI: 0.995–1.308.
[d] 95% CI: 0.996–1.658.

that would enable them to develop healthy lifestyles in the period when healthy eating habits (Huang et al., 2015; Palmisano et al., 2016) or cooking habits (Hartmann, Dohle, & Siegrist, 2013) are learnt.

It should be mentioned that other detrimental outcomes that have also been associated with ACEs, e.g., poor health, depressive symptoms, low educational attainment, loss of employment and social deprivation (Liu et al., 2013; Wade et al., 2016), might also link ACEs with FVI. For example, an earlier study showed that ACEs can have a negative impact on instrumental activities of daily living (which include shopping and cooking) (Amemiya et al., 2018) and cognitive function (Tani, Fujiwara, & Kondo, 2020). It is possible that the increased risk for functional limitations associated with ACEs makes it difficult for some individuals to buy and/or prepare fruit and vegetables, thus resulting in low FVI. This supposition gains some support from the attenuated associations between ACEs and low FVI in Model 4 after we included functional limitations in the analysis. These chains-of-risk may be particularly important among the older population, for whom the effects of ACEs might have accumulated across the life course.

We found a sex difference in the association between ACEs and FVI, i.e., more pronounced associations observed among women compared to men. Several previous studies on the association between ACEs and other health outcomes (e.g., smoking, mental health problems and cancer) have also reported more pronounced associations in women (Alcalá, Tomiyama, & von Ehrenstein, 2017; Cunningham et al., 2014; Fisher et al., 2009; Fuller-Thomson, Filippelli, & Lue-Crisostomo, 2013; Haatainen et al., 2003; Isohookana, Riala, Hakko, & Räsänen, 2013). While no explanation is readily available in relation to the sex difference reported in this study, one possible interpretation based on findings reported in the previous literature is that women are more vulnerable to the effects of ACEs, and thus ACEs might have been more likely to manifest as negative health behaviors in women compared to men (Alcalá et al., 2017; Cunningham et al., 2014; Fisher et al., 2009; Fuller-Thomson et al., 2013; Haatainen et al., 2003; Isohookana et al., 2013). From a different perspective the weaker associations observed among Japanese men might be related to the fact that they tend to eat meals that are prepared by their spouse. Consequently, given their limited role in all aspects of meal preparation, ACEs might be less important in terms of their own FVI. In addition, as our study population comprised older adults, it is also possible that those men who experienced ACEs may have been more likely to die prematurely due to negative health behaviors linked to ACEs (i.e., we are observing a survival effect).

When examining the specific effect of each ACE, we found that psychological neglect was the childhood adversity that had the strongest association with the risk of low FVI among women. Although it is uncertain what underlies this association, it can be speculated that those who were neglected in childhood may have lacked role models to enable them to develop healthy dietary habits. At the same time, as the effects of ACEs are known to coexist and accumulate, the potential contribution of each individual ACE should not be underestimated. It should also be noted that these analyses were subject to low statistical power, and thus caution should be exercised when interpreting the findings.

One of the strengths of this study is that we were able to collect information from 31 municipalities across Japan to ensure the generalizability of the study findings. However, this study also has several limitations. First, the information on ACEs might not have been accurate; for example, we used self-reported information which means that reporting bias might have been an issue, especially as the participants were older (Hardt & Rutter, 2004; Maughan & Rutter, 1997). In addition, there might have been other types of ACEs that we did not ask about (e.g., sexual abuse) that might have been important for the observed associations. Second, as regards the reporting of fruit and vegetable intake, caution should also be exercised because of the possibility of social desirability bias (Maynard & Blane, 2009). A response to a single question may not have fully captured the actual FVI situation, compared to if the information on FVI had been collected using a standardized food frequency table or food diary. We also lacked

information on the quantity of FVI. Third, we did not collect information on some variables that may have helped elucidate the association between ACEs and low FVI (e.g., dietary practices, food delivery services, and cooking skills). Fourth, our findings may be subject to selection bias. Specifically, as individuals with high ACE counts are more likely to die earlier (Brown et al., 2009), it is possible that those who were most severely affected by ACEs may have already died and thus would not have participated in the survey.

There are several directions for future work. First, the focus should be directed towards the primary prevention of ACEs. In particular, more effort is needed to identify those at risk of ACEs in the first instance. Second, as it is also important to understand how to mitigate the detrimental effects of ACEs among those who experience such events, research investigating whether clinical treatment(s) (e.g., neuro-counseling) (Lorelle & Michel, 2017) or changing the neighborhood environment (e.g., by creating a favorable food environment) (Keyes et al., 2012) can modify the association between ACEs and low FVI is also warranted. Third, prospective research is now also needed to elucidate how the association between ACEs and low FVI is linked to negative health outcomes such as physical illness, mental illness and mortality. Finally, the reasons for the sex difference in the association between ACEs and FVI should also be investigated to determine if this might be linked to factors such as different food cultures, traditional customs, or differences between local communities.

5. Conclusions

We found that among older Japanese adults, those with ACEs were more likely to report having low FVI, with a stronger association observed among women than men. Future research should focus on not only the primary prevention of ACEs but also, on the role of FVI as a possible mediator linking ACEs and more severe negative health outcomes.

CRediT authorship contribution statement

Natsuyo Yanagi: Conceptualization, Formal analysis, Writing - original draft. **Yosuke Inoue:** Conceptualization, Formal analysis, Writing - original draft. **Takeo Fujiwara:** Conceptualization, Methodology, Writing - review & editing. **Andrew Stickley:** Conceptualization, Writing - original draft, Writing - review & editing. **Toshiyuki Ojima:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing - review & editing. **Akira Hata:** Conceptualization, Supervision, Writing - review & editing. **Katsunori Kondo:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing - review & editing.

Declaration of competing interest

The authors declare that there are no conflicts of interest.

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