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**Title**

# Association between adverse childhood experiences and adult diseases in older adults: A comparative cross-sectional study in Japan and Finland

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## ABSTRACT

**Objective:** We aimed to examine associations between adverse childhood experiences (ACEs) and adult diseases in older adults in Japan and Finland.

**Design:** Cross-sectional comparative study.

**Setting:** Data were evaluated from a gerontological study in Japan and two public health studies in Finland.

**Participants:** A total of 13,123 adults from Japan (mean age, 69.5 years) and 10,353 adults (mean age, 64.4 years) were included in this study. Logistic regression was used to examine the associations of each, any, and the number of ACEs (parental divorce, fear in the family, and poverty in childhood) with poor self-rated health, cancer, heart disease or stroke, diabetes mellitus, smoking, and body mass index. Models were adjusted for sex, age, education, marital status, and working status.

**Results:** Half of the respondents in Japan and 37% of those in Finland reported having experienced at least one of the measured ACEs. Number of ACEs was associated with self-rated health in both countries, and the point estimates were similar (odds ratio [OR]: 1.35, 95% confidence interval [CI]: 1.25-1.46 in Japan; OR: 1.34, 95% CI: 1.27-1.41 in Finland). Number of ACEs was associated with the prevalence of cancer (OR: 1.20, 95% CI: 1.04-1.38 in Japan; OR: 1.13, 95% CI: 0.99-1.28 in Finland), heart

disease or stroke (OR: 1.10, 95% CI: 1.01-1.20 in Japan; OR 1.11, 95% CI: 0.98-1.25: in Finland), diabetes mellitus (OR: 1.08, 95% CI: 0.995-1.17 in Japan; OR 1.17, 95% CI: 1.06-1.28 in Finland), current smoking (OR: 1.11, 95% CI: 1.02-1.22 in Japan; OR: 1.15, 95% CI: 1.06-1.26 in Finland), and an increase in body mass index in both countries.

**Conclusions:** Associations between ACEs and self-rated health, adult diseases, and health behaviours were similar in Japan and Finland. This suggests that the impact of ACEs on health is noteworthy and consistent across cultural and social environments.

**Strength and limitations of this study**

- This is an international comparative study that investigated the impact of adverse childhood experiments on the health of older adults in Japan and Finland.
- We used data from the Japan Gerontological Evaluation Study from Japan, and the Finnish Public Sector Study and Health and Social Support Study from Finland.
- The results suggest that ACEs have a remarkable impact on health, a finding that is consistent across cultural and social environments.

## INTRODUCTION

Adverse childhood experiences (ACEs), including long-term financial difficulties, parental divorce, and fear of a family member,[1] are increasingly recognised as determinants of unhealthy behaviours (e.g., obesity,[1, 2] alcohol consumption, smoking, and lower levels of physical activity[1]), adult diseases (e.g., cardiovascular disease, diabetes,[1, 3] stroke, cancer,[1] and depression[1, 2]), and even early death.[4] However, it is not known whether the impact of ACEs on adult health varies by country, although the pathways linking childhood adversities with adult health likely depend on cultural or social environments.[5–7] Therefore, international comparisons of countries with different cultural and/or social environments in childhood but similar welfare state regimes may provide further understanding of the mechanisms underlying ACEs and adult health.

Japan and Finland are both members of the Organization for Economic Co-operation and Development (OECD), employ a universal healthcare system,[8, 9] and provide free education to those aged 6 to 15 years.[10] According to the World Happiness Report, the level of social support received (as measured by having someone to count on in times of trouble) is relatively high in both countries (92.3% and 94.8% in 2015, in Japan and Finland, respectively).[11] However, the two countries differ in

terms of equality (e.g., the Gini coefficient was 0.33 in Japan [2012] and 0.26 in Finland [2015]). Japan ranked 22$^{th}$ and Finland ranked 7$^{th}$, in terms of equality, out of 37 OECD countries in 2015.[12]

The purpose of this study was, therefore, to examine the associations and related risk factors between ACEs and adult diseases in older adults in Japan and Finland.

## METHODS

### Sample

The data in this study were collected from surveys conducted among older individuals in Finland and Japan. The Japanese data were from the Japan Gerontological Evaluation Study (JAGES), which comprises community-dwelling individuals aged 65 years and older from 30 municipalities (in 14 municipalities the entire population was surveyed, whereas in the remaining 16 municipalities, random sampling was performed) who were not eligible to receive benefits from public long-term care insurance services. The data used in this study were from participants (n = 137,736, response rate = 71%) aged ≥65 years, one-fifth of whom were questioned for information on adverse experiences in childhood (n = 25,928) in 2013. Participants with missing data on age, sex, ACEs,

self-rated health (SRH), body mass index (BMI), and smoking were excluded.

The Finnish data were drawn from two prospective cohort studies: the Finnish Public Sector (FPS) study and the Health and Social Support (HeSSup) study. The FPS study included employees representing a wide range of occupations working in 10 towns and six hospital districts. The FPS data used in this study were derived from employed and retired participants in the 2008/2009 survey, and included information on self-reported ACEs (n = 42,877, response rate = 69%).[13] For this study, all FPS study respondents aged ≥60 years (n = 7169) were selected. The HeSSup study targeted a sample representative of the Finnish population in four age groups (20–24, 30–34, 40–44, and 50–54 years), in 1998.[14] In the 2012 follow-up survey, information on self-reported ACEs was obtained from 11,924 participants (response rate = 78%). Of them, those in the oldest age group (64–68 years) were selected (n = 3184). The two Finnish cohorts were pooled. The studies together included 13,123 (6,214 men and 6,909 women) participants from Japan and 10,353 (3,201 men and 7,152 women) participants from Finland.

The JAGES was approved by the Ethics Committee for Research on Human Subjects at Nihon Fukushi University, Japan (No. 10–05) and the Ethics Committee for Medical Research at the University of Tokyo (No. 10555). The FPS study was approved

by the Ethics Committee of the Helsinki and Uusimaa Hospital District and HeSSup study by the joint Ethics Committee of the University of Turku and the Turku University Central Hospital.

**Measurement of adverse childhood experiences**

The questions related to ACEs were somewhat different between the three studies, but the variables were harmonised. In short, we assessed three ACEs: (1) parental divorce (the FPS study, HeSSup study, and JAGES), (2) fear of a family member (FPS and HeSSup studies)/witness of domestic violence or physical abuse (JAGES), and (3) financial difficulties in the family (FPS study, HeSSup study, and JAGES).

In the JAGES, we assessed ACEs using four questions modified from Felitti's original ACE study[1] and the World Mental Health survey in Japan.[15] Respondents were asked if they had experienced the following adversities in their childhood (yes/no): parents' divorce/separation, financial difficulties in the family, being witness to domestic violence, or physical abuse. We categorised those who responded having experienced "being witness to domestic violence" and/or "physical abuse" as having "frequent fear in a family". These ACEs measures have been shown to predict the number of remaining teeth[16] and higher functional limitation in Japan.[17] In the FPS

and HeSSup studies, we assessed ACEs using three survey questions modified from Statistics Finland's Survey of Living Conditions.[18] Respondents were asked whether they had experienced the following adversities: parent's divorce/separation, long-term financial difficulties in the family, and frequent fear of a family member (the response categories "no", "yes", and "cannot say" were coded as missing variables), and the findings have been used in other studies to predict the presence of coronary heart disease,[19] depression,[19] and non-adherence to statin therapy.[7]

For the present study, the three ACEs were analysed separately and also as a summary variable (0 to 3). For the summary variable, missing data were coded as not having that specific ACE.

**Measurement of adult health and health behaviours**

Questions on adult health and health behaviours were somewhat different between the countries. In the JAGES, SRH was measured using the question: "How do you feel about your current health status: excellent, good, fair, or poor?" Responses were recoded into dichotomous response variables (fair/poor as 0, and excellent/good as 1). A history of being diagnosed with cancer, heart diseases or stroke, or diabetes mellitus was self-reported (response categories: "yes" and "no"). BMI was calculated as participants'

self-reported weight in kilograms divided by height in meters squared. The smoking status (current, former, or never) was based on replies to survey questionnaires.

In the FPS and HeSSup studies, SRH was measured through the question: "How is your current health status?" with five response categories (from 1 [poor] to 5 [excellent]). The responses "moderate", "good", and "excellent" were categorised as good (1), and the other response options as poor (0). Information on cancer was derived from the National Cancer Registry, and prevalent cardiovascular disease (heart disease or stroke) and diabetes mellitus were defined based on the special reimbursement for the medication for these diseases, as obtained from the Social Insurance Institution of Finland.[20] BMI was calculated from self-reported weight and height. The smoking status (current, former, and never) was based on survey responses.

**Covariates**

Education was divided into three levels: (i) 9 years or less, referring to a comprehensive school education in Finland and junior high school education in Japan, (ii) 9–12 years, describing post-compulsory secondary general academic and vocational education in Finland and high school or technical college education in Japan, and (iii) 12 years or more, referring to a university degree in both countries. Marital status was divided into

four categories: (i) single, never married and non-cohabiting, (ii) widowed, (iii) divorced, and (iv) married or cohabiting with a partner. Working status was divided into two categories: (i) working and (ii) retired or never worked (Japan). Missing values were treated as dummy variables.

**Statistical analysis**

Logistic regression analysis was performed to examine the association of each ACE, any ACE, and the total number of ACEs with health outcomes. Linear regression analysis was used for BMI. Multinomial logistic regression was used for smoking status. Model 1 was adjusted for age and sex. Model 2 was further adjusted for education, marital status, and working status.

The odds ratios (ORs) and their 95% confidence intervals (95% CIs) were calculated. Statistical analysis was performed using Stata (ver. 13.1; StataCorp, College Station, TX, USA).

**RESULTS**

Table 1 shows the distribution of the variables for each country. The prevalence rates of parental divorce, fear in the family, and childhood poverty were 3%, 9%, and 47%,

respectively, in Japan. In Finland, these proportions were 9%, 13%, and 29%, respectively. Half of the respondents in Japan and 37% of those in Finland reported having experienced at least one ACE. The mean age of the participants and the proportion of men were higher in Japan than in Finland.

Table 1. Characteristics of the study participants

| | | | Japan (JAGES) (N = 13,123) | | Finland (pooled FPS and HeSSup studies) (N = 10,353) | |
|---|---|---|---|---|---|---|
| | | | N or mean | % or SD | N or mean | % or SD |
| Parental divorce | | | 336 | 2.6 | 958 | 9.3 |
| Fear in family | | | 1195 | 9.1 | 1348 | 13.0 |
| Childhood poverty | | | 6135 | 46.8 | 3013 | 29.1 |
| Any adverse childhood experience | | | 6561 | 50.0 | 3852 | 37.2 |
| Total number of adverse childhood experiences | | 0 | 6562 | 50.0 | 6501 | 62.8 |
| | | 1 | 5517 | 42.0 | 2634 | 25.4 |
| | | 2 | 983 | 7.5 | 969 | 9.4 |
| | | 3 | 61 | 0.5 | 249 | 2.4 |
| Age | | | 69.5 | 2.8 | 64.4 | 2.9 |
| Sex | male | | 6214 | 47.4 | 3201 | 30.9 |
| | female | | 6909 | 52.7 | 7152 | 69.1 |
| SRH | poor/fair | | 1770 | 13.5 | 3780 | 36.5 |
| Cancer | | | 460 | 3.5 | 388 | 3.8 |
| | missing | | | | 54 | 0.5 |

| | | | | | |
|---|---|---|---|---|---|
| Heart disease or stroke | | 1353 | 10.3 | 466 | 4.5 |
| | missing | | | 54 | 0.5 |
| Diabetes mellitus | | 1738 | 13.2 | 714 | 6.9 |
| | missing | | | 54 | 0.5 |
| BMI mean | | 23.0 | 3.1 | 26.7 | 4.4 |
| Smoking | never | 9221 | 70.3 | 6973 | 67.4 |
| | former | 2221 | 16.9 | 2444 | 23.6 |
| | current | 1681 | 12.8 | 936 | 9.0 |
| Education | <9 years | 4395 | 33.5 | 1868 | 18.0 |
| | 10-12 years | 5476 | 41.7 | 3168 | 30.6 |
| | 12+ years | 3103 | 23.7 | 5234 | 50.6 |
| | missing | 149 | 1.1 | 83 | 0.8 |
| Marital status | single | 326 | 2.5 | 574 | 5.5 |
| | divorced | 535 | 4.1 | 1414 | 13.7 |
| | widowed | 1606 | 12.2 | 741 | 7.2 |
| | married/cohabit | 10441 | 79.6 | 7557 | 73.0 |
| | missing | 215 | 1.6 | 67 | 0.7 |
| Working status | not working | 8604 | 65.6 | 3092 | 29.9 |
| | working | 4062 | 31.0 | 7230 | 69.8 |
| | missing | 457 | 3.5 | 31 | 0.3 |

JAGES; Japan Gerontological Evaluation Study, FPS; Finnish Public Sector, HeSSup; Health and Social Support, SD; standard deviation, SRH; self-rated health, BMI; body mass index

As for SRH, the rate of “poor or fair” was higher in Finland than in Japan (37%

and 14%, respectively). The prevalence of cancer was similar in both countries; however, that of heart disease or stroke and diabetes mellitus was higher in Japan. As for BMI, the mean BMI was higher in Finland than in Japan. The distribution of smoking status was similar. In the case of socioeconomic status, 50% of the people in Finland and a quarter of those in Japan were educated for 12 years or more. Two-thirds of the participants in Finland were currently working, whereas two-thirds of those in Japan were currently not working.

Table 2 shows the association between ACEs and SRH, and diseases (e.g., cancer, heart disease or stroke, and diabetes mellitus). SRH was associated with each type of ACE and the number of ACEs, for both countries. Interestingly, the point estimates were similar. For example, the OR of the number of ACEs for poor/fair SRH was 1.35 (95% CI: 1.25-1.46) in Japan and 1.34 (95% CI: 1.27-1.41) in Finland, after adjusting the covariates (Model 2). The ORs of the number of ACEs for cancer, heart disease or stroke, and diabetes mellitus were also similar in both studies in Model 2.

Table 2. Association between adverse childhood experiences and self-rated health and diseases

| | | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| SRH (poor/fair) | Parental divorce | **1.40** | **1.05 - 1.86** | **1.34** | **1.004 - 1.80** | **1.37** | **1.20 - 1.57** | **1.30** | **1.13 - 1.49** |
| | Fear in family | **1.77** | **1.52 - 2.05** | **1.70** | **1.46 - 1.98** | **1.65** | **1.47 - 1.85** | **1.56** | **1.39 - 1.76** |
| | Childhood poverty | **1.46** | **1.32 - 1.62** | **1.32** | **1.19 - 1.47** | **1.68** | **1.54 - 1.83** | **1.60** | **1.46 - 1.75** |
| | Any ACE | **1.50** | **1.36 - 1.67** | **1.37** | **1.23 - 1.52** | **1.66** | **1.53 - 1.80** | **1.60** | **1.47 - 1.74** |
| | Number of ACEs | **1.43** | **1.33 - 1.54** | **1.35** | **1.25 - 1.46** | **1.39** | **1.32 - 1.46** | **1.34** | **1.27 - 1.41** |
| Cancer | Parental divorce | 1.32 | 0.78 - 2.24 | 1.40 | 0.82 - 2.38 | 1.16 | 0.82 - 1.62 | 1.19 | 0.84 - 1.67 |
| | Fear in family | 0.99 | 0.72 - 1.37 | 1.01 | 0.73 - 1.40 | **1.36** | **1.03 - 1.80** | **1.40** | **1.06 - 1.85** |
| | Childhood poverty | **1.26** | **1.04 - 1.52** | **1.31** | **1.08 - 1.59** | 1.05 | 0.84 - 1.32 | 1.07 | 0.86 - 1.35 |
| | Any ACE | **1.26** | **1.04 - 1.52** | **1.31** | **1.08 - 1.59** | 1.11 | 0.90 - 1.36 | 1.13 | 0.91 - 1.39 |
| | Number of ACEs | **1.16** | **1.008 - 1.33** | **1.20** | **1.04 - 1.38** | 1.11 | 0.97 - 1.26 | 1.13 | 0.99 - 1.28 |
| Heart disease or stroke | Parental divorce | 1.30 | 0.94 - 1.81 | 1.26 | 0.91 - 1.76 | 0.93 | 0.66 - 1.32 | 0.90 | 0.63 - 1.27 |
| | Fear in family | 1.13 | 0.94 - 1.37 | 1.10 | 0.91 - 1.32 | 1.16 | 0.88 - 1.54 | 1.11 | 0.84 - 1.48 |
| | Childhood poverty | **1.16** | **1.03 - 1.30** | 1.11 | 0.99 - 1.25 | **1.35** | **1.10 - 1.64** | **1.30** | **1.07 - 1.59** |
| | Any ACE | **1.15** | **1.02 - 1.29** | 1.10 | 0.97 - 1.24 | **1.32** | **1.09 - 1.59** | **1.28** | **1.05 - 1.55** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of ACEs | **1.14** | **1.04 - 1.24** | **1.10** | **1.01 - 1.20** | **1.14** | **1.01 - 1.28** | 1.11 | 0.98 - 1.25 |
| Diabetes mellitus | Parental divorce | 1.29 | 0.96 - 1.73 | 1.30 | 0.97 - 1.74 | **1.37** | **1.07 - 1.75** | **1.34** | **1.05 - 1.72** |
| | Fear in family | 1.11 | 0.94 - 1.32 | 1.12 | 0.95 - 1.33 | **1.46** | **1.18 - 1.80** | **1.42** | **1.15 - 1.76** |
| | Childhood poverty | 1.07 | 0.97 - 1.19 | 1.06 | 0.95 - 1.18 | 1.15 | 0.97 - 1.35 | 1.12 | 0.95 - 1.32 |
| | Any ACE | **1.12** | **1.01 - 1.24** | **1.11** | **1.001 - 1.24** | **1.21** | **1.04 - 1.42** | **1.19** | **1.02 - 1.39** |
| | Number of ACEs | **1.08** | **1.001 - 1.17** | 1.08 | 0.995 - 1.17 | **1.18** | **1.08 - 1.30** | **1.17** | **1.06 - 1.28** |

“Any” denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, OR; odds ratio, CI; confidence interval; SRH, self-rated health

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Odds ratios (95% confidence intervals) were derived from logistic regression models.

Table 3 shows the associations between ACEs and smoking. Former smoking and current smoking were positively associated with the number of ACEs for both counties, and the ORs were similar. Table 4 shows the association between ACEs and BMI. BMI was positively associated with each type of ACE, and the number of ACEs in Finland. This association was also observed in Japan; however, the coefficients in Japan were lower than in Finland.

Table 3. Association between adverse childhood experiences and smoking

| | | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Former smoking (ref: never) | Parental divorce | 1.13 | 0.82 - 1.57 | 1.12 | 0.81 - 1.56 | **1.54** | **1.31 - 1.81** | **1.48** | **1.26 - 1.74** |
| | Fear in family | 1.14 | 0.96 - 1.36 | 1.11 | 0.93 - 1.32 | **1.45** | **1.26 - 1.67** | **1.38** | **1.20 - 1.60** |
| | Childhood poverty | **1.14** | **1.02 - 1.26** | **1.13** | **1.02 - 1.26** | **1.42** | **1.28 - 1.57** | **1.37** | **1.24 - 1.53** |
| | Any ACE | **1.13** | **1.02 - 1.26** | **1.12** | **1.01 - 1.25** | **1.45** | **1.31 - 1.60** | **1.40** | **1.27 - 1.55** |
| | Number of ACEs | **1.11** | **1.03 - 1.21** | **1.11** | **1.02 - 1.20** | **1.30** | **1.22 - 1.38** | **1.26** | **1.19 - 1.35** |
| Current smoking (ref: never) | Parental divorce | **1.46** | **1.06 - 2.01** | 1.32 | 0.95 - 1.82 | **1.64** | **1.32 - 2.03** | **1.49** | **1.20 - 1.85** |
| | Fear in family | **1.29** | **1.07 - 1.55** | 1.16 | 0.96 - 1.40 | **1.45** | **1.19 - 1.76** | **1.32** | **1.09 - 1.61** |
| | Childhood poverty | **1.20** | **1.07 - 1.35** | 1.10 | 0.98 - 1.24 | 1.15 | 0.99 - 1.40 | 1.07 | 0.92 - 1.25 |
| | Any ACE | **1.24** | **1.10 - 1.39** | **1.13** | **1.01 - 1.27** | **1.33** | **1.16 - 1.53** | **1.24** | **1.08 - 1.43** |
| | Number of ACEs | **1.20** | **1.10 - 1.31** | **1.11** | **1.02 - 1.22** | **1.22** | **1.12 - 1.33** | **1.15** | **1.06 - 1.26** |

“Any” denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, RR; Relative risk ratio, CI; confidence interval; ref, reference

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Relative risk ratios (95% confidence intervals) were derived from multinomial logistic regression models.

Table 4. Association between adverse childhood experiences and body mass index

| | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|
| | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | Coef. | 95% CI | Coef. | 95% CI | Coef. | 95% CI | Coef. | 95% CI |
| Parental divorce | 0.18 | -0.15 - 0.52 | 0.18 | -0.15 - 0.51 | **0.60** | **0.31 - 0.89** | **0.52** | **0.23 - 0.81** |
| Fear in family | **0.22** | **0.03 - 0.40** | **0.20** | **0.02 - 0.39** | **0.49** | **0.24 - 0.75** | **0.40** | **0.15 - 0.65** |
| Childhood poverty | **0.15** | **0.04 - 0.25** | 0.07 | -0.03 - 0.18 | **0.49** | **0.30 - 0.67** | **0.40** | **0.22 - 0.59** |
| Any ACE | **0.14** | **0.03 - 0.24** | 0.07 | -0.04 - 0.18 | **0.40** | **0.23 - 0.57** | **0.33** | **0.15 - 0.50** |
| Number of ACEs | **0.14** | **0.06 - 0.22** | **0.09** | **0.01 - 0.18** | **0.36** | **0.25 - 0.47** | **0.30** | **0.19 - 0.41** |

"Any" denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, Coef.; coefficient, CI; confidence interval; BMI, body mass index.

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Coefficients (95% confidence intervals) were derived from regression models.

## DISCUSSION

This study showed that elderly individuals in Japan and Finland who had experienced ACEs had worse health profiles (sub-optimal SRH and presence of chronic diseases) and more often had biological and behavioural risk factors (high BMI and smoking) than those with no ACEs. The strength of these associations was also similar. The only exception was BMI, which showed a more robust association in the Finnish cohorts than in the Japanese cohort.

Our finding, highlighting the association between ACEs and worse adult health, is consistent with those of other studies.[1, 21, 22] Importantly, the consistency of our results in harmonised cohorts from two different countries suggests that childhood adversities affect health similarly in these two societies. These associations were observed in older adults from the two countries, born during or soon after World War II (WWII). Although both Japan and Finland were among the countries that lost WWII, Finland, in contrast to Japan, was not occupied and suffered less damage than Japan, during and after the war. Thus, the adversities experienced by elderly Japanese adults in their childhood are likely to have been more severe than those experienced by elderly Finnish adults. In spite of the differences in these histories, as well as the cultural and social environments of older adults in these countries,[23, 24] it is interesting to note that the associations observed were similar. A potential explanation could be the presence of universal healthcare systems in these countries, which offer adequate medical treatment for diseases over one's life span, and likely lead to the attenuation of the

impact of ACEs on health later in life. In addition, the presence of equal free educational opportunities in both countries may explain the similar impact of ACEs on adult health, as educational attainment can attenuate the impact of ACEs on later health.[25] The presence of high social support in both countries may also attenuate the impact of ACEs on later health.[26] The effect of ACEs on health, in different educational or healthcare systems, requires further study.

Similarly, ACEs were associated with smoking, which is consistent with the findings of a previously conducted international comparison research in eight eastern European countries[5] and other studies in the United States (US),[1, 27] United Kingdom (UK),[28] and Finland.[29] The eastern European comparison study reported that ACEs were associated with smoking among adults aged 14–66 years.[5] The relationships between ACEs and smoking have predominantly been investigated among adults towards middle age; however, few studies have examined these relationships using large community samples of older adults. The current study showed that ACEs had an effect on smoking among older individuals, even though the association may have been underestimated because of early death due to smoking and ACEs (e.g., survival bias). Our results suggest that ACEs have a consistent long-term effect on smoking among older adults despite differences in the price of cigarettes or smoking advertisements, between the countries.

ACEs were associated with an increase in BMI in both countries; however, the

impact of ACEs was higher in Finland. This association was consistent with that observed in a previously conducted study, which showed that ACEs elevated the risk of obesity in the US,[1, 2] UK,[28] and Finland.[30] The obesity rate among older individuals was higher in Finland than in Japan in the current study; thus, we used continuous BMI as an outcome. The presence of sampling bias in the current study may also have led to the lower impact of ACEs on BMI in Japan, as the JAGES includes only individuals without nursing care.

There are several limitations to this study. First, this was a cross-sectional study conducted among older adults; thus, differential recall and selection bias cannot be ruled out, especially if those with a disease were more likely to recall ACEs or if those with the most difficult ACEs did not participate. Second, these results, although based on harmonised measures, were derived from highly developed countries. Third, we did not assess other ACEs such as sexual abuse, neglect, or childhood neighbourhood deprivation. Further studies are warranted to investigate the association between other ACEs and adult disease in different cultural settings, and in low- and middle-income countries.

In conclusion, we observed that ACEs were associated in a similar manner with SRH, diseases, and smoking, in both Japan and Finland. The impact of ACEs on BMI was stronger in Finland than in Japan. These results suggest that the association between ACEs and health is noteworthy, and is consistent even in countries with different historical and cultural heritages.

**Competing interests:** The authors declare that they have no conflict of interest.

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**Authors' contribution:** TF conceived the design of the work. KK and JV obtained the data. TF and JP analysed data. All authors interpret the findings. AA wrote the first draft of the manuscript. TF, JV and TO revised it critically for important intellectual content. All authors approved the final version of the manuscript.

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# Association between adverse childhood experiences and adult diseases in older adults: A comparative cross-sectional study in Japan and Finland

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**Title:**

# Association between adverse childhood experiences and adult diseases in older adults: A comparative cross-sectional study in Japan and Finland

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## ABSTRACT

**Objective:** We aimed to examine associations between adverse childhood experiences (ACEs) and adult diseases in older adults in Japan and Finland.

**Design:** Cross-sectional comparative study.

**Setting:** Data were evaluated from a gerontological study in Japan and two public health studies in Finland.

**Participants:** A total of 13,123 adults (mean age, 69.5 years) from Japan and 10,353 adults (mean age, 64.4 years) from Finland were included in this study. Logistic regression was used to examine the associations of each of, any of, and the cumulative number of ACEs (parental divorce, fear of a family member, and poverty in childhood; treated as ordered categorical variables) with poor self-rated health, cancer, heart disease or stroke, diabetes mellitus, smoking, and body mass index. Models were adjusted for sex, age, education, marital status, and working status.

**Results:** Of the respondents, 50% of those in Japan and 37% of those in Finland reported having experienced at least one of the measured ACEs. Number of ACEs was associated with poor self-rated health in both countries, and the point estimates were similar (odds ratio [OR]: 1.35, 95% confidence interval [CI]: 1.25-1.46 in Japan; OR: 1.34, 95% CI: 1.27-1.41 in Finland). Number of ACEs was associated with the prevalence of cancer,

heart disease or stroke, diabetes mellitus, current smoking, and an increase in body mass index in both countries.

**Conclusions:** Associations between ACEs and poor self-rated health, adult diseases, and health behaviours were similar among older adults in both Japan and Finland. Although the results are potentially subjected to recall and survival bias, this international comparative study suggests that the impact of ACEs on health is noteworthy and consistent across cultural and social environments.

**Strength and limitations of this study**

- The strength of this study is that it is an international comparative study that investigated the impact of adverse childhood experiments (ACEs) on the health of older adults in different cultural and social environments (Japan and Finland) using harmonised data.
- The limitation of this study is that it was a cross-sectional study, and therefore differential recall and selection bias cannot be ruled out. Survival bias is also possible because the participants were older adults.
- Another limitation of this study is that the pooled data of the two countries were not accessible, and therefore interactive effects of the countries and ACE on adult health

were not clear.

## INTRODUCTION

An increasing number of studies have investigated the association between adverse childhood experiences (ACEs), including long-term financial difficulties, parental divorce, and fear of a family member, and unhealthy behaviours (e.g., obesity, alcohol consumption, smoking, and lower levels of physical activity), adult diseases (e.g., cardiovascular disease, diabetes, stroke, cancer, and depression), and even early death.[1-4] Although some recent studies have investigated the impact of ACEs on adult health, it is not known whether ACEs has an impact on the health of older adults. The investigation of this topic is important to confirm the long-term adverse effects of ACE and manage ACEs. Further, the impact varies by country, although the pathways linking childhood adversities with adult health is likely to be dependent on cultural or social environments.[5-7] Therefore, a comparison of countries with different cultural and/or social environments in childhood but similar welfare state regimes may provide further understanding of the underlying mechanisms of ACEs and older adult health.

Japan and Finland are both members of the Organization for Economic Co-operation and Development (OECD). The two countries employ a universal healthcare system [8 9] and provide free education to those aged 6 to 15 years.[10] According to the World Happiness Report, the level of social support received (measured by having someone to

count on in times of trouble) is relatively high in both countries (92.3% and 94.8% in 2015, in Japan and Finland, respectively).[11] However, the two countries differ in terms of equality (e.g., the Gini coefficient, a measure which represents the income distribution of a country's residents,[12] was 0.38 in Japan in 2014 and 0.26 in Finland 2015). Out of 37 OECD countries, Japan ranked 22th and Finland ranked 7th in 2015 in terms of equality.[13] Furthermore, immigration policies the two countries were different at the time of this study; international migrants made up 1.3% of the total Japanese population, whereas 6.2% of the Finnish population were international migrants in 2017.[14] Another cultural aspect that is between the two countries was divorce rate; the divorce rate in Japan in 2017 was 1.7/1,000 people,[15] and in Finland it was 2.5/1,000 people in 2015.[16] Finally, the prevalence of ACEs also differed between Japan and Finland, with 37% of participants (mean age of 73 years old) in a Japanese study reporting at least one ACE,[17] and 61% of participants (mean age of 48 years old) in a Finnish study reporting at least one ACE.[18]

According to a systematic review, most of the recent studies evaluating the impact of multiple ACEs on health throughout life were performed in the United states (US) and the United Kingdom (UK), with only a few studies conducted in other countries,[19] such as Asian [20]or Nordic countries.[21 22] The US and the UK are also members

of the OECD. However, while Japan, Finland and the UK employ a universal healthcare system, the US does not. Further, only one study focused on older adults.[23] The purpose of this study was, therefore, to examine the associations and related risk factors between ACEs and adult diseases in older adults in Japan and Finland.

## METHODS

### Sample

The data in this study were collected from surveys conducted among older individuals in Finland and Japan. The Japanese data were from the Japan Gerontological Evaluation Study (JAGES), which comprises community-dwelling individuals aged 65 years and older from 30 municipalities (in 14 municipalities the entire population was surveyed, whereas in the remaining 16 municipalities, random sampling was performed) who were not eligible to receive benefits from public long-term care insurance services (e.g., those without functional disability). Self-administered survey questionnaires were delivered by post to those who were listed in a ledger of individuals insured for long-term care. The participants of the JAGES might be healthier than the average older Japanese population because they were living in a municipality where municipal officers were keen to participate in the JAGES. The data used in this study were from participants (n = 137,736,

response rate = 71%) aged ≥65 years, one-fifth of whom were randomly chosen and questioned for information on adverse experiences in childhood (n = 26,229) in 2013. The participants of the current study were restricted to an age range of 65-74 years (n = 15,070). Participants with missing data on any ACEs (n=1,158), self-rated health (SRH) (n=325), body mass index (BMI) (n= 483), and smoking (n=163) were excluded.

The Finnish data were drawn from two prospective cohort studies: the Finnish Public Sector (FPS) study[24] and the Health and Social Support (HeSSup) study.[25] The FPS study included employees representing a wide range of occupations working in ten towns and six hospital districts. The participants of the FPS were individuals who were at the time of the study, or had previously been, public sector employees; thus, they did not fully represent the general Finnish population of the same age. The FPS data used in this study were derived from employed and retired participants in the 2008/2009 survey, and included information on self-reported ACEs (n = 42,877, response rate = 69%). For this study, all FPS study respondents aged ≧60 years (n = 7,169) were selected. The HeSSup study targeted a sample representative of the Finnish population in four age groups (20–24, 30–34, 40–44, and 50–54 years), in 1998. Therefore, the participants of the HeSSup may be representative of the Finnish population.[26] In the 2012 follow-up survey, information on self-reported ACEs was obtained from 11,924 participants

(response rate = 78%). Of them, those in the oldest age group (64–68 years) were selected (n = 3,184). Self-administered survey questionnaires were used in the FPS and HeSSup studies. The two Finnish cohorts were pooled. The studies together included 13,123 (6,214 men and 6,909 women) participants from Japan and 10,353 (3,201 men and 7,152 women) participants from Finland.

The JAGES was approved by the Ethics Committee for Research on Human Subjects at Nihon Fukushi University, Japan (No. 10–05) and the Ethics Committee for Medical Research at the University of Tokyo (No. 10555). The FPS study was approved by the Ethics Committee of the Helsinki and Uusimaa Hospital District and HeSSup study by the joint Ethics Committee of the University of Turku and the Turku University Central Hospital. The studies include ethical approval for these secondary analyses. The information about data management and handling is relevant and available for the study administrators in each country.

**Participants and Public Involvement**

Patients were not involved in the development of the research question, outcome measures, design, or conduct of the study.

**Measurement of adverse childhood experiences**

The questions related to ACEs were somewhat different between the three studies, but the variables were harmonised. In short, we assessed three ACEs: (1) parental divorce (the FPS study, HeSSup study, and JAGES), (2) fear of a family member (FPS and HeSSup studies)/witness of domestic violence or physical abuse (JAGES), and (3) financial difficulties in the family (FPS study, HeSSup study, and JAGES).

In the JAGES, we assessed ACEs using four questions modified from Felitti's original ACE study[1] and the World Mental Health survey in Japan.[27] Respondents were asked if they had experienced the following adversities in their childhood (yes/no): parents' divorce/separation, financial difficulties in the family, being witness to domestic violence, or physical abuse. We categorised those who responded having experienced "being witness to domestic violence" and/or "physical abuse" as having "frequent fear of a family member" to make these ACEs comparable to those in the FPS and HeSSup studies. Violence against the child (physical abuse) and the mother (witnessing domestic violence) may both result in "fear of a family member", and we therefore coded witness of domestic violence or physical abuse as "fear of a family member". These ACEs measures have been shown to predict the number of remaining teeth[28] and higher functional limitation in Japan.[29] In the FPS and HeSSup studies, we assessed ACEs using three survey questions modified from Statistics Finland's Survey of Living Conditions.[30]

Respondents were asked whether they had experienced the following adversities: parent's divorce/separation, long-term financial difficulties in the family, and frequent fear of a family member (the response categories "no", "yes", and "cannot say" were coded as dummy variables), and the findings have been used in other studies to predict the presence of coronary heart disease,[31] depression,[31] and non-adherence to statin therapy.[7] The questions regarding each ACE are shown in Supplemental table S1.

For the present study, the three ACEs were analysed both separately and as a summary variable (0, 1, 2 and 3 ACEs).

**Measurement of adult health and health behaviours**

Questions on adult health and health behaviours were somewhat different between the countries. In the JAGES, SRH was measured using the question: "How do you feel about your current health status: excellent, good, fair, or poor?" Responses were recoded to dichotomous response variables (fair/poor as 0, and excellent/good as 1). A history of being diagnosed with cancer, heart diseases or stroke, or diabetes mellitus was self-reported (response categories: "yes" and "no"). BMI was calculated as participants' self-reported weight in kilograms divided by height in meters squared. The smoking status (current, former, or never) was based on replies to survey questionnaires.

In the FPS and HeSSup studies, SRH was measured through the question: "How is your current health status?" with five response categories (from 1 [poor] to 5 [excellent]). The responses "moderate", "good", and "excellent" were categorised as good (1), and the other response options as poor (0). Information on cancer was derived from the National Cancer Registry, and prevalent cardiovascular disease (heart disease or stroke) and diabetes mellitus were defined based on the special reimbursement for the medication for these diseases, as obtained from the Social Insurance Institution of Finland. In FPS and HeSSup, we used personal identification codes, assigned to all Finnish citizens, to link the respondents to their records in national health registers. BMI was calculated from self-reported weight and height. Smoking status (current, former, and never) was based on survey responses. Questions regarding health and health behaviours are shown in Supplemental table S2.

**Covariates**

Education was divided into three levels: (i) 9 years or less, referring to a comprehensive school education in Finland and junior high school education in Japan, (ii) 9–12 years, describing post-compulsory secondary general academic and vocational education in Finland and high school or technical college education in Japan, and (iii) 12 years or

more, referring to a university degree in both countries. Marital status was divided into four categories: (i) single, never married and non-cohabiting, (ii) widowed, (iii) divorced, and (iv) married or cohabiting with a partner. Working status was divided into two categories: (i) working and (ii) retired or never worked (Japan). Regarding working status, those who had never worked was not included in FPS because FPS is a study of individuals who were at the time of study, or had previously been, public sector employees and represented a wide range of occupations. Therefore, we combined 'retired and never worked' as 'not working' in Japan to be comparable with the studies in Finland. Missing values were treated as dummy variables.

**Statistical analysis**

Logistic regression analysis was performed to examine the association of each ACE, any ACE, and the cumulative number of ACEs (e.g., 0, 1, 2, and 3 ACEs) with health outcomes. Linear regression analysis was used for BMI. Multinomial logistic regression was used for smoking status. Model 1 was adjusted for age and sex. Model 2 was further adjusted for education, marital status, and working status.

The odds ratios (ORs) and their 95% confidence intervals (95% CIs) were calculated. Statistical analysis was performed using Stata (ver. 13.1; StataCorp, College

Station, TX, USA).

## RESULTS

Table 1 shows the distribution of the variables for each country. The prevalence rates of parental divorce, fear of a family member, and childhood poverty were 3%, 9%, and 47%, respectively, in Japan. In Finland, these proportions were 9%, 13%, and 29%, respectively. Of the respondents, 50% of those in Japan and 37% of those in Finland reported having experienced at least one ACE. The mean age of the participants and the proportion of men were higher in Japan than in Finland.

Table 1. Characteristics of the study participants

| | | Japan (JAGES) (N = 13,123) | | Finland (pooled FPS and HeSSup studies) (N = 10,353) | | |
|---|---|---|---|---|---|---|
| | | N or mean | % or SD | N or mean | % or SD | |
| Parental divorce | | 336 | 2.6 | 958 | 9.3 | p <0.01[a] |
| Fear of a family member | | 1195 | 9.1 | 1348 | 13.0 | p <0.01[a] |
| Childhood poverty | | 6135 | 46.8 | 3013 | 29.1 | p <0.01[a] |
| Any adverse childhood experience | | 6561 | 50.0 | 3852 | 37.2 | p <0.01[a] |
| Total number of adverse childhood experiences | 0 | 6562 | 50.0 | 6501 | 62.8 | p <0.01[a] |
| | 1 | 5517 | 42.0 | 2634 | 25.4 | |
| | 2 | 983 | 7.5 | 969 | 9.4 | |
| | 3 | 61 | 0.5 | 249 | 2.4 | |
| Age | | 69.5 | 2.8 | 64.4 | 2.9 | p <0.01[b] |
| Sex | male | 6214 | 47.4 | 3201 | 30.9 | p <0.01[a] |
| | female | 6909 | 52.7 | 7152 | 69.1 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| SRH | poor/fair | 1770 | 13.5 | 3780 | 36.5 | p <0.01[a] |
| Cancer | | 460 | 3.5 | 388 | 3.8 | p <0.32[a] |
| | missing | | | 54 | 0.5 | |
| Heart disease or stroke | | 1353 | 10.3 | 466 | 4.5 | p <0.01[a] |
| | missing | | | 54 | 0.5 | |
| Diabetes mellitus | | 1738 | 13.2 | 714 | 6.9 | p <0.01[a] |
| | missing | | | 54 | 0.5 | |
| BMI mean | | 23.0 | 3.1 | 26.7 | 4.4 | p <0.01[b] |
| Smoking | never | 9221 | 70.3 | 6973 | 67.4 | p <0.01[a] |
| | former | 2221 | 16.9 | 2444 | 23.6 | |
| | current | 1681 | 12.8 | 936 | 9.0 | |
| Education | <9 years | 4395 | 33.5 | 1868 | 18.0 | p <0.01[a] |
| | 10-12 years | 5476 | 41.7 | 3168 | 30.6 | |
| | 12+ years | 3103 | 23.7 | 5234 | 50.6 | |
| | missing | 149 | 1.1 | 83 | 0.8 | |
| Marital status | single | 326 | 2.5 | 574 | 5.5 | p <0.01[a] |
| | divorced | 535 | 4.1 | 1414 | 13.7 | |
| | widowed | 1606 | 12.2 | 741 | 7.2 | |
| | married /cohabit | 10441 | 79.6 | 7557 | 73.0 | |
| | missing | 215 | 1.6 | 67 | 0.7 | |
| Working status | not working | 8604 | 65.6 | 3092 | 29.9 | p <0.01[a] |
| | working | 4062 | 31.0 | 7230 | 69.8 | |
| | missing | 457 | 3.5 | 31 | 0.3 | |

JAGES; Japan Gerontological Evaluation Study, FPS; Finnish Public Sector, HeSSup; Health and Social Support, SD; standard deviation, SRH; self-rated health, BMI; body mass index

a: Chi-squared test. b: t-test

As for SRH, the rate of "poor or fair" was higher in Finland than in Japan (37% and 14%, respectively). The prevalence of cancer was similar in both countries; however,

that of heart disease or stroke and diabetes mellitus was higher in Japan. As for BMI, the mean BMI was higher in Finland than in Japan. The distribution of smoking status was similar. In the case of socioeconomic status, 50% of the people in Finland and 24% of those in Japan were educated for 12 years or more. Of the participants in Finland, 70% were currently working, whereas 66% of those in Japan were currently not working.

Table 2 shows the association between ACEs and SRH, and diseases (e.g., cancer, heart disease or stroke, and diabetes mellitus). SRH was associated with each type of ACE and the number of ACEs, for both countries. Interestingly, the point estimates were similar. For example, the OR of the number of ACEs for poor/fair SRH was 1.35 (95% CI: 1.25-1.46) in Japan and 1.34 (95% CI: 1.27-1.41) in Finland, after adjusting the covariates (Model 2). The ORs of the number of ACEs for cancer, heart disease or stroke, and diabetes mellitus were also similar in both studies in Model 2.

Table 2. Association between adverse childhood experiences and poor self-rated health and diseases among older adults in Japan and Finland.

| | | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| SRH (poor/fair) | Parental divorce (ref.no): Yes | **1.40** | **1.05 - 1.86** | **1.34** | **1.004 - 1.80** | **1.37** | **1.20 - 1.57** | **1.30** | **1.13 - 1.49** |
| | Fear of a family member (ref.no): Yes | **1.77** | **1.52 - 2.05** | **1.70** | **1.46 - 1.98** | **1.65** | **1.47 - 1.85** | **1.56** | **1.39 - 1.76** |
| | Childhood poverty (ref.no): Yes | **1.46** | **1.32 - 1.62** | **1.32** | **1.19 - 1.47** | **1.68** | **1.54 - 1.83** | **1.60** | **1.46 - 1.75** |
| | Any ACE (ref.no): Yes | **1.50** | **1.36 - 1.67** | **1.37** | **1.23 - 1.52** | **1.66** | **1.53 - 1.80** | **1.60** | **1.47 - 1.74** |
| | Number of ACEs (continuous variable) | **1.43** | **1.33 - 1.54** | **1.35** | **1.25 - 1.46** | **1.39** | **1.32 - 1.46** | **1.34** | **1.27 - 1.41** |
| Cancer | Parental divorce (ref.no): Yes | 1.32 | 0.78 - 2.24 | 1.40 | 0.82 - 2.38 | 1.16 | 0.82 - 1.62 | 1.19 | 0.84 - 1.67 |
| | Fear of a family member (ref.no): Yes | 0.99 | 0.72 - 1.37 | 1.01 | 0.73 - 1.40 | **1.36** | **1.03 - 1.80** | **1.40** | **1.06 - 1.85** |
| | Childhood poverty (ref.no): Yes | **1.26** | **1.04 - 1.52** | **1.31** | **1.08 - 1.59** | 1.05 | 0.84 - 1.32 | 1.07 | 0.86 - 1.35 |
| | Any ACE (ref.no): Yes | **1.26** | **1.04 - 1.52** | **1.31** | **1.08 - 1.59** | 1.11 | 0.90 - 1.36 | 1.13 | 0.91 - 1.39 |
| | Number of ACEs (continuous variable) | **1.16** | **1.008 - 1.33** | **1.20** | **1.04 - 1.38** | 1.11 | 0.97 - 1.26 | 1.13 | 0.99 - 1.28 |
| Heart disease or stroke | Parental divorce (ref.no): Yes | 1.30 | 0.94 - 1.81 | 1.26 | 0.91 - 1.76 | 0.93 | 0.66 - 1.32 | 0.90 | 0.63 - 1.27 |
| | Fear of a family member (ref.no): Yes | 1.13 | 0.94 - 1.37 | 1.10 | 0.91 - 1.32 | 1.16 | 0.88 - 1.54 | 1.11 | 0.84 - 1.48 |
| | Childhood poverty (ref.no): Yes | **1.16** | **1.03 - 1.30** | 1.11 | 0.99 - 1.25 | **1.35** | **1.10 - 1.64** | **1.30** | **1.07 - 1.59** |
| | Any ACE (ref.no): Yes | **1.15** | **1.02 - 1.29** | 1.10 | 0.97 - 1.24 | **1.32** | **1.09 - 1.59** | **1.28** | **1.05 - 1.55** |
| | Number of ACEs (continuous variable) | **1.14** | **1.04 - 1.24** | **1.10** | **1.01 - 1.20** | **1.14** | **1.01 - 1.28** | 1.11 | 0.98 - 1.25 |
| Diabetes mellitus | Parental divorce (ref.no): Yes | 1.29 | 0.96 - 1.73 | 1.30 | 0.97 - 1.74 | **1.37** | **1.07 - 1.75** | **1.34** | **1.05 - 1.72** |
| | Fear of a family member (ref.no): Yes | 1.11 | 0.94 - 1.32 | 1.12 | 0.95 - 1.33 | **1.46** | **1.18 - 1.80** | **1.42** | **1.15 - 1.76** |
| | Childhood poverty (ref.no): Yes | 1.07 | 0.97 - 1.19 | 1.06 | 0.95 - 1.18 | 1.15 | 0.97 - 1.35 | 1.12 | 0.95 - 1.32 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Any ACE (ref.no): Yes | **1.12** | **1.01 - 1.24** | **1.11** | **1.001 - 1.24** | **1.21** | **1.04 - 1.42** | **1.19** | **1.02 - 1.39** |
| Number of ACEs (continuous variable) | **1.08** | **1.001 - 1.17** | 1.08 | 0.995 - 1.17 | **1.18** | **1.08 - 1.30** | **1.17** | **1.06 - 1.28** |

"Any" denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, OR; odds ratio, CI; confidence interval; SRH, self-rated health; ref., reference

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Odds ratios (95% confidence intervals) were derived from logistic regression models.

Bold text indicates statistically significant with a p-value less than 0.05.

Table 3 shows the associations between ACEs and smoking. Former smoking and current smoking were positively associated with the number of ACEs for both counties, and the ORs were similar. Table 4 shows the association between ACEs and BMI. BMI was positively associated with each type of ACE, and the number of ACEs in Finland. This association was also observed in Japan; however, the coefficients in Japan were lower than those in Finland.

Table 3. Association between adverse childhood experiences and former and current smoking among older adults in Japan and Finland.

| | | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Former smoking (ref: never) | Parental divorce (ref.no): Yes | 1.13 | 0.82 - 1.57 | 1.12 | 0.81 - 1.56 | **1.54** | **1.31 - 1.81** | **1.48** | **1.26 - 1.74** |
| | Fear of a family member (ref.no): Yes | 1.14 | 0.96 - 1.36 | 1.11 | 0.93 - 1.32 | **1.45** | **1.26 - 1.67** | **1.38** | **1.20 - 1.60** |
| | Childhood poverty (ref.no): Yes | **1.14** | **1.02 - 1.26** | **1.13** | **1.02 - 1.26** | **1.42** | **1.28 - 1.57** | **1.37** | **1.24 - 1.53** |
| | Any ACE (ref.no): Yes | **1.13** | **1.02 - 1.26** | **1.12** | **1.01 - 1.25** | **1.45** | **1.31 - 1.60** | **1.40** | **1.27 - 1.55** |
| | Number of ACEs (continuous variable) | **1.11** | **1.03 - 1.21** | **1.11** | **1.02 - 1.20** | **1.30** | **1.22 - 1.38** | **1.26** | **1.19 - 1.35** |
| Current smoking (ref: never) | Parental divorce (ref.no): Yes | **1.46** | **1.06 - 2.01** | 1.32 | 0.95 - 1.82 | **1.64** | **1.32 - 2.03** | **1.49** | **1.20 - 1.85** |
| | Fear of a family member (ref.no): Yes | **1.29** | **1.07 - 1.55** | 1.16 | 0.96 - 1.40 | **1.45** | **1.19 - 1.76** | **1.32** | **1.09 - 1.61** |
| | Childhood poverty (ref.no): Yes | **1.20** | **1.07 - 1.35** | 1.10 | 0.98 - 1.24 | 1.15 | 0.99 - 1.40 | 1.07 | 0.92 - 1.25 |
| | Any ACE (ref.no): Yes | **1.24** | **1.10 - 1.39** | **1.13** | **1.01 - 1.27** | **1.33** | **1.16 - 1.53** | **1.24** | **1.08 - 1.43** |
| | Number of ACEs (continuous variable) | **1.20** | **1.10 - 1.31** | **1.11** | **1.02 - 1.22** | **1.22** | **1.12 - 1.33** | **1.15** | **1.06 - 1.26** |

"Any" denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, OR; odds ratio, CI; confidence interval; ref, reference

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Odds ratios (95% confidence intervals) were derived from multinomial logistic regression models.

Bold text indicates statistically significant with a p-value less than 0.05.

Table 4. Association between adverse childhood experiences and body mass index among older adults in Japan and Finland.

| | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|
| | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | Coef. | 95% CI | Coef. | 95% CI | Coef. | 95% CI | Coef. | 95% CI |
| Parental divorce (ref.no): Yes | 0.18 | -0.15 - 0.52 | 0.18 | -0.15 - 0.51 | **0.60** | **0.31 - 0.89** | **0.52** | **0.23 - 0.81** |
| Fear of a family member (ref.no): Yes | **0.22** | **0.03 - 0.40** | **0.20** | **0.02 - 0.39** | **0.49** | **0.24 - 0.75** | **0.40** | **0.15 - 0.65** |
| Childhood poverty (ref.no): Yes | **0.15** | **0.04 - 0.25** | 0.07 | -0.03 - 0.18 | **0.49** | **0.30 - 0.67** | **0.40** | **0.22 - 0.59** |
| Any ACE (ref.no): Yes | **0.14** | **0.03 - 0.24** | 0.07 | -0.04 - 0.18 | **0.40** | **0.23 - 0.57** | **0.33** | **0.15 - 0.50** |
| Number of ACEs (continuous variable) | **0.14** | **0.06 - 0.22** | **0.09** | **0.01 - 0.18** | **0.36** | **0.25 - 0.47** | **0.30** | **0.19 - 0.41** |

“Any” denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, Coef.; coefficient, CI; confidence interval; BMI, body mass index.

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Coefficients (95% confidence intervals) were derived from regression models.

Bold text indicates statistically significant with a p-value less than 0.05.

## DISCUSSION

To our knowledge, this is the first study that compares the impact of ACEs on health of older adults between two countries. This study showed that elderly individuals in Japan and Finland who had experienced ACEs had worse health profiles (sub-optimal SRH and presence of chronic diseases) and more often had biological and behavioural risk factors (high BMI and smoking) than those with no ACEs. The strength of these associations was weak or modest, and similar between the two countries. The only exception was BMI, which showed a more robust association in the Finnish cohorts than in the Japanese cohort.

Our finding which highlights the association between ACEs and poor adult health, is consistent with those of other studies. Although the association was weaker compared with other studies,[5-7 19] this might be due to survival bias as we focused on older adults. Regarding SRH, the association between fear of a family member in childhood and poor SRH among older adults was slightly stronger than that for parental divorce or childhood poverty in Japan; however, in Finland, such a difference was not observed. This result suggests that the prevention and detection of childhood abuse and intimate partner violence, as well as the follow-up provided, may not be as adequate in Japan compared with Finland. Alternatively, physical punishment might be more pervasive in Japan than in Finland;[32] physical punishment is legally forbidden in Finland but not in Japan. Regarding cancer, childhood poverty was associated with cancer among older people in Japan, but this association was not observed in

Finland. Childhood poverty in Japan might lead to poverty in adulthood, which may result in delays in medical check-ups or consultations. In spite of the provision of universal health care in Japan, individual payment of medical expenses is at least 10% of the total cost, even among older adults.

Generally, the strength of these associations was similar between the two countries. The consistency of our results in harmonised cohorts from two different countries suggests that childhood adversities affect health similarly in these two societies. In spite of the differences in the cultural and social environments of older adults in these countries,[33 34] it is interesting to note that the associations observed were similar. A likely explanation could be the presence of universal healthcare systems in these countries, which offer adequate medical treatment for diseases over one's life span, and likely lead to the attenuation of the impact of ACEs on health later in life. This might explain the lower OR of ACEs for diseases comparing previous studies, because universal health care system might be effective to protect older adults with ACEs. In addition, the presence of equal free educational opportunities in both countries may explain the similar impact of ACEs on adult health, as educational attainment can attenuate the impact of ACEs on later health.[35] The presence of high social support,[36] cultural engagement, access to trusted adults[37] in both countries may also attenuate the impact of ACEs on later health through the enhancement of resilience, described as the ability to adapt to adverse environment.[38] The effect of ACEs on health, in different educational or healthcare systems, requires further study.

Similarly, ACEs were associated with smoking, which is consistent with the findings of a previously conducted international comparison research in eight Eastern European countries[5] and other studies in the US,[1 39] UK,[40] and Finland[41], although this association was weak in the current study. The Eastern European comparison study reported that ACEs were associated with smoking among adults aged 14–66 years.[5] The relationships between ACEs and smoking have predominantly been investigated among adults towards middle age; however, few studies have examined these relationships using large community samples of older adults. Our results suggest that ACEs have a consistent long-term effect on smoking among older adults despite differences in the price of cigarettes or smoking advertisements between the countries. A meta-analysis showed a moderate odds ratio for smoking among those with four or more ACEs compared with those with no ACEs.[19] The association was weaker in the current study than the results of the meta-analysis, possibly because there were only three ACEs measured in the current study, and the association may have been underestimated because of early death due to smoking and ACEs (e.g., survival bias).

ACEs were associated with an increase in BMI in both countries; however, the impact of ACEs was higher in Finland. This association was consistent with that observed in a previous study which showed that ACEs elevated the risk of obesity in the US,[1 2] UK,[40] and Finland.[42] The obesity rate among older individuals was higher in Finland than in Japan in the current study; thus, we used continuous BMI as an outcome. The presence of sampling bias in the

current study may have also led to the lower impact of ACEs on BMI in Japan, as the JAGES included only individuals without nursing care.

There are several limitations to this study. First, this was a cross-sectional study conducted among older adults. Thus, differential recall and selection bias cannot be ruled out, especially if those with a disease were more likely to recall ACEs or if those with the most difficult ACEs did not participate. Second, these results, although based on harmonised measures, were derived from only two egalitarian developed countries, which preclude to generalize the findings to other countries. Further studies are warranted to investigate the association between other ACEs and adult disease in different cultural settings, and in low- and middle-income countries. Third, we did not assess other ACEs such as sexual abuse, neglect, childhood neighbourhood deprivation, or family disfunction (i.e., mental disorder of a family member, or incarcerated family member), and thus the number of ACEs were limited to only three. Further studies are necessary to investigate the impact of other ACEs on the health of older adults. Fourth, the assessment of fear of a family member in the JAGES, FPS and HeSSup was different, which may result in heterogeneity between study estimates. Fifth, the participants in the JAGES were without functional disability, and hence might be healthier than the average Japanese older population. Therefore, the results of the study might be underestimated. Sixth, there is a disparity in the measurement of ACEs and health, and ACEs and health behaviours, across the JAGES, FPS, and HeSSup. The differences in measurement might result in

heterogeneity of the results. Seventh, considering other covariates such as levels of inequality, current and previous household income, environmental risks (e.g., parental smoking), or genetic variation was not feasible due to data availability. Eighth, the results might be subjected to survival bias. The average age of the study participants was 69.5 years in Japan and 64.4 years in Finland. People who passed away before the current study from ACE-related diseases or health risk behaviours would not have been included in the current study. Therefore, the results of the current study may underestimate the health effects of ACEs. Ninth, all the ACEs were self-reported. Therefore, there may be recall or reporting biases. Finally, the data from Japan (e.g., data from JAGES) excluded those with functional disability; therefore, the association between ACE and health throughout life might be underestimated in Japan. Further, FPS and HeSSup were not representative sample, thus prevalence of diseases, such as cancer, may be different from other studies.

Nonetheless, this is the first study that investigated the association between ACEs and health and health behaviour among older people in two countries. In Japan and Finland, the relationship between ACEs and health was similar for SRH, specific diseases and smoking. The impact of ACEs on BMI was stronger in Finland than in Japan. These results suggest a notable association between ACEs and health among older people, and that this association remains consistent even in countries with different historical and cultural heritages.

**Competing interests:** The authors declare that they have no conflict of interest.

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**Authors' contribution:** AA and TF conceived the design of the work. KK and JV obtained the data. TF and JP analysed data. All authors interpret the findings. AA wrote the first draft of the manuscript. TF and JV revised it critically for important intellectual content. All authors approved the final version of the manuscript.

**Data sharing statement:** All available data can be obtained by contacting the corresponding

author.

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**Supplemental table S1**. Measurement of adverse childhood experience

**Supplemental table S2**. Measurement of health and health behaviours

256 Supplemental table S1. Measurement of adverse childhood experience

| Items | JAGES | | | FPS, HeSSup | | |
|---|---|---|---|---|---|---|
| | Question | Answer | Code | Question | Answer | Code |
| **Parental divorce in childhood** | Did you experience any of the following before the age of 18?; Parents' divorce | No | 0 | The respondents were asked whether they had experienced the following adversities in their childhood: Divorce/separation of the parents | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |
| **Severe financial difficulties** | Financial trouble | No | 0 | Long-term financial difficulties in the family | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |
| **Fear of a family member** | 1) Your father was violent with your mother (being witness to domestic violence) 2) You were hit hard by your mother/father causing an injury (physical abuse) | No | 0 | Frequent fear for a family member | No | 0 |
| | | Yes[a] | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |

**a: If someone answers yes to the question of either of 1) or 2), the code is "Yes".**

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Supplemental table S2. Measurement of health and health behaviours

| Items | JAGES | | | FPS | | |
|---|---|---|---|---|---|---|
| | Question | Answer | Code | Question | Answer | Code |
| Self-rated health | How is your current health status? | Excellent | 0 | **How is your current health status?** | Good | 0 |
| | | Good | 0 | | Fairly good | 0 |
| | | Fair | 1 | | Moderate | 1 |
| | | Poor | 1 | | Fairly poor | 1 |
| | | | | | Poor | 1 |
| Cancer | Circle the number of all diseases for which you are currently receiving treatment or experiencing; Cancer | No | 0 | National Cancer Register | No | 0 |
| | | Yes | 1 | | Yes within 5 years | 1 |
| | | | | | Unknown | Missing |
| Heart disease or stroke | Circle the number of all diseases for which you are currently receiving treatment or experiencing; 1) Heart disease, 2) Stroke (e.g. brain hemorrhage, cerebral infarction) | No | 0 | Special reimbursement for the medication, from Social Insurance Institution of Finland | No | 0 |
| | | Yes[a] | 1 | | Yes | 1 |
| | | | | | Unknown | Missing |
| Diabetes mellitus | Circle the number of all diseases for which you are currently receiving treatment or experiencing; Diabetes mellitus | No | 0 | Special reimbursement for the medication, from Social Insurance Institution of Finland | No | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Yes | 1 | | Yes | 1 |
| | | | | | Unknown | Missing |
| Smoking | Do you smoke cigarettes? | No | 0 | Do you smoke or have you ever smoked regularly, i.e. every day or almost every day? | Never | 0 |
| | | I used to smoke | 1 | | Yes, before | 1 |
| | | Yes | 2 | | Yes, I still do | 2 |

**a: If someone answers yes to the question of either of 1) or 2), the code is "Yes".**

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4 1 **Supplemental table S1**. Measurement of adverse childhood experience

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7 2 **Supplemental table S2**. Measurement of health and health behaviours

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Supplemental table S1. Measurement of adverse childhood experience

| Items | JAGES | | | FPS, HeSSup | | |
|---|---|---|---|---|---|---|
| | Question | Answer | Code | Question | Answer | Code |
| | Did you experience any of the following before the age of 18?; | | | The respondents were asked whether they had experienced the following adversities in their childhood: | | |
| **Parental divorce in childhood** | Parents' divorce | No | 0 | Divorce/separation of the parents | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |
| **Severe financial difficulties** | Financial trouble | No | 0 | Long-term financial difficulties in the family | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |
| **Fear of a family member** | 1) Your father was violent with your mother (being witness to domestic violence) 2) You were hit hard by your mother/father causing an injury (physical abuse) | No | 0 | Frequent fear for a family member | No | 0 |
| | | Yes[a] | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |

**a: If someone answers yes to the question of either of 1) or 2), the code is "Yes".**

Supplemental table S2. Measurement of health and health behaviours

| Items | JAGES | | | FPS | | |
|---|---|---|---|---|---|---|
| | Question | Answer | Code | Question | Answer | Code |
| Self-rated health | How is your current health status? | Excellent | 0 | **How is your current health status?** | Good | 0 |
| | | Good | 0 | | Fairly good | 0 |
| | | Fair | 1 | | Moderate | 1 |
| | | Poor | 1 | | Fairly poor | 1 |
| | | | | | Poor | 1 |
| Cancer | Circle the number of all diseases for which you are currently receiving treatment or experiencing; Cancer | No | 0 | National Cancer Register | No | 0 |
| | | Yes | 1 | | Yes within 5 years | 1 |
| | | | | | Unknown | Missing |
| Heart disease or stroke | Circle the number of all diseases for which you are currently receiving treatment or experiencing; 1) Heart disease, 2) Stroke (e.g. brain hemorrhage, cerebral infarction) | No | 0 | Special reimbursement for the medication, from Social Insurance Institution of Finland | No | 0 |
| | | Yes[a] | 1 | | Yes | 1 |
| | | | | | Unknown | Missing |
| Diabetes mellitus | Circle the number of all diseases for which you are currently receiving treatment or experiencing; Diabetes mellitus | No | 0 | Special reimbursement for the medication, from Social Insurance Institution of Finland | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | | | | Unknown | Missing |
| Smoking | Do you smoke cigarettes? | No | 0 | Do you smoke or have you ever smoked regularly, i.e. every day or almost every day? | Never | 0 |

| | | | | | |
|---|---|---|---|---|---|
| | I used to smoke | 1 | | Yes, before | 1 |
| | Yes | 2 | | Yes, I still do | 2 |

**a: If someone answers yes to the question of either of 1) or 2), the code is "Yes".**

BMJ Open

# Association between adverse childhood experiences and adult diseases in older adults: A comparative cross-sectional study in Japan and Finland

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**Title:**

# Association between adverse childhood experiences and adult diseases in older adults: A comparative cross-sectional study in Japan and Finland

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## ABSTRACT

**Objective:** We aimed to examine the association between adverse childhood experiences (ACEs) and adult diseases in older adults in Japan and Finland.

**Design:** Cross-sectional comparative study.

**Setting:** Data from a gerontological study in Japan and two public health studies in Finland were evaluated.

**Participants:** A total of 13,123 adults (mean age, 69.5 years) from Japan and 10,353 adults (mean age, 64.4 years) from Finland were included in this study. Logistic regression was used to examine the associations of each of, any of, and the cumulative number of ACEs (parental divorce, fear of a family member, and poverty in childhood; treated as ordered categorical variables) with poor self-rated health, cancer, heart disease or stroke, diabetes mellitus, smoking, and body mass index. Models were adjusted for sex, age, education, marital status, and working status.

**Results:** Of the respondents, 50% of those in Japan and 37% of those in Finland reported having experienced at least one of the measured ACEs. Number of ACEs was associated with poor self-rated health in both countries, and the point estimates were similar (odds ratio [OR]: 1.35, 95% confidence interval [CI]: 1.25-1.46 in Japan; OR: 1.34, 95% CI: 1.27-1.41 in Finland). Number of ACEs was associated with the prevalence of cancer,

heart disease or stroke, diabetes mellitus, current smoking, and an increase in body mass index in both countries.

**Conclusions:** The association between ACEs and poor self-rated health, adult diseases, and health behaviours was similar among older adults in both Japan and Finland. This international comparative study suggests that the impact of ACEs on health is noteworthy and consistent across cultural and social environments.



**Strength and limitations of this study**

- This is an international comparative study that investigated the impact of adverse childhood experiments (ACEs) on the health of older adults in different cultural and social environments (Japan and Finland) using harmonised data.
- The limitation of this study is that it was a cross-sectional study, and therefore differential recall and selection bias cannot be ruled out. Survival bias is also possible because the participants were older adults.
- Another limitation of this study is that the pooled data of the two countries were not accessible, and therefore interactive effects of the countries and ACE on adult health were not clear.

## INTRODUCTION

Although there is an increasing number of studies that have investigated the association between adverse childhood experiences (ACEs, such as long-term financial difficulties, parental divorce, and fear of a family member) and unhealthy behaviours (e.g., obesity, alcohol consumption, smoking, and lower levels of physical activity), adult diseases (e.g., cardiovascular disease, diabetes, stroke, cancer, and depression), and even early death,[1-4] few studies have investigated whether ACEs has an impact on the health of older adults. Because of the rising number of older adults in the world, it is therefore necessary to elucidate the risk factors for diseases among older people.

Further, to address the impact of ACEs on health of older people, it is also crucial to elucidate the commonality of the association, because the pathways linking childhood adversities with adult health are likely to be dependent on cultural or social environments.[5-7] Therefore, a comparison of countries with different cultural and/or social environments in childhood, but with similar welfare state regimes, may provide further understanding of the underlying mechanisms of ACEs and older adult health. According to a systematic review, most of the recent studies evaluating the impact of multiple ACEs on health were performed in the United States (US) and the United Kingdom (UK), with only a few studies conducted in other countries,[8] such as Asia[9] or Nordic countries.[10 11]

Because the US and UK are developed countries with high inequality, there is a need to confirm the association in developed but relatively equal, egalitarian countries, such as Japan or Finland.

Japan (population: approximately 127 million) and Finland (population: approximately 5.5 million) are members of the Organization for Economic Co-operation and Development (OECD). The two countries employ a universal healthcare system [12 13] and provide free education to those aged 6 to 15 years.[14] According to the World Happiness Report, the level of social support received (measured by having someone to count on in times of trouble) is relatively high in both countries (92.3% and 94.8% in Japan and Finland in 2015, respectively).[15] However, the two countries differ in terms of equality (e.g., the Gini coefficient, a measure which represents the income distribution of a country's residents,[16] was 0.38 in Japan in 2014 and 0.26 in Finland 2015). Out of the 37 OECD countries, Japan ranked 22$^{th}$ and Finland ranked 7$^{th}$ in 2015 in terms of equality.[17] Furthermore, immigration policies in the two countries were different at the time of this study; international migrants made up 1.3% of the total Japanese population, whereas 6.2% of the Finnish population were international migrants in 2017.[18] Moreover, the divorce rate in Japan in 2017 was 1.7/1,000 people,[19] whereas it was 2.5/1,000 people in Finland in 2015.[20] Finally, the prevalence of ACEs also differed between Japan and

Finland, with 37% of participants (mean age of 73 years old) in a Japanese study reporting at least one ACE,[21] and 61% of participants (mean age of 48 years old) in a Finnish study reporting at least one ACE.[22] Corporal punishment is not forbidden in Japan, but in Finland, it has been prohibited by law since 1983. In summary, both Japan and Finland are developed and egalitarian countries, but their differences in terms of inequality, immigration percentage, divorce rate, or policy on corporal punishment might contribute to the differential impact of ACEs on diseases in older adults. For example, deetiolated social capital due to inequality[23] might contribute to stronger impact of ACEs on health in older adults.

Therefore, the purpose of this study was to examine and compare the association between ACEs and adult diseases, including unhealthy behaviours such as smoking, in older adults in Japan and Finland.

## METHODS

### Sample

The data in this study were collected from surveys conducted among older individuals in Finland and Japan. The Japanese data were from the Japan Gerontological Evaluation Study (JAGES), which comprises community-dwelling individuals aged 65 years and

older from 30 municipalities (in 14 municipalities the entire population was surveyed, whereas in the remaining 16 municipalities random sampling was performed) who were not eligible to receive benefits from public long-term care insurance services (e.g., those without functional disability). Self-administered survey questionnaires were delivered by post to those who were listed in a ledger of individuals insured for long-term care. The participants of the JAGES might be healthier than the average older Japanese population because one of the inclusion criteria to participate in the JAGES study is not receiving long-term care. The data used were from participants aged ≥65 years (n = 137,736, response rate = 71%), with a fifth randomly chosen and questioned for information on adverse experiences in childhood (n = 26,229) in 2013. The participants of the current study were restricted to an age range of 65-74 years (n = 15,070). Participants with missing data on any ACEs (n=1,158), self-rated health (SRH) (n=325), body mass index (BMI) (n= 483), and smoking (n=163) were excluded.

The Finnish data were drawn from two prospective cohort studies, the Finnish Public Sector (FPS) study[24] and the Health and Social Support (HeSSup) study.[25] The FPS study included employees representing a wide range of occupations working in ten towns and six hospital districts. The participants of the FPS were individuals who were, at the time of the study or had previously been, public sector employees; thus, they did

not fully represent the general Finnish population of the same age. The FPS data used in this study were derived from employed and retired participants in the 2008/2009 survey, and included information on self-reported ACEs (n = 42,877, response rate = 69%). For this study, all FPS study respondents were aged ≥60 years, and those who provided information on any ACEs, SRH, BMI, and smoking were selected (n=7,169). The HeSSup study targeted a sample representative of the Finnish population in four age groups (20–24, 30–34, 40–44, and 50–54 years), in 1998. Therefore, the participants of the HeSSup may be representative of the Finnish population.[26] In the 2012 follow-up survey, information on self-reported ACEs was obtained from 11,924 participants (response rate = 78%). Of them, those in the oldest age group (64–68 years) who provided data on any ACEs, SRH, BMI, and smoking were selected (n = 3,184). Self-administered survey questionnaires were used in the FPS and HeSSup studies. The two Finnish cohorts were pooled. The studies together included 13,123 (6,214 men and 6,909 women) participants from Japan and 10,353 (3,201 men and 7,152 women) participants from Finland.

The JAGES was approved by the Ethics Committee for Research on Human Subjects at Nihon Fukushi University, Japan (No. 10–05) and the Ethics Committee for Medical Research at the University of Tokyo (No. 10555). The FPS study was approved

by the Ethics Committee of the Helsinki and Uusimaa Hospital District and HeSSup study by the joint Ethics Committee of the University of Turku and the Turku University Central Hospital. The studies include ethical approval for secondary analyses. The information on data management and handling is relevant and available for the study administrators in each country. We did not handle any personal identifiers in the analysis.

**Participants and Public Involvement**

Patients were not involved in the development of the research question, outcome measures, design, or conduct of the study.

**Measurement of adverse childhood experiences**

The questions related to ACEs were somewhat different between the three studies, but the variables were harmonised. In short, we assessed three ACEs: (1) parental divorce (the FPS study, HeSSup study, and JAGES), (2) fear of a family member (FPS and HeSSup studies)/witness of domestic violence or physical abuse (JAGES), and (3) financial difficulties in the family (FPS study, HeSSup study, and JAGES).

In the JAGES, we assessed ACEs using four questions modified from Felitti's original ACE study[1] and the World Mental Health survey in Japan.[27] Respondents were asked if they had experienced the following adversities in their childhood (yes/no):

parents' divorce/separation, financial difficulties in the family, being witness to domestic violence, or physical abuse. We categorised those who responded having experienced "being witness to domestic violence" and/or "physical abuse" as having "frequent fear of a family member" to make these ACEs comparable to those in the FPS and HeSSup studies. Violence against the child (physical abuse) and the mother (witnessing domestic violence) may both result in "fear of a family member", and we therefore coded witness of domestic violence or physical abuse as "fear of a family member". These ACEs measures have been shown to predict the number of remaining teeth[28] and higher functional limitation in Japan.[29] In the FPS and HeSSup studies, we assessed ACEs using three survey questions modified from Statistics Finland's Survey of Living Conditions.[30] Respondents were asked whether they had experienced the following adversities: parent's divorce/separation, long-term financial difficulties in the family, and frequent fear of a family member (the response categories "no", "yes", and "cannot say" were coded as dummy variables), and the findings have been used in other studies to predict the presence of coronary heart disease,[31] depression,[31] and non-adherence to statin therapy.[7] The questions regarding each ACE are shown in Supplemental table S1.

For the present study, the three ACEs were analysed both separately and as a summary variable (0, 1, 2 and 3 ACEs).

**Measurement of adult health and health behaviours**

Questions on adult health and health behaviours were somewhat different between the countries. In the JAGES, SRH was measured using the question: "How do you feel about your current health status: excellent, good, fair, or poor?" Responses were recoded to dichotomous response variables (fair/poor as 0, and excellent/good as 1). A history of being diagnosed with cancer, heart diseases or stroke, or diabetes mellitus was self-reported (response categories: "yes" and "no"). BMI was calculated as participants' self-reported weight in kilograms divided by height in meters squared. The smoking status (current, former, or never) was based on replies to survey questionnaires.

In the FPS and HeSSup studies, SRH was measured through the question: "How is your current health status?" with five response categories (from 1 [poor] to 5 [excellent]). The responses "moderate", "good", and "excellent" were categorised as good (1), and the other response options as poor (0). Information on cancer was derived from the National Cancer Registry, and prevalent cardiovascular disease (heart disease or stroke) and diabetes mellitus were defined based on the special reimbursement for the medication for these diseases, as obtained from the Social Insurance Institution of Finland. In FPS and HeSSup, we used personal identification codes, assigned to all Finnish citizens,

to link the respondents to their records in national health registers. BMI was calculated from self-reported weight and height. Smoking status (current, former, and never) was based on survey responses. Questions regarding health and health behaviours are shown in Supplemental table S2.

**Covariates**

Education was divided into three levels: (i) 9 years or less, referring to a comprehensive school education in Finland and junior high school education in Japan, (ii) 9–12 years, describing post-compulsory secondary general academic and vocational education in Finland and high school or technical college education in Japan, and (iii) 12 years or more, referring to a university degree in both countries. Marital status was divided into four categories: (i) single, never married and non-cohabiting, (ii) widowed, (iii) divorced, and (iv) married or cohabiting with a partner. Working status was divided into two categories: (i) working and (ii) retired or never worked (Japan). Regarding working status, those who had never worked were not included in FPS because FPS is a study of individuals who were at the time of study, or had previously been, public sector employees and represented a wide range of occupations. Therefore, we combined 'retired and never worked' as 'not working' in Japan to be comparable with the studies in Finland.

Missing values were treated as dummy variables.

**Statistical analysis**

Logistic regression analysis was performed to examine the association of each ACE, any ACE, and the cumulative number of ACEs (e.g., 0, 1, 2, and 3 ACEs) with health outcomes. Linear regression analysis was used for BMI. Multinomial logistic regression was used for smoking status. Model 1 was adjusted for age and sex. Model 2 was further adjusted for education, marital status, and working status.

The odds ratios (ORs) and their 95% confidence intervals (95% CIs) were calculated. Statistical analysis was performed using Stata (ver. 13.1; StataCorp, College Station, TX, USA).

**RESULTS**

Table 1 shows the distribution of the variables for each country. The prevalence rates of parental divorce, fear of a family member, and childhood poverty were 3%, 9%, and 47%, respectively, in Japan. In Finland, these proportions were 9%, 13%, and 29%, respectively. Of the respondents, 50% of those in Japan and 37% of those in Finland reported having experienced at least one ACE. The mean age of the participants and the proportion of men

were higher in Japan than in Finland.

Table 1. Characteristics of the study participants

| | | Japan (JAGES) (N = 13,123) | | Finland (pooled FPS and HeSSup studies) (N = 10,353) | | |
|---|---|---|---|---|---|---|
| | | N or mean | % or SD | N or mean | % or SD | |
| Parental divorce | | 336 | 2.6 | 958 | 9.3 | p <0.01[a] |
| Fear of a family member | | 1195 | 9.1 | 1348 | 13.0 | p <0.01[a] |
| Childhood poverty | | 6135 | 46.8 | 3013 | 29.1 | p <0.01[a] |
| Any adverse childhood experience | | 6561 | 50.0 | 3852 | 37.2 | p <0.01[a] |
| Total number of adverse childhood experiences | 0 | 6562 | 50.0 | 6501 | 62.8 | p <0.01[a] |
| | 1 | 5517 | 42.0 | 2634 | 25.4 | |
| | 2 | 983 | 7.5 | 969 | 9.4 | |
| | 3 | 61 | 0.5 | 249 | 2.4 | |
| Age | | 69.5 | 2.8 | 64.4 | 2.9 | p <0.01[b] |
| Sex | Male | 6214 | 47.4 | 3201 | 30.9 | p <0.01[a] |
| | Female | 6909 | 52.7 | 7152 | 69.1 | |
| SRH | Poor/fair | 1770 | 13.5 | 3780 | 36.5 | p <0.01[a] |
| Cancer | | 460 | 3.5 | 388 | 3.8 | p <0.32[a] |
| | Missing | | | 54 | 0.5 | |
| Heart disease or stroke | | 1353 | 10.3 | 466 | 4.5 | p <0.01[a] |
| | Missing | | | 54 | 0.5 | |
| Diabetes mellitus | | 1738 | 13.2 | 714 | 6.9 | p <0.01[a] |
| | Missing | | | 54 | 0.5 | |
| BMI mean | | 23.0 | 3.1 | 26.7 | 4.4 | p <0.01[b] |

| | | | | | | |
|---|---|---|---|---|---|---|
| Smoking | Never | 9221 | 70.3 | 6973 | 67.4 | p <0.01[a] |
| | Former | 2221 | 16.9 | 2444 | 23.6 | |
| | Current | 1681 | 12.8 | 936 | 9.0 | |
| Education | <9 years | 4395 | 33.5 | 1868 | 18.0 | p <0.01[a] |
| | 10-12 years | 5476 | 41.7 | 3168 | 30.6 | |
| | 12+ years | 3103 | 23.7 | 5234 | 50.6 | |
| | Missing | 149 | 1.1 | 83 | 0.8 | |
| Marital status | Single | 326 | 2.5 | 574 | 5.5 | p <0.01[a] |
| | Divorced | 535 | 4.1 | 1414 | 13.7 | |
| | Widowed | 1606 | 12.2 | 741 | 7.2 | |
| | Married/cohabit | 10441 | 79.6 | 7557 | 73.0 | |
| | Missing | 215 | 1.6 | 67 | 0.7 | |
| Working status | Not working | 8604 | 65.6 | 3092 | 29.9 | p <0.01[a] |
| | Working | 4062 | 31.0 | 7230 | 69.8 | |
| | Missing | 457 | 3.5 | 31 | 0.3 | |

JAGES; Japan Gerontological Evaluation Study, FPS; Finnish Public Sector, HeSSup; Health and Social Support, SD; standard deviation, SRH; self-rated health, BMI; body mass index

a: Chi-squared test. b: t-test

As for SRH, the rate of "poor or fair" was higher in Finland than in Japan (37% and 14%, respectively). The prevalence of cancer was similar in both countries; however, that of heart disease or stroke and diabetes mellitus was higher in Japan. As for BMI, the mean BMI was higher in Finland than in Japan. The distribution of smoking status was

similar. In the case of socioeconomic status, 50% of the people in Finland and 24% of those in Japan were educated for 12 years or more. Of the participants in Finland, 70% were currently working, whereas 66% of those in Japan were currently not working.

Table 2 shows the association between ACEs and SRH, and diseases (e.g., cancer, heart disease or stroke, and diabetes mellitus). SRH was associated with each type of ACE and the number of ACEs, for both countries. Interestingly, the point estimates were similar. For example, the OR of the number of ACEs for poor/fair SRH was 1.35 (95% CI: 1.25-1.46) in Japan and 1.34 (95% CI: 1.27-1.41) in Finland, after adjusting the covariates (Model 2). The ORs of the number of ACEs for cancer, heart disease or stroke, and diabetes mellitus were also similar in both studies in Model 2. As for each ACE, fear of a family member showed significant risk for cancer and diabetes in Finland, which was not observed in Japan.

Table 2. Association between adverse childhood experiences and poor self-rated health and diseases among older adults in Japan and Finland.

| | | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| SRH (poor/fair) | Parental divorce (ref.no): Yes | **1.40** | **1.05 - 1.86** | **1.34** | **1.004 - 1.80** | **1.37** | **1.20 - 1.57** | **1.30** | **1.13 - 1.49** |
| | Fear of a family member (ref.no): Yes | **1.77** | **1.52 - 2.05** | **1.70** | **1.46 - 1.98** | **1.65** | **1.47 - 1.85** | **1.56** | **1.39 - 1.76** |
| | Childhood poverty (ref.no): Yes | **1.46** | **1.32 - 1.62** | **1.32** | **1.19 - 1.47** | **1.68** | **1.54 - 1.83** | **1.60** | **1.46 - 1.75** |
| | Any ACE (ref.no): Yes | **1.50** | **1.36 - 1.67** | **1.37** | **1.23 - 1.52** | **1.66** | **1.53 - 1.80** | **1.60** | **1.47 - 1.74** |
| | Number of ACEs (continuous variable) | **1.43** | **1.33 - 1.54** | **1.35** | **1.25 - 1.46** | **1.39** | **1.32 - 1.46** | **1.34** | **1.27 - 1.41** |
| Cancer | Parental divorce (ref.no): Yes | 1.32 | 0.78 - 2.24 | 1.40 | 0.82 - 2.38 | 1.16 | 0.82 - 1.62 | 1.19 | 0.84 - 1.67 |
| | Fear of a family member (ref.no): Yes | 0.99 | 0.72 - 1.37 | 1.01 | 0.73 - 1.40 | **1.36** | **1.03 - 1.80** | **1.40** | **1.06 - 1.85** |
| | Childhood poverty (ref.no): Yes | **1.26** | **1.04 - 1.52** | **1.31** | **1.08 - 1.59** | 1.05 | 0.84 - 1.32 | 1.07 | 0.86 - 1.35 |
| | Any ACE (ref.no): Yes | **1.26** | **1.04 - 1.52** | **1.31** | **1.08 - 1.59** | 1.11 | 0.90 - 1.36 | 1.13 | 0.91 - 1.39 |
| | Number of ACEs (continuous variable) | **1.16** | **1.008 - 1.33** | **1.20** | **1.04 - 1.38** | 1.11 | 0.97 - 1.26 | 1.13 | 0.99 - 1.28 |
| Heart disease or stroke | Parental divorce (ref.no): Yes | 1.30 | 0.94 - 1.81 | 1.26 | 0.91 - 1.76 | 0.93 | 0.66 - 1.32 | 0.90 | 0.63 - 1.27 |
| | Fear of a family member (ref.no): Yes | 1.13 | 0.94 - 1.37 | 1.10 | 0.91 - 1.32 | 1.16 | 0.88 - 1.54 | 1.11 | 0.84 - 1.48 |
| | Childhood poverty (ref.no): Yes | **1.16** | **1.03 - 1.30** | 1.11 | 0.99 - 1.25 | **1.35** | **1.10 - 1.64** | **1.30** | **1.07 - 1.59** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Any ACE (ref.no): Yes | **1.15** | **1.02 - 1.29** | 1.10 | 0.97 - 1.24 | **1.32** | **1.09 - 1.59** | **1.28** | **1.05 - 1.55** |
| | Number of ACEs (continuous variable) | **1.14** | **1.04 - 1.24** | **1.10** | **1.01 - 1.20** | **1.14** | **1.01 - 1.28** | 1.11 | 0.98 - 1.25 |
| Diabetes mellitus | Parental divorce (ref.no): Yes | 1.29 | 0.96 - 1.73 | 1.30 | 0.97 - 1.74 | **1.37** | **1.07 - 1.75** | **1.34** | **1.05 - 1.72** |
| | Fear of a family member (ref.no): Yes | 1.11 | 0.94 - 1.32 | 1.12 | 0.95 - 1.33 | **1.46** | **1.18 - 1.80** | **1.42** | **1.15 - 1.76** |
| | Childhood poverty (ref.no): Yes | 1.07 | 0.97 - 1.19 | 1.06 | 0.95 - 1.18 | 1.15 | 0.97 - 1.35 | 1.12 | 0.95 - 1.32 |
| | Any ACE (ref.no): Yes | **1.12** | **1.01 - 1.24** | **1.11** | **1.001 - 1.24** | **1.21** | **1.04 - 1.42** | **1.19** | **1.02 - 1.39** |
| | Number of ACEs (continuous variable) | **1.08** | **1.001 - 1.17** | 1.08 | 0.995 - 1.17 | **1.18** | **1.08 - 1.30** | **1.17** | **1.06 - 1.28** |

"Any" denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, OR; odds ratio, CI; confidence interval; SRH, self-rated health; ref., reference

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Odds ratios (95% confidence intervals) were derived from logistic regression models.

Bold text indicates statistically significant with a p-value less than 0.05.

Table 3 shows the associations between ACEs and smoking. Former smoking and current smoking were positively associated with the number of ACEs for both counties, and the ORs were similar. Table 4 shows the association between ACEs and BMI. BMI was positively associated with each type of ACE, and with the number of ACEs in Finland. This positive association was also significant in Japan.

Table 3. Association between adverse childhood experiences and former and current smoking among older adults in Japan and Finland.

| | | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Former smoking (ref: never) | Parental divorce (ref.no): Yes | 1.13 | 0.82 - 1.57 | 1.12 | 0.81 - 1.56 | **1.54** | **1.31 - 1.81** | **1.48** | **1.26 - 1.74** |
| | Fear of a family member (ref.no): Yes | 1.14 | 0.96 - 1.36 | 1.11 | 0.93 - 1.32 | **1.45** | **1.26 - 1.67** | **1.38** | **1.20 - 1.60** |
| | Childhood poverty (ref.no): Yes | **1.14** | **1.02 - 1.26** | **1.13** | **1.02 - 1.26** | **1.42** | **1.28 - 1.57** | **1.37** | **1.24 - 1.53** |
| | Any ACE (ref.no): Yes | **1.13** | **1.02 - 1.26** | **1.12** | **1.01 - 1.25** | **1.45** | **1.31 - 1.60** | **1.40** | **1.27 - 1.55** |
| | Number of ACEs (continuous variable) | **1.11** | **1.03 - 1.21** | **1.11** | **1.02 - 1.20** | **1.30** | **1.22 - 1.38** | **1.26** | **1.19 - 1.35** |
| Current smoking (ref: never) | Parental divorce (ref.no): Yes | **1.46** | **1.06 - 2.01** | 1.32 | 0.95 - 1.82 | **1.64** | **1.32 - 2.03** | **1.49** | **1.20 - 1.85** |
| | Fear of a family member (ref.no): Yes | **1.29** | **1.07 - 1.55** | 1.16 | 0.96 - 1.40 | **1.45** | **1.19 - 1.76** | **1.32** | **1.09 - 1.61** |
| | Childhood poverty (ref.no): Yes | **1.20** | **1.07 - 1.35** | 1.10 | 0.98 - 1.24 | 1.15 | 0.99 - 1.40 | 1.07 | 0.92 - 1.25 |
| | Any ACE (ref.no): Yes | **1.24** | **1.10 - 1.39** | **1.13** | **1.01 - 1.27** | **1.33** | **1.16 - 1.53** | **1.24** | **1.08 - 1.43** |
| | Number of ACEs (continuous variable) | **1.20** | **1.10 - 1.31** | **1.11** | **1.02 - 1.22** | **1.22** | **1.12 - 1.33** | **1.15** | **1.06 - 1.26** |

"Any" denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, OR; odds ratio, CI; confidence interval; ref, reference

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Odds ratios (95% confidence intervals) were derived from multinomial logistic regression models.

Bold text indicates statistically significant with a p-value less than 0.05.

Table 4. Association between adverse childhood experiences and body mass index among older adults in Japan and Finland.

| | Japan | | | | Finland | | | |
|---|---|---|---|---|---|---|---|---|
| | Model 1 | | Model 2 | | Model 1 | | Model 2 | |
| | Coef. | 95% CI | Coef. | 95% CI | Coef. | 95% CI | Coef. | 95% CI |
| Parental divorce (ref.no): Yes | 0.18 | -0.15 - 0.52 | 0.18 | -0.15 - 0.51 | **0.60** | **0.31 - 0.89** | **0.52** | **0.23 - 0.81** |
| Fear of a family member (ref.no): Yes | **0.22** | **0.03 - 0.40** | **0.20** | **0.02 - 0.39** | **0.49** | **0.24 - 0.75** | **0.40** | **0.15 - 0.65** |
| Childhood poverty (ref.no): Yes | **0.15** | **0.04 - 0.25** | 0.07 | -0.03 - 0.18 | **0.49** | **0.30 - 0.67** | **0.40** | **0.22 - 0.59** |
| Any ACE (ref.no): Yes | **0.14** | **0.03 - 0.24** | 0.07 | -0.04 - 0.18 | **0.40** | **0.23 - 0.57** | **0.33** | **0.15 - 0.50** |
| Number of ACEs (continuous variable) | **0.14** | **0.06 - 0.22** | **0.09** | **0.01 - 0.18** | **0.36** | **0.25 - 0.47** | **0.30** | **0.19 - 0.41** |

“Any” denotes the presence of at least 1 ACE.

ACE; Adverse childhood experience, Coef.; coefficient, CI; confidence interval; BMI, body mass index.

Model 1: Adjusted for age and sex. Model 2: Further adjusted for education, marital status, and working status.

Coefficients (95% confidence intervals) were derived from regression models.

Bold text indicates statistically significant with a p-value less than 0.05.

## DISCUSSION

To our knowledge, this is the first study that compares the impact of ACEs on health of older adults between two countries. This study showed that elderly individuals in Japan and Finland who had experienced ACEs had worse health profiles (sub-optimal SRH and presence of chronic diseases) and more often had biological and behavioural risk factors (high BMI and smoking) than those with no ACEs. The strength of these associations was weak or modest, and similar between the two countries, although careful interpretation is needed because the assessment of ACEs in Japan and Finland was different. The only exception was BMI, which showed a more robust association in the Finnish cohorts than in the Japanese cohort.

Our finding which highlights the association between ACEs and poor health among older adults is consistent with those of other studies. The association was weaker compared with those in other studies,[5-7 8] and this might be due to survival bias as we focused on older adults. Regarding SRH, the association between fear of a family member in childhood (i.e. in Japan, it was assessed as witness of intimate partner violence) and poor SRH among older adults was slightly stronger than that for parental divorce or childhood poverty in Japan; however, in Finland, such a difference was not observed. Considering that the prevalence of intimate partner violence in Japan was 0.1%, while 0.25% in Finland in the OECD report,[32] this result can be interpreted as the detection of intimate partner violence may not be as adequate in Japan compared with Finland, and thus the problem might be unresolved and showed stronger impact

for SRH in older age. Alternatively, physical punishment might be more pervasive in Japan than in Finland;[33] physical punishment is forbidden by law in Finland but not in Japan. Regarding cancer, childhood poverty was associated with cancer among older people in Japan, but this association was not observed in Finland. Childhood poverty in Japan might lead to poverty in older age,[29] which may result in delays in medical check-ups or consultations. Previous study has shown that adults with lower health literacy, which is more likely to happen among those living in poverty, are less likely to use healthcare services in Japan.[34]

Generally, the strength of these associations was similar between the two countries. The consistency of our results in harmonised cohorts from two different countries suggests that childhood adversities affect health similarly in these two societies. In spite of the differences in the cultural and social environments of older adults in these countries,[35 36] it is interesting to note that the associations observed were similar. A likely explanation could be the presence of universal healthcare system in these countries, which offers adequate medical treatment for diseases over one's life span, and is likely lead to the attenuation of the impact of ACEs on health later in life. This might explain the lower OR of ACEs for diseases comparing previous studies, because universal health care system might be effective to protect older adults with ACEs. In addition, the presence of equal free educational opportunities in both countries may explain the similar impact of ACEs on adult health, as educational attainment can attenuate the impact of ACEs on later health.[37] The presence of high social support,[38] cultural engagement,

access to trusted adults[39] in both countries may also attenuate the impact of ACEs on later-life health through the enhancement of resilience, described as the ability to adapt to adverse environment.[40] The effect of ACEs on health, in different educational or healthcare systems, requires further study.

Similarly, ACEs were associated with smoking, which is consistent with the findings of a previous comparative research in eight Eastern European countries[5] and other studies in the US,[1 41] UK,[42] and Finland[43], although this association was weak in the current study. The Eastern European comparative study reported that ACEs were associated with smoking among adults aged 14–66 years.[5] The relationship between ACEs and smoking has predominantly been investigated among adults towards middle age; however, few studies have examined these relationships using large community samples of older adults. Our results suggest that ACEs have a consistent long-term effect on smoking among older adults despite the differences in the price of cigarettes or smoking advertisements between the countries. A meta-analysis showed a moderate odds ratio for smoking among those with four or more ACEs compared with those with no ACEs.[8] The association was weaker in the current study than that in the meta-analysis, possibly because there were only three ACEs measured in the current study, and the association may have been underestimated because of early death due to smoking and ACEs (e.g., survival bias).

ACEs were associated with an increase in BMI in both countries; however, the impact

of ACEs was higher in Finland. This association was consistent with that observed in a previous study which showed that ACEs elevated the risk of obesity in the US,[1 2] UK,[42] and Finland.[44] The obesity rate among older individuals was higher in Finland than in Japan in the current study; thus, we used continuous BMI as an outcome. The presence of sampling bias in the current study may have also led to the lower impact of ACEs on BMI in Japan, as the JAGES included only individuals without nursing care.

On the contrary, "fear of a family member" showed significant positive association with cancer and diabetes in Finland, which was not observed in Japan. This might be due to the difference in the assessment of fear of a family member. In the Finnish study, it was asked as it is, while in JAGES, witness of domestic violence was used as a proxy measurement of fear of a family member. It may be possible that in Japan, witness of domestic violence may not always induce fear of a family member, say, if the child was used to it. Thus, in Japan the association was weak. Alternatively, fear of a family member may not necessarily be a risk factor for adult disease in Japan because of the rich social network, especially among kin relatives,[45 46] which provides an environment for children to escape from a fearful family member. Further study using the same question is needed to confirm whether the discrepancy is due to the difference in the assessment of social environment.

There are several limitations to this study. First, this was a cross-sectional study conducted among older adults. As ACEs were self-reported, differential recall bias cannot be

ruled out. Recent review showed poor agreement between prospective and retrospective assessment of childhood maltreatment.[47] However, in contrast, other review studies reported that the validity of retrospective assessment of ACEs is acceptable.[48 49] Second, these results, although based on harmonised measures, were derived from only two egalitarian developed countries, which preclude the generalisation of the findings to other countries. Further studies are warranted to investigate the association between other ACEs and adult disease in different cultural settings, and in low- and middle-income countries. Third, we did not assess other ACEs such as sexual abuse, neglect, childhood neighbourhood deprivation, or family disfunction (i.e., mental disorder of a family member, or incarcerated family member), and thus the number of ACEs were limited to only three. The limited number of ACEs precluded to assess stronger impact of ACEs on adult diseases, as a previous meta-analysis revealed.[8] Further studies are necessary to investigate the impact of other ACEs on the health of older adults. Fourth, there is a disparity in the measurement of ACEs and health, and ACEs and health behaviours, across the JAGES, FPS, and HeSSup. The differences in measurement might result in heterogeneity of the results. More specifically, the assessment of fear of a family member in the JAGES, FPS and HeSSup was different, which may result in heterogeneity between study estimates. Fifth, the participants in the JAGES did not have functional disability, and hence might be healthier than the average Japanese older population. Therefore, the results of the study might be underestimated. Alternatively, the results might be subjected to survival bias. The average age

of the study participants was 69.5 years in Japan and 64.4 years in Finland. People who passed away before the current study from ACE-related diseases or health risk behaviours would not have been included in the current study. Therefore, the results of the current study may underestimate the health effects of ACEs. Further, FPS was a not representative sample, thus the prevalence of diseases, such as cancer, may be different from other studies. Sixth, considering other covariates such as levels of inequality, current and previous household income, environmental risks (e.g., parental smoking), or genetic variation was not feasible due to data availability. In fact, education level was higher in the Finnish sample than in the Japanese sample. Finally, we were unable to pool the data of the two countries due to restriction on the Finnish data, and therefore interactive effects of the countries and ACE on adult health were unclear.

Nonetheless, this is the first study that investigated the association between ACEs and health and health behaviour among older people in two countries. In Japan and Finland, the relationship between ACEs and health was similar for SRH, specific diseases and smoking. The impact of ACEs on BMI was stronger in Finland than in Japan. These results suggest a notable association between ACEs and health among older people, and that this association remains consistent even in countries with a different social environment. Based on these findings, health policy to address ACEs is needed to prevent future diseases among older adults.

**Competing interests:** The authors declare that they have no conflict of interest.

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**Data sharing statement:** FPS and HeSSup data is not available for out of research team. JAGES data may be available if proposal is approved by research team.

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4 1 **Supplemental table S1**. Measurement of adverse childhood experience

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7 2 **Supplemental table S2**. Measurement of health and health behaviours

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Supplemental table S1. Measurement of adverse childhood experience

| Items | JAGES | | | FPS, HeSSup | | |
|---|---|---|---|---|---|---|
| | Question | Answer | Code | Question | Answer | Code |
| | Did you experience any of the following before the age of 18?; | | | The respondents were asked whether they had experienced the following adversities in their childhood: | | |
| **Parental divorce in childhood** | Parents' divorce | No | 0 | Divorce/separation of the parents | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |
| **Severe financial difficulties** | Financial trouble | No | 0 | Long-term financial difficulties in the family | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |
| **Fear of a family member** | 1) Your father was violent with your mother (being witness to domestic violence) 2) You were hit hard by your mother/father causing an injury (physical abuse) | No | 0 | Frequent fear for a family member | No | 0 |
| | | Yes[a] | 1 | | Yes | 1 |
| | | Unknown | missing | | Do not know or cannot say | missing |

**a: If someone answers yes to the question of either of 1) or 2), the code is "Yes".**

Supplemental table S2. Measurement of health and health behaviours

| Items | JAGES | | | FPS | | |
|---|---|---|---|---|---|---|
| | Question | Answer | Code | Question | Answer | Code |
| Self-rated health | How is your current health status? | Excellent | 0 | **How is your current health status?** | Good | 0 |
| | | Good | 0 | | Fairly good | 0 |
| | | Fair | 1 | | Moderate | 1 |
| | | Poor | 1 | | Fairly poor | 1 |
| | | | | | Poor | 1 |
| Cancer | Circle the number of all diseases for which you are currently receiving treatment or experiencing; Cancer | No | 0 | National Cancer Register | No | 0 |
| | | Yes | 1 | | Yes within 5 years | 1 |
| | | | | | Unknown | Missing |
| Heart disease or stroke | Circle the number of all diseases for which you are currently receiving treatment or experiencing; 1) Heart disease, 2) Stroke (e.g. brain hemorrhage, cerebral infarction) | No | 0 | Special reimbursement for the medication, from Social Insurance Institution of Finland | No | 0 |
| | | Yes[a] | 1 | | Yes | 1 |
| | | | | | Unknown | Missing |
| Diabetes mellitus | Circle the number of all diseases for which you are currently receiving treatment or experiencing; Diabetes mellitus | No | 0 | Special reimbursement for the medication, from Social Insurance Institution of Finland | No | 0 |
| | | Yes | 1 | | Yes | 1 |
| | | | | | Unknown | Missing |
| Smoking | Do you smoke cigarettes? | No | 0 | Do you smoke or have you ever smoked regularly, i.e. every day or almost every day? | Never | 0 |

| | | | | | |
|---|---|---|---|---|---|
| | I used to smoke | 1 | | Yes, before | 1 |
| | Yes | 2 | | Yes, I still do | 2 |

**a: If someone answers yes to the question of either of 1) or 2), the code is "Yes".**