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Lifetime determinants of cognitive ageing, dementia and early death

## Childhood socioeconomic disadvantage is associated with lower mortality in older Japanese men: the JAGES cohort study

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### Abstract

**Background:** Childhood socioeconomic disadvantage has been previously linked to increased mortality risk in adulthood. However, most previous studies have focused on middle-aged adults in Western contexts. Here, we sought to examine the association between childhood socioeconomic status (SES) and mortality among healthy older Japanese adults.

**Methods:** We conducted a 3-year follow-up of participants in the Japan Gerontological Evaluation Study (JAGES), a population-based cohort of 65- to 103-year-old Japanese adults. Childhood SES was assessed by survey at baseline. Mortality from 2010 to 2013 was analysed for 15 449 respondents (7143 men and 8306 women). Cox regression models were used to estimate hazard ratios (HR) for risk of death.

**Results:** A total of 754 deaths occurred during the 3-year follow-up. Lower childhood SES was significantly associated with lower mortality in men, but not in women. Compared with men growing up in more advantaged childhood socioeconomic circumstances, the age-adjusted HR for men from low childhood SES backgrounds was 0.75 [95% confidence interval (CI): 0.56–1.00]. The association remained significant after adjustment for height, education, adult SES, municipalities of residence, health behaviours, disease status and current social relationships (HR = 0.64; 95% CI 0.47–0.87). This association was stronger among men aged 75 years or older, HR = 0.67 (95% CI: 0.47–0.95), compared with men aged 65–74 years, HR = 0.90 (95% CI: 0.54–1.51).

**Conclusions:** Childhood socioeconomic disadvantage is associated with lower mortality among men aged 75 years or older, which may be due to selective survival, or alternatively to childhood physical training or postwar calorie restriction in this generation of Japanese males.

**Key words:** Childhood socioeconomic status, mortality, older adults, life course epidemiology

#### Key messages

- Childhood socioeconomic disadvantage was 'paradoxically' associated with lower mortality in Japanese men, but not in women.
- The association between childhood socioeconomic disadvantage and lower mortality was stronger among the 75-years-old or older participants compared with those aged 65–74 years, which may be due to selective survival, childhood physical training or postwar calorie restriction in this generation of Japanese males.

## Introduction

Childhood socioeconomic disadvantage is usually associated with increased risks of disease and mortality in adulthood, especially from cardiovascular disease.<sup>1</sup> The mechanism of this association is attributed to a combination of latency effects—for example, exposure to infectious disease during critical periods of development—and accumulation of risks over the life course (for example, low SES (socioeconomic status) children are more likely to be born with low birthweight, which may in turn affect school performance and SES achieved in adulthood).<sup>2,3</sup>

Most of the evidence, however, derives from middle-aged populations in Western contexts.<sup>4–9</sup> In Japan, improvements in life expectancy during the past half-century have been achieved in part through a swift decline in mortality rates from communicable diseases and stroke, beginning in the 1950s to early 1960s, followed by the introduction of universal health coverage from 1961.<sup>10,11</sup> High levels of literacy and education, as well as comparative equality in the distribution of incomes (at least through the 1980s) also contributed to the expansion of Japanese longevity.<sup>10,12,13</sup>

In addition to the foregoing factors, exposure to poverty and undernutrition in the aftermath of the Second World War (WWII) may be contributing to Japanese longevity, especially for the generation exposed to these conditions during childhood, i.e. people who are aged 70 years and older today. That is, the estimated average calorie intake after WWII in Japan was around 1900–2100 kcal,<sup>14</sup> which was lower than the estimated energy intake for Japanese in 2015 (2850 and 2300 kcal for men and women,

respectively, aged 15–17 years, physical activity level: 2),<sup>15</sup> and substantially lower than postwar UK calorie intake (2474 kcal in 1950).<sup>16</sup> Although the study was initiated in adult monkeys, experimental evidence from animal studies suggests that calorie restriction reduces age-related morbidity and prolongs survival.<sup>17</sup> When initiated in young monkeys, there was a trend for a delay in age-associated disease onset in calorie-restricted monkeys.<sup>18</sup> We therefore hypothesized that Japanese individuals who survived deprived circumstances in childhood might paradoxically experience lower mortality in later adulthood.

The Japan Gerontological Evaluation Study (JAGES) is a large-scale cohort study of community-dwelling older Japanese people aged 65 or older at the time of cohort inception in 2010. The youngest cohort participants were born around 1945 and grew up in the postwar period. They survived food shortages during and after WWII,<sup>19</sup> and the study thus affords a test of the hypothesis that deprived childhood socioeconomic circumstances might prolong longevity.

## Materials and Methods

### Study design and subjects

The JAGES was established in 2010 to evaluate the social determinants of healthy ageing among non-disabled people aged 65 years or older, sampled from 23 municipalities in 8 (out of 47) prefectures throughout Japan. The baseline survey was conducted between August 2010 and January 2012, wherein self-reported questionnaires were distributed by mail to 106 468 people aged 65 years or older who

were physically and cognitively independent and living independently in the community. A simple random sample was obtained from the official residence registers in 12 large municipalities, as well as a complete census of older residents residing in the remaining 11 smaller municipalities. A total of 70 538 participants returned the questionnaire (response rate: 66%). One-fifth of the sample ( $n = 16\,465$ ) were randomly selected to receive the survey module enquiring about childhood socioeconomic circumstances. The analytical sample for the present study comprised 15 449 participants (7143 men and 8306 women), after the following exclusions: participants missing responses to the questions related to childhood SES ( $N = 682$ ); and participants who reported limitations in activities of daily living, defined as being unable to walk, take a bath or use the toilet without assistance, who were included in this study accidentally, to ensure that the sample is actually physically and cognitively independent ( $N = 334$ ).<sup>20</sup> The Human Subjects Committees of Nihon Fukushi University (No. 10–05) and Chiba University Faculty of Medicine (No. 1777) approved the parent JAGES protocol. The Ethics Committee of the University of Tokyo, Faculty of Medicine (No. 10555) approved the analysis of data in the present study.

### Ascertainment of vital status

Ascertainment of vital status during the mean follow-up period of 3 years, from 2010 to 2013 (minimum: 2.1 years, maximum: 3.8 years), was conducted by linking the cohort participants to the mortality records of the national long-term care insurance database. Under the Japanese long-term care insurance system (introduced in 2001), physicians submit information from death records to their local municipal government. Among the respondents, 98% of participants were successfully linked to the death records, and a total of 754 deaths occurred during the 3-year follow-up (cumulative mortality = 754/15 449, 4.9%). Number of cumulative mortality (deaths) was 306 (11.7%) for the 75 years or older men, 192 (4.3%) for 65–74-years-old men, 170 (5.1%) for the 75 years or older women, 86 (1.7%) for 65–74-years-old women (Supplementary Table 2, available as Supplementary data at *IJE* online). Information on specific cause of death was not released due to the small number of deaths in each municipality, and thus our main outcome was all-cause mortality.

### Childhood socioeconomic status

We asked participants to rate their childhood socioeconomic circumstances using the following question: ‘How

would you rate your socioeconomic status at the age of 15 years according to standards at that time?’ For example, an 80-year old respondent in 2010 would be recalling circumstances in 1945 when they were 15 years old. Responses were arranged on a five-point Likert scale: ‘high’, ‘middle-high’, ‘middle’, ‘middle-low’ and ‘low’. We collapsed responses into three categories: high (including ‘high’ and ‘middle-high’), middle, and low, (including ‘middle-low’ and ‘low’) to maximize the sample size for each category.<sup>21</sup>

### Covariates

Age at entry was categorized into four groups (65–69, 70–74, 75–79 and  $\geq 80$  years; corresponding birth years are 1941–45, 1936–40, 1931–35 and  $\leq 1930$ , respectively). Potential mediators of the association between childhood SES and mortality, such as years of schooling, height, adult SES, health behaviours, disease status, depressive symptoms and current social relationships, were assessed by self-administered questionnaire. Height was used as a proxy of the childhood nutritional environment and disease history,<sup>22</sup> and was categorized into five groups at 5-cm intervals for each sex: for men:  $< 155$ , 155–159.9, 160–164.9, 165–169.9 and  $\geq 170$  cm; and for women:  $< 145$ , 145–149.9, 150–154.9, 155–159.9 and  $\geq 160$  cm.<sup>21</sup> Years of schooling were categorized into three groups ( $\leq 9$ , 10–12 or  $\geq 13$  years). Indicators of adulthood SES included current annual household income ( $< 2.00$ , 2.00–3.99 or  $\geq 4.00$  million yen), home ownership (own home, or renting) and longest-held occupation, categorized as: non-manual (professional, technical or managerial workers), manual (clerical, sales/service, skilled/labour or agricultural/forestry/fishery workers or other) or no occupation.<sup>23</sup> Health behaviours included smoking status (non-smoker or smoker/ex-smoker), frequency of meat/fish intake ( $\geq 1$ /day or  $< 1$ /day), frequency of vegetable/fruit intake ( $\geq 1$ /day or  $< 1$ /day), walking time ( $< 30$  min/day or  $\geq 30$  min/day) and body mass index [obesity ( $\geq 30.0$  kg/m<sup>2</sup>), overweight (25.0–29.9 kg/m<sup>2</sup>), normal (18.5–24.9 kg/m<sup>2</sup>) or underweight ( $< 18.5$  kg/m<sup>2</sup>)]. History of disease was assessed whether currently under medical treatment for any of the following 21 diseases (multiple responses were allowed): cancer, heart disease, stroke, diabetes mellitus, respiratory disease or others (hypertension, obesity, hyperlipidaemia, osteoporosis, joint disease/neuralgia, external injury/fracture, gastrointestinal disease, liver disease, psychiatric disease, dysphagia, visual impairment, hearing impairment, impaired excretion, sleep disorder and other). Depressive symptoms were assessed by the 15-item short form of the Geriatric Depression Scale (GDS) (Japanese version).<sup>24</sup> The assessment of current social relationships included

marital status (married, widowed or divorced/unmarried/other), number of social interactions with friends/acquaintances during the past month ( $\leq 5$  vs 6 or more times), providing and receiving emotional social support,<sup>25,26</sup> and social participation in a variety of groups or activities such as volunteer groups, sports groups, leisure activity groups, senior citizens' clubs, neighbourhood or residents' associations, etc.

### Statistical analysis

Data were analysed separately for men and women because the interaction term between sex and childhood SES showed marginal interaction effect ( $P = 0.19$ ), and previous study supports sex difference in the impact of SES on mortality in Japanese.<sup>27</sup> Cox proportional hazards models were estimated, yielding hazard ratios (HR) and 95% confidence intervals (CI) for all-cause mortality over the 3-year follow-up period. The following sequence of models was constructed: Model 1 was adjusted for age; Model 2 was additionally adjusted for height and education; Model 3 was further adjusted for adult SES (current annual household income, home ownership and longest-held occupation) as well as municipality of residence; Model 4 was additionally adjusted for health behaviours (smoking, frequency of meat or fish intake, frequency of vegetable or fruit intake, walking time and BMI), disease status and depressive symptoms; and Model 5 was additionally adjusted for current social relationships (marital status, number of social interactions, providing and receiving emotional social support, social participation). We further stratified our analyses by age group—65–74 years old vs 75 years or older—since the impact of childhood SES on mortality might differ for those who experienced WWII before adolescence (i.e. 65–74 years old) or after adolescence (75 years or older). We applied the multiple imputation methods for adequately addressing missing data on covariates. We generated 50 imputed datasets using the multiple imputation by chained equations by the 'mi impute chained' command in STATA. All analyses were conducted using Statistical Analysis Systems software version 9.4 (SAS Institute Inc., Cary, NC, USA) and STATA v13.

### Results

Overall, 53.1% of men and 37.3% of women reported low or middle-low SES in childhood and 8.7% of men and 16.2% of women reported high or middle-high SES (Table 1). As shown in Supplementary Table 1 (available as Supplementary data at *IJE* online), the validity of self-reported childhood socioeconomic circumstances is

supported by the correlation between low childhood SES and other indicators of deprivation, such as height, years of schooling and adult socioeconomic attainment. Around half of participants completed less than 10 years of formal schooling. Interestingly, percentage of missing values on current SES and smoking status was higher among females than males, which may represent the current Japanese situation among older adults that females worked as homemakers and tend not to work outside the home;<sup>28</sup> thus they fail to capture their current SES. Lower prevalence of smoking among older females may reflect their reluctance to admit to a socially proscribed habit.<sup>29</sup>

Data were analysed separately men from middle-low or low SES backgrounds in childhood. These 0.75 times less likely to die (95% CI: 0.56–1.00) compared with those who grew up in high or middle-high socioeconomic circumstance in childhood (Table 2). The proportional hazards assumption was checked by log-log survival plots. We observed no serious violation of the proportional hazards assumption. Successive adjustment for height and education, adult SES, municipality of residence, health behaviours, disease status and depressive symptoms strengthened the protective association between childhood deprivation and reduced mortality risk (HR 0.65; 95% CI: 0.48–0.88) (Model 4, Table 2). In the final model, after adjustment for social relationships, men from middle-low or low SES backgrounds in childhood were 0.64 (95% CI: 0.47–0.87) times less likely to die compared with their more advantaged peers. In contrast to men, no significant association between childhood SES and mortality was found for women (Table 3).

When we age-stratified the analyses, the protective association of deprived childhood socioeconomic circumstances and mortality was found for the 75-years-old or older males, but not for the 65–74-years-old males (Table 4), although the interaction term between age group and childhood SES was not statistically significant ( $P = 0.15$ ). Among women, childhood SES was not associated with mortality in either age group.

### Discussion

In this cohort of older Japanese individuals, deprived childhood socioeconomic circumstances were 'paradoxically' associated with reduced mortality risk among the 75-years-old or older males. Among women, low childhood SES was unrelated to later mortality. Neither pattern is consistent with findings previously reported from middle-aged populations in Western countries.<sup>5,6</sup> We found that the impact of low childhood SES on mortality was weak among the 65–74-years-old group compared with those among the 75-years-old or older group. This may result

**Table 1.** Characteristics of older Japanese male ( $n = 7143$ ) and female ( $n = 8306$ ) participants

	Male ( $n = 7143$ )		Female ( $n = 8306$ )	
	N	%	N	%
Age (years)				
65–69 (birth year: 1941–45)	2496	34.9	2663	32.1
70–74 (birth year: 1936–40)	2022	28.3	2305	27.8
75–79 (birth year: 1931–35)	1489	20.9	1768	21.3
80 ≤ (birth year: -1930)	1136	15.9	1570	18.9
Childhood SES				
High or middle-high	620	8.7	1346	16.2
Middle	2733	38.3	3859	46.5
Middle-low or low	3790	53.1	3101	37.3
Height <sup>a</sup>				
Short	592	8.3	1142	13.8
Middle-short	1220	17.1	2376	28.6
Middle	2276	31.9	2637	31.8
Middle-tall	1810	25.3	1301	15.7
Tall	922	12.9	360	4.3
Missing	323	4.5	490	5.9
Education (years)				
High (≥ 13)	1330	18.6	801	9.6
Middle (10–12)	2194	30.7	2579	31.1
Low (≤ 9)	3316	46.4	4545	54.7
Other	43	0.6	41	0.5
Missing	260	3.64	340	4.1
Normalized current household income (million yen)				
High (≥ 4.00)	726	10.2	685	8.3
Middle (2.00–3.99)	2468	34.6	2276	27.4
Low (< 2.00)	2914	40.8	3278	39.5
Missing	1035	14.5	2067	24.9
Living situation				
Own home	6436	90.1	7384	88.9
Rent home	330	4.6	457	5.5
Other	47	0.7	90	1.1
Missing	330	4.6	375	4.5
Longest occupation				
Non-manual	2285	32.0	732	8.8
Manual	4230	59.2	5225	62.9
No occupation	27	0.4	625	7.5
Missing	601	8.4	1724	20.8
Smoking				
Non-smoker	1720	24.1	6664	80.2
Smoker/ex-smoker	4892	68.5	557	6.7
Missing	531	7.4	1085	13.1
Frequency of meat or fish intake over the past month				
≥ 1/day	2503	35.0	3308	39.8
< 1/day	4178	58.5	4506	54.3
Missing	462	6.5	492	5.9
Frequency of vegetable or fruit intake over the past month				
≥ 1/day	5026	70.4	6570	79.1
< 1/day	1688	23.6	1313	15.8
Missing	429	6.0	423	5.1
Walking time				
< 30 min/day	2082	29.2	2771	33.4
≥ 30 min/day	4629	64.8	4874	58.7

(continued)



Table 1. Continued

	Male (n = 7143)		Female (n = 8306)	
	N	%	N	%
Missing	432	6.1	661	8.0
Body weight status (BMI, kg/m <sup>2</sup> )				
Obesity ( $\geq 30.0$ )	138	1.9	246	3.0
Overweight (25.0–29.9)	1478	20.7	1511	18.2
Normal (18.5–24.9)	4804	67.3	5364	64.6
Underweight ( $< 18.5$ )	374	5.2	638	7.7
Missing	349	4.9	547	6.6
Disease				
Cancer (yes)	431	6.0	236	2.8
Heart disease (yes)	1029	14.4	759	9.1
Stroke (yes)	141	2.0	72	0.9
Diabetes mellitus (yes)	1133	15.9	862	10.4
Respiratory disease (yes)	329	4.6	212	2.6
Other (yes)	4574	64.0	5950	71.6
Depressive symptoms				
No depression (GDS $< 5$ )	4438	62.1	4797	57.8
Moderate depression ( $5 \leq \text{GDS} < 10$ )	1261	17.7	1397	16.8
Depression ( $10 \leq \text{GDS}$ )	412	5.8	481	5.8
Missing	1032	14.5	1631	19.6
Marital status				
Married	6071	85.0	4748	57.2
Widowed	570	8.0	2741	33.0
Divorced/unmarried/other	248	3.5	458	5.5
Missing	254	3.6	359	4.3
Social participation				
Yes	4888	68.4	5375	64.7
No	1569	22.0	1964	23.7
Missing	686	9.6	967	11.6
Number of social interactions with friends/acquaintances				
$\leq 5$ /month	3376	47.3	3441	41.4
$\geq 6$ /month	3232	45.3	4111	49.5
Missing	535	7.5	754	9.1
Social support (providing)				
Present	6019	84.3	7144	86.0
Absent	572	8.0	476	5.7
Missing	552	7.7	686	8.3
Social support (receiving)				
Present	6114	85.6	7482	90.1
Absent	541	7.6	277	3.3
Missing	488	6.8	547	6.6

<sup>a</sup>Height:  $< 155$ , 155–159.9, 160–164.9, 165–169.9 and  $\geq 170$  cm for men, and  $< 145$ , 145–149.9, 150–154.9, 155–159.9 and  $\geq 160$  cm for women.

from a weaker statistical power due to fewer deaths among the 65–74-years-old group, although the point estimates of HR for childhood SES in the 75-years-old or older group and in the 65–74-years-old group differ (Table 4, with interaction  $P = 0.15$  for childhood SES).

One explanation for our finding is selective survival at older ages, i.e. people who survive adverse circumstances earlier in life are a select group of hardy individuals.<sup>30</sup> This type of mortality ‘cross-over’ has been observed for African-Americans who experience higher mortality rates

than White Americans at younger ages, but higher survival rates after about 80 years.<sup>31,32</sup> In the context of our study, the participants from lower SES backgrounds during childhood were more likely to be exposed to adversities such as wartime food shortages and infectious diseases, and hence more likely to have died during younger ages (i.e. earlier than the baseline of observation). Further, it is possible that low childhood SES during WWII in Japan may be a specific aspect, such as childhood physical training through manual work, which acts as protective effect on mortality

**Table 2.** Hazard ratios (HR) with 95% CI for association of mortality with childhood SES in older Japanese men ( $n = 7143$ )

		Model 1	Model 2	Model 3	Model 4	Model 5
		HR (95%CI)	HR (95%CI)	HR (95%CI)	HR (95%CI)	HR (95%CI)
Childhood SES						
	High or middle-high	ref	ref	ref	ref	ref
	Middle	0.80 (0.60–1.08)	0.77 (0.57–1.03)	0.78 (0.58–1.06)	0.75 (0.56–1.02)	0.75 (0.55–1.01)
	Middle-low or low	0.75 (0.56–1.00)*	0.69 (0.51–0.93)*	0.71 (0.52–0.95)*	0.65 (0.48–0.88)**	0.64 (0.47–0.87)**
Childhood other environment						
Height	Short		ref	ref	ref	ref
	Middle-short		0.66 (0.48–0.91)*	0.69 (0.50–0.95)*	0.67 (0.49–0.93)*	0.67 (0.48–0.93)*
	Middle		0.71 (0.53–0.95)*	0.72 (0.54–0.97)*	0.67 (0.50–0.89)**	0.67 (0.50–0.90)**
	Middle-tall		0.79 (0.58–1.07)	0.81 (0.60–1.10)	0.73 (0.53–0.99)*	0.74 (0.54–1.01)
	Tall		0.79 (0.54–1.14)	0.79 (0.55–1.15)	0.68 (0.47–0.99)*	0.68 (0.47–0.99)*
Education	High		ref	ref	ref	ref
	Middle		1.05 (0.79–1.40)	1.03 (0.77–1.38)	1.01 (0.76–1.35)	0.99 (0.74–1.33)
	Low		1.26 (0.97–1.64)	1.15 (0.86–1.52)	1.12 (0.84–1.48)	1.06 (0.80–1.40)
	Other		0.65 (0.16–2.65)	0.64 (0.16–2.60)	0.60 (0.15–2.47)	0.56 (0.13–2.30)

Model 1: adjusted for age; Model 2: Model 1 + adjusted for childhood other environment (height and education); Model 3: Model 2 + adjusted for adult SES (normalized current household income, living situation and longest occupation) and municipalities of residence; Model 4: Model 3 + adjusted for health behaviours: smoking, frequency of meat or fish and vegetable or fruit intakes, walking time, BMI, disease status, and depressive symptoms; Model 5: Model 4 + adjusted for social relationship (marital status, number of social interactions with friends/acquaintances, providing and receiving emotional social support, and social participation).

\* $P < 0.05$ ; \*\* $P < 0.01$ .

**Table 3.** Hazard ratios (HR) with 95% CI for association of mortality with childhood SES in older Japanese women ( $n = 8306$ )

		Model 1	Model 2	Model 3	Model 4	Model 5
		HR (95%CI)	HR (95%CI)	HR (95%CI)	HR (95%CI)	HR (95%CI)
Childhood SES						
	High or middle-high	ref	ref	ref	ref	ref
	Middle	0.98 (0.69–1.38)	0.97 (0.68–1.38)	0.96 (0.67–1.38)	0.97 (0.68–1.39)	0.95 (0.66–1.36)
	Middle-low or low	1.04 (0.73–1.48)	0.98 (0.67–1.42)	0.98 (0.67–1.43)	0.94 (0.64–1.38)	0.91 (0.62–1.34)
Other characteristics						
Height	Short		ref	ref	ref	ref
	Middle-short		0.76 (0.54–1.07)	0.79 (0.56–1.10)	0.77 (0.55–1.09)	0.78 (0.55–1.10)
	Middle		0.68 (0.48–0.99)*	0.70 (0.49–1.01)	0.67 (0.47–0.97)*	0.68 (0.47–0.99)*
	Middle-tall		0.78 (0.50–1.22)	0.81 (0.51–1.27)	0.76 (0.48–1.20)	0.76 (0.48–1.21)
	Tall		0.84 (0.40–1.77)	0.84 (0.40–1.78)	0.77 (0.36–1.64)	0.77 (0.36–1.64)
Education	High		ref	ref	ref	ref
	Middle		0.70 (0.42–1.11)	0.65 (0.40–1.06)	0.69 (0.42–1.13)	0.70 (0.42–1.15)
	Low		0.92 (0.58–1.44)	0.84 (0.53–1.34)	0.92 (0.57–1.47)	0.90 (0.56–1.44)
	Other		1.23 (0.28–5.12)	1.07 (0.25–4.64)	1.14 (0.26–4.92)	1.06 (0.24–4.60)

Model 1: adjusted for age; Model 2: Model 1 + adjusted for childhood other environment (height and education); Model 3: Model 2 + adjusted for adult SES (current normalized household income, living situation and longest occupation) and municipalities of residence; Model 4: Model 3 + adjusted for health behaviours: smoking, frequency of meat or fish and vegetable or fruit intakes, walking time, BMI, disease status and depressive symptoms; Model 5: Model 4 + adjusted for social relationship (marital status, number of social interactions with friends/acquaintances, providing and receiving emotional social support, and social participation).

\* $P < 0.05$ ; \*\* $P < 0.01$ .

in older age. For example, childhood physical training through manual work was more likely to occur among low childhood SES. Post-WWII childhood manual work such as farming may strengthen physical toughness.<sup>33</sup> Kimura also showed that about 80% of men and about 60% of

women aged 15–19 years had jobs before WWII, and most of men were sent out to an apprenticeship after graduating from higher elementary school at the age of 14 years.<sup>34</sup> Further, men aged 10–14 years were mainly involved in agriculture with hard physical tasks, unlike young women



**Table 4.** Hazard ratios (HR) with 95% CI for association of mortality with childhood SES in older Japanese men ( $n = 7143$ ) and women ( $n = 8306$ ) by age group

			Model 1	Model 2	Model 3	Model 4	Model 5
			HR (95%CI)	HR (95%CI)	HR (95%CI)	HR (95%CI)	HR (95%CI)
Male	Younger (65–74 years)	Childhood SES High or middle-high	ref	ref	ref	ref	ref
		Middle	0.84 (0.49–1.43)	0.81 (0.47–1.38)	0.88 (0.51–1.51)	0.79 (0.46–1.36)	0.78 (0.45–1.35)
		Middle-low or low	0.90 (0.54–1.51)	0.84 (0.50–1.41)	0.88 (0.52–1.49)	0.78 (0.46–1.33)	0.76 (0.45–1.31)
	Older ( $75 \leq$ years)	Childhood SES High or middle-high	ref	ref	ref	ref	ref
		Middle	0.79 (0.55–1.12)	0.75 (0.53–1.08)	0.76 (0.53–1.09)	0.75 (0.52–1.08)	0.74 (0.51–1.07)
		Middle-low or low	0.67 (0.47–0.95)*	0.61 (0.42–0.88)**	0.63 (0.43–0.91)*	0.58 (0.40–0.85)**	0.57 (0.39–0.83)**
Female	Younger (65–74 years)	Childhood SES High or middle-high	ref	ref	ref	ref	ref
		Middle	0.81 (0.43–1.51)	0.81 (0.43–1.52)	0.77 (0.40–1.46)	0.76 (0.40–1.46)	0.72 (0.38–1.39)
		Middle-low or low	1.11 (0.60–2.04)	1.05 (0.55–1.98)	1.00 (0.52–1.92)	1.01 (0.52–1.96)	0.95 (0.49–1.85)
	Older ( $75 \leq$ years)	Childhood SES High or middle-high	ref	ref	ref	ref	ref
		Middle	1.10 (0.72–1.66)	1.06 (0.69–1.62)	1.05 (0.68–1.61)	1.05 (0.68–1.62)	1.04 (0.67–1.61)
		Middle-low or low	1.01 (0.65–1.58)	0.93 (0.58–1.49)	0.92 (0.57–1.48)	0.89 (0.55–1.45)	0.87 (0.54–1.42)

Model 1: adjusted for age; Model 2: Model 1 + adjusted for other childhood environment (height and education); Model 3: Model 2 + adjusted for adult SES (current normalized household income, living situation and longest occupation) and municipalities of residence; Model 4: Model 3 + adjusted for health behaviours: smoking, frequency of meat or fish and vegetable or fruit intakes, walking time, BMI, disease status and depressive symptoms; Model 5: Model 4 + adjusted for social relationship (marital status, number of social interactions with friends/acquaintances, providing and receiving emotional social support, and social participation). \* $P < 0.05$ ; \*\* $P < 0.01$ .

involved in housework.<sup>35</sup> The additional fact that men aged 17–40 years had to go off to war would further explain the protective effect of low childhood SES on mortality only among men.

In addition, ceiling effects from high background mortality rates could explain the lack of association between childhood SES and survival in women. That is, when background rates of events are very high, the associations with most risk factors become more difficult to detect. For example, the association between cigarette smoking and mortality becomes progressively weaker at older ages.<sup>36</sup> Turrell *et al.* also showed that risk of low childhood SES for mortality tended to be highest in the youngest age groups and the weakest in the oldest group.<sup>37</sup> However, a ceiling effect from high background mortality cannot explain the stronger association between low childhood SES and improved survival found in the 75-years-old or older men in our sample.

We hypothesized that the paradoxical protective effect of lower childhood SES on mortality derives from calorie restriction theory. Colman *et al.* proposed that caloric restriction during adult life, without malnutrition, reduced mortality in rhesus monkeys,<sup>38</sup> and caloric restriction during childhood may be associated with less chronic disease.<sup>18</sup> Indeed, food shortages were recorded in some parts of the country even before Pearl Harbor. Hunger in the aftermath

of WWII was compounded by a disastrous harvest in 1945 (the worst on record since 1910—a shortfall of almost 40% from normal yield) and further exacerbated by inefficiency and corruption in the postwar food distribution system.<sup>39</sup> Although we do not collect information about whether people with low childhood SES were more likely to be exposed to calorie restriction, it is possible that nutritional deprivation was more likely occur among those with low childhood SES, especially those growing up in urban areas after WWII.<sup>40</sup> Thus, the calorie restriction hypothesis may partially explain the protective effect of low childhood SES on later mortality, so long as the individual survived the adverse childhood experiences (e.g. more infectious disease) associated with low SES. Lower height—used as a proxy for childhood malnutrition<sup>22</sup>—was also associated with increased mortality; however, height is determined not only by childhood nutrition but also infection *in utero* or during childhood, as well as other adversity (e.g. psychosocial stress). In other words, in this cohort, height may not be strongly associated with nutritional status.

The difference between the sexes in the association between childhood SES and mortality may be a reflection of the biological fragility of males *in utero* and during infancy.<sup>41</sup> Male fetuses have a higher risk of death,<sup>42</sup> and boys are also affected by a higher infant mortality. Therefore, males, especially from deprived socioeconomic

backgrounds in childhood, may have been more likely to die earlier in life compared with females.

We observed that education was not associated with mortality in men and women. Again, this is possibly because childhood working, especially among male,<sup>35</sup> functioned as educational opportunity.

Several limitations of this study should be mentioned. First, childhood SES was assessed via subjective recall. Moreover, differential recall bias may occur between different age groups (e.g. adults aged 75 years or older may be more prone to recall bias). Previous research, however, supports the reliability of retrospective assessments of childhood SES using siblings' recall of childhood SES.<sup>43</sup> Moreover, we confirmed that childhood subjective SES was correlated with other objective indicators of deprivation such as height and SES achieved in adulthood (Supplementary Table 1). Subjective SES has been found to be a better predictor of health status than objective SES,<sup>44–46</sup> however, it is not easy to confirm the possible extent and direction of the resulting bias. Further research is needed to confirm the findings using objective childhood SES, such as parental occupation. Another limitation is that we did not directly enquire about wartime and post-war experiences such as experiences of hunger or the childhood hygiene environment. Specifically, we needed to enquire about occupational status and physical activity when participants were 15 years old or younger. Our analysis was limited to all-cause mortality, not cause-specific mortality. Future studies should examine cause-specific mortality, such as coronary heart disease, stroke or cancer, to clarify the effect of childhood SES. Lastly, the duration of follow-up (3 years) was comparatively short, which may result in underestimation of the effect of childhood SES on mortality among the 65–74-years-old group and among females.

In conclusion, our study provides new and contradictory findings on the association between adverse childhood socioeconomic circumstances and survival in a healthy older population. The evidence on the early life course impacts of socioeconomic deprivation—hitherto dominated by studies from Western contexts—may not be transferable to other contexts. Whether low childhood SES is a risk factor for increased mortality at advanced ages would seem to depend on the specific historical context, of which this cohort of Japanese who grew up during and after WWII provides an illustrative counter-example.

## Supplementary Data

Supplementary data are available at *IJE* online.

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## Author contributions

T.F., Y.T. and K.K. conceived the design; K.K. collected data; Y.T. reviewed literature; Y.T. wrote the first draft of the paper; I.K. and T.F. revised the first draft; N.K., Y.N.T., T.S. and K.K. edited the manuscript and all authors approved the final version of the manuscript.

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