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Article

Trends in socioeconomic inequalities in self-rated health, smoking, and physical activity of Japanese adults from 2000 to 2010

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ABSTRACT

Health disparities in Japan are attracting increasing attention. Temporal trends in health disparities should be continuously monitored using multiple indices of socioeconomic status (SES) and health-related outcomes. We explored changes in socioeconomic differences in the health of Japanese adults during 2000–2010. The data was taken from the Japanese General Social Surveys, the cross-sectional surveys for nationally representative samples of Japanese adults. We used 14,193 samples (individuals of 20–64 years of age) in our analysis. We estimated age-adjusted prevalence ratios of the lowest SES group in comparison with the highest SES group using Poisson regression models with robust error variance. Relative index of inequality (RII) and slope index of inequality (SII) were also calculated. We examined the changes in the association between health-related outcomes (self-rated health (SRH), smoking, and physical activity) and SES indices (income, education, occupation, and subjective social class identification). The results showed temporally expanding trends for the associations of current smoking with SES, especially among women, in both relative and absolute measures. In contrast, no expanding trends were seen for SRH and physical activity. Although the smoking rates declined through the first decade of the 21st century, the socioeconomic disparities in smoking prevalence among Japanese adults expanded, especially among women. Researchers and policymakers should continuously monitor the trends that may cause future disparities in smoking-related morbidity and mortality.

1. Introduction

A social gradient in health has been widely observed and is considered a common feature of societies, especially in Western countries (Kawachi & Kennedy, 2002; Marmot, 2004). The associations between socioeconomic status (SES) and health have been reported in many countries worldwide. However, the strength of the associations may vary depending on the SES indices, health outcomes, and countries (Davey Smith et al., 1998; Eikemo, Bambra, Joyce& Dahl, 2008; Geyer, Hemstrom, Peter, & Vagero, 2006; Hanibuchi, Nakaya, & Murata, 2012; von dem Knesebeck, Verde, & Dragano, 2006).

In recent times, health disparities in Japan have attracted increasing attention. The relatively low level of socioeconomic inequalities has previously been discussed as one of the possible determinants of the longevity in the Japanese population (Ikeda et al., 2011; Marmot & Smith, 1989). However, during the last few decades, the number of empirical studies on health inequalities in Japan has rapidly increased, probably due to the growing interest in the widening economic disparity (Tachibanaki, 2005), and the studies have shown associations between SES and health. Some of the examples are mortality (Fujino et al., 2005; Ito et al., 2008), cardiovascular disease incidence (Honjo, Iso, Inoue, Tsugane, & Japan Public Health Center-based Prospective Study, 2008), self-rated health (SRH) (Honjo et al., 2006; Shibuya, Hashimoto, &Yano, 2002), and health behaviors including smoking (Fukuda, Nakamura, & Takano, 2005a, 2005b). However, the strength of the associations seemed to be weaker in Japan than in other countries (Hanibuchi et al., 2012; Kagamimori, Gaina, & Nasermoaddeli, 2009; Martikainen, Lahelma, Marmot, Sekine, Nishi, & Kagamimori, 2004; Nakaya and Dorling 2005).

Trends in socioeconomic inequalities in health have been sufficiently reported in many European countries (Kunst et al., 2005). However, in Japan, most studies have considered a specific point in time and temporal changes in health inequalities have not been sufficiently investigated. A few studies have pointed out that changes in the trends of health disparity were seen in the 1990s.

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An ecological study examining the trends in the association between life expectancy and age-adjusted mortality and per capita income has reported that health inequalities had been decreasing until 1995 but increased between 1995 and 2000 (Fukuda, Nakao, Yahata, & Imai, 2007). However, individual level studies using the Comprehensive Survey of Living Conditions (CSLC), a large-scale nationwide survey by the Japanese government, have reported stable or narrowing trends in income-related health inequalities (Hiyoshi, Fukuda, Shipley, & Brunner, 2013b; Kondo, Subramanian, Kawachi, Takeda, & Yamagata, 2008; Asada & Ohkusa, 2004; Kachi, Inoue, Nishikitani, Tsurugano, Yano, 2013). Kachi et al. (2013) used CSLC between 1986 and 2007 and found that despite widening income inequalities, income-related inequalities in SRH among working age adults narrowed during the period of economic stagnation. This phenomenon, observed since the late 1990s, has been caused by the deterioration in SRH among the middle and high income groups.

These early studies have several limitations. Most of the studies used the same data (CSLC). Validation using other data sources is required to strengthen the evidence. As the health-related data from CSLC have been available every three years, they are not sufficient to explore temporal changes within relatively short periods. The SES indices of these studies, also related to the data source, have been limited to the income- and occupation-based classes. Education and subjective social class identification have remained unexplored. Outcome measures have been limited to SRH and health-related quality of life; however, health-related risk behaviors should also be explored in terms of temporal trends.

The present study analyzes the changes in socioeconomic disparities in health among Japanese adults since 2000. We examined (for the 2000–2010 period) the changes in associations between three health-related outcomes—SRH, smoking, and physical activity—and four SES measures—income, education, occupation, and subjective social class identification.

2. Methods

2.1. Data

We used the data from the Japanese General Social Surveys (JGSS) 2000–2010 for our analysis. The JGSSs are the cross-sectional social surveys that were conducted every one or two years: in 2000, 2001, 2002, 2003, 2005, 2006, 2008, and 2010. The JGSS data consists of a nationally representative sample of individuals of 20–89 years of age living in Japan selected using a two-stage stratified random sampling design. Data were collected using a combination of interviews and self-administered questionnaires. More details about the survey methods are available at the website of the JGSS (JGSS Research Center, 2016).

JGSSs in 2003, 2006, 2008, and 2010 used two types of self-administered questionnaires (Forms A and B) and assigned Form A to half of the subjects, and Form B to the other half. Form A mainly consists of replicating core questions, while Form B contains a module for specific topics in each survey year. In the present study, we only used the data from the Form A, which included our main outcome variables for health and health behaviors. The data were suitable for tracing time trend due to the consistency of the questionnaire. The numbers of valid response (response rates, for the years from 2000 to 2010) were 2893 (64.9%), 2790 (63.1%), 2953 (62.3%), 1957 (55.0%), 2023 (50.5%), 2124 (59.8%), 2060 (58.2%), and 2507 (62.2%). We limited the analytic samples to those of working age (20–64 years old) because, in older people, health disparity might have different characteristics (Nakaya & Dorling, 2005). The number of respondents was not sufficiently large for stratified analysis by age groups, and we removed the people aged 65–89 from our analysis. Therefore, the number of samples used for our analysis was 14,193 (6547 men and 7646 women).

An ethical review was not required because the JGSS data are available via the Social Science Japan Data Archive (Center for Social Research and Data Archives, 2016) for the secondary analysis for academic purposes.

2.2. Outcome

SRH was obtained using the question of "How would you rate your health condition?" with possible responses on a 5-point scale from 1 (Good) to 5 (Poor). The variable was dichotomized into 1 ("4" and "5": poor) and 0 ("1," "2," and "3": good). Smoking was defined as "1" if the respondent was a current smoker and as "0" otherwise. The frequency of exercise or sports activity was used as the outcome variable of physical activity. The respondents were asked, "Do you regularly do any exercises or play any sports (walking, swimming, baseball, etc.)?" The choice of answers was "several times a week, about once a week, about once a month, several times a year, and scarcely any exercise." Physical activity was defined as "1" if the respondents exercised or participated in sports about once a week or less and as "0" if they exercised several times a week. The question about physical activity was first included in the JGSS-2002; thus, the study period for this variable was 2002–2010.

2.3. Socioeconomic status (SES)

Income, education, occupation, and class identification were used as SES measures. Household incomes were used as categorical values. We took the median value of each category and then calculated equivalent income by dividing the household income by the square root of the number of family members. The equivalent income was categorized into four groups: <150 million yen, 150–299.9 million yen, 300–449.9 million yen, and ≥ 450 million yen, using about one-half of the median equivalent income as a cut-off value. Education was classified into four groups: junior high school, high school, junior/technical college, and university or above. For occupation, the original classification consisted of 188 categories. To obtain a ranked category according to the occupational class, we applied occupational prestige score from the National Survey of Social Stratification and Social Mobility in 1995 (Tsuzuki, 1998) and reclassified into quartiles. Occupational prestige score is an index of social positions based on occupation. A survey of the Japanese population was conducted, and the score was calculated as an average value of the occupational rating for each occupational category. For subjective class identification, respondents were asked, "If we were to divide the contemporary Japanese society into the following five strata, which would you say you belong to?" There were five strata: Upper, Upper Middle, Middle, Lower Middle, and Lower. Considering the extremely small number of "Upper" cases, "Upper" and "Upper Middle" were merged into one category, and thus the variable was reclassified into four groups.

2.4. Statistical analysis

We estimated age-adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) for the lowest SES category in comparison with the highest category, using binary health-related outcomes including SRH, smoking, and physical activity as dependent variables and each SES index as an independent variable. Poisson regression models with robust error variance (Zou, 2004) were fitted because odds ratios by logistic regression were considered inappropriate when the prevalence of outcomes was not rare and

changed over time. PRs were estimated for each survey year. We tested temporal trends of PRs using the slope coefficient of the linear regression with the estimated PR of each year as the dependent variable and survey year as the independent variable. The regression is weighted by the inverse of the variance of the PR estimates. Additionally, we calculated the relative index of inequality (RII) and slope index of inequality (SII), to take into account the cumulative distribution of each SES, and to evaluate both relative and absolute inequalities (Mackenbach & Kunst, 1997). Analyses were separated by gender and were performed using samples without missing values on health-related outcome, SES indices, or age. Students, homemakers, and those who were unemployed were not included in the analysis of occupation. All the statistical analysis were conducted by Stata 12.

3. Results

Table 1 shows the characteristics of the respondents and the percentages of those with poor SRH, currently smoking, and physically inactive for the survey year, age, and SES indices. As a whole, the prevalence of poor SRH and risk behaviors reduced during the study period, although the differences in physical inactivity were not statistically significant. Poor SRH became more

Table 1
Characteristics of the respondents and the percentages of poor self-rated health, current smoking, and physical inactivity.

			Men (n=6547)			Women (n=7646)		
	n	%	% Poor self-rated health	% Current smoking	% Physical inactivity	% Poor self-rated health	% Current smoking	% Physical inactivity
TOTAL	14,193	100.0	16.3	49.6	83.6	15.5	15.9	82.9
Year								
2000	2200	15.5	17.8	54.3		18.8	19.1	
2001	2067	14.6	17.5	52.8		17.5	16.4	
2002	2209	15.6	18.4	52.5	86.0	18.1	15.5	83.9
2003	1386	9.8	19.6	51.6	85.3	16.7	15.1	82.3
2005	1445	10.2	14.4	47.1	83.0	13.6	16.7	83.1
2006	1549	10.9	15.2	43.8	82.2	11.8	15.2	85.3
2008	1506	10.6	11.7	43.9	82.7	12.5	13.5	80.9
2010	1831	12.9	14.2	47.6	81.8	12.1	14.2	81.9
			$p < 0.001$[a]	$p < 0.001$[a]	n.s.[a]	$p < 0.001$[a]	$p < 0.05$[a]	n.s.[a]
Age								
20–29	2113	14.9	12.9	54.2	85.5	13.1	21.5	88.1
30–39	2928	20.6	13.9	54.3	88.6	13.2	20.0	88.8
40–49	3202	22.6	16.9	48.2	84.5	15.4	15.7	84.2
50–59	4003	28.2	17.6	49.1	83.2	17.3	12.7	79.8
60–64	1947	13.7	19.4	41.7	74.5	18.2	9.6	71.8
			$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]
Income								
< 150 million yen	994	10.3	26.6	54.4	84.8	21.9	22.0	84.3
150–299.9 million yen	3011	31.4	14.6	52.9	85.5	14.9	17.8	82.4
300–449.9 million yen	2784	29.0	16.6	48.1	82.5	14.0	14.1	85.5
≥ 450 million yen	2815	29.3	14.9	44.8	80.5	14.1	13.4	78.5
			$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.05$[a]	$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]
Education								
Junior high school	1666	11.8	20.6	55.1	87.6	22.7	18.9	84.0
High school	6978	49.5	16.4	55.4	84.7	15.8	18.8	82.1
Junior/technical college	2223	15.8	16.3	52.5	82.4	14.2	12.6	83.9
University or above	3228	22.9	14.4	39.0	81.0	10.7	7.7	83.6
			$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.01$[a]	$p < 0.001$[a]	$p < 0.001$[a]	n.s.[a]
Occupation								
prestige score ≤ 45.6	2939	27.5	14.6	54.4	85.8	14.2	19.2	86.4
45.61-49.70	2443	22.8	15.5	57.0	88.3	11.9	22.3	85.5
49.71-52.90	3183	29.8	14.7	45.6	83.2	13.5	15.5	85.0
≥ 52.91	2130	19.9	14.5	41.2	79.7	13.4	14.0	83.9
			n.s.[a]	$p < 0.001$[a]	$p < 0.001$[a]	n.s.[a]	$p < 0.001$[a]	n.s.[a]
Identification								
Lower	1032	7.3	31.8	57.1	87.3	28.2	28.7	86.1
Lower middle	4909	35.0	19.4	55.2	86.7	20.2	19.9	85.9
Middle	6515	46.4	11.9	46.3	81.8	12.3	12.6	82.3
Upper middle & Upper	1589	11.3	11.1	39.0	77.8	8.3	11.1	73.9
			$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]	$p < 0.001$[a]

n.s., not significant.

[a] p value for chi-square test.

prevalent with increasing age. The individuals currently smoking and physically inactive were more frequent among younger adults. Poor SRH, current smoking, and physical inactivity were clearly more prevalent in the lowest SES groups than in the higher groups, although this was not true for poor SRH for occupation in both genders as well as physical inactivity for education and occupation among women.

The results of Poisson regression are shown in Table 2 (men) and 3 (women). Age-adjusted PRs (95% CIs) for each outcome by survey year and *p*-values for temporal trends are presented. Although point estimates varied by year, the associations of SRH and health behavior with SES were observed, with some exceptions. For example, the associations between SRH and class identification, and between smoking and education were clear for both genders. These associations were significant for all survey years. In contrast, no significant associations were seen between SRH and occupation for either gender or between income and physical activity for men, regardless of the survey year.

Significant temporal trends in the associations between health-related outcomes and SES indices were seen for smoking. Among men, PRs for current smoking by income groups changed from 0.96 (0.69–1.35) in 2000 to 1.61 (1.18–2.21) in 2008 and 1.33 (0.97–1.84) in 2010. Among women, we observed significant temporal trends in the associations of current smoking with occupation and class identification. For occupation, PRs for current smoking changed from 1.46 (0.90–2.35) in 2000 to 2.17 (1.16–4.07) in 2010. For class identification, PRs were 1.50 (0.84–2.66) in 2000 and increased to 4.20 (2.27–7.78) in 2010. Income also showed increasing PRs during the study period: from 1.17 (0.70–1.96) in 2000 to 2.90 (1.48–5.67) in 2010, with marginal significance.

Similar temporal trends in smoking disparities were seen when we used RII. The results are summarized in Fig. 1 and the details

Table 2
Prevalence ratios (PRs) and temporal trends of poor self-rated health, current smoking, and physical inactivity in the lowest socioeconomic status group in comparison with the highest (men).

	Poor self-rated health			Current smoking			Physical inactivity		
	PRs		95%CIs	PRs		95%CIs	PRs		95%CIs
Income									
2000	1.84	*	(1.09–3.09)	0.96		(0.69–1.35)			
2001	1.74	+	(0.96–3.15)	1.10		(0.79–1.53)			
2002	2.47	***	(1.49–4.08)	1.14		(0.89–1.47)	1.07		(0.96–1.19)
2003	1.05		(0.51–2.15)	1.33	+	(0.97–1.83)	1.07		(0.92–1.23)
2005	2.53	**	(1.27–5.03)	1.03		(0.69–1.55)	0.99		(0.82–1.21)
2006	1.51		(0.67–3.41)	1.47	*	(1.06–2.02)	1.01		(0.83–1.22)
2008	1.26		(0.64–2.48)	1.61	**	(1.18–2.21)	1.08		(0.96–1.22)
2010	2.13	**	(1.21–3.75)	1.33	+	(0.97–1.84)	1.05		(0.91–1.21)
p for trend	n.s.			$p < 0.05$			n.s.		
Education									
2000	1.35		(0.89–2.03)	1.57	***	(1.28–1.92)			
2001	1.07		(0.67–1.70)	1.28	*	(1.04–1.58)			
2002	1.42	+	(0.94–2.15)	1.55	***	(1.28–1.88)	1.13	**	(1.04–1.22)
2003	1.68	*	(1.00–2.82)	1.33	*	(1.00–1.78)	1.19	**	(1.07–1.33)
2005	1.20		(0.66–2.20)	1.65	***	(1.28–2.12)	1.06		(0.94–1.18)
2006	0.86		(0.46–1.62)	1.61	**	(1.22–2.13)	1.12	*	(1.00–1.25)
2008	0.74		(0.35–1.59)	1.89	***	(1.44–2.49)	1.17	**	(1.05–1.29)
2010	1.77	+	(0.99–3.16)	1.45	*	(1.08–1.96)	1.09		(0.95–1.25)
p for trend	n.s.			n.s.			n.s.		
Occupation									
2000	0.94		(0.58–1.54)	1.34	**	(1.10–1.62)			
2001	1.15		(0.70–1.90)	1.19	+	(0.98–1.45)			
2002	1.01		(0.68–1.51)	1.30	**	(1.08–1.58)	1.06		(0.98–1.14)
2003	0.97		(0.55–1.71)	1.43	*	(1.04–1.96)	1.12	+	(0.99–1.28)
2005	1.15		(0.58–2.29)	1.31	+	(1.00–1.72)	1.15	*	(1.02–1.30)
2006	0.87		(0.47–1.63)	1.32	*	(1.02–1.71)	1.12	+	(0.99–1.25)
2008	0.70		(0.34–1.47)	1.64	**	(1.21–2.21)	1.01		(0.91–1.12)
2010	1.21		(0.71–2.07)	1.11		(0.87–1.43)	1.02		(0.91–1.14)
p for trend	n.s.			n.s.			n.s.		
Identification									
2000	2.11	*	(1.11–4.02)	1.46	**	(1.11–1.92)			
2001	4.03	***	(2.33–6.98)	1.11		(0.82–1.51)			
2002	3.20	***	(1.91–5.39)	1.27	+	(0.98–1.66)	1.09		(0.95–1.24)
2003	2.39	**	(1.25–4.59)	1.94	**	(1.32–2.84)	1.15	*	(1.00–1.31)
2005	2.53	*	(1.07–5.97)	1.39	+	(0.99–1.95)	1.12		(0.95–1.31)
2006	2.44	*	(1.23–4.86)	1.58	*	(1.05–2.38)	1.06		(0.91–1.23)
2008	2.26	*	(1.05–4.87)	2.01	***	(1.38–2.92)	1.11		(0.98–1.26)
2010	6.77	***	(2.46–18.57)	1.43	*	(1.02–2.00)	1.20	*	(1.04–1.40)
p for trend	n.s.			n.s.			n.s.		

+ $p < 0.1$.
n.s., not significant.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table 3
Prevalence ratios (PRs) and temporal trends of poor self-rated health, current smoking, and physical inactivity in the lowest socioeconomic status group in comparison with the highest (women).

	Poor self-rated health			Current smoking			Physical activity		
	PRs		95%CI	PRs		95%CI	PRs		95%CI
Income									
2000	1.89	**	(1.27–2.82)	1.17		(0.70–1.96)			
2001	1.75	*	(1.10–2.80)	1.84	*	(1.13–3.00)			
2002	1.56	+	(0.96–2.54)	1.18		(0.68–2.03)	1.10	+	(0.99–1.22)
2003	1.18		(0.72–1.92)	1.88	*	(1.09–3.26)	0.99		(0.87–1.13)
2005	1.29		(0.68–2.46)	1.97	*	(1.07–3.62)	1.22	**	(1.09–1.36)
2006	2.09	+	(0.98–4.49)	1.45		(0.74–2.84)	1.05		(0.93–1.18)
2008	1.57		(0.72–3.44)	2.08	*	(1.13–3.82)	1.04		(0.88–1.23)
2010	1.13		(0.54–2.38)	2.90	**	(1.48–5.67)	1.07		(0.93–1.22)
p for trend	n.s.			$p < 0.1$			n.s.		
Education									
2000	1.40		(0.86–2.30)	2.42	**	(1.44–4.06)			
2001	1.97	*	(1.13–3.45)	7.25	***	(3.28–16.01)			
2002	1.91	*	(1.05–3.47)	5.17	***	(2.33–11.46)	1.12	*	(1.01–1.24)
2003	1.20		(0.64–2.24)	3.50	**	(1.41–8.69)	1.17	*	(1.03–1.34)
2005	2.12	+	(0.89–5.02)	2.43	+	(0.99–5.95)	1.12	+	(0.99–1.27)
2006	2.06		(0.85–4.98)	5.74	***	(2.30–14.30)	1.13	*	(1.01–1.27)
2008	3.73	**	(1.59–8.76)	6.18	***	(2.44–15.66)	0.96		(0.80–1.14)
2010	1.96	+	(0.98–3.91)	5.34	***	(2.61–10.93)	1.13		(0.96–1.32)
p for trend	n.s.			n.s.			n.s.		
Occupation									
2000	1.12		(0.69–1.82)	1.46		(0.90–2.35)			
2001	0.97		(0.56–1.68)	1.18		(0.70–2.00)			
2002	1.16		(0.72–1.88)	1.11		(0.71–1.74)	1.06		(0.97–1.16)
2003	0.88		(0.44–1.73)	1.10		(0.55–2.19)	1.18	*	(1.00–1.39)
2005	1.45		(0.68–3.11)	2.14	*	(1.13–4.05)	0.99		(0.90–1.10)
2006	1.83		(0.80–4.18)	1.84	+	(0.98–3.43)	1.02		(0.92–1.11)
2008	0.62		(0.31–1.24)	2.28	*	(1.14–4.54)	1.04		(0.93–1.17)
2010	0.70		(0.36–1.36)	2.17	*	(1.16–4.07)	1.04		(0.95–1.14)
p for trend	$p < 0.1$			$p < 0.05$			n.s.		
Identification									
2000	2.74	***	(1.56–4.82)	1.50		(0.84–2.66)			
2001	3.83	***	(1.87–7.83)	1.97	*	(1.04–3.74)			
2002	3.66	***	(1.97–6.80)	2.93	**	(1.52–5.63)	1.20	*	(1.04–1.38)
2003	3.48	**	(1.71–7.11)	2.39	*	(1.12–5.11)	1.28	*	(1.06–1.54)
2005	2.71	*	(1.11–6.62)	2.27	*	(1.02–5.10)	1.19	+	(0.99–1.42)
2006	15.97	**	(2.13–119.45)	2.27	*	(1.02–5.05)	1.15	*	(1.01–1.32)
2008	5.03	*	(1.47–17.24)	4.62	**	(1.81–11.80)	1.05		(0.88–1.25)
2010	3.27	**	(1.59–6.73)	4.20	***	(2.27–7.78)	1.15	*	(1.00–1.32)
p for trend	n.s.			$p < 0.05$			n.s.		

+ $p < 0.1$.
n.s., not significant.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

are shown in Appendices A (men) and B (women). Among women, a significant increasing trend in the association of education with smoking was also observed; therefore, all of the four SES indices showed significant or marginally significant increasing trends in RII for smoking. Among men, trends in the association between smoking and income were no longer statistically significant, while trends in the associations of smoking with class identification were significant. The results of SII are also summarized in Fig. 1 and the details are shown in Appendices C (men) and D (women). Significant increasing trends were observed in the associations of smoking with occupation (for women) and class identification (for men and women).

No significant increasing trends were observed for the associations of SRH and physical activity with the SES indices.

4. Discussion

Using the JGSS data from 2000 to 2010—a representative sample of Japanese adult population obtained by repeated cross-sectional social surveys—we found that socioeconomic differences in smoking between 2000 and 2010 increased in the general population and especially among women. In contrast, no such temporal expanding trends were seen for the associations of SRH and physical activity with SES indices. Our analysis has an advantage over the previous studies (Asada & Ohkusa, 2004; Hiyoshi, Fukuda, Shipley, & Brunner, 2013b; Kachi et al. 2013; Kondo et al., 2008) in that we used a variety of health outcomes and SES indices. This approach resulted in the detection of increasing trends in smoking disparity depending on occupation and class identification, which

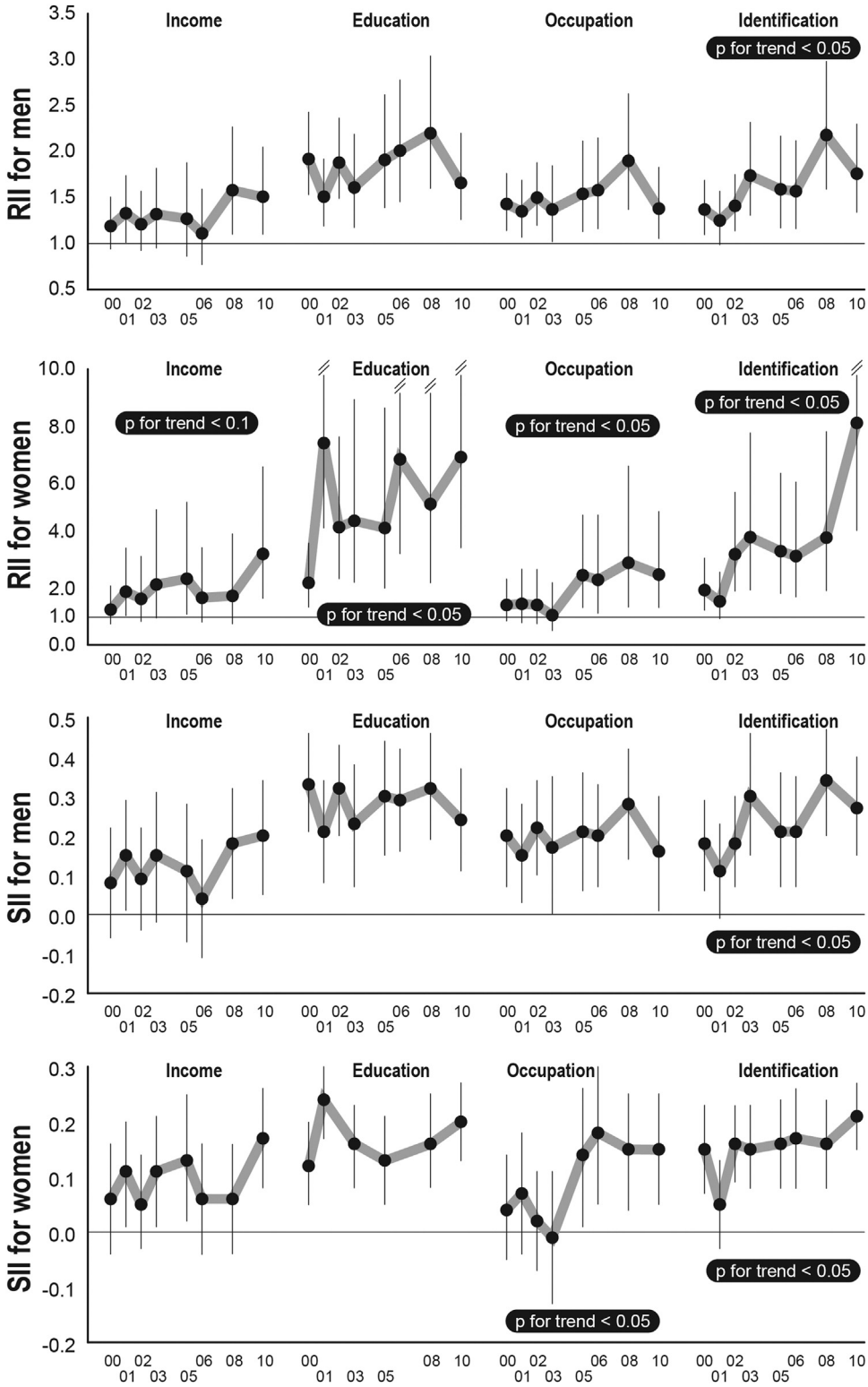

Fig. 1. Trends in relative index of inequality (RII) and slope index of inequality (SII) for smoking.

has not been examined in the previous studies.

The reason for the expansion of smoking disparity related to SES might be associated with recent changes in policies and social environment of Japan. Some policy changes occurred during our study period, for example introducing smoking cessation therapy covered by health insurance, smoking bans in specific locations (e.g., the workplace or the street) as well as the repeatedly raised tobacco prices. These changes might have also affected the social norms directed against smoking. Such changes in policies and norms may have contributed to the reduction of smoking rates. However, they could have also accompanied the expanding socioeconomic disparity in smoking; health intervention might benefit the high SES populations more than the low SES ones at the early stage of such policies, as indicated by the inverse equity hypothesis (Victora,Vaughan, BarrosSilva, & Tomasi, 2000).

Fukuda (2008) has anticipated the expansion of smoking

disparities related to SES with a decrease in smoking rates in Japan. In fact, an earlier study in Japan had found that the white collar workers tend to quit smoking more often in comparison with the outdoor workers or small factory employees (Honjo et al., 2010). White-collar workers at a large company might be more health conscious and more likely to stop smoking, encouraged by health checkups and smoking restrictions at their workplace. Tabuchi, Fujiwara, and Shinozaki (2016) have found that the tobacco price increase in 2010 (implemented after our study period) was associated with an increase in smoking cessation among all income subgroups. Previous studies had indicated that the increases in tobacco price had been more effective in reducing smoking among the low income adults (Thomas et al. 2008). It is possible that Japan is still at the "early stage" of the tobacco intervention policies, and therefore, the differences in smoking rates depending on SES have been widened.

Gender differences in smoking disparities is worthy of attention. In most countries, smoking has been found to be more prevalent among men of lower SES. However, women showed different patterns by country; higher smoking rates were observed among higher SES groups in some countries (Hosseinpoor, Parker, Tursan d'Espaignet, & Chatterji, 2012; Huisman, Kunst, & Mackenbach, 2005). In Japan, the pattern in smoking disparity was the same in both genders (i.e., more prevalent in lower SES group); however, the increase in socioeconomic disparities in smoking habits was clearer for women than men. Despite the fact that smoking rates have been much lower in women than in men, and that they have declined during the study period, smoking disparity among women was larger than among men in relative measures, and expanded in both relative and absolute measures.

Gender differences in the trends in smoking disparities might also be related to the changes in the policies and social norms described above. One of the reasons for this difference might be that the women were more exposed and more sensitive to social norms against smoking than men were. The large difference between the smoking rates for the genders probably reflects a general disapproval of women smoking, long prevalent in Japan. For example, Hanibuchi et al. (2015) have reported the inverse association between women smoking and the residential stability of the neighborhood (considered a surrogate measure of the strength of social norms in the community). Recent changes in the policies and norms might have affected the smoking behavior of women disproportionally depending on their SES, and, especially, their occupation and class identification. Women with higher SES might be more sensitive to social norms against smoking, and more likely to be exposed to smoking restrictions and social pressure at their workplace.

Factors behind this trend may include recent societal changes in Japan concerning women. According to the Labor Force Survey and Vital Statistics, more women have become engaged in the labor market, and the mean age for first marriage and bearing the first child has increased. These factors may have increased the smoking rate among young women during 1990s. However, as mentioned above, recent changes in smoking policies and norms may have reduced smoking rates specifically in women of higher SES, whereas women of lower SES, such as those in poverty or working with insecure employment, may experience much more psychosocial stress. Previously, marriage and having young children may have reduced smoking rates among women and could have modified the associations between SES and smoking. However, the increasing rates of single women and single mothers, in conjunction with poverty and job insecurity, could lead to a weakened modification effect. The interactions between these factors may have cumulatively resulted in the expansion of socioeconomic disparities in smoking.

In contrast, no expanding trends were seen for SRH and physical activity. Our results for SRH are generally consistent with those of the previous studies using CSLC (Kachi et al. 2013; Hiyoshi, Fukuda, Shipley, & Brunner, 2013b). The previous studies have observed narrowing trends in income-related health inequalities of Japan in the 1990s. These inequalities remained relatively stable after the year 2000. It is noteworthy that socioeconomic disparities in SRH have not increased since 2000, despite the growing interest in the widening economic disparities in Japan. However, there might be a time lag between the changes in socioeconomic conditions and their effect on health. The results for smoking disparity could be a manifestation of future disparities in SRH or other health indicators, including morbidity and mortality (Koch, Diderichsen, Grønbæk, & Juel, 2015). Researchers and policymakers need to monitor continuously the trends that might cause future disparities in the levels of smoking-related morbidity and mortality.

Several limitations of our study should be noted. The data were the results of repeated cross-sectional design; thus, we were not able to analyze longitudinal changes in health status and health behaviors (e.g., smoking initiation or cessation). Longitudinal data analyses are needed to explore how the widening of socioeconomic disparities in smoking prevalence occurs. In addition, a longer period (e.g., 2000–2015 or later) should be employed in future research because some events, such as the economic crisis in 2008 or the tobacco price increase in 2010, could affect the trends in health inequalities. With respect to occupation, we used the occupational prestige score as a simplified index of social position, but other factors such as company size or employment status may also be important in Japan (Hanibuchi et al., 2012; Hiyoshi, Fukuda, Shipley, Bartley, & Brunner, 2013a). Occupational rating may change overtime, although it has been reported that the score is highly stable (Tsuzuki, 1998). These factors need to be considered in a future study. Differential trends in the associations of smoking with SES by age groups have been reported (Federico, Kunst, Vannoni, Damiani, & Costa, 2004; Khang & Cho 2006); however, our sample size was not sufficiently large to perform stratified analysis by population subgroups. The exclusion of older adults from the sample could have made it difficult to detect some associations (e.g., SRH and occupation or income and physical activity among men). The strength of the association between SES and health may also differ depending on the characteristics of residential areas (Nakaya & Hanibuchi, 2013). The differences between urban and rural areas are of particular interest in this regard. Therefore, further studies are required to investigate the temporal changes in health disparities between population subgroups, using multiple sources of data, indicators of SES, and health-related outcomes.

Competing interests

None declared.

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Appendix A. Relative Index of Inequality (RII) for poor self-rated health, current smoking, and physical inactivity (men)

	Poor self-rated health			Current smoking			Physical activity		
	RII		95%CI	RII		95%CI	RII		95%CI
Income									
2000	1.37		(0.78–2.41)	1.19		(0.94–1.51)			
2001	1.20		(0.67–2.13)	1.33	*	(1.01–1.74)			
2002	2.23	**	(1.27–3.92)	1.21		(0.93–1.57)	1.07		(0.96–1.20)
2003	0.87		(0.42–1.80)	1.32	+	(0.95–1.82)	1.06		(0.92–1.23)
2005	3.12	*	(1.18–8.20)	1.27		(0.86–1.88)	1.08		(0.91–1.28)
2006	1.26		(0.62–2.56)	1.11		(0.77–1.60)	1.08		(0.93–1.25)
2008	0.82		(0.35–1.93)	1.58	*	(1.10–2.27)	1.06		(0.92–1.21)
2010	1.47		(0.69–3.12)	1.51	*	(1.10–2.05)	1.12		(0.98–1.30)
p for trend	n.s.			n.s.			n.s.		
Education									
2000	1.44		(0.84–2.44)	1.92	***	(1.53–2.43)			
2001	1.20		(0.70–2.05)	1.51	**	(1.19–1.92)			
2002	1.59	+	(0.97–2.60)	1.88	***	(1.49–2.37)	1.18	**	(1.07–1.30)
2003	1.62		(0.85–3.08)	1.61	**	(1.18–2.19)	1.22	**	(1.07–1.39)
2005	1.24		(0.60–2.56)	1.91	***	(1.39–2.62)	1.12	+	(0.98–1.29)
2006	0.69		(0.36–1.33)	2.01	***	(1.45–2.78)	1.10		(0.97–1.25)
2008	0.54		(0.25–1.18)	2.20	***	(1.60–3.04)	1.12	+	(0.99–1.27)
2010	1.88	+	(0.98–3.63)	1.66	***	(1.26–2.20)	1.09		(0.96–1.24)
p for trend	$p < 0.1$			n.s.			$p < 0.05$		
Occupation									
2000	0.99		(0.60–1.65)	1.43	**	(1.15–1.77)			
2001	1.22		(0.72–2.06)	1.35	*	(1.07–1.70)			
2002	1.07		(0.64–1.78)	1.50	***	(1.20–1.88)	1.10	*	(1.00–1.20)
2003	1.08		(0.55–2.11)	1.37	*	(1.02–1.85)	1.13	+	(0.99–1.30)
2005	1.21		(0.56–2.61)	1.54	**	(1.13–2.11)	1.19	*	(1.04–1.37)
2006	0.82		(0.42–1.58)	1.58	**	(1.16–2.15)	1.14	+	(1.00–1.30)
2008	0.87		(0.38–2.00)	1.90	***	(1.37–2.63)	1.06		(0.94–1.19)
2010	1.16		(0.55–2.43)	1.38	*	(1.05–1.83)	1.09		(0.96–1.24)
p for trend	n.s.			n.s.			n.s.		
Identification									
2000	3.01	***	(1.82–5.00)	1.37	**	(1.10–1.69)			
2001	4.74	***	(2.69–8.35)	1.25	+	(0.99–1.57)			
2002	5.53	***	(3.22–9.49)	1.41	**	(1.14–1.75)	1.14	**	(1.04–1.26)
2003	2.52	**	(1.34–4.74)	1.74	***	(1.31–2.32)	1.14	*	(1.02–1.29)
2005	3.08	**	(1.51–6.29)	1.59	**	(1.17–2.17)	1.10		(0.97–1.26)
2006	1.98	*	(1.01–3.89)	1.57	**	(1.16–2.12)	1.14	*	(1.01–1.30)
2008	3.29	**	(1.44–7.54)	2.18	***	(1.59–2.98)	1.11	+	(0.99–1.26)
2010	6.03	***	(3.16–11.50)	1.76	***	(1.34–2.30)	1.20	**	(1.06–1.35)
p for trend	n.s.			$p < 0.05$			n.s.		

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; $^{+}p < 0.1$; n.s., not significant.

Appendix B. Relative Index of Inequality (RII) for poor self-rated health, current smoking, and physical inactivity (women)

	Poor self-rated health			Current smoking			Physical activity		
	RII		95%CI	RII		95%CI	RII		95%CI
Income									
2000	1.78	*	(1.01–3.11)	1.28		(0.76–2.14)			
2001	1.78	+	(0.99–3.19)	1.93	*	(1.06–3.52)			
2002	1.56		(0.91–2.69)	1.67		(0.87–3.21)	1.10		(0.98–1.24)
2003	0.94		(0.47–1.86)	2.19	+	(0.98–4.91)	0.96		(0.82–1.11)
2005	1.12		(0.46–2.70)	2.40	*	(1.11–5.18)	1.22	**	(1.06–1.41)
2006	1.95		(0.82–4.66)	1.71		(0.83–3.53)	0.99		(0.87–1.13)
2008	1.87		(0.84–4.15)	1.78		(0.79–4.03)	1.05		(0.89–1.24)
2010	1.46		(0.69–3.09)	3.30	***	(1.69–6.46)	1.06		(0.92–1.21)
p for trend	n.s.			$p < 0.1$			n.s.		
Education									
2000	1.48		(0.89–2.45)	2.25	**	(1.38–3.69)			
2001	1.53		(0.90–2.58)	7.32	***	(4.24–12.63)			
2002	1.55	+	(0.96–2.51)	4.27	***	(2.42–7.55)	1.07		(0.97–1.19)
2003	1.10		(0.58–2.11)	4.50	***	(2.27–8.93)	1.20	**	(1.05–1.37)
2005	1.97	+	(0.97–3.98)	4.24	***	(2.09–8.60)	1.02		(0.90–1.15)
2006	2.27	+	(0.94–5.47)	6.73	***	(3.31–13.70)	1.06		(0.95–1.18)
2008	2.43	*	(1.12–5.27)	5.11	***	(2.26–11.56)	0.99		(0.87–1.13)
2010	1.86	+	(0.95–3.66)	6.81	***	(3.52–13.18)	1.11	+	(0.99–1.25)
p for trend	n.s.			$p < 0.05$			n.s.		
Occupation									
2000	1.16		(0.65–2.06)	1.45		(0.88–2.39)			
2001	0.97		(0.49–1.91)	1.49		(0.80–2.77)			
2002	1.18		(0.63–2.22)	1.45		(0.77–2.75)	1.06		(0.95–1.18)
2003	1.02		(0.47–2.20)	1.08		(0.52–2.27)	1.12		(0.96–1.31)
2005	1.19		(0.53–2.67)	2.53	**	(1.36–4.71)	1.00		(0.88–1.13)
2006	2.29		(0.83–6.34)	2.36	*	(1.18–4.72)	1.07		(0.94–1.21)
2008	0.54		(0.23–1.29)	2.98	**	(1.37–6.49)	1.05		(0.91–1.21)
2010	0.66		(0.29–1.52)	2.55	**	(1.35–4.84)	1.05		(0.94–1.18)
p for trend	$p < 0.05$			$p < 0.05$			n.s.		
Identification									
2000	3.22	***	(2.03–5.11)	1.99	**	(1.26–3.15)			
2001	4.59	***	(2.81–7.51)	1.58	+	(0.95–2.64)			
2002	3.78	***	(2.36–6.05)	3.29	***	(1.95–5.54)	1.12	*	(1.01–1.24)
2003	5.33	***	(2.79–10.19)	3.91	***	(1.99–7.69)	1.22	**	(1.07–1.39)
2005	3.85	***	(1.96–7.53)	3.40	***	(1.86–6.23)	1.17	*	(1.04–1.32)
2006	3.12	**	(1.59–6.12)	3.22	***	(1.75–5.91)	1.14	*	(1.03–1.27)
2008	4.90	***	(2.48–9.67)	3.89	***	(1.95–7.74)	1.12	+	(0.99–1.28)
2010	2.60	**	(1.34–5.02)	8.05	***	(4.15–15.61)	1.18	**	(1.06–1.32)
p for trend	n.s.			$p < 0.05$			n.s.		

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; +$p < 0.1$; n.s., not significant.

Appendix C. Slope Index of Inequality (SII) for poor self-rated health, current smoking, and physical inactivity (men)

	Poor self-rated health			Current smoking			Physical activity		
	SII		95%CI	SII		95%CI	SII		95%CI
Income									
2000	0.05		(−0.05–0.15)	0.08		(−0.06–0.22)			
2001	0.03		(−0.08–0.14)	0.15	*	(0.01–0.29)			
2002	0.13	**	(0.04–0.23)	0.09		(−0.04–0.22)	0.06		(−0.04–0.16)
2003	−0.03		(−0.16–0.10)	0.15	+	(−0.02–0.31)	0.06		(−0.07–0.19)
2005	0.13	*	(0.02–0.24)	0.11		(−0.07–0.28)	0.06		(−0.08–0.21)
2006	0.04		(−0.08–0.16)	0.04		(−0.11–0.19)	0.06		(−0.06–0.18)
2008	a)			0.18	*	(0.04–0.32)	0.04		(−0.07–0.15)
2010	0.03		(−0.06–0.13)	0.20	*	(0.05–0.34)	0.10	+	(−0.02–0.21)
p for trend	n.s.			n.s.			n.s.		
Education									
2000	0.06		(−0.03–0.15)	0.33	***	(0.21–0.46)			
2001	0.04		(−0.05–0.13)	0.21	**	(0.08–0.34)			
2002	0.09	+	(0.00–0.18)	0.32	***	(0.20–0.43)	0.14	**	(0.06–0.23)
2003	0.09		(−0.03–0.21)	0.23	**	(0.07–0.38)	0.18	**	(0.06–0.29)
2005	0.03		(−0.07–0.13)	0.30	***	(0.15–0.44)	0.10	+	(−0.01–0.21)
2006	−0.06		(−0.15–0.04)	0.29	***	(0.16–0.42)	0.08		(−0.02–0.18)
2008	a)			0.32	***	(0.19–0.46)	0.09	+	(−0.01–0.20)
2010	0.09	+	(0.00–0.17)	0.24	***	(0.11–0.37)	0.07		(−0.03–0.17)
p for trend	n.s.			n.s.			$p < 0.05$		
Occupation									
2000	0.00		(−0.09–0.10)	0.20	**	(0.07–0.32)			
2001	0.04		(−0.06–0.14)	0.15	*	(0.03–0.28)			
2002	0.01		(−0.08–0.10)	0.22	***	(0.10–0.34)	0.08	*	(0.00–0.16)
2003	0.01		(−0.10–0.13)	0.17	+	(0.00–0.35)	0.12	+	(−0.01–0.24)
2005	0.02		(−0.08–0.12)	0.21	**	(0.06–0.36)	0.15	*	(0.03–0.27)
2006	−0.03		(−0.13–0.07)	0.20	**	(0.07–0.33)	0.11	+	(0.00–0.22)
2008	a)			0.28	***	(0.14–0.42)	0.05		(−0.05–0.15)
2010	0.01		(−0.07–0.10)	0.16	*	(0.01–0.30)	0.07		(−0.03–0.18)
p for trend	n.s.			n.s.			n.s.		
Identification									
2000	0.18	***	(0.10–0.26)	0.18	**	(0.06–0.29)			
2001	0.22	***	(0.15–0.29)	0.11	+	(−0.01–0.23)			
2002	0.23	***	(0.16–0.30)	0.18	**	(0.07–0.30)	0.12	**	(0.03–0.21)
2003	0.17	**	(0.06–0.28)	0.30	***	(0.15–0.46)	0.11	*	(0.01–0.21)
2005	0.15	**	(0.06–0.25)	0.21	**	(0.07–0.36)	0.08		(−0.03–0.20)
2006	0.09	*	(0.00–0.18)	0.21	**	(0.07–0.35)	0.11	*	(0.01–0.21)
2008	a)			0.34	***	(0.20–0.47)	0.09	+	(−0.01–0.19)
2010	0.21	***	(0.13–0.28)	0.27	***	(0.15–0.40)	0.15	**	(0.05–0.26)
p for trend	n.s.			$p < 0.05$			n.s.		

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; +$p < 0.1$; n.s., not significant.
a) SII were not obtained because convergence was not achieved.

Appendix D. Slope Index of Inequality (SII) for poor self-rated health, current smoking, and physical inactivity (women)

	Poor self-rated health			Current smoking			Physical activity		
	SII		95%CI	SII		95%CI	SII		95%CI
Income									
2000	0.09	+	(0.00–0.18)	0.06		(−0.04–0.16)			
2001	0.08		(−0.02–0.18)	0.11	*	(0.01–0.20)			
2002	0.08		(−0.03–0.18)	0.05		(−0.03–0.14)	0.08		(−0.02–0.19)
2003	−0.03		(−0.14–0.09)	0.11	*	(0.01–0.21)	−0.03		(−0.16–0.09)
2005	0.00		(−0.10–0.11)	0.13	*	(0.02–0.25)	0.17	**	(0.05–0.29)
2006	0.05		(−0.05–0.14)	0.06		(−0.04–0.16)	−0.01		(−0.12–0.11)
2008	0.07		(−0.03–0.18)	0.06		(−0.04–0.16)	0.04		(−0.10–0.17)
2010	0.04		(−0.04–0.13)	0.17	***	(0.08–0.26)	0.05		(−0.07–0.16)
p for trend	n.s.			n.s.			n.s.		
Education									
2000	0.07		(−0.02–0.16)	0.12	**	(0.05–0.20)			
2001	0.07		(−0.02–0.16)	0.24	***	(0.17–0.30)			
2002	0.09	+	(−0.01–0.19)	a)			0.06		(−0.03–0.14)
2003	0.01		(−0.11–0.12)	0.16	***	(0.08–0.23)	0.14	**	(0.04–0.25)
2005	0.09	+	(−0.01–0.20)	0.13	**	(0.05–0.21)	0.02		(−0.08–0.13)
2006	0.09	*	(0.01–0.17)	a)			0.05		(−0.04–0.14)
2008	0.11	*	(0.02–0.20)	0.16	***	(0.08–0.25)	−0.01		(−0.12–0.10)
2010	0.07	+	(−0.01–0.15)	0.20	***	(0.13–0.27)	0.09	+	(−0.01–0.19)
p for trend	n.s.			n.s.			n.s.		
Occupation									
2000	0.01		(−0.09–0.12)	0.04		(−0.05–0.14)			
2001	−0.01		(−0.11–0.09)	0.07		(−0.04–0.18)			
2002	0.02		(−0.07–0.12)	0.02		(−0.07–0.11)	0.05		(−0.04–0.14)
2003	0.00		(−0.12–0.13)	−0.01		(−0.13–0.11)	0.10		(−0.03–0.23)
2005	0.01		(−0.09–0.12)	0.14	*	(0.01–0.26)	0.00		(−0.11–0.11)
2006	0.08		(−0.02–0.17)	0.18	**	(0.05–0.30)	0.06		(−0.05–0.16)
2008	−0.09		(−0.20–0.02)	0.15	**	(0.04–0.25)	0.04		(−0.08–0.16)
2010	−0.05		(−0.13–0.04)	0.15	**	(0.05–0.25)	0.04		(−0.06–0.14)
p for trend	n.s.			$p < 0.05$			n.s.		
Identification									
2000	0.19	***	(0.11–0.26)	0.15	***	(0.07–0.23)			
2001	0.23	***	(0.16–0.31)	0.05		(−0.03–0.13)			
2002	0.23	***	(0.15–0.30)	0.16	***	(0.09–0.23)	0.10	*	(0.01–0.19)
2003	0.22	***	(0.13–0.30)	0.15	***	(0.08–0.23)	0.18	**	(0.07–0.29)
2005	0.16	***	(0.09–0.24)	0.16	***	(0.08–0.24)	0.14	**	(0.04–0.25)
2006	0.17	**	(0.06–0.27)	0.17	***	(0.08–0.26)	0.12	*	(0.02–0.22)
2008	0.20	***	(0.12–0.28)	0.16	***	(0.08–0.24)	0.09	+	(−0.01–0.20)
2010	0.10	**	(0.03–0.17)	0.21	***	(0.15–0.27)	0.15	**	(0.06–0.24)
p for trend	$p < 0.05$			$p < 0.05$			n.s.		

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; +$p < 0.1$; n.s., not significant.
a) SII were not obtained because convergence was not achieved.

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