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Retirement and cardiovascular disease: a longitudinal study in 35 countries

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Abstract

Background: Many countries have been increasing their state pension age (SPA); nonetheless, there is little consensus on whether retirement affects the risk of cardiovascular disease (CVD). This study examined the associations of retirement with CVD and risk factors.

Methods: We used harmonized longitudinal datasets from the Health and Retirement Study and its sister surveys in 35 countries. Data comprised 396 904 observations from 106 927 unique individuals aged 50–70 years, with a mean follow-up period of 6.7 years. Fixed-effects instrumental variable regressions were performed using the SPA as an instrument.

Results: We found a 2.2%-point decrease in the risk of heart disease [coefficient = -0.022 (95% confidence interval: -0.031 to -0.012)] and a 3.0%-point decrease in physical inactivity [-0.030 (-0.049 to -0.010)] among retirees, compared with workers. In both sexes, retirement was associated with a decreased heart disease risk, whereas decreased smoking was observed only among women. People with high educational levels showed associations between retirement and decreased risks of stroke, obesity and physical inactivity. People who retired from non-physical labour exhibited reduced risks of heart disease, obesity and physical inactivity, whereas those who retired from physical labour indicated an increased risk of obesity.

Conclusions: Retirement was associated with a reduced risk of heart disease on average. Some associations of retirement with CVD and risk factors appeared heterogeneous by individual characteristics.

Key words: Retirement, state pension age, heart disease, stroke, hypertension, diabetes, physical inactivity, smoking, binge drinking

Key Messages

- Evidence on the association between retirement and cardiovascular disease (CVD) is inconsistent, and no studies have reported a beneficial association between retirement and CVD.
- This study indicated the beneficial effect of retirement on heart disease for the first time, using fixed-effects instrumental variable regression. Retirement was also associated with decreased physical inactivity.
- Some associations of retirement with CVD and risk factors appeared heterogeneous by individual characteristics such as educational attainment and experience of physical labour.
- The present study contributed to the literature by providing a holistic view of the associations of retirement with CVD and various risk factors, using harmonized longitudinal datasets in 35 countries.
- Policy makers need to consider the benefits of raising the state pension age and allowing older people to continue working versus the costs from the potential risk of expensive medical conditions such as CVD.

Introduction

Many countries have been increasing the state pension age (SPA) to accommodate the ageing population.[1] For example, the UK and the USA plan to increase their SPA to age 67. The SPA influences individual workers' decisions regarding the timing of their retirement. Nonetheless, the potential impact of delayed retirement on health has not been considered in political debates. In particular, cardiovascular disease (CVD) ranks as the leading cause of mortality worldwide, killing 16.5 million people aged ≥55 in 2019.[2] A growing body of literature has explored the association between retirement and CVD; however, the findings are inconsistent. Several studies from European countries found an increased CVD risk among retirees, whereas studies from the USA seldom showed a clear association between retirement and CVD.[3] No studies reported a beneficial association between retirement and CVD.[3]

The observed detrimental association may be attributable to the healthy worker survivor effect ('those who remain employed tend to be healthier than those who leave employment'[4]). There is conflicting evidence on an increased CVD risk in the literature. For instance, job strain is a known risk factor for CVD.[5] Based on the psychosocial mechanism, relief from job strain can be protective against CVD. There are other inconsistencies in several findings regarding preferable changes in CVD risk factors, such as increased physical activity, sleep quality and smoking cessation after retirement.[6–14] Although evidence is mixed, some studies also suggested decreases in body weight, hypertension, diabetes and heavy drinking among retirees.[13–15] To address the potential healthy worker survivor effect, several studies have used the SPA as an instrumental variable (IV) that is strongly correlated with retirement but does not directly affect the outcomes. IV studies using data from the Health and Retirement Study (HRS) and the English Longitudinal Study on Ageing (ELSA) have reported an ambiguous association between retirement and CVD.[16,17] Because IV estimates tend to have wide confidence intervals (CIs),[18] these studies may be less conclusive. Most previous studies were conducted in a single country or region and had limitations with respect to statistical power and generalizability to other countries. Moreover, researchers were unable to determine whether the inconsistent results were due to differences in the study population or other factors (e.g. study designs, measures of retirement and outcomes, analytical methods).

Therefore, the present study aimed to investigate the association of retirement with CVD and various risk factors and to provide a holistic view using data from 35 countries. The endogenous decision regarding retirement was handled using the SPA as an IV.

Methods

Database and study participants

This study used the harmonized datasets of the HRS and its sister surveys provided by the Gateway to Global Aging Data project.[19] Our datasets comprised the following surveys with multiple observations: waves 1, 2 and 4–8 (2004–19) of the Survey of Health, Ageing and Retirement in Europe (SHARE); waves 1–9 (2002–18) of the ELSA; waves 1–5 (2005–12) of the Costa Rican Longevity and Healthy Aging Study (CRELES); waves 1–5 (2001–18) of the Mexican Health and Aging Study (MHAS); waves 1–14 (1992–2018) of the RAND HRS; waves 1–4 (2011–18) of the China Health and Retirement Longitudinal Study (CHARLS); waves 1–3 (2007–11) of the Japanese Study of Aging and Retirement (JSTAR); and waves 1–7 (2006–18) of the Korean Longitudinal Study of Aging (KLoSA). All surveys were designed to represent the national older population except for the JSTAR, which recruited participants randomly from 10 specific municipalities. The same individuals were followed up approximately biennially; however, the MHAS and CHARLS conducted the interviews

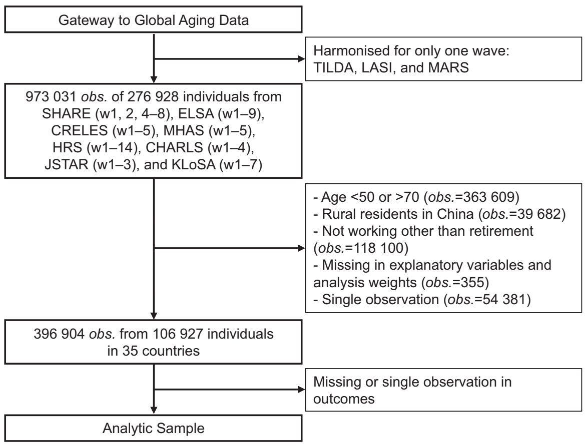

Figure 1 A flowchart of the analytical sample. Obs., observations; SHARE, Survey of Health, Ageing and Retirement in Europe; ELSA, English Longitudinal Study on Ageing; CRELES, Costa Rican Longevity and Healthy Aging Study; MHAS, Mexican Health and Aging Study; HRS, Health and Retirement Study; CHARLS, China Health and Retirement Longitudinal Study; JSTAR, Japanese Study of Aging and Retirement; KLoSA, Korean Longitudinal Study of Aging; TILDA, the Irish Longitudinal Study on Ageing; LASI, Longitudinal Aging Study in India; MARS, Malaysia Ageing and Retirement Study

triennially since 2012 and 2015, respectively. The CRELES included a cohort interviewed in waves 1–3 (2005–09) and another cohort interviewed in waves 4–5 (2010–12).

Figure 1 describes the flowchart of our analytical sample. Originally, the harmonized data involved 973 031 observations from 276 928 unique individuals. In the analysis we included people aged 50–70 years, whose timing of retirement could be affected by the SPA. Of note, the CRELES interviewed adults aged ≥60 years in waves 1–3 and individuals aged 55–65 years in waves 4–5, whereas the HRS interviewed adults aged ≥51 years. We excluded the following observations in the analyses: rural residents in the CHARLS because China had different pension systems in rural and urban areas[20]; those who were not working for reasons other than retirement (e.g. unemployed, disabled, homemaker); observations with missing values for explanatory variables; and individuals with only one observation because keeping them in a fixed-effects model could underestimate standard errors.[21] Thus, our study participants comprised 396 904 observations from 106 927 unique individuals in 35 countries. We additionally excluded observations with missing outcome from the analysis, and the number of missing values varied across outcomes.

Outcomes

The outcomes included the occurrence of heart disease and stroke. At the first interview, participants were asked whether a doctor had ever told them that they had or currently have these conditions (Supplementary File pp. 2–3).[22] The variable indicated 1 if the participants had ever had the condition and 0 if otherwise. Their previous reports were carried forward to the subsequent waves, and they were asked about updates from the last interview. If participants later disputed reports from previous waves, they were corrected retrospectively.

We also investigated six CVD risk factors, namely hypertension, diabetes, obesity, physical inactivity, smoking and binge drinking, although the data on health behaviours were not collected in some countries (Supplementary File page 3). We hypothesied that reduced unhealthy behaviours (i.e. physical inactivity, smoking and binge drinking) would prevent hypertension, diabetes and obesity and result in a decreased occurrence of heart disease and stroke. Diagnosed health conditions of hypertension and diabetes were asked in the same manner as heart disease and stroke. Obesity was defined as a body mass index of 30 kg/m^2 or higher.[23] We considered those who engaged in vigorous or moderate physical activity less than once per week as physically inactive individuals. Smoking status indicated whether the participants were currently smoking. Binge drinking was defined as consuming five or more drinks per day for men and four or more for women.[24] All variables were coded as binary.

Retirement status

Retirement status was determined based on the harmonized variable of self-reported labour force status (Supplementary File pages 4–5).[25] We considered individuals who mentioned retirement in an interview as retirees, irrespective of whether they were currently working (i.e. including those ‘partly retired’), and compared them with workers (Supplementary Table S1, available as Supplementary data at *IJE* online), as in the previous literature.[9–11] There is a narrower definition of retirement, which refers to the complete exit from the labour market.[10,12,16] Hence, considering this alternative definition, we determined individuals who declared being retired but were currently working by combining the variables of labour force status and engagement in paid work; subsequently, we excluded these individuals in a sensitivity analysis.

Instrumental variables

We used the SPA as an IV for retirement to eliminate the potential healthy worker survivor effect. In some countries, early pension is available with reduced benefits or sufficient years of social security contributions. Thus, we used the early retirement age (ERA) and official retirement age (ORA) as joint instruments to predict retirement, as in a previous study.[12] A dummy variable of ERA indicated whether the participants had attained the earliest age at which individuals are entitled to reduced pensions or full pensions with some conditions. That of ORA indicated whether the participants had attained the age at which individuals are entitled to minimum guaranteed pensions or full pensions without any conditions. For countries without early pension, the ERA variable was set to zero for all participants. For each country, we collected the data on ERA, ORA and their changes during the study period (Supplementary Table S2, available as Supplementary data at *IJE* online).

Statistical analyses

We investigated the association of retirement with CVD and risk factors using linear probability models estimated by the fixed-effects instrumental variable (FEIV) method with the two-stage least squares procedure (Supplementary File page 9). The FEIV model has several advantages with respect to pooling data from different countries and estimating the potential causal retirement effect on outcomes. We included FEs of individuals and countries in the model, which controlled for both observable and unobservable time-invariant factors such as genes and educational attainment as well as institutional and cultural differences across countries. To account for time-variant factors, we adjusted for individuals' centred age, its squared term and marital status. Additionally, we included year FE and its interaction with country FE to capture global and country-specific time trends. To eliminate the healthy worker survivor effect, we applied the IV method using the ERA and ORA as instruments for retirement; at the first stage estimation, the retirement probability was predicted by the ERA, ORA and their interactions with age and age squared, as in a previous study,[26] along with other time-variant variables. We compared the FEIV estimates with those of FE models without IVs.

We also assessed heterogeneity across several subgroups. First, we checked heterogeneity across countries using I^2 statistics as an analogy to meta-analysis.[27] Additionally, the test of interaction was performed across region [i.e. Europe (including Israel), America (Costa Rica, Mexico, and the USA)] and Asia [China, Japan, and South Korea]) and income level (i.e. high-income countries and low-middle-income countries (Bulgaria, Romania, Costa Rica, Mexico and China)]. Second, we examined sex differences because the SPA, employment environment and CVD risks differ by sex.[28] Third, we stratified participants according to educational attainment because previous studies reported that people with higher education levels tend to present more evident association between retirement and an increase in physical activity.[6,7,10] Fourth, we stratified the participants based on whether they had experienced physical labour or not, because previous studies showed that retirement from physically demanding jobs was associated with increased obesity and decreased physical activity.[29,30]

In all analyses, individual-cluster robust standard errors were estimated. All analyses were performed using Stata version 17.0 (StataCorp, College Station, TX, USA), except for multiple imputation in sensitivity analysis.

Sensitivity analyses

First, considering the alternative definition of retirement (i.e. fully retired), we excluded from our analysis those who reported being retired but were still working (i.e. partly retired). Second, we narrowed the age window to 52–68 years to check the robustness of findings. Third, we excluded countries in which the IV appeared to be weakly correlated with retirement (i.e. F statistic was below the Stock-Yogo's critical value of 10% maximal relative bias).[31] Fourth, given that 24.1% of the pooled sample came from the USA, we excluded data from the HRS and checked the robustness of findings. Fifth, to reduce potential bias from missing observations, we adopted multiple imputation[32] using R 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria). Sixth, given that outcomes were binary, we also performed FEIV Poisson regressions using the control function approach.[33] Seventh, we excluded those who retired within 2 years from analysis to reduce the healthy worker survivor effect in another way. Finally, as the retirement effect on CVD has been suggested by previous studies to be time-varying,[17,34] we examined the short- and long-term retirement effects. Each group of retirees who retired within 5 years and who retired over 5 years ago was compared with those who were working.

Results

A total of 106 927 individuals were followed up for a mean period of 6.7 years (Table 1). Some participants failed to be followed up. Nonetheless, we confirmed that there was no difference in characteristics between individuals who were followed up and those who were lost to follow-up, except for age; those who were lost to follow-up were older by 0.84 years than those who were followed up (Supplementary Table S3, available as Supplementary data at *IJE* online). Table 2 presents the descriptive statistics by labour force status for 396 904 observations from 106 927 individuals, which consisted of 217 166 (54.7%) with working status and 179 738 (45.3%) with retired status. Supplementary Figures S1 and S2 (available as

Table 1 Cohort characteristics of the surveys

Survey	Country	Interview years	No. of unique individuals	Mean follow-up period (years)	Mean no. of interviews	% of men
SHARE	Austria	2004, 2006, 2011, 2013, 2015, 2017, 2019	2877	5.4	3.3	46.2
	Belgium	2004, 2006, 2011, 2013, 2015, 2017, 2019	4118	5.7	3.3	51.8
	Bulgaria	2017, 2019	377	2.0	2.0	43.0
	Croatia	2015, 2017, 2019	1119	2.8	2.4	49.5
	Cyprus	2017, 2019	124	2.0	2.0	42.7
	Czech Republic	2006, 2011, 2013, 2015, 2017, 2019	3827	5.8	3.4	41.4
	Denmark	2004, 2006, 2011, 2013, 2015, 2017, 2019	3031	6.6	3.5	48.2
ELSA	England	2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018	9895	7.7	4.5	47.6
SHARE	Estonia	2011, 2013, 2015, 2017, 2019	3662	4.8	3.2	42.3
	Finland	2017, 2019	550	2.0	2.0	47.3
	France	2004, 2006, 2011, 2013, 2015, 2017, 2019	3540	6.4	3.4	47.1
	Germany	2004, 2006, 2011, 2013, 2015, 2017, 2019	3437	5.3	3.2	49.7
	Greece	2004, 2006, 2015, 2017, 2019	2187	6.5	2.7	60.5
	Hungary	2011, 2017, 2019	788	6.4	2.3	41.1
	Israel	2004, 2006, 2013, 2015, 2017, 2019	1447	8.2	3.3	46.9
	Italy	2004, 2006, 2011, 2013, 2015, 2017, 2019	3026	5.9	3.2	56.1
	Latvia	2017, 2019	303	2.0	2.0	41.6
	Lithuania	2017, 2019	528	2.0	2.0	37.1
	Luxembourg	2013, 2015, 2017, 2019	841	3.9	2.8	54.5
	Malta	2017, 2019	239	2.0	2.0	72.8
	Netherlands	2004, 2006, 2011, 2013, 2019	1862	6.4	2.7	55.6
	Poland	2006, 2011, 2015, 2017, 2019	1700	5.6	2.7	41.4
	Portugal	2011, 2015, 2017	761	4.6	2.3	50.5
	Romania	2017, 2019	560	2.0	2.0	45.5
	Slovakia	2017, 2019	665	2.0	2.0	47.7
	Slovenia	2011, 2013, 2015, 2017, 2019	2531	4.5	3.1	44.6
	Spain	2004, 2006, 2011, 2013, 2015, 2017, 2019	2731	5.3	3.0	59.6
	Sweden	2004, 2006, 2011, 2013, 2015, 2017, 2019	3151	6.2	3.2	45.1
	Switzerland	2004, 2006, 2011, 2013, 2015, 2017, 2019	2178	6.4	3.6	48.8
CRELES	Costa Rica	2005, 2007, 2009, 2010, 2012	1244	2.3	2.1	76.9
MHAS	Mexico	2001, 2003, 2012, 2015, 2018	8148	6.8	2.7	66.7
HRS	USA	1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018	25 753	9.2	5.2	46.9
CHARLS	China	2011, 2013, 2015, 2018	2819	4.8	2.9	54.1
JSTAR	Japan	2007, 2009, 2011	1775	3.0	2.5	64.8
KLoSA	South Korea	2006, 2008, 2010, 2012, 2014, 2016, 2018	5133	7.0	4.2	53.1
Overall			106 927	6.7	3.7	50.5

SHARE, Survey of Health, Ageing and Retirement in Europe; ELSA, English Longitudinal Study on Ageing; CRELES, Costa Rican Longevity and Healthy Aging Study; MHAS, Mexican Health and Aging Study; HRS, Health and Retirement Study; CHARLS, China Health and Retirement Longitudinal Study; JSTAR, Japanese Study of Aging and Retirement; KLoSA, Korean Longitudinal Study of Aging.

Table 2 Descriptive statistics of observations by labour force status (396 904 observations from 106 927 individuals)

Variables, obs. (%)	Labour force status	
	Working (obs. = 217 166)	Retired (obs. = 179 738)
Age, years, mean (SD)	57.9 (4.7)	64.2 (4.3)
Men	113 377 (52.2)	83 958 (46.7)
Married	173 581 (79.9)	136 461 (75.9)
Education		
Low	50 673 (23.3)	53 159 (29.6)
Middle	93 304 (43.0)	83 463 (46.4)
High	55 364 (25.5)	35 754 (19.9)
Missing	17 825 (8.2)	7362 (4.1)
Job type		
Physical labour	104 359 (48.1)	39 952 (22.2)
Non-physical labour	77 364 (35.6)	37 235 (20.7)
Missing	35 443 (16.3)	102 551 (57.1)
Heart disease		
Ever had	16 158 (7.4)	31 688 (17.6)
Never	200 363 (92.3)	147 743 (82.2)
Missing or single observation	645 (0.3)	307 (0.2)
Stroke		
Ever had	3632 (1.7)	10 814 (6.0)
Never	212 884 (98.0)	168 607 (93.8)
Missing or single observation	650 (0.3)	317 (0.2)
Hypertension		
Ever had	73 349 (33.8)	89 924 (50.0)
Never	143 151 (65.9)	89 550 (49.8)
Missing or single observation	666 (0.3)	264 (0.2)
Diabetes		
Ever had	22 359 (10.3)	31 643 (17.6)
Never	194 099 (89.4)	147 756 (82.2)
Missing or single observation	708 (0.3)	339 (0.2)
Obesity		
BMI ≥30	44 184 (20.4)	44 339 (24.7)
BMI <30	147 527 (67.9)	115 958 (64.5)
Missing or single observation	25 455 (11.7)	19 441 (10.8)
Physical inactivity		
<1 per week	26 627 (12.3)	25 492 (14.2)
≥1 per week	116 137 (53.5)	104 568 (58.2)
Missing or single observation	74 402 (34.3)	49 678 (27.6)
Smoking		
Currently smoking	37 588 (17.3)	25 688 (14.3)
Not smoking	146 405 (67.4)	114 838 (63.9)
Missing or single observation	33 173 (15.3)	39 212 (21.8)
Binge drinking		
≥4/5 drinks per day	14 271 (6.6)	6449 (3.6)
<4/5 drinks per day	124 079 (57.1)	97 412 (54.2)
Missing or single observation	78 816 (36.3)	75 877 (42.2)

Obs, observations; SD, standard deviation; BMI, body mass index.

Supplementary data at *IJE* online) shows a graph depicting age and the corresponding retirement rate by country; changes in the retirement rate around the SPA were observed.

Before pooling data from different countries, we checked heterogeneity across countries. Country-by-country analyses using FEIV models indicated moderate heterogeneity in hypertension (I^2 statistic = 52.6%), diabetes (34.7%) and smoking (41.4%) (Supplementary Figures S3–S10, available as Supplementary data at *IJE* online). After adjusting for country FEs, the test of interaction did not indicate signs of heterogeneity except for hypertension among Asian countries (Supplementary Table S4, available as Supplementary data at *IJE* online) and low-middle-income countries (Supplementary Table S5, available as Supplementary data at *IJE* online). Thus, it should be noted that the association between retirement and hypertension could be heterogeneous across countries, whereas other outcomes appeared to be homogeneous.

Figure 2 and Supplementary Table S6 (available as Supplementary data at *IJE* online) present the results of the FE and FEIV models using pooled data. F statistics[35] indicated that our IVs were strongly correlated with retirement, and the over-identification tests[36] showed that the instruments of ERA and ORA were uncorrelated with residuals (Supplementary Table S6). In FE models without IVs, retirement was associated with an increased heart disease risk [coefficient = 0.007 (95% CI: 0.004 to 0.010)], stroke [0.005 (0.003 to 0.006)], hypertension [0.009 (0.006 to 0.013)] and diabetes [0.005 (0.002 to 0.007)]. In contrast, the FEIV models showed a 2.2%-point decrease in the heart disease risk [-0.022 (-0.031 to -0.012)] as well as a 3.0%-point decrease in physical inactivity [-0.030 (-0.049 to -0.010)] among retirees, compared with workers. Readers concerned about multiple testing can interpret *P*-values using a Bonferroni correction (α = 0.05/8 outcomes = 0.006).

In subgroup analyses, we found some heterogeneous associations of retirement with CVD and risk factors. Figure 3 and Supplementary Table S7 (available as Supplementary data at *IJE* online) present the results of subgroup analyses by sex using the FEIV. In both sexes, retirement was associated with a decreased heart disease risk. Among women it was also associated with a 1.9%-point decrease in smoking [-0.019 (-0.034 to -0.004)]. In Figure 4 and Supplementary Table S8 (available as Supplementary data at *IJE* online), people with high educational levels showed the associations between retirement and decreased risks of stroke [-0.014 (-0.028 to -0.001)], obesity [-0.029 (-0.057 to -0.001)] and physical inactivity [-0.045 (-0.080 to -0.011)]. Figure 5 and Supplementary Table S9 (available as Supplementary data at *IJE* online) show that people retired from non-physical labour exhibited reduced risks of heart disease [-0.031 (-0.050 to -0.013)], obesity [-0.031 (-0.056 to -0.007)] and physical inactivity [-0.048 (-0.082 to -0.013)] compared with those

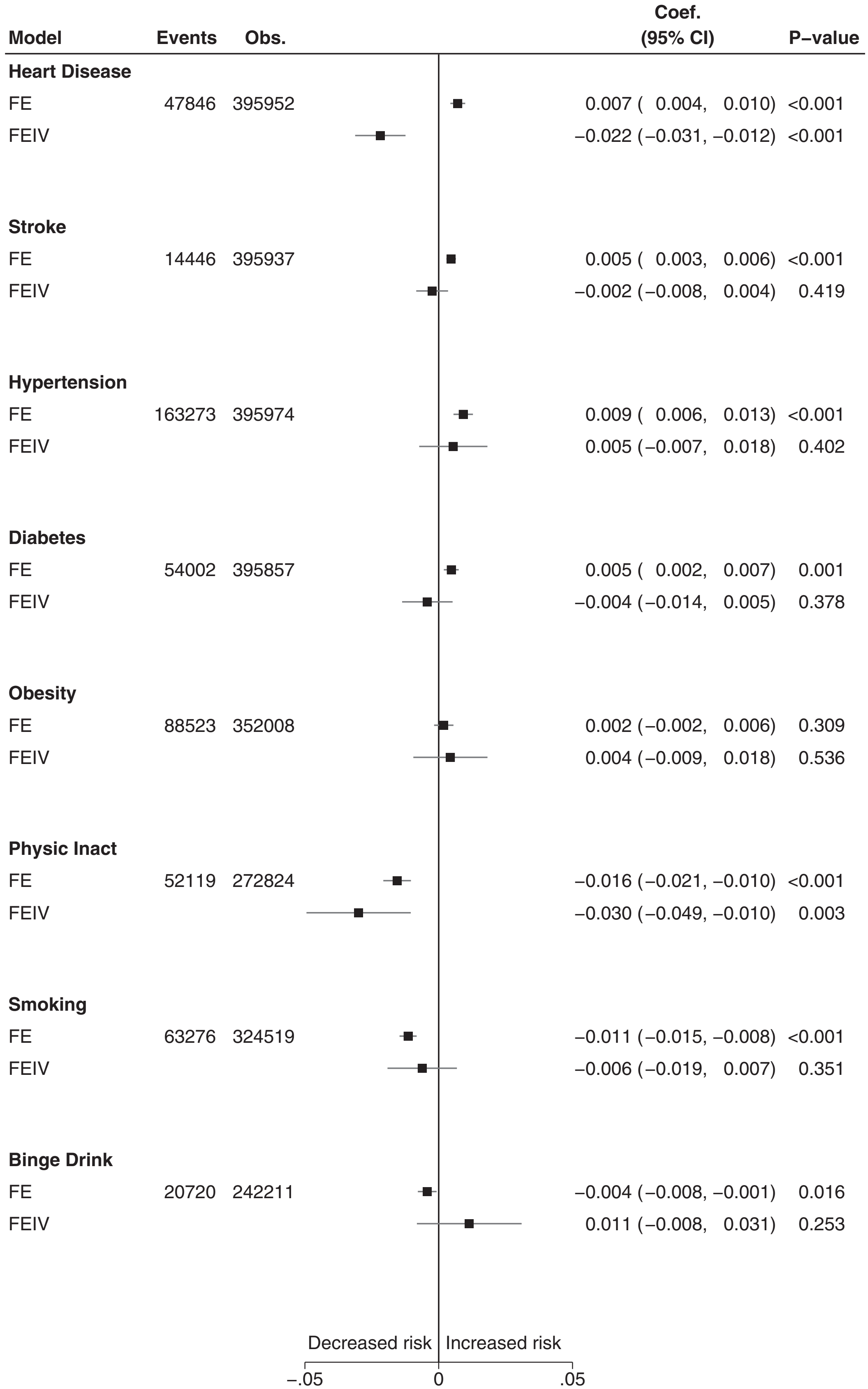

Figure 2 The association of retirement with cardiovascular diseases and risk factors. FE, fixed effects; FEIV, fixed-effects instrumental variable; obs, observations; oecf, coefficient; CI, confidence interval; physic inact, physical inactivity. All models were adjusted for age, age squared, marital status and fixed-effects of individuals, countries and years. The number of observations varied across outcomes due to missing values in outcomes

Subgroup	Events	Obs.	Coef. (95% CI)	P–value
Heart Disease				
Men	27071	196713	−0.026 (−0.042, −0.010)	0.001
Women	20775	199239	−0.031 (−0.043, −0.020)	<0.001
Stroke				
Men	7842	196696	−0.004 (−0.014, 0.007)	0.482
Women	6604	199241	−0.006 (−0.013, 0.001)	0.083
Hypertension				
Men	81747	196710	0.013 (−0.007, 0.033)	0.211
Women	81526	199264	−0.009 (−0.025, 0.007)	0.273
Diabetes				
Men	29785	196638	−0.002 (−0.017, 0.014)	0.829
Women	24217	199219	−0.011 (−0.023, 0.001)	0.063
Obesity				
Men	41845	176109	−0.007 (−0.029, 0.014)	0.517
Women	46678	175899	0.012 (−0.006, 0.030)	0.195
Physic Inact				
Men	23465	131204	−0.017 (−0.047, 0.013)	0.255
Women	28654	141620	−0.043 (−0.068, −0.018)	0.001
Smoking				
Men	37315	162583	0.015 (−0.007, 0.037)	0.175
Women	25961	161932	−0.019 (−0.034, −0.004)	0.013
Binge Drink				
Men	15006	119539	0.026 (−0.007, 0.058)	0.122
Women	5714	122672	−0.006 (−0.028, 0.016)	0.584

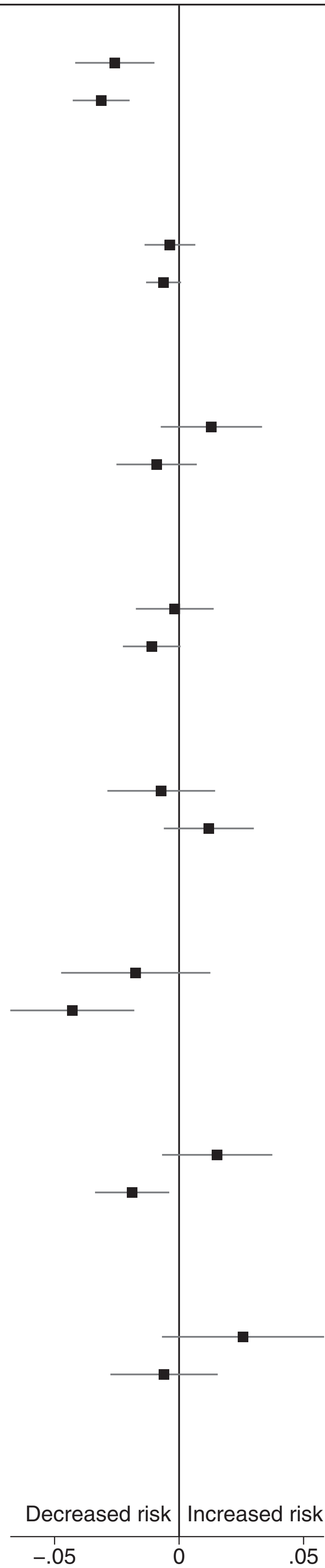

Figure 3 Subgroup analysis by sex for the association of retirement with cardiovascular diseases and risk factors. Obs, observations; coef, coefficient; CI, confidence interval; physic inact, physical inactivity. All models were adjusted for age, age squared, marital status and fixed-effects of individuals, countries and years. The number of observations varied across outcomes due to missing values in outcomes

Subgroup	Events	Obs.	Coef. (95% CI)	P–value
Heart Disease				
Low	13730	103285	−0.028 (−0.045, −0.010)	0.002
Middle	23684	176504	−0.023 (−0.036, −0.009)	0.001
High	8881	90977	−0.033 (−0.055, −0.011)	0.003
Stroke				
Low	4539	103285	−0.002 (−0.014, 0.010)	0.760
Middle	6813	176497	0.007 (−0.001, 0.015)	0.098
High	2296	90973	−0.014 (−0.026, −0.001)	0.034
Hypertension				
Low	46967	103273	0.024 (−0.001, 0.049)	0.055
Middle	76070	176532	0.006 (−0.011, 0.023)	0.500
High	32711	90983	−0.001 (−0.030, 0.027)	0.935
Diabetes				
Low	17802	103199	−0.005 (−0.023, 0.014)	0.622
Middle	23786	176496	−0.003 (−0.016, 0.009)	0.594
High	9279	90976	0.006 (−0.014, 0.026)	0.554
Obesity				
Low	25142	88932	0.018 (−0.010, 0.047)	0.211
Middle	45708	157438	0.016 (−0.003, 0.035)	0.101
High	17054	83176	−0.029 (−0.057, −0.001)	0.044
Physic Inact				
Low	11743	60902	−0.019 (−0.054, 0.016)	0.284
Middle	20050	121857	−0.030 (−0.056, −0.004)	0.024
High	6220	65078	−0.045 (−0.080, −0.011)	0.010
Smoking				
Low	20500	83801	−0.012 (−0.037, 0.013)	0.348
Middle	28758	144117	−0.012 (−0.028, 0.005)	0.178
High	8821	71452	−0.017 (−0.044, 0.009)	0.189
Binge Drink				
Low	4653	56127	−0.015 (−0.054, 0.024)	0.451
Middle	6586	108497	0.005 (−0.016, 0.027)	0.619
High	2653	53392	0.028 (−0.014, 0.070)	0.196

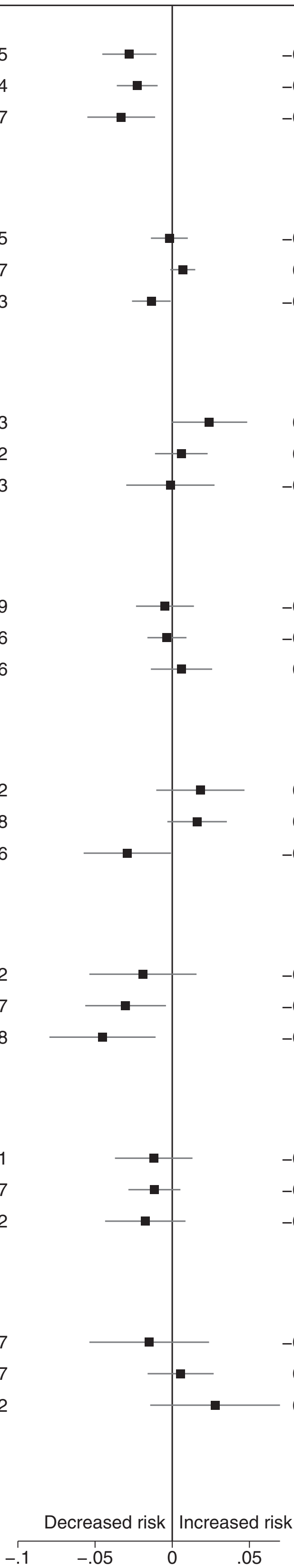

Figure 4 Subgroup analysis by education for the association of retirement with cardiovascular diseases and risk factors. Obs, observations; oef, coefficient; CI, confidence interval; physic inact, physical inactivity; low, less than upper secondary education; middle, upper secondary and vocational training; high, tertiary education. All models were adjusted for age, age squared, marital status and fixed-effects of individuals, countries and years. The number of observations varied across outcomes due to missing values in outcomes

Subgroup	Events	Obs.	Coef. (95% CI)	P–value
Heart Disease				
Physical labour	14996	143993	−0.010 (−0.026, 0.007)	0.239
Non−physical labour	12295	114395	−0.031 (−0.050, −0.013)	0.001
Stroke				
Physical labour	3819	143987	0.002 (−0.009, 0.012)	0.765
Non−physical labour	3154	114385	−0.006 (−0.017, 0.005)	0.302
Hypertension				
Physical labour	54857	144006	0.013 (−0.009, 0.035)	0.258
Non−physical labour	44099	114398	0.014 (−0.010, 0.037)	0.254
Diabetes				
Physical labour	17133	143999	0.003 (−0.014, 0.020)	0.710
Non−physical labour	13388	114389	0.010 (−0.008, 0.028)	0.266
Obesity				
Physical labour	31522	129996	0.025 (0.002, 0.048)	0.032
Non−physical labour	25602	104209	−0.031 (−0.056, −0.007)	0.012
Physic Inact				
Physical labour	23459	110529	−0.001 (−0.035, 0.033)	0.942
Non−physical labour	12195	83696	−0.048 (−0.082, −0.013)	0.008
Smoking				
Physical labour	27086	125472	0.009 (−0.013, 0.031)	0.424
Non−physical labour	15234	98157	−0.018 (−0.040, 0.004)	0.105
Binge Drink				
Physical labour	10486	99077	−0.007 (−0.035, 0.022)	0.637
Non−physical labour	4880	75604	0.025 (−0.002, 0.053)	0.070

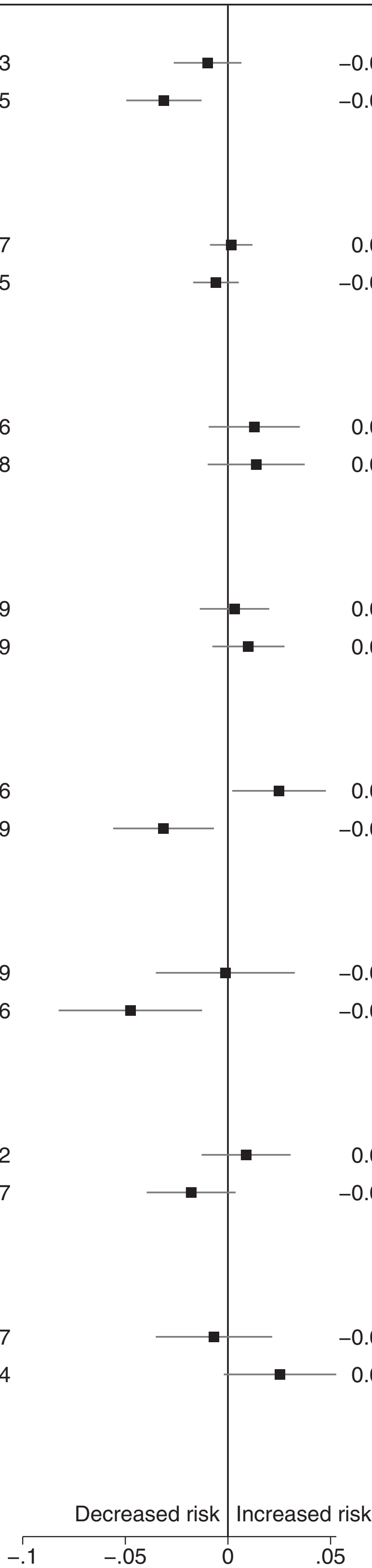

Figure 5 Subgroup analysis by job type for the association of retirement with cardiovascular diseases and risk factors. Obs, observations; coef, coefficient; CI, confidence interval; physic linact, physical inactivity. All models were adjusted for age, age squared, marital status and fixed-effects of individuals, countries and years. The number of observations varied across outcomes due to missing values in outcomes

continuing non-physical labour. In contrast, those retired from physical labour indicated increased risk of obesity [0.025 (0.002 to 0.048)] compared with those engaging in physical labour.

Sensitivity analyses

First, we excluded the partly retired individuals and examined the association between full retirement and outcomes; the point estimates were similar to our main results though broader CIs were indicated in physical inactivity (Supplementary Table S10, available as Supplementary data at *IJE* online). Second, restricting the participants to those aged 52–68 years revealed similar associations of retirement with decreased heart disease risks and physical inactivity, whereas it showed amplified associations with decreased risks of diabetes, compared with the main results (Supplementary Table S11, available as Supplementary data at *IJE* online). Third, we excluded data from Greece, Latvia, Malta, Portugal, Romania, Costa Rica, Japan and South Korea, in which the IVs appeared to be weak. The exclusion of these countries did not make a considerable difference to the results (Supplementary Table S12, available as Supplementary data at *IJE* online). Fourth, excluding data from the USA did not affect the results (Supplementary Table S13, available as Supplementary data at *IJE* online). Fifth, analysis using an imputed dataset showed similar results (Supplementary Table S14, available as Supplementary data at *IJE* online). Sixth, FEIV Poisson models indicated consistent results with linear probability models [heart disease: risk ratio = 0.89 (0.81 to 0.98); physical inactivity: 0.87 (0.77 to 0.97)] (Supplementary Table S15, available as Supplementary data at *IJE* online). Seventh, we found consistent results even after excluding those who retired within 2 years (Supplementary Table S16, available as Supplementary data at *IJE* online). Finally, people who retired over 5 years ago exhibited larger reductions in heart disease risks and physical inactivity, whereas those who retired within 5 years presented a clearer reduction in stroke, compared with their counterparts (Supplementary Figure S11, available as Supplementary data at *IJE* online).

Discussion

In this multicountry longitudinal study, we examined the association of retirement with CVD and its associated risk factors, using the IV method. The FE models without IVs showed an increased CVD risk among retirees and suggested that sicker workers retired earlier. In contrast, the FEIV models using the SPA as an IV showed the association of retirement with a decreased heart disease risk for the first time. These discrepancies in estimates between the FE and the FEIV models suggest the presence of the healthy worker survivor effect in previous research which showed the detrimental association of retirement on CVD risks.[3] Our study provides updated results and highlights the importance of reconsidering the possible beneficial retirement effects on cardiovascular health. Our FEIV models also presented decreased physical inactivity after retirement, consistent with previous findings.[9–14] Physical activity may contribute to the decreased risk of heart disease among retirees.

The subgroup analyses revealed heterogeneous associations between retirement and risk factors. We found decreased smoking among women but not among men after retirement. Gender differences in workplace stress[37] and post-retirement social networks[38] might be correlated with cigarette consumption. Association between retirement and reduced obesity and physical inactivity among people with high educational levels was shown. They may be aware of their health and able to invest in health-promoting activities such as exercise and healthy eating after retirement. Although the analysis was limited to those who had working experience during the study period, people retired from non-physical labour exhibited reduced obesity and physical inactivity, whereas those retired from physical labour indicated increased obesity risk, in line with previous studies.[29,30] Retirement provides time to undertake physical activity for those who engaged in sedentary jobs, whereas those who engaged in physical labour lose financial incentives for being physically active after retirement and may gain weight unless they continue exercising to the same extent as before. As a previous study suggested,[12] these differences in post-retirement health behaviours may be attributable to the differentiated CVD outcomes, specifically a reduced risk of stroke among highly educated people and heart disease among retirees from non-physical labour.

This study has several limitations. First, we could not determine the mechanism underlying the reduced CVD risk after retirement. Our analyses suggested that trends in the CVD incidence and its risk factors were consistent; however, they were not conclusive because risk factor outcomes were only available in limited countries. Moreover, other important health behaviours (e.g. sleep duration, dietand adherence to medication) were also not available in the harmonized datasets. We assumed that hypertension, diabetes and obesity are on the pathway between retirement and CVD, but did not find clear patterns between retirement and these outcomes. Unobserved factors may have offset the beneficial effect of retirement on them, though the net effect of retirement on heart disease appeared to be protective. Further studies are required to confirm the mechanism. Second, although harmonization across different surveys was performed by specialists in the field,[19,22,25] some differences remained. Although these inconsistencies may induce bias in the estimates, some part of the potential bias could be reduced by adding the FEs of countries. Third, both retirement status and outcomes were self-reported and subject to measurement errors. Nevertheless, the direct question of retirement status is face-valid and reflects individuals' recognition of retirement. Such recognition plays an important role in adjusting post-retirement health behaviours.[12] Moreover, a previous study using data from the HRS showed that self-reporting of stroke has acceptable validity.[39] If the reports of diagnosed health conditions were missed, it would tend to bias associations towards the null.

Conclusion

This novel study suggests that retirement was associated with a decreased heart disease risk on average. Some associations of retirement with CVD and risk factors appeared heterogeneous by individual characteristics. Policy makers need to consider the benefits of raising SPA and allowing older people to continue working versus the costs from the potential risk of expensive medical conditions such as CVD.

Ethics approval

The present study used publicly available data that have obtained informed consent from all participants and ethical approval from relevant local ethics committees. Thus, the Ethics Committee of Kyoto University exempted this study from review.

Data availability

The harmonized datasets are available through the Gateway to Global Aging Data website [https://g2aging.org/].

Supplementary data

Supplementary data are available at *IJE* online.

Author contributions

K.S. conceived the study design, performed statistical analysis, and drafted the manuscript. H.N., K.I., I.K. and N.K. interpreted the results and critically revised the manuscript. K.S. and K.I. directly accessed and verified the underlying data reported in the manuscript. All authors confirm that they have full access to all data in the study and accept responsibility to submit for publication.

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Conflict of interest

None declared.

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