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Impact of residing in neighborhoods of high social participation on health of retired workers: A multilevel analysis using nationwide longitudinal data in Japan

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ABSTRACT

Retirement is a key determinant of health among middle-aged and older adults. Social participation (SP) has a favorable impact on health outcomes. Combining these two issues, we examined how neighborhood-level SP may affect the health outcomes of retired workers. We used 94,661 longitudinal observations of 13,185 full-time workers aged 50–59 years in 2005 from a nationwide 14-wave survey conducted in Japan from 2005 to 2018. First, we computed neighborhood SP using an econometric method. We then conducted multilevel analysis to examine how neighborhood SP, retirement, and their interaction affected the probabilities of SP, poor self-rated health (SRH), problems in activities of daily living (ADL), and psychological distress (SD). The estimation results showed that retirement in a high-SP neighborhood reduced the probabilities of poor SRH, ADL problems, and SD by 1.1 (95% confidence interval [CI]:0.5–1.7), 0.9 (95% CI:0.0–1.8), and 2.1 (95% CI:0.6–3.7) percentage points, respectively. These effects were substantial in magnitude, considering that the prevalence of poor SRH, ADL problems, and SD were 3.7%, 7.4%, and 18.5%, respectively, among retired men. In contrast, such interaction effects between retirement and neighborhood SP were not observed among the women. The results suggest that policy measures to encourage SP at the neighborhood level should be developed to help individuals enjoy a healthier life in retirement.

1. Introduction

Retirement is considered a key determinant of health outcomes in middle-aged and elderly individuals. Considering the stressful influence of work, it is reasonable to predict that retirement would have a favorable impact on health. However, as surveyed by van der Heide et al. (2013), these studies have provided conflicting results. Regarding self-rated health (SRH) and general health conditions, many studies, including Coe and Zamarro (2011), Hessel (2016), Neuman (2008), and Westerlund et al. (2009), showed a favorable impact of retirement, whereas Behncke (2012) and, Curl and Townsend (2014) revealed its adverse impact. The impact on mental health is also controversial. As surveyed by Li et al. (2021) and Odone et al. (2021), many studies have observed both beneficial and adverse effects of retirement on mental health. The same is true for the impact on physical health. Some studies, including Gall et al. (1997) and Westerlund et al. (2010), indicated a physical health improvement after retirement; while others, including Mänty et al. (2018) and Mein et al. (2003), were skeptical of such an impact.

Several factors may result in mixed and inconsistent observations about the effects of retirement, besides differences inherent in datasets collected from different countries and study groups. As already stressed by preceding studies, the endogeneity of retirement, reverse causation from health to retirement, different types of retirement (voluntary, involuntary, or statutory), and an individual's socioeconomic attributes, such as educational attainment, may affect the observed impact of retirement on health.

Another major factor that may potentially affect the impact of retirement on health is the attributes of the neighborhood in which an individual resides. In this study, we specifically focused on social

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participation (SP) at the neighborhood level. SP refers to an individual's involvement in activities and interactions with others in society or the community, such as participating in community work, sports/hobby clubs, and volunteer activities (Levasseur et al., 2010). SP is known to have a favorable impact on health outcomes in terms of functional disability (Ashida et al., 2016; Kanamori et al., 2014), psychological distress (Amagasa et al., 2017), and cognitive impairment (Bourassa et al., 2017; Hsu, 2007). Recent studies have found that SP moderates the adverse impact of retirement on mental health (Liu et al., 2019; Shiba et al., 2017). However, it is questionable whether individual-level SP is exogenous or not. We cannot rule out the possibility that it is affected by health as well as an individual's attributes, and if this is the case, the observed association between SP and health outcomes may be overestimated.

Hence, we focused on neighborhood-level SP, which can be considered largely exogenous, as a potential modifier of the impact of retirement on health. Researchers focusing on social capital, a concept overlapping with that of SP, have distinguished individual- and area-level social capital and have shown that area-level social capital affects an individual's health independent of individual-level social capital (Kim et al., 2006; Mohnen et al., 2011, 2015; Snelgrove et al., 2009; Sundquist & Yang, 2007). Tsuji et al. (2018) also observed a beneficial effect of community-level sports group participation on older individuals' mental health. Accordingly, neighborhood-level SP is expected to affect health outcomes after retirement independent of individual-level SP.

Based on these observations, we tentatively hypothesized that residing in a high-SP neighborhood would be beneficial to retired workers' health. To evaluate the validity of this hypothesis, we focused on the change in health outcomes of full-time workers after achieving the statutory retirement age, and how the impact of retirement on health was modified by neighborhood SP using multilevel longitudinal data. If this hypothesis is supported, it can be argued that policy measures to encourage SP at the neighborhood level should be further developed to help individuals enjoy a healthy life in retirement.

2. Materials and methods

2.1. Study sample

We used data obtained from a nationwide 14-wave panel survey, the "Longitudinal Survey of Middle-Aged and Elderly Persons," conducted every year from 2005 to 2018 by the Japanese Ministry of Health, Labour and Welfare (MHLW). The survey began with a cohort of people aged 50–59 years (born between 1946 and 1955) in the first wave in 2005. Samples in the first wave were collected from individuals nationwide between the ages of 50 and 59 years in November 2005, using a two-stage random sampling procedure. First, 2,515 of the 5,280 districts were randomly selected from approximately 940,000 national census districts. Each district was chosen to consist of approximately 50 households; thus, each district could be characterized as a "neighborhood." Second, 40,877 residents aged 50–59 years were randomly selected from these districts as of October 30, 2005. In total, 34,240 individuals responded to the survey (response rate:83.8%). The second to fourteenth waves were conducted in early November of each year, from 2006 to 2018, with no new samples added during the survey period.

We identified the neighborhood in which each respondent resided at the baseline (the first wave). We removed data from 1,386 participants who stated that they had moved within the past year in each survey wave at least once during the second to fourteenth waves. We then focused on those who were working full-time or as managers at baseline, considering that retirement may have different meanings for self-employed and part-time workers. In addition, we removed the data of the participants when and after they left their primary job for reasons other than statutory retirement (see Methods section). After further removing respondents who did not answer key questions regarding health outcomes and SP, we used 84,398 longitudinal data points from 13,185 individuals (9,907 men and 3,278 women). The total number of neighborhoods used in this study was 2,440, with 9.0 residents on average (range:1–84) living in each neighborhood. Fig. 1 shows the construction of the study sample using the original dataset.

2.2. Measures

2.2.1. Retirement

To construct the retirement variable, we focused on the experience of retirement at the statutory retirement age, which is often set at 60 or 65 years in Japanese firms. Statutory retirement programs are considered exogenous to employees and the timing of retirement is predictable. The survey asked the respondents whether they had stopped working over one year prior to the survey, and if the respondents answered *yes*, they were asked to choose the reason (multiple answers permitted) from (1) statutory retirement, (2) contract term completed, (3) early retirement, (4) bankruptcy, (5) dismissal, (6) finding a new job, (7) health problems, (8) nursing care for family members, (9) childcare, (10) problems in personal relations, (11) dissatisfaction with working conditions, (12) started to receive pension benefits, and (13) others.

We constructed a binary variable for retirement by allocating one to the wave in which a respondent stopped working because of statutory retirement and subsequent waves, and zero to the waves before retirement. A small proportion of those who answered "statutory retirement" simultaneously answered another reason for retirement (such as bankruptcy). However, we treated them equally with those who only answered "statutory retirement".

A substantial proportion of retired full-time workers in Japan tend to keep or resume working as part-time or freelance workers for a while after statutory retirement, and some earn both wage income and public pension benefits (Shimizutani & Oshio, 2010). Hence, we included individuals who kept or resumed working after statutory retirement in our main statistical analysis. We also conducted a sensitivity analysis in which we removed the observations of participants who kept or resumed working after statutory retirement from the regression analysis (see the Methods section).

Regarding the respondents who stopped working for reasons other than statutory retirement, such as dismissal, bankruptcy, and health problems, we used their observations only before retirement and disregarded the data after retirement, because these types of retirement may have different impacts on health as compared to statutory retirement.

2.2.2. Social participation at the individual level

We constructed the SP variable based on the answers to questions about participation in social activities. The survey asked respondents whether they participated in six types of social activities (multiple answers permitted): (1) hobbies or entertainment, (2) sports or physical exercises, (3) community activities, (4) childcare support or educational or cultural activities, (5) support for the elderly, and (6) others. If the respondents answered *yes*, they were asked to indicate with whom they participated in each activity by choosing (a) alone, (b) family members or friends, (c) workplace colleagues, (d) members of a neighborhood association, or (e) members of a non-profit organization or public service corporation (multiple answers permitted). We constructed a binary variable for individual SP by allocating 1 to respondents who chose at least one item from (b)–(e) in at least one of the six social activities (1)–(6), and 0 otherwise. We excluded those who participated in SP activities alone, as SP refers to activities that provide interaction with others (Levasseur et al., 2010).

2.2.3. Social participation at the neighborhood level

To construct a variable for neighborhood SP, we applied the econometric method proposed in previous studies (Mohnen et al., 2001;

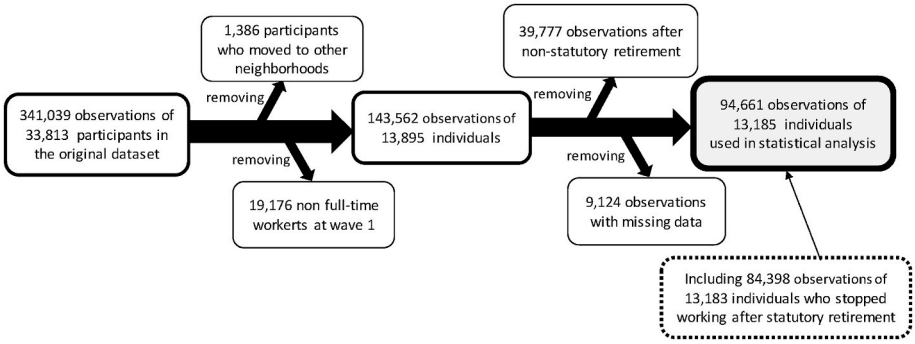

Fig. 1. Constructing the study sample.

Mohnen et al., 2015; Mujahid et al., 2007; Raudenbush and Sampson, 1999). Specifically, we first estimated a linear regression model with multiple-level fixed effects (Guimarães & Portugal, 2010) to explain a binary variable for the SP of individual i residing in neighborhood j in wave w as follows:

$$SP_{ijw} = \alpha + \sum_{k} \gamma_k x_{kijw} + e_{1i} + e_{2j} + e_{3w} + \varepsilon_{ijw,} \quad (1)$$

using the entire dataset (individual × neighborhood × wave). Here, x is an individual-level time-variant covariate (age, marital status, household spending, smoking, and leisure-time physical inactivity), where k indicates the k-th covariate; e_1, e_2, and e_3 are individual-, neighborhood-, and wave-level fixed effects, respectively; and ε is an error term. This approach aimed to capture the SP component attributable to each neighborhood by controlling for individual- and wave-specific factors. The key parameter is the neighborhood fixed effect e_2, which indicates the degree to which the SP in neighborhood j differs from the grand mean of the SP, α (Mohnen et al., 2011, 2015). Hence, e_2 is considered to constitute the neighborhood SP measure; higher (lower) values indicate higher (lower) levels of the neighborhood SP. We constructed a binary variable of high neighborhood SP by allocating 1 to $e_2 > 0$, which means that the neighborhood fixed effect was above the average (weighted by the number of respondents in each neighborhood), and 0 otherwise.

2.2.4. Health outcomes

We considered three types of health outcomes: activities of daily living (ADL), poor SRH, and psychological distress (SD). Regarding ADL problems, we constructed a binary variable for each by allocating 1 to those who answered that they had some problems with at least one of the ten ADLs (walking, getting into and out of bed, standing up from and sitting down on a chair, getting dressed, washing one's hands and face, eating, toileting, bathing, going up and down stairs, and carrying shopping bags) and 0 otherwise. We further constructed a binary variable for more serious ADL problems by allocating 1 to those who answered that they needed assistance in at least one of the ten ADLs.

Regarding SRH, respondents were asked to choose from 1 (*very good*), 2 (*good*), 3 (*somewhat good*), 4 (*somewhat poor*), 5 (*poor*), or 6 (*very poor*) based on their current health condition. We constructed a binary variable for poor SRH by allocating 1 to scores 5 and 6, and 0 otherwise.

We defined SD using the Kessler 6 (K6) scores (Kessler et al., 2002, 2010). Furukawa et al. (2008) and Sakurai et al. (2011) confirmed the reliability and validity of this score in psychological analyses of Japanese people. The survey required participants to complete a six-item SD questionnaire, which included the following question: "During the past 30 days, how often did you feel a) nervous, b) hopeless, c) restless or fidgety, d) so depressed that nothing could cheer you up, e) that everything was an effort, and f) worthless?" They were rated on a five-point scale (0 = *none of the time*; 4 = *all of the time)*). The sum of the reported scores (range:0–24) was defined as the K6 score. K6 scores ≥5 indicated the presence of moderate or more serious SD in a Japanese sample, as validated by Kessler et al. (2010) and Sakurai et al. (2011). We constructed a binary variable of SD by allocating 1 to K6 scores ≥5, and 0 otherwise. The Cronbach's alpha for the entire study sample was 0.897. For the supplementary analysis, we also constructed a 4-point score variable for SD by allocating 1, 2, 3, and 4 to 0 ≤ K6 scores ≤4, 5 ≤ K6 scores ≤8, 9 ≤ K6 scores ≤12, and 13 ≤ K6 scores ≤24, respectively; considering that cutoffs of 5, 9, and 13 were used to indicate the severity of psychological illness (e.g., Furukawa et al., 2008).

2.2.5. Covariates

For individual-level covariates, we considered educational attainment, marital status, household spending, lack of leisure-time physical activity, smoking, and age at baseline. For educational attainment, we constructed binary variables for graduating from junior high school, high school, junior college, or college or higher. We also merged respondents who graduated from other institutions and those who did not respond to the questions into one group, and constructed a binary variable for them. Household spending was adjusted for household size by dividing it by the square root of the number of household members (Organization for Economic Co-Operation and Development, 2015). We categorized these variables into quartiles and constructed binary variables for each quartile. For respondents who did not answer questions on household spending, we allocated a binary variable to the unanswered questions. As for health behavior, we constructed binary variables for no leisure-time physical activity and smoking based on self-reported answers in the survey. We further constructed binary variables for the married, living alone, and age groups.

2.3. Statistical analysis

Using this binary variable for neighborhood SP, we estimated multilevel regression models that linearly explained the probability of each health outcome by neighborhood SP and retirement after controlling for individual attributes and wave-specific fixed effects. Specifically, we fitted the three-level model with random intercepts at the neighborhood and individual levels:

$$Y_{ijw} = \beta_0 + \beta_1 Ret_i + \beta_2 HiSP_j + \beta_3 Ret_i \times HiSP_j + \sum_{m} \delta_m X_{mijw} + u_{1i} + u_{2j} + u_{3w} + \eta_{ijw.} \quad (2)$$

Here, Y indicates a binary variable for each health outcome (poor SRH, ALD problems, and SD), while *Ret* and *HiSP* are binary variables for after-retirement and high-neighborhood SP, respectively. X is an individual-level covariate (sex, age, marital status, living alone, household spending, smoking, and leisure-time physical inactivity) where m indicates the m-th covariate. u_1 and u_2 indicate random intercepts at the individual and neighborhood levels, respectively; whereas u_3 indicates wave-level fixed effects, which are captured by binary variables for each wave.

The focus was placed on the estimated values of coefficients β_1, β_2, and β_3, which represent the impacts of retirement, neighborhood SP, and their interactions, respectively. The probability of the outcome is projected to increase by β_1 after retirement if the participant resided in a low-SP neighborhood, whereas it is projected to increase by $\beta_1+\beta_3$ after retirement if the participant resided in a high-SP neighborhood.

Three supplementary analyses were conducted. First, we removed the observations of participants who kept or resumed working after statutory retirement from the regression analysis to examine how the estimation results would change.

Second, we formally tested the sex differences in the results. To this end, we included *Woman*, an indicator variable for being a woman, and its interaction terms with *Ret*, *HiSP*, and *Ret* × *HiSP* in regression model (2) and estimated it for the entire sample (including men and women). We focus on the estimated values of the coefficients for these interaction terms.

Third, we estimated multilevel ordered logistic models for SRH and SD to check the robustness of the results based on their binary variables. For SRH, we replaced the binary variable for poor SRH with the original six-point scores. For SD, we replaced a binary variable for SD (K6 scores ≥5) with a four-point score. As in the case of linear regression model (2), we focused on the estimated values of coefficients β_1, β_2, and β_3.

3. Results

3.1. Description analysis

Table 1 summarizes the descriptive statistics of all respondents observed over the 14 waves. Female respondents accounted for only one-fourth of the sample, reflecting the limited share of full-time workers. More than 70% of the sample participated in one or more social activities; 17.5% of male respondents (person × wave), and 15.7% of female respondents had experienced statutory retirement. The proportion of respondents who reported poor SRH and ADL problems was lower than 10%, while approximately one-fourth of the respondents reported moderate or serious SD.

Table 1
Key features of the study sample over 14 waves.

		All	Men	Women
Prevalence (%)				
Experienced statutory retirement		20.7	20.9	20.1
Fully retired		10.3	9.4	13.1
Individual SP				
Hobby or entertainment		51.1	48.6	58.8
Sports or physical exercises		30.8	31.9	27.3
Community activities		34.5	34.9	33.2
Childcare support, or educational or cultural activities		4.0	3.8	4.6
Support for the elderly		4.1	3.8	5.0
Others		12.1	12.1	11.8
One or more activities		71.4	70.7	73.8
Educational attainment				
Junior high school		13.0	13.0	12.7
High school		53.9	51.3	61.9
Junior college		5.5	2.8	13.8
College or above		25.8	30.8	10.2
Other and unanswered		1.8	2.0	1.4
Married		87.0	91.1	74.2
Living alone		6.2	4.5	11.4
Poor self-rated health		2.9	3.0	2.5
ADL problems		6.2	5.5	8.5
Psychological distress		24.2	23.0	27.7
Smoking		29.6	36.3	9.1
No leisure-time physical activity		38.8	38.9	38.2
Household spending	*M*	200.9	202.6	195.9
(Monthly, thousand JPY)	*SD*	(321.7)	(302.0)	(376.7)
Age at baseline	*M*	59.1	59.2	59.0
(Years)	*SD*	(4.6)	(4.6)	(4.7)
N		94,661	71,415	23,246

Fig. 2 depicts the distribution of the statutory retirement age at which the respondents stopped working, at least temporarily, due to statutory retirement. The majority of the sample had a statutory retirement age of 60 years, while the age of 65 years accounted for a much lesser extent for both men and women. Note that 53.1% of the respondents who had stopped working due to statutory retirement were working, and 74.9% of them were working part-time or self-employed workers (not reported in the figure).

Before examining the impact of neighborhood social participation, Table 2 compares the prevalence of each health outcome before and after retirement. The results were mixed. For men, SRH and ADL problems worsened somewhat after retirement, whereas SD improved. For women, ADL problems and SD echoed men's results, whereas SRH remained almost unchanged after retirement.

Fig. 3 shows how neighborhood SP affected the prevalence of each health outcome in both men and women. For men, the prevalence of each outcome was lower in higher-SP neighborhoods, both before and after retirement, confirming the favorable impact of high neighborhood SP. After retirement, the prevalence of poor SRH and ADL problems increased, and that of SD declined, indicating a mixed impact of retirement. For women, a high neighborhood SP had a favorable impact on SRH and ADL problems, but this was less clear for SD. The impact of retirement is mixed, as in the case of men. However, we should be cautious when interpreting the results in this figure because we did not control for any other variables, including age effects.

3.2. Regression analysis

Table 3 summarizes the estimation results of the multilevel regression models, which explain the probability of poor SRH among men. The binary variable for high-neighborhood SP was based on the estimation results of Equation (1), as explained in the Methods section (the estimation results are available upon request from the authors). For men, retirement increased the probability of poor SRH by 1.1 (95% confidence interval [CI]:0.5–1.7) percentage points, while high neighborhood SP did not. More noticeably, the interaction of retirement and high neighborhood SP reduced the probability by 1.2 (95% CI:0.5–1.9) percentage points, indicating that retirement amplified the favorable impact of high neighborhood SP. In contrast, there was no such interaction effect for women, although high neighborhood SP was beneficial to health.

We repeated similar estimations for ADL problems and SD and summarized their key results in Table 4, along with those of poor SRH (already reported in Table 2). For men, high neighborhood SP consistently had a favorable impact on the three outcomes. However, retirement showed mixed results: it increased the probability of poor SRH (as already reported in Table 2), reduced that of SD, and had little impact on

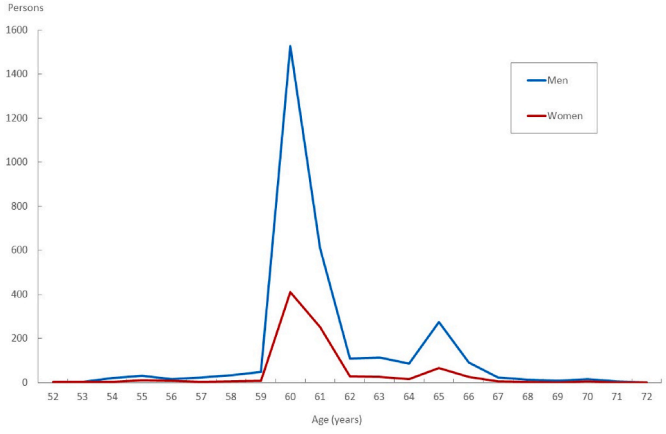

Fig. 2. Distribution of statutory retirement ages.

Table 2
Prevalence (%) of each health outcome by retirement status.

	Before retirement	After retirement	Difference	
	(A)	(B)	(B) – (A)	*p*-value
Men				
Poor self-rated health	2.8	3.7	0.8	<.001
ADL[a] problem	5.0	7.4	2.5	<.001
Psychological distress	24.2	18.5	−5.7	<.001
N	56,483	14,932		
Women				
Poor self-rated health	2.5	2.6	0.1	.560
ADL[a] problem	7.9	11.2	3.4	<.001
Psychological distress	28.8	23.1	−5.7	<.001
N	26,357	4,918		

[a] Activities of daily living.

ADL problems. More noticeably, the interaction between retirement and high neighborhood SP had a favorable impact consistently, as it reduced the probabilities of poor SRH, ADL problems, and SD by 1.2 (95% CI:0.5–1.9), 0.9 (95% CI:0.0–1.8), and 2.1 (95% CI:0.6–3.7) percentage points, respectively. These effects were substantial in magnitude, considering that the prevalence of poor SRH, ADL problems, and SD were 3.7%, 7.4%, and 18.5%, respectively, among retired men (see Table 2). We also found that high-SP neighborhoods and, albeit modestly, retirement, had no impact on their interactions. In contrast, for women, neither retirement nor neighborhood SP had a consistent effect on health outcomes. Moreover, the interaction between the two did not significantly affect health outcomes.

We further examined how the results would change if we removed the participants who kept or resumed working after statutory retirement, and summarized the results in Table S1. As seen in this table, the results for these limited samples showed a pattern similar to that in Table 4; retirement in a high-SP neighborhood had favorable impacts on health outcomes among men. We also observed somewhat larger magnitudes of the estimated values of each coefficient compared with those in Table 4, presumably reflecting the endogeneity of working status after statutory retirement.

To formally test for sex differences in the estimation results, Table S2 in the supplementary file shows the estimation results of the models for the entire sample, including the interaction terms with a binary variable for women. As seen in Table S2, any interaction term other than "After retirement × High neighborhood SP × Women" in the SP model was not significant, although being a woman independently reduced the probability of poor SRH and increased the probability of ADL problems and SD. These results required us to be cautious regarding the sex differences observed in Table 4.

To help understand the estimation results in Table 4, Fig. 4 graphically compares the impact of retirement in a low-SP neighborhood (β_1) and that in a high-SP neighborhood ($\beta_1+\beta_3$) on each outcome for men and women. For men, retirement in a high-SP neighborhood had a greater impact on health than retirement in a low-SP neighborhood, reflecting the significant effect of the interaction between retirement and neighborhood SP (β_3). Retirement in a high-SP neighborhood improved all three health outcomes, whereas retirement in a low-SP neighborhood increased the risk of poor SRH, had little impact on ADL problems, and had a smaller impact on SD than retirement in a high-SP neighborhood did. For women, the impact of retirement was indeterminate regardless of the neighborhood SP level, and the positive impact of retirement on SD was somewhat smaller in a high-SP neighborhood.

To check the robustness of the estimation results, we estimated multilevel ordered logistic models for SRH and SD using their six- and four-point scores, respectively. Table S3 in the supplementary file provides the estimation results. The direction and significance of the estimated associations measured by the odds ratio showed patterns similar to those shown in Table 4. Most noticeably, retirement in a high-SP neighborhood independently had a favorable impact on both SRH and SD among men, although retirement itself did not significantly affect SRH among men unlike the results in Table 4.

4. Discussion

We investigated how neighborhood SP affects post-retirement health outcomes using large-scale nationwide longitudinal data from middle-aged individuals in Japan. We identified the timing of retirement by taking advantage of longitudinal data, and thus divided the life state of middle-aged individuals into pre- and post-retirement stages. We also estimated neighborhood SP using the econometric method based on

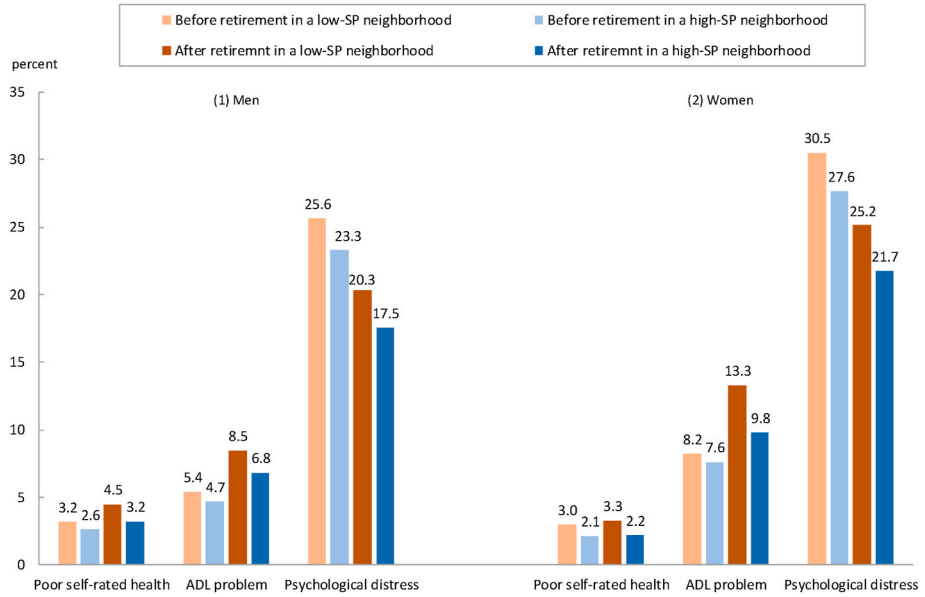

Fig. 3. Prevalence of each health outcome by retirement status and neighborhood social participation.

Table 3
Estimated effects of neighborhood social participation and retirement on the probability of poor self-rated health (SRH)[a].

	Men				Women			
	Coef.		95% CI[b]		Coef.		95% CI	
After retirement (β_1)	0.011	***	(0.005,	0.017)	−0.001		(–0.011,	0.009)
High neighborhood SP[c] (β_2)	−0.004		(–0.009,	0.001)	−0.009	*	(–0.017,	−0.001)
After retirement × High neighborhood SP(–β_3)	−0.012	***	(–0.019,	−0.005)	0.000		(–0.011,	0.012)
Married	−0.007		(–0.015,	0.002)	−0.006		(–0.015,	0.003)
Living alone	0.002		(–0.008,	0.013)	0.007		(–0.004,	0.017)
Educational attainment (ref. = college or above)								
Junior high school	0.024	***	(0.016,	0.032)	0.002		(–0.014,	0.017)
High school	0.012	***	(0.006,	0.017)	−0.001		(–0.014,	0.011)
Junior college	0.004		(–0.012,	0.019)	0.006		(–0.009,	0.022)
Unanswered	0.021	***	(0.008,	0.034)	0.039	***	(0.015,	0.063)
Household spending (ref. = 4th quartile [highest])								
1st quartile	−0.007	**	(–0.011,	−0.003)	−0.013	***	(–0.020,	−0.006)
2nd quartile	−0.003		(–0.007,	0.001)	−0.003		(–0.010,	0.003)
3rd quartile	−0.002		(–0.005,	0.001)	−0.003		(–0.009,	0.003)
Unanswered	−0.009	**	(–0.015,	−0.003)	−0.011	*	(–0.020,	−0.002)
Smoking	−0.017	***	(–0.021,	−0.013)	0.000		(–0.010,	0.009)
No leisure-time physical activity	0.009	***	(0.006,	0.012)	0.012	***	(0.007,	0.017)
Observations	71,415				23,246			
Individuals	9,907				3,278			
Neighborhoods	2,218				1,529			

***$p < .001$, **$p < .01$, *$p < .05$.
[a] Further controlled for ages and wave-level fixed effects.
[b] Confidence interval.
[c] Social participation.

Table 4
Estimated effects of neighborhood social participation and retirement on the probability of each health outcome.[a].

	Men				Women			
	Coef.		95% CI[b]		Coef.		95% CI	
Poor self-rated health								
After retirement (β_1)	0.011	***	(0.005,	0.017)	−0.001		(−0.011,	0.009)
High neighborhood SP[c] (β_2)	−0.004		((−0.009,	0.001)	−0.009	*	(−0.017,	−0.001)
After retirement × High neighborhood SP (β_3)	−0.012	***	(−0.019,	−0.005)	0.000		(−0.011,	0.012)
ADL[d] problem								
After retirement (β_1)	0.012	**	(0.004,	0.020)	0.018	*	(0.002,	0.035)
High neighborhood SP (β_2)	−0.006		(−0.012,	0.001)	−0.006		(−0.021,	0.008)
After retirement × High neighborhood SP (β_3)	−0.009	*	(−0.018,	0.000)	−0.024	*	(−0.043,	−0.005)
Psychological distress								
After retirement (β_1)	−0.019	**	(−0.032,	−0.005)	−0.035	**	(−0.060,	−0.010)
High neighborhood SP (β_2)	−0.018	*	(−0.032,	−0.004)	−0.014		(−0.039,	0.011)
After retirement × High neighborhood SP (β_3)	−0.021	**	(−0.037,	−0.006)	0.007		(−0.022,	0.037)
Observations	71,415				23,246			
Individuals	9,907				3,278			
Neighborhoods	2,218				1,529			

***$p < .001$, **$p < .01$, *$p < .05$.
[a] Controlled for individual-level covariates and wave-level fixed effects.
[b] Confidence interval.
[c] Social participation.
[d] Activities of daily living.

information about each respondent's SP and the address available from the survey. We focused on the neighborhood-level SP rather than the individual-level SP, and the experience of statutory retirement to mitigate potential endogeneity biases.

Our descriptive and regression analyses confirmed that high-neighborhood SP had a favorable impact on health in general. This result is largely consistent with the results of previous studies, which argued that area-level social capital can affect an individual's health independently of individual-level social capital (Mohnen et al., 2011, 2015; Snelgrove et al., 2009; Sundquist & Yang, 2007) or SP (Tsuji et al., 2018). Regarding the impact of retirement on health, our analyses provided mixed results, consistent with observations in previous studies (Li et al., 2021; Odone et al., 2021; van der Heide et al., 2013).

The results suggest that the interaction effect between retirement and neighborhood SP is a key factor influencing the impact of retirement on health. Changes in health outcomes after retirement depended heavily on neighborhood SP. As illustrated in Fig. 3, health outcomes improved after retirement in high-SP neighborhoods, but not (or, to a lesser extent) in low-SP neighborhoods.

This interaction effect between retirement and neighborhood SP suggests that retirement triggered a favorable impact of neighborhood SP to retired workers. Even if they live in a high-SP neighborhood, full-time workers may have limited opportunities to recognize it before retirement. However, once they retire, they are likely to have more

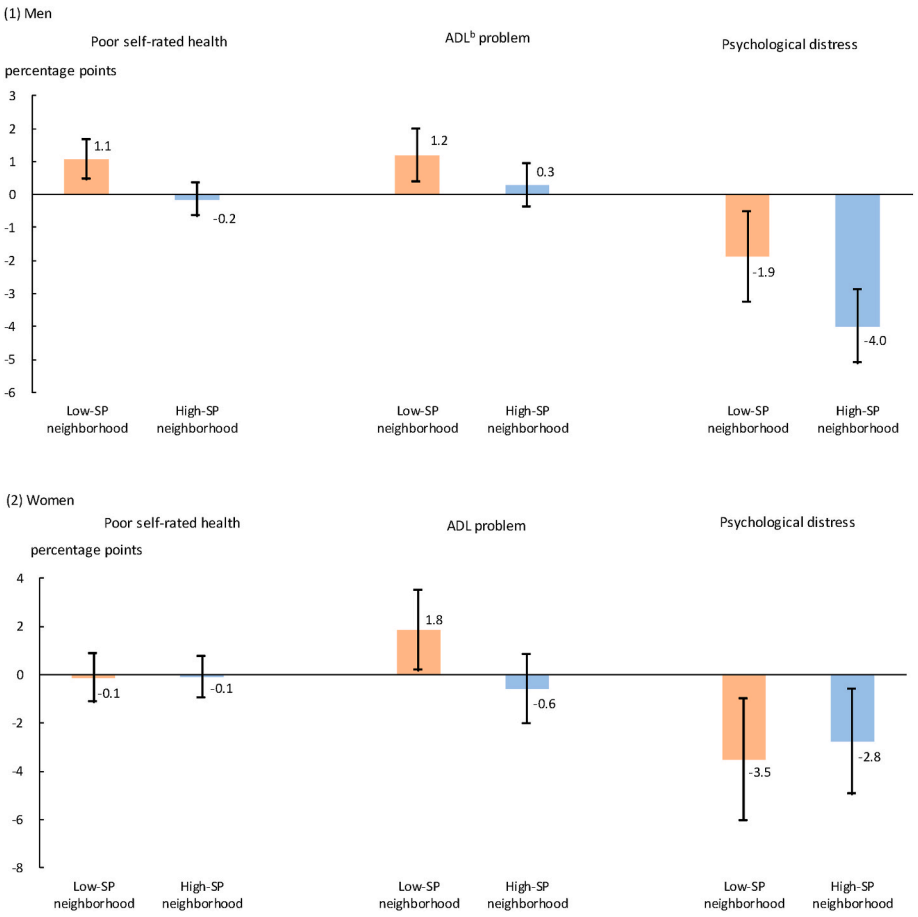

Fig. 4. Impact of retirement on health outcomes depending on the level of neighborhood social participation (SP)[a]
[a] Based on the estimation results reported in Table 3. Low- and high-SP neighborhoods indicate β_1 and $\beta_1 + \beta_3$, respectively. Error bars indicate 95% confidence intervals. [b] Activities of daily living.

opportunities to communicate with their neighbors, obtain more information about community activities, and feel comfortable with a high level of neighborhood SP; probably resulting in better health outcomes. In this sense, retirement can work as a catalyst for neighborhood SP to enhance health. However, the results showed that the interaction between retirement and neighborhood SP had no effect on individual SP. This observation points to the limited role played by an individual SP as a mediator of the impact of neighborhood SP on health. In contrast, the results highlighted an independent and direct impact of neighborhood SP on the health of men.

We also found a difference in the impact of neighborhood SP and retirement on health between men and women. Among women, the favorable impact of high neighborhood SP was less clear, and an interaction effect between retirement and neighborhood SP was not observed. Takagi et al. (2013) found that higher individual SP had a favorable effect on mental health only for women. Combined with their observations, the results of this study suggest that neighborhood and individual SPs may affect health in different ways. Meanwhile, retirement reduced SD more remarkably for women than men.

Considering that we restricted our analysis to full-time workers, who were much less prevalent among middle-aged women than men of the same age, this result suggests that full-time work may be more stressful for women, making retirement more beneficial to their mental health than men. However, we should be cautious in interpreting these sex differences considering the results of the supplementary analysis; the interaction terms with a binary variable of being a woman were not generally significant in the models estimated for the entire sample.

This study has several limitations. Most importantly, we cannot rule out the possibility that the same factor that affects where people reside may impact the association between retirement and health. It should be noted that the current study, which did not identify such a potential confounder, may have overestimated the association between neighborhood SP and the health of retired workers.

Second, we focused on statutory retirement, the timing of which is exogenously given and predictable in general, and limited the study sample to full-time workers at baseline. Hence, caution should be exercised when generalizing current observations. Retirement may have different meanings for part-time and self-employed workers, and other types of workers. Additionally, retirement for reasons other than achieving a statutory retirement age may have different implications for health outcomes. More generally, the relevance of retirement to health may depend heavily on the socio-institutional background.

Third, the scope of the SP measurements in this study was relatively narrow. SP may take place, for example, when chatting with people in local grocery stores, neighborhood parks, or responding to messages on the Facebook community page and Twitter. A wider definition of SP may make the relationships between retirement, health, and SP different from those observed in the current study.

Fourth, the exogeneity of neighborhood SP was not fully guaranteed, although we removed data of the participants who had moved within the past year in each survey wave at least once during the second to fourteenth waves. For example, this treatment may have disregarded individuals whose pre-existing health problems were so serious that they moved to a more urban area where both medical facilities and community activities were more abundant. It might be also possible that individuals with health problems had moved to such an area earlier than

one year before and had been staying there since then. To address potential biases due to the endogeneity between heath and residential areas, we need more data that allow us to track changes in each individual's residential address.

Fifth, we did not directly examine the endogeneity of the working status. We observed that the magnitudes of the estimated associations between retirement, neighborhood SP, and health differed substantially between the models, including the participants who kept or resumed working after statutory retirement, and the models removing them. This finding suggests the importance of the endogeneity of working status for health among middle-aged individuals, an issue that was not addressed in this study.

Finally, we did not examine the mechanisms linking retirement and health outcomes. The results did not support the view that individual SP, which is encouraged by retirement, mediates the impact of neighborhood SP on health. Instead, the results suggest that neighborhood SP, which is likely to be more clearly recognized after retirement, may directly affect an individual's health outcomes.

In addition to these limitations, this study did not consider (i) attrition bias, which means that unhealthier individuals were more likely to drop out of the survey; (ii) the frequency or different types of SP or satisfaction with it; and (iii) dynamic adjustment in health after statutory retirement. These issues should be addressed in future research.

5. Conclusions

The results suggest that neighborhood SP is a key determinant of retired workers' health outcomes. Living in an active neighborhood in terms of SP is expected to enhance health after retirement, which gives individuals more chances to notice neighborhood SP and obtain its health benefits, pointing to the risk that inequality in neighborhood SP may add to inequality in health among retired individuals. Policy measures to encourage SP at the neighborhood level must be developed to help individuals enjoy a healthier life in retirement.

Ethics approval

We used data obtained from a nationwide fourteen wave panel survey, "The Longitudinal Survey of Middle-Aged and Older Adults," conducted by the Japanese Ministry of Health, Labour and Welfare (MHLW) each year from 2005 to 2018. Japan's Statistics Law required the survey to be reviewed from statistical, legal, ethical, and other viewpoints. We obtained the survey data from the MHLW with its official permission; therefore, the current study did not require ethical approval.

Author statement

Takashi Oshio: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Writing-Original draft preparation, Supervision, Project administration, Funding acquisition. Kemmyo Sugiyama: Conceptualization, Validation Writing-Reviewing and Editing. Toyo Ashida: Conceptualization, Validation Writing-Reviewing and Editing.

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Declaration of competing interest

None declared.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2022.101281.

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