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Original Study

Comparison of the Incidence of Functional Disability Correlated With Social Participation Among Older Adults in Japan

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A B S T R A C T

Background: Japan, which has the world's longest life expectancy, has been reporting rejuvenation of physical function among its older adult population. However, evidence for the incidence of functional disability is limited. This study aimed to investigate the comparison in the incidence of functional disability.
Design: We used data from the Japan Gerontological Evaluation Study.
Setting and Participants: The participants were 2 nonoverlapping cohorts of 22,522 (2010–2013 cohort) and 26,284 (2016–2019 cohort) individuals aged 65 years and older from 5 municipalities who were followed for 3 years each.
Methods: The incidence rates of functional disability during the 3-year follow-up period were compared between cohorts. To examine the incident differences between the cohorts, we adjusted for social participation and 9 additional factors that would be expected to improve with social participation using the Weibull survival models adjusting for municipalities as random effects. The analysis was stratified by age groups (65–74 years old and ≥75).
Results: The incidence rate of functional disability per 10,000 person-years decreased from 68.6 (2010–2013 cohort) to 51.4 (2016–2019 cohort) in the 65 to 74 years old group and 380.0 (2010–2013 cohort) to 282.6 (2016–2019 cohort) in the ≥75 group; the hazard ratios (95% CIs) were 0.75 (0.64–0.89) and 0.73 (0.67–0.80), respectively. However, these significant decreases disappeared with adjustments for social participation and additional factors.
Conclusions and Implications: The incidence of functional disability decreased in a recent cohort, which may be explained by social participation and possibly related factors. Promoting social participation could contribute to a decreasing incidence of functional disability among older adults.

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Life expectancy and healthy life expectancy are increasing worldwide,[1] and older populations are increasing rapidly.[2] The increase in the older population also leads to an increase in the incidence of functional disability. Therefore, it is important for public health to understand changes in the circumstances of incidence of functional disability.

Previous studies have reported that the prevalence of disability has decreased over the past 20 years.[3-7] In addition, it has been reported that the incidence of functional disability has decreased in Asia excluding Japan and Europe.[8-10] Because the prevalence ratio depends on the duration of the disease, it differs from the incidence rate. Researchers observed rejuvenation among older adults in Japan in terms of improved physical function over time.[7] Comparing the fitness levels of 65- to 79-year-olds in 2019 with levels in the same age group from 20 years earlier reveals that the older adults in 2019 have a fitness level that is about 5 years younger than their chronological age.[11] Therefore, it is likely that the incidence of functional disability in Japan is also decreasing.

The Japanese government has also been promoting diverse social participation among older adults as a long-term care prevention policy since 2015,[12] and systematic and narrative reviews have shown that this social participation has protective effects on health indicators such as reduced risk of death, reduced risk of functional disability, and improved quality of life.[13-15] A Japanese longitudinal study of independent older adults also reported that social participation, such as in community organizations and work, was associated with a lower incidence of functional disability among older individuals.[16,17] In addition, systematic reviews, literature reviews, and longitudinal studies have shown that social participation improves lifestyle,[18-20] mental health,[21,22] social support,[13,23] and instrumental activities of daily living (IADLs).[24]

Between 2010 and 2019, there has been an increase in social participation in Japan[25,26] that is associated with health indicators and reduced risk of developing long-term care needs. However, researchers have not examined whether disability is decreasing or whether social participation is contributing to a decrease in disability in the older Japanese population, which has the longest life expectancy in the world.[27] Therefore, the purpose of this study was twofold. First, we compared 2 cohorts of older adults in Japanese populations separated by 6 years and followed up for 3 years each to determine whether the incidence of functional disability is decreasing. Second, we determined whether differences in the incidence of functional disability between the cohorts are associated with social participation.

Methods

Study Participants

We used data from the Japan Gerontological Evaluation Study (JAGES) from 2 nonoverlapping 3-year cohorts, 2010–2013 and 2016–2019 cohorts. The JAGES is an ongoing cohort study investigating social and behavioral factors related to health decline, including the incidence of functional disability or cognitive impairment among individuals aged ≥65 years.[28,29] The participants were older people from 5 municipalities in 4 prefectures in Japan who were not certified for receiving public long-term care insurance, and complete enumeration surveys for all municipalities in both cohorts were conducted. A flowchart of participant enrollment for this study is shown in Figure 1.

The baseline self-reported surveys were distributed by mail to 38,577 individuals aged 65 and older between August 2010 and January 2011 (2010–2013 cohort) and to 42,995 individuals aged 65 and older between October and November 2016 (2016–2019 cohort). Baseline responses were received from 23,948 (62.1%) respondents to the 2010–2013 cohort and 29,810 (69.3%) to the 2016–2019 cohort.

Of these respondents, 23,062 to the 2010–2013 cohort and 26,906 to the 2016–2019 cohort were validated for sex, age, and region of residence. Of the validated respondents, 22,522 (97.7%) participants in the 2010–2013 cohort and 26,284 (97.7%) participants in the 2016–2019 cohort were successfully linked to the incident records of long-term care insurance certification (LTCI) during the 3-year follow-up period after their respective baselines. The analytical sample for this study comprised 22,522 participants (10,279 men and 12,243 women) from the 2010–2013 cohort and 26,284 participants (11,864 men and 14,420 women) from the 2016–2019 cohort. Ethical approval for the study was obtained from the National Center for Geriatrics and Gerontology (application number: No. 1274-2), Chiba University (application number: No. 3442), and Japan Agency for Gerontological Evaluation Study (application number: 2019-01).

Constructing the Hypothetical Model

Figure 2 shows the hypothesized framework for the decrease in the incidence of functional disability from the 2010–2013 to 2016–2019 cohorts. First, we used the 3-year incidence rates of functional disability (Y) in 2010–2013 and 2016–2019 cohorts (Z) to assess the incidence decrease over time. We hypothesized that the between-cohort incidence decrease (ie, Z-Y association) was partly due to the social participation (X), distribution of factors associated with social participation (M), and distribution of characteristics (C) from 2010–2013 and 2016–2019 cohorts. Although unmeasured characteristics U other than X, M, and C would have created the differences between the cohorts, we assumed that U was not associated with X and M conditional on C within cohort Z.

We used social participation for X and set the characteristics as C concerning previous examinations of associations between social participation and the incidence of functional disability.[16,17] We set 9 factors as M, expected to be improved by social participation from systematic reviews, literature reviews, and longitudinal studies.[18-24,30] The assumptions of 9 factors that are expected to improve social participation were verified by the method described in the Supplementary Methods.

Our analytical strategy was as follows: (1) estimate Z-Y association adjusting only for C to show the decrease in the incidence of functional disability over time; (2) estimate Z-Y association adjusting for X and C to assess the role of change in social participation itself; and (3) estimate Z-Y association adjusting for X, C, and M to assess the roles of the factors related to social participation.

Dependent Variable

The dependent variable was the incidence of functional disability,[16,17] which was defined as newly certified LTCI level 2 or higher[31]; this definition was also used as a criterion for life expectancy.[32] Eligibility for LTCI was determined based on nationally standardized procedures, physical and cognitive functions by physician, and investigator evaluation.[33] Moreover, we verified eligibility status during the follow-up period by linking cohort participants to the

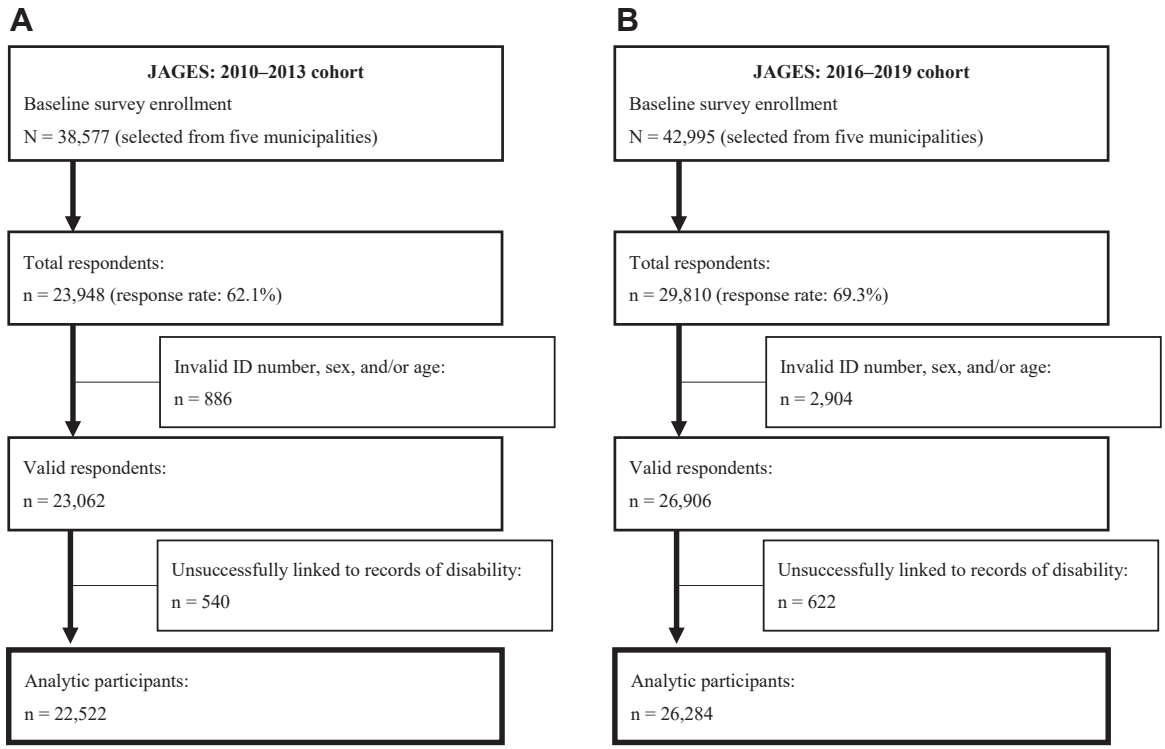


Fig. 1. Flowchart of the study population: JAGES from 2010–2013 cohort and 2016–2019 cohorts.

municipal LTCI database records after the older person submitted an application to the municipality.

Independent Variable

We used cohort as an independent variable to verify differences in the incidence rates of functional disability over time. Social participation was an additional independent variable to assess whether it explained the differences in the incidence of functional disability. We defined social participation as participation in hobby groups (hobby), sports groups or clubs (sports), volunteer groups (volunteer), and work. Participating in sports, hobbies, or volunteering was considered as community participation.[34]

Participants in each cohort were asked the same questions: "How often do you participate in the following clubs or groups?" The choices were "at least 4 times a week," "twice or thrice a week," "once a week," "once or thrice a month," "a few times a year," and "never." We categorized participants as engaging in community participation if they reported participating in any of the listed organizations at least once a month.[26,35] The survey also asked, "What is your current working status?" The answer options were "working," "retired and not working now," and "never had a job," and we considered respondents as working if they selected the first response.

Covariates for Adjustment

We adjusted for the following 15 factors: 6 characteristics earlier researchers have used as confounding factors in studies on social participation and incidence of functional disability (sex, age, educational attainment, equivalent income, marital status, and self-reported

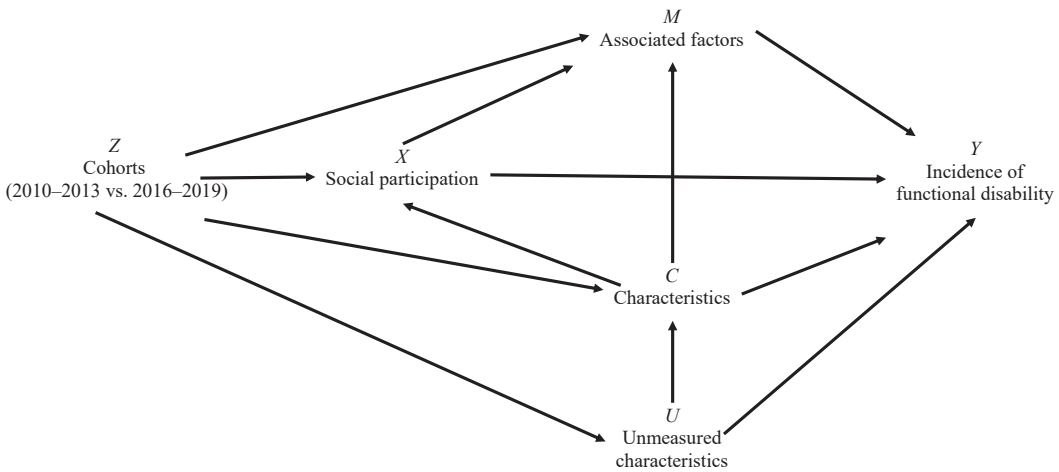


Fig. 2. Hypothesis of decrease in the incidence of functional disability from the 2010–2013 to 2016–2019 cohort.

medical conditions).[16,17] In addition, we adjusted for 9 factors documented in earlier research as promoters of social participation (smoking, alcohol consumption, walking time, frequency of going outdoors, depressive symptoms, emotional support, instrumental support, frequency of meeting with friends, and IADLs).[18-24,30]

The JAGES collected age group (65–69, 70–74, 75–79, 80–84, ≥85), marital status (married or unmarried), educational attainment (≥10, <10 years), annual equivalent income (≥$20,000 or <$20,000 per year where $1 = 130 yen), and self-reported medical conditions (illness, no illness), as well as smoking (smoking, no smoking), alcohol consumption (drinking, no drinking), walking time (≥60 min, 30 min–59 min, or <30 min per day), and frequency of going outdoors (≥2 times, once, or <1 time per week). The 15-item Geriatric Depression Scale (GDS) score was used to assess depressive symptoms,[36,37] which were classified into 3 groups: no symptoms (GDS <5), mild (GDS: 5–9 points), or moderate to severe (GDS ≥10). Emotional support (available, not available), instrumental support (available, not available), and frequency of meeting with friends (≥2 times/week, 1 time/week, 1–3 times/month, or a few times a year or less) were also collected, and IADLs were measured as the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) score,[38] classified as no decline (5 points) or decline (≤4 points).

Statistical Analysis

The baseline characteristics in the 2 cohorts were summarized and compared by χ^2 tests. We calculated the incidence rates (per 10,000 person-years) of functional disability during the 3-year follow-up period in each cohort. We pooled the data from the 2010–2013 and 2016–2019 cohorts and performed the Weibull survival models adjusting for municipalities as random effects to compare the incidence of functional disability between cohorts. According to the strategy described in "Constructing the hypothetical model," we estimated the following 3 separate models: Model 1, which adjusts for sex, age, educational attainment, equivalent income, marital status, and self-reported medical conditions; Model 2, which additionally adjusts for social participation; and Model 3, which further adjusts for smoking, alcohol consumption, walking time, frequency of going outdoors, depressive symptoms, emotional support, instrumental support, frequency of meeting with friends, and IADLs. All analyses were stratified by older people aged 65–74 years or ≥75 years.

We performed multiple imputations based on multivariate normal imputation to address the potential bias caused by missing values.[39] We created 20 data sets for all variables used in the current analysis and then combined the estimated parameters using Rubin's rule.[40] A sensitivity analysis was performed by restricting the analysis to those with no decline in IADLs at baseline to account for health status at baseline for the 2 cohorts. Statistical significance was set at $P < .05$, and data were analyzed using "mestreg: Weibull" commands in Stata V.16.1 (StataCorp).

Results

The baseline characteristics of both cohorts were as follows. The 2016–2019 cohort had attained more education but also showed more medical illness; a higher proportion was married as well. Additionally, smoking increased in the group aged 65–74 years and decreased in those aged 75 and older, and there were fewer drinkers. The later cohort had longer walking times, went outdoors more frequently, had less depression and more social support available, and met more frequently with friends. Finally, in the later cohort, there were more workers and there was less community participation in the group aged 65–74 years, and both of these were higher in the group aged ≥75 (Supplementary Tables 1 and 2).

Table 1 shows the incidence rates (per 10,000 person-years) of functional disability stratified by age for both cohorts. Rates decreased from 190.8 in the 2010–2013 cohort to 145.7 in the 2016–2019 cohort. The individual decreases in incidence rates were from 68.6 to 51.4 greater for those aged 65–74 and from 380.0 to 282.6 for those aged ≥75.

In our analyses of the 9 factors that we expected to improve with social participation, results for each variable were better for respondents who engaged in some form of community participation. For work, there were no differences in smoking and social support, but health indicators were better for other factors (Supplementary Table 3).

Figure 3 shows the results of a Weibull survival analysis adjusted for municipalities as random effects using pooled data from both cohorts with incidence of functional disability as the outcome. In Model 1, we adjusted for basic attributes and again found significantly lower hazard ratios (HRs) in the 2016–2019 cohort for both age groups: age 65–74 HR, 0.75 (95% CI, 0.64–0.89), age ≥75 HR, 0.73 (95% CI, 0.67–0.80). In Model 2, we added social participation and again found significantly lower HRs in the 2016–2019 cohort: age 65–74 = 0.76 (95% CI, 0.64–0.90), age ≥75 = 0.75 (95% CI, 0.69–0.82). In Model 3, we added variables that were expected to improve with social participation, and the association disappeared for both age groups: age 65–74 = 0.94 (95% CI, 0.78–1.12), age ≥75 = 0.95 (95% CI, 0.87–1.04) (Supplementary Tables 4 and 5). The sensitivity analysis was only conducted for those whose IADLs were not declined at baseline. More than 80% of the population had this feature, showing the same trend, although the association slightly weakened (Supplementary Figure 1).

Discussion

We compared 2 cohorts of older people and showed that the incidence of functional disability was lower in the 2016–2019 cohort than it was in the 2010–2013 cohort, indicating that this difference can be explained by both social participation itself and the factors that were expected to improve with social participation. This is an

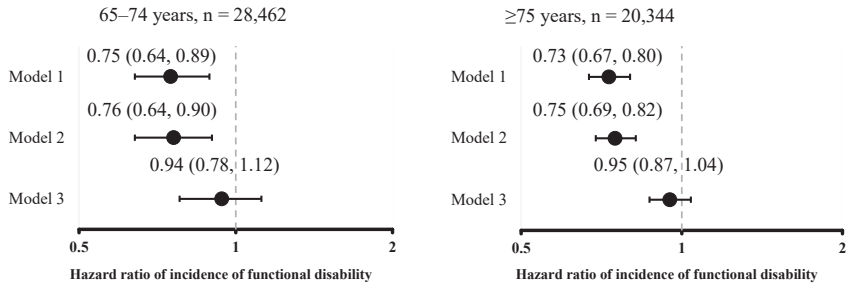


Fig. 3. Weibull survival analysis for incidence of functional disability between cohorts (2010–2013 and 2016–2019) stratified by age.

Table 1
Incidence Rates (per 10,000 Person-Years) of Disability Stratified by Age Between 2010–2013 and 2016–2019 Cohorts

Characteristic	2010–2013 Cohort				2016–2019 Cohort				Absolute Decrease	HR*	95% CI	P
	n	Person-Years	Incidence of Functional Disability (n)	Incidence Rate (per 10,000 Person-Years)	n	Person-Years	Incidence of Functional Disability (n)	Incidence Rate (per 10,000 Person-Years)				
	22,522	70,765.2	1350	190.8	26,284	86,368.2	1258	145.7	45.1	0.77	0.71–0.83	<.001
Age, y												
65–74	13,257	42,998.5	295	68.6	15,205	51,159.7	263	51.4	17.2	0.74	0.62–0.87	<.001
≥75	9265	27,766.7	1055	380.0	11,079	35,208.5	995	282.6	97.3	0.75	0.69–0.82	<.001

2010–2013 cohort: 3-year cohort data with 2010 as the baseline.
2016–2019 cohort: 3-year cohort data with 2016 as the baseline.
*To compare the incidence of functional disability across cohorts, the 2010–2013 cohort was used as reference and the HR for the 2016–2019 cohort as the Weibull survival analysis adjusted for the random effects of the municipalities.

important finding given that Japan currently has the longest healthy life expectancy in the world.

In Asia, researchers identified a decrease in the incidence of functional disability from 1993 to 2014 among community-dwelling older adults living in China,[9,10] and in Japan, when cohorts were linked and older people were compared between 2007 and 2017, the later cohort showed better physical[41] and cognitive[42] function and less frailty,[43] which aligns with our findings. The fact that the risk of disability was decreased in the old-old might provide a basis for reducing ageism.

Previous researchers have reported increasing social participation in Japan,[25,26] including increased proportions of workers among the 65–74 group and increased community participation among persons aged ≥75,[26] and found that older adults who participate in social activities have fewer disabilities than those who do not.[16,17] Because the proportion of social participation has increased in recent years, researchers have proposed that increased social participation is contributing to improved physical function in older adults.[41] In this study, we added factors that have been associated with social participation and examined differences between cohorts, and we found that the significant differences between cohorts disappeared, suggesting that these factors explained the difference in incidence rates between the 2 cohorts. In this study, the movement of HRs was greater when the 9 factors expected to improve by addition of social participation than when social participation itself was added. The reason that social participation alone cannot account for the variation between cohorts may be attributed to the time required for the 9 factors to exhibit positive changes that are subsequent to social participation. Moreover, the recent cohort with increased social participation over the past 6 years, may have included more frail individuals, which potentially limits the effectiveness of social participation. However, our results align with findings that social participation has a positive effect on health through social support[30] and that social factors worsen before physical factors.[44] Furthermore, research on the reasons older adults spend time outside the home indicated that social contacts were the main reason among older adults who spent time outside the home.[45] Although it is not possible to estimate which factors have a significant effect on differences between populations,[46] relevant factors such as mobility and interaction with friends outside of the home that relate to social participation could have contributed to the decrease in functional decline among older adults.

Regarding the variables we expected to improve with social participation, gathered from previous studies,[18-24,30] we found that JAGES respondents who engaged in community participation had better scores on all 9 variables. Workers did not differ on smoking and social support compared with nonworkers but did better on the other indicators. Prior research has shown that subsequent health status varies with motivation to work in older adults. Specifically, older adults who work solely for financial purposes have worse future health risk than adults who work for nonfinancial reasons,[47] and it has been pointed out that stress from work can lead to chronic diseases.[48] In contrast, people who work for a nonfinancial reason might be doing work that fits their goals or offers some other nonmonetary reward. We could not separate out motives for work, but these motives could have influenced smoking and social support.

The strength of this study is that we followed 2 large cohorts in the same way; using the same sampling method enhances the quality of comparison between populations.[46] However, there are 5 limitations, as follows. First, we used the results of questionnaire respondents, and it is known that survey nonrespondents have high mortality.[49] Complete enumeration surveys were conducted with both cohorts in this study, but the 2016–2019 cohort had a 7-point higher response rate. Because of that high response rate, we expected that the 2016–2019 cohort would include more people with

advanced functional disability. However, we found a decreased incidence of functional disability in the 2016–2019 cohort, which might indicate an underestimate of the differences between populations. Second, some of the variables we treated as independently expected to improve with social participation indicated interactions such that when they improved, social participation improved.[30] We could not know the temporal pre- and postsurvey relationships, and therefore, we cannot rule out the influence of other factors on encouraging social participation. In addition, improvements across the 9 factors may be influenced by factors beyond social participation, and the presence of unmeasured confounding variables cannot be ruled out. Third, the degrees of social participation that are measured in this study were self-reported, which may have led to misclassification and measurement error. However, the methods of assessing social participation across the 2 cohorts were the same so that any bias owing to survey methods between the cohorts was as balanced as possible. Fourth, the incidence of functional impairment was defined by LTCI, a voluntary reporting system. However, not all individuals with reduced activities of daily living choose to apply for LTCI. Finally, our findings might not apply beyond the population of older residents from the 5 Japanese municipalities; geographic or regional differences we did not explore could make this study population different from others in Japan or elsewhere. Verification in other settings is desired to confirm the robustness of this finding.

Conclusions and Implications

In this study, we examined the differences in the incidence of functional disability between 2 cohorts, from 2010–2013 and 2016–2019, of older residents of 5 municipalities in Japan, and we found that the 2016–2019 cohort had an approximately 25% decreased risk of developing functional disability than that in the 2010–2013 cohort. The reduced incidence of functional disability could be explained by social participation itself and by factors that we expected social participation would improve based on earlier research. Promoting social participation could contribute to a decreasing incidence of functional disability among older adults.

Data Availability

Data are from the JAGES study. All inquiries are to be addressed to the data management committee via e-mail: dataadmin.ml@jages.net. All JAGES datasets have ethical or legal restrictions for public deposition due to inclusion of sensitive information from the human participants. Following the regulation of local governments that cooperated on our survey, the JAGES data management committee has imposed the restrictions on the data.

Disclosure

The authors declare no conflicts of interest.

References

1. Spiers GF, Kunonga TP, Beyer F, et al. Trends in health expectancies: a systematic review of international evidence. *BMJ Open*. 2021;11:e045567.
2. World Health Organization. Decade of healthy ageing: plan of action. 2020. Accessed October 14, 2021. https://cdn.who.int/media/docs/default-source/decade-of-healthy-ageing/final-decade-proposal/decade-proposal-final-apr2020-en.pdf?sfvrsn=b4b75ebc_25&download=true
3. Feng Q, Zhen Z, Gu D, et al. Trends in ADL and IADL disability in community-dwelling older adults in Shanghai, China, 1998-2008. *J Gerontol B Psychol Sci Soc Sci*. 2013;68:476–485.
4. Freedman VA, Spillman BC, Andreski PM, et al. Trends in late-life activity limitations in the United States: an update from five national surveys. *Demography*. 2013;50:661–671.
5. Liang Y, Song A, Du S, et al. Trends in disability in activities of daily living among Chinese older adults, 1997-2006: the China health and nutrition survey. *J Gerontol A Biol Sci Med Sci*. 2015;70:739–745.
6. Martin LG, Feng Q, Schoeni RF, et al. Trends in functional and activity limitations among Chinese oldest-old, 1998 to 2008. *Popul Dev Rev*. 2014;40:475–495.
7. Ouchi Y, Rakugi H, Arai H, et al. Redefining the elderly as aged 75 years and older: proposal from the Joint Committee of Japan gerontological society and the Japan geriatrics society. *Geriatr Gerontol Int*. 2017;17:1045–1047.
8. Angleman SB, Santoni G, Von Strauss E, et al. Temporal trends of functional dependence and survival among older adults from 1991 to 2010 in Sweden: toward a healthier aging. *J Gerontol A Biol Sci Med Sci*. 2015;70:746–752.
9. Li ZH, Lv YB, Kraus VB, et al. Trends in the incidence of activities of daily living disability among Chinese older adults from 2002 to 2014. *J Gerontol A Biol Sci Med Sci*. 2020;75:2113–2118.
10. Liang Y, Welmer AK, Wang R, et al. Trends in incidence of disability in activities of daily living in Chinese older adults: 1993-2006. *J Am Geriatr Soc*. 2017;65:306–312.
11. Agency JS. FY2021, physical fitness and athletic ability survey report. 2022. Accessed February 17, 2023. https://www.mext.go.jp/sports/content/20221011-spt_kensport01-000025410_3.pdf
12. Ministry of Health, Labour and Welfare. Care prevention manual. 2015. Accessed December 21, 2022. https://www.mhlw.go.jp/topics/2009/05/dl/tp0501-1_1.pdf
13. Coll-Planas L, Nyqvist F, Puig T, et al. Social capital interventions targeting older people and their impact on health: a systematic review. *J Epidemiol Community Health*. 2017;71:663–672.
14. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLoS Med*. 2010;7:e1000316.
15. Stuck AE, Walthert JM, Nikolaus T, et al. Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Soc Sci Med*. 1999;48:445–469.
16. Ide K, Tsuji T, Kanamori S, et al. Social participation and functional decline: a comparative study of rural and urban older people, using Japan gerontological evaluation study longitudinal data. *Int J Environ Res Public Health*. 2020;17:617.
17. Kanamori S, Kai Y, Aida J, et al. Social participation and the prevention of functional disability in older Japanese: the JAGES cohort study. *PLoS One*. 2014;9:e99638.
18. Giordano GN, Lindström M. The impact of social capital on changes in smoking behaviour: a longitudinal cohort study. *Eur J Public Health*. 2011;21:347–354.
19. Ihara S, Ide K, Kanamori S, et al. Social participation and change in walking time among older adults: a 3-year longitudinal study from the JAGES. *BMC Geriatr*. 2022;22:238.
20. Kelly S, Olanrewaju O, Cowan A, et al. Alcohol and older people: a systematic review of barriers, facilitators and context of drinking in older people and implications for intervention design. *PLoS One*. 2018;13:e0191189.
21. Choi E, Han KM, Chang J, et al. Social participation and depressive symptoms in community-dwelling older adults: emotional social support as a mediator. *J Psychiatr Res*. 2021;137:589–596.
22. Uemura K, Makizako H, Lee S, et al. Behavioral protective factors of increased depressive symptoms in community-dwelling older adults: a prospective cohort study. *Int J Geriatr Psychiatry*. 2018;33:e234–e241.
23. Dickens AP, Richards SH, Greaves CJ, et al. Interventions targeting social isolation in older people: a systematic review. *BMC Publ Health*. 2011;11:647.
24. Fujihara S, Tsuji T, Miyaguni Y, et al. Does community-level social capital predict decline in instrumental activities of daily living? A JAGES prospective cohort study. *Int J Environ Res Public Health*. 2019;16:828.
25. Ide K, Jeong S, Tsuji T, et al. Suggesting indicators of age-friendly city: social participation and happiness, an ecological study from the JAGES. *Int J Environ Res Public Health*. 2022;19:5096.
26. Watanabe R, Tsuji T, Ide K, et al. Change in prevalence of social participation among community-dwelling older adults: JAGES 6-year repeated cross-sectional study. *J Health Welf Stat*. 2021;68:2–9.
27. World Health Organization. World health statistics 2022: monitoring health for the SDGs, sustainable development goals. 2022. https://www.who.int/publications/i/item/9789240051157
28. Kondo K. Progress in aging epidemiology in Japan: the JAGES Project. *J Epidemiol*. 2016;26:331–336.
29. Kondo K, Rosenberg M. *World Health Organization, Advancing Universal Health Coverage through Knowledge Translation for Healthy Ageing: Lessons Learnt from the Japan Gerontological Evaluation Study*. Geneva: World Health Organization; 2018.
30. Douglas H, Georgiou A, Westbrook J. Social participation as an indicator of successful aging: an overview of concepts and their associations with health. *Aust Health Rev*. 2017;41:455–462.
31. Ministry of Health, Labour and Welfare. Long-term care insurance in Japan. 2002. Accessed December 21, 2022. https://www.mhlw.go.jp/english/topics/elderly/care/index.html
32. Ministry of Health, Labour and Welfare. Guidelines for calculating healthy life expectancy. 2012. Accessed February 22, 2023. http://toukei.umin.jp/kenkoujyumyou/syuyou/kenkoujyumyou_shishin.pdf
33. Tsutsui T, Muramatsu N. Japan's universal long-term care system reform of 2005: containing costs and realizing a vision. *J Am Geriatr Soc*. 2007;55:1458–1463.
34. Aida J, Hanibuchi T, Nakade M, et al. The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis. *Soc Sci Med*. 2009;69:512–518.
35. Yazawa A, Inoue Y, Fujiwara T, et al. Association between social participation and hypertension among older people in Japan: the JAGES study. *Hypertens Res*. 2016;39:818–824.

36. Burke WJ, Roccaforte WH, Wengel SP. The short form of the geriatric depression scale: a comparison with the 30-item form. *J Geriatr Psychiatry Neurol*. 1991;4:173–178.
37. Wada T, Ishine M, Kita T, et al. Depression screening of elderly community-dwelling Japanese. *J Am Geriatr Soc*. 2003;51:1328–1329.
38. Koyano W, Shibata H, Nakazato K, et al. Measurement of competence: reliability and validity of the TMIG index of competence. *Arch Gerontol Geriatr*. 1991;13:103–116.
39. Lee KJ, Carlin JB. Multiple imputation for missing data: fully conditional specification versus multivariate normal imputation. *Am J Epidemiol*. 2010;171:624–632.
40. Rubin DB. Multiple imputation after 18+ years. *J Am Stat Assoc*. 1996;91:473–489.
41. Suzuki T, Nishita Y, Jeong S, et al. Are Japanese older adults rejuvenating? Changes in health-related measures among older community dwellers in the last decade. *Rejuvenation Res*. 2021;24:37–48.
42. Nishita Y, Makizako H, Jeong S, et al. Temporal trends in cognitive function among community-dwelling older adults in Japan: findings from the ILSA-J integrated cohort study. *Arch Gerontol Geriatr*. 2022;102:104718.
43. Makizako H, Nishita Y, Jeong S, et al. Trends in the prevalence of frailty in Japan: a meta-analysis from the ILSA-J. *J Frailty Aging*. 2021;10:211–218.
44. Makizako H, Shimada H, Doi T, et al. Social frailty leads to the development of physical frailty among physically non-frail adults: a four-year follow-up longitudinal cohort study. *Int J Environ Res Public Health*. 2018;15:490.
45. Mikolaizak AS, Klenk J, Rothenbacher D, et al. Purpose, frequency, and mode of transport by which older adults leave their home-a cross-sectional analysis. *J Aging Phys Act*. 2019;27:688–695.
46. Moreno-Betancur M, Koplin JJ, Ponsonby AL, et al. Measuring the impact of differences in risk factor distributions on cross-population differences in disease occurrence: a causal approach. *Int J Epidemiol*. 2018;47:217–225.
47. Nemoto Y, Takahashi T, Nonaka K, et al. Working for only financial reasons attenuates the health effects of working beyond retirement age: a 2-year longitudinal study. *Geriatr Gerontol Int*. 2020;20:745–751.
48. Kivimäki M, Kawachi I. Work stress as a risk factor for cardiovascular disease. *Curr Cardiol Rep*. 2015;17:630.
49. Tolonen H, Laatikainen T, Helakorpi S, et al. Marital status, educational level and household income explain part of the excess mortality of survey non-respondents. *Eur J Epidemiol*. 2010;25:69–76.

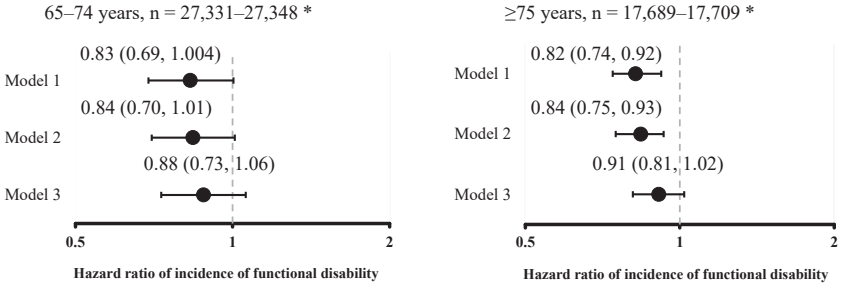
Appendix

Supplementary Method 1: Analytical method confirming the assumptions of the hypothetical model

To support the hypothesized model presented in Figure 2, we conducted analyses to examine the association between social participation and the nine factors that previous researchers found to have improved with social participation. We conducted a cross-sectional analysis using pooled data from the 2010–2013 and 2016–2019 cohorts, with each of the nine factors as a dependent variable and social participation as an independent variable. Based on the characteristics of the dependent variable, we used different analytical methods—multiple regression analysis, adjusting for municipalities as random effects when the outcome was a continuous variable (walking time per day, frequency of going outdoors, depressive symptoms, and frequency of meeting friends); logistic regression analysis adjusting for municipalities as random effects when the outcomes were binary data and the percentage of outcome occurrence was less than 10% (emotional support, instrumental support); and modified Poisson regression analysis adjusting for municipalities as random effects when the outcome were binary data and the percentage of outcome occurrence was 10% or greater (smoking, alcohol consumption, instrumental activity of daily living). Odds ratios that are calculated by logistic regression analysis deviate from actual risk ratios.[1] Therefore, for outcomes exceeding 10%, risk ratios were calculated using modified Poisson regression analysis.[2] The data were analyzed using the "mixed," "melogit," and "mepoisson: robust" commands in Stata V.16.1 (StataCorp, College Station, Texas, USA). The results of this analysis are presented in Supplementary Table 3.

References

1. Zhang J, Yu KF. What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA*. 1998;280:1690–1691.
2. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159:702–706.



Supplementary Fig. 1. Weibull survival analysis for incidence of functional disability between cohorts (2010–2013 and 2016–2019) of IADL no decline individuals, stratified by age.

Supplementary Table 1
Baseline Characteristics Stratified by Age From the 2010–2013 Cohort and the 2016–2019 Cohort

	65–74 years				*P*	≥75 years				*P*
	2010–2013 cohort		2016–2019 cohort			2010–2013 cohort		2016–2019 cohort		
	n	%	n	%		n	%	n	%	
Sex										
Men	6294	47.5	7015	46.1	.024	3985	43.0	4849	43.8	.279
Women	6963	52.5	8190	53.9		5280	57.0	6230	56.2	
Age, y										
65–69	6989	52.7	8369	55.0	<.001					
70–74	6268	47.3	6836	45.0						
75–79						4843	52.3	5795	52.3	.730
80–84						2966	32.0	3504	31.6	
≥85						1456	15.7	1780	16.1	
Educational attainment, y										
≥10	7248	54.7	10,667	70.2	<.001	3638	39.3	5405	48.8	<.001
<10	5549	41.9	4290	28.2		4887	52.7	5365	48.4	
Missing	460	3.5	248	1.6		740	8.0	309	2.8	
Equivalent income										
≥$20,000	5279	39.8	5994	39.4	<.001	2881	31.1	3123	28.2	<.001
<$20,000	5865	44.2	6222	40.9		3668	39.6	4428	40.0	
Missing	2113	15.9	2989	19.7		2716	29.3	3528	31.8	
Marital status										
Married	10,216	77.1	11,979	78.8	<.001	5077	54.8	6729	60.7	<.001
Unmarried	2520	19.0	2959	19.5		3499	37.8	3901	35.2	
Missing	521	3.9	267	1.8		689	7.4	449	4.1	
Self-reported medical conditions										
No illness	3592	27.1	3177	20.9	<.001	1361	14.7	1247	11.3	<.001
Illness	8851	66.8	11,395	74.9		6948	75.0	9265	83.6	
Missing	814	6.1	633	4.2		956	10.3	567	5.1	
Smoking										
No smoking	10,562	79.7	12,894	84.8	<.001	7314	78.9	10,010	90.4	<.001
Smoking	1582	11.9	2035	13.4		706	7.6	672	6.1	
Missing	1113	8.4	276	1.8		1245	13.4	397	3.6	
Alcohol consumption										
No drinking	7618	57.5	8718	57.3	<.001	6033	65.1	6210	56.1	<.001
Drinking	5034	38.0	6032	39.7		2633	28.4	4358	39.3	
Missing	605	4.6	455	3.0		599	6.5	511	4.6	
Walking time per day, m in										
≥60	4422	33.4	5595	36.8	<.001	2046	22.1	3387	30.6	<.001
30–59	4358	32.9	5169	34		2608	28.1	3490	31.5	
<30	3868	29.2	4011	26.4		3758	40.6	3701	33.4	
Missing	609	4.6	430	2.8		853	9.2	501	4.5	
Frequency of going outdoors										
≥2 times/wk	11,208	84.5	14,185	93.3	<.001	6400	69.1	9607	86.7	<.001
Once/wk	920	6.9	419	2.8		1171	12.6	572	5.2	
<once/wk	603	4.5	390	2.6		1111	12.0	702	6.3	
Missing	526	4.0	211	1.4		583	6.3	198	1.8	
Depressive symptoms										
No symptoms (GDS < 5)	8190	61.8	10,138	66.7	<.001	4748	51.2	6185	55.8	<.001
Mild (GDS 5–9 points)	2357	17.8	2032	13.4		1737	18.7	1644	14.8	
Moderate to severe (GDS ≥10)	810	6.1	682	4.5		621	6.7	520	4.7	
Missing	1900	14.3	2353	15.5		2159	23.3	2730	24.6	
Emotional support										
Available	12,040	90.8	14,301	94.1	<.001	7873	85.0	10,155	91.7	<.001
Not available	664	5	639	4.2		532	5.7	559	5.0	
Missing	553	4.2	265	1.7		860	9.3	365	3.3	

(*continued on next page*)

Supplementary Table 1 (*continued*)

	65–74 years				*P*	≥75 years				*P*
	2010–2013 cohort		2016–2019 cohort			2010–2013 cohort		2016–2019 cohort		
	n	%	n	%		n	%	n	%	
Instrumental support										
Available	12,124	91.5	14,362	94.5	<.001	8139	87.8	10,355	93.5	<.001
Not available	574	4.3	602	4		383	4.1	452	4.1	
Missing	559	4.2	241	1.6		743	8.0	272	2.5	
Frequency of meeting friends										
≥2 times/wk	5062	38.2	5739	37.7	<.001	3170	34.2	4227	38.2	<.001
1 time/wk	2202	16.6	1867	12.3		1472	15.9	1486	13.4	
1–3 times/mo	2628	19.8	3598	23.7		1611	17.4	2210	19.9	
A few times a year or less	2702	20.4	3671	24.1		2024	21.8	2639	23.8	
Missing	663	5.0	330	2.2		988	10.7	517	4.7	
IADL										
No decline	11,862	89.5	14,766	97.1	<.001	6993	75.5	9968	90	<.001
Decline	888	6.7	213	1.4		1777	19.2	801	7.2	
Missing	507	3.8	226	1.5		495	5.3	310	2.8	
Social participation										
Work										
No working	8498	64.1	8375	55.1	<.001	6241	67.4	6745	60.9	<.001
Working	3346	25.2	4818	31.7		855	9.2	1257	11.3	
Missing	1413	10.7	2012	13.2		2169	23.4	3077	27.8	
Community participation										
No participation	5761	43.5	6896	45.4	<.001	3899	42.1	4377	39.5	<.001
Participation	4825	36.4	5047	33.2		1885	20.3	2770	25.0	
Missing	2671	20.1	3262	21.5		3481	37.6	3932	35.5	

2010–13 cohort: 3-year cohort data with 2010 as the baseline.
2016–19 cohort: 3-year cohort data with 2016 as the baseline.

Supplementary Table 2
Baseline Characteristics Distribution of Each Variable Following Complete Case and Multiple Imputation

	65–74 Years						≥75 Years					
	2010–2013 Cohort			2016–2019 Cohort			2010–2013 Cohort			2016–2019 Cohort		
	Complete Cases*		Missing Value Imputed†	Complete Cases*		Missing Value Imputed†	Complete Cases*		Missing Value Imputed†	Complete Cases*		Missing Value Imputed†
	n	%	%	n	%	%	n	%	%	n	%	%
Sex												
Men	3737	55.8	47.5	3999	54.2	46.1	1578	54.7	43.0	1874	53.7	43.8
Women	2955	44.2	52.5	3377	45.8	53.9	1308	45.3	57.0	1614	46.3	56.2
Age, y												
65–69	3904	58.3	52.7	4405	59.7	55.0						
70–74	2788	41.7	47.3	2971	40.3	45.0						
75–79							1653	57.3	52.3	2031	58.2	52.3
80–84							832	28.8	32.0	990	28.4	31.6
≥85							401	13.9	15.7	467	13.4	16.1
Educational attainment, y												
≥10	4299	64.2	56.6	5749	77.9	71.2	1466	50.8	42.8	2100	60.2	50.3
<10	2393	35.8	43.4	1627	22.1	28.8	1420	49.2	57.2	1388	39.8	49.7
Equivalent income												
≥$20,000	3485	52.1	46.4	3874	52.5	47.7	1496	51.8	41.5	1684	48.3	38.9
<$20,000	3207	47.9	53.6	3502	47.5	52.3	1390	48.2	58.5	1804	51.7	61.1
Marital status												
Married	5599	83.7	79.7	6154	83.4	79.9	1842	63.8	58.6	2408	69.0	62.8
Unmarried	1093	16.3	20.3	1222	16.6	20.1	1044	36.2	41.4	1080	31.0	37.2
Self-reported medical conditions												
No illness	1965	29.4	28.9	1650	22.4	22.0	445	15.4	16.8	424	12.2	12.1
Illness	4727	70.6	71.1	5726	77.6	78.0	2441	84.6	83.2	3064	87.8	87.9
Smoking												
No smoking	5727	85.6	87.3	6314	85.6	86.5	2584	89.5	91.5	3249	93.1	93.7
Smoking	965	14.4	12.7	1062	14.4	13.5	302	10.5	8.5	239	6.9	6.3
Alcohol consumption												
No drinking	3624	54.2	60.1	4054	55.0	59.3	1920	66.5	73.6	2293	65.7	71.4
Drinking	3068	45.8	39.9	3322	45.0	40.7	966	33.5	26.4	1195	34.3	28.6
Walking time per day, min												
≥60	2379	35.5	35.0	2807	38.1	38.0	657	22.8	24.4	1128	32.3	32.0
30–59	2404	35.9	34.5	2653	36.0	35.0	956	33.1	31.4	1253	35.9	33.1
<30	1909	28.5	30.5	1916	26.0	27.0	1273	44.1	44.2	1107	31.7	34.9
Frequency of going outdoors												
≥2 times/wk	6056	90.5	87.9	7025	95.2	94.6	2224	77.1	73.4	3148	90.3	88.1
Once/wk	409	6.1	7.5	202	2.7	2.9	347	12.0	14.2	154	4.4	5.5
<once/wk	227	3.4	4.6	149	2.0	2.6	315	10.9	12.4	186	5.3	6.4
Depressive symptoms												
No symptoms (GDS < 5)	4964	74.2	70.8	5944	80.6	77.5	1983	68.7	63.9	2640	75.7	71.8
Mild (GDS 5–9 points)	1297	19.4	21.6	1098	14.9	16.9	679	23.5	26.2	639	18.3	21.3
Moderate to severe (GDS ≥10)	431	6.4	7.6	334	4.5	5.6	224	7.8	9.9	209	6.0	6.9
Emotional support												
Available	6399	95.6	94.4	7057	95.7	95.6	2720	94.2	92.5	3326	95.4	94.6
Not available	293	4.4	5.6	319	4.3	4.4	166	5.8	7.5	162	4.6	5.4
Instrumental support												
Available	6438	96.2	95.1	7115	96.5	95.9	2781	96.4	94.5	3382	97.0	95.6
Not available	254	3.8	4.9	261	3.5	4.1	105	3.6	5.5	106	3.0	4.4
Frequency of meeting friends												
≥2 times/wk	2535	37.9	39.7	2774	37.6	38.4	1011	35.0	37.2	1302	37.3	39.4
1 time/wk	1181	17.6	17.8	904	12.3	12.8	498	17.3	18.4	490	14.0	14.5
1–3 times/mo	1419	21.2	21.0	1818	24.6	24.2	562	19.5	19.9	740	21.2	21.1
A few times a year or less	1557	23.3	21.5	1880	25.5	24.7	815	28.2	24.6	956	27.4	25.1
IADL												
No decline	6316	94.4	93.2	7306	99.1	98.6	2365	81.9	80.4	3214	92.1	92.5
Decline	376	5.6	6.8	70	0.9	1.4	521	18.1	19.6	274	7.9	7.5
Social participation												
Work												
No working	4767	71.2	72.1	4712	63.9	64.5	2551	88.4	87.6	2968	85.1	84.0
Working	1925	28.8	27.9	2664	36.1	35.5	335	11.6	12.4	520	14.9	16.0
Community participation												
No participation	3504	52.4	50.4	4158	56.4	52.8	1852	64.2	56.3	2019	57.9	51.8
Participation	3188	47.6	49.6	3218	43.6	47.2	1034	35.8	43.7	1469	42.1	48.2

2010–2013 cohort: 3-year cohort data with 2010 as the baseline.
2016–2019 cohort: 3-year cohort data with 2016 as the baseline.
*Restricted to those with no missing values for all variables.
†For missing values. Twenty datasets were created using the multivariate normal replacement method. Percentages for each variable are listed as the mean of the 20 datasets.

Supplementary Table 3
Relationship Between Variables Expected to Improve and Social Participation Stratified by Age From the 2010–2013 to 2016–2019 Cohorts

Outcomes	Community Participation									
	65–74 years (n = 28,462)					≥75 years (n = 20,344)				
	No Participation	Participation				No Participation	Participation			
	Reference	RR/OR/B	95% CI		*P*	Reference	RR/OR/B	95% CI		*P*
Smoking	1.00	0.74	0.67	0.81	<.001	1.00	0.72	0.65	0.80	<.001
Alcohol consumption	1.00	1.14	1.10	1.18	<.001	1.00	1.28	1.21	1.35	<.001
Walking time per day	0.00	−0.12	−0.14	−0.10	<.001	0.00	−0.16	−0.19	−0.14	<.001
Frequency of going outdoors	0.00	−0.09	−0.10	−0.08	<.001	0.00	−0.22	−0.24	−0.20	<.001
Depressive symptoms	0.00	−0.16	−0.18	−0.15	<.001	0.00	−0.18	−0.20	−0.17	<.001
Emotional support	1.00	0.52	0.45	0.59	<.001	1.00	0.56	0.48	0.65	<.001
Instrumental support	1.00	0.63	0.55	0.73	<.001	1.00	0.76	0.66	0.89	<.001
Frequency of meeting friends	0.00	−0.77	−0.80	−0.74	<.001	0.00	−0.84	−0.87	−0.81	<.001
IADL	1.00	0.41	0.30	0.55	<.001	1.00	0.37	0.32	0.43	<.001
Outcomes	Work									
	65–74 years (n = 28,462)					≥75 years (n = 20,344)				
	No Participation	Participation				No Participation	Participation			
	Reference	RR/OR/B	95% CI		*P*	Reference	RR/OR/B	95% CI		*P*
Smoking	1.00	1.09	0.99	1.18	.069	1.00	1.06	0.92	1.23	.408
Alcohol consumption	1.00	1.11	1.08	1.13	<.001	1.00	1.10	1.03	1.17	.003
Walking time per day	0.00	−0.20	−0.22	−0.18	<.001	0.00	−0.25	−0.28	−0.21	<.001
Frequency of going outdoors	0.00	−0.01	−0.03	0.00	.015	0.00	−0.04	−0.07	−0.02	.002
Depressive symptoms	0.00	−0.08	−0.09	−0.06	<.001	0.00	−0.09	−0.12	−0.06	<.001
Emotional support	1.00	0.85	0.74	0.98	.025	1.00	1.02	0.83	1.25	.856
Instrumental support	1.00	0.94	0.81	1.08	.371	1.00	0.97	0.77	1.23	.819
Frequency of meeting friends	0.00	−0.16	−0.19	−0.13	<.001	0.00	−0.20	−0.26	−0.15	<.001
IADL	1.00	0.70	0.57	0.86	.001	1.00	0.76	0.64	0.90	.001

B, unstandardized regression coefficients; OR, odds ratio; RR, risk ratio.
Missing values were imputed by using a multivariate normal imputation method.
Adjusted for sex, age, educational involvement, equivalent income, marital status, and self-reported medical conditions.
For all continuous outcomes (walking time per day, frequency of going outdoors, depressive symptoms, frequency of meeting friends), unstandardized regression coefficients (B) were estimated by multiple linear regression. The ORs were estimated by logistic regression for the binary outcomes whose prevalence was less than 10% (emotional support, instrumental support). For other dichotomized outcomes (smoking, alcohol consumption, instrumental activity of daily living), RRs were estimated by modified Poisson regression. Municipalities were adjusted for random effects in all analyses.

Supplementary Table 4
The Weibull Survival Analysis for the Incidence of Functional Disability Between the Cohorts (2010–2013 vs 2016–2019) in 65- to 74-Year-Olds

	65–74 years (n = 28,462)								
	Model 1			Model 2			Model 3		
	HR	95% CI	*P*	HR	95% CI	*P*	HR	95% CI	*P*
Cohorts									
2010–13 cohort	1.00			1.00			1.00		
2016–19 cohort	0.75	0.64–0.89	.001	0.76	0.64–0.90	.002	0.94	0.78–1.12	.457
Sex									
Men	1.00			1.00			1.00		
Women	0.61	0.51–0.72	<.001	0.62	0.52–0.74	<.001	0.63	0.51–0.77	<.001
Age, y									
65–69	1.00			1.00			1.00		
70–74	1.88	1.58–2.24	<.001	1.84	1.54–2.20	<.001	1.82	1.53–2.18	<.001
Community participation									
No participation				1.00			1.00		
Participation				0.57	0.47–0.69	<.001	0.78	0.63–0.96	.018
Work									
No working				1.00			1.00		
Working				0.57	0.45–0.72	<.001	0.66	0.52–0.84	.001
Educational attainment, y									
≥10	1.00			1.00			1.00		
<10	1.38	1.15–1.66	<.001	1.31	1.09–1.57	.004	1.22	1.01–1.46	.036
Equivalent income									
≥$20,000	1.00			1.00			1.00		
<$20,000	1.35	1.13–1.63	.001	1.25	1.04–1.51	.019	1.08	0.89–1.30	.427
Marital status									
Married	1.00			1.00			1.00		
Unmarried	1.18	0.95–1.47	.124	1.15	0.93–1.42	.210	1.11	0.88–1.39	.372
Self-reported medical conditions									
No illness	1.00			1.00			1.00		
Illness	2.01	1.57–2.59	<.001	1.93	1.50–2.48	<.001	1.72	1.33–2.21	<.001
Smoking									
No smoking							1.00		
Smoking							1.58	1.26–1.96	<.001
Alcohol consumption									
No drinking							1.00		
Drinking							0.85	0.70–1.03	.095
Walking time per day									
≥60 min							1.00		
30 min–59 min							1.51	1.18–1.92	.001
<30 min							2.04	1.61–2.58	<.001
Frequency of going outdoors									
≥2 times/wk							1.00		
Less than once/wk							1.21	0.88–1.67	.245
<once/wk							1.74	1.30–2.33	<.001
Depressive symptoms									
No symptoms (GDS < 5)							1.00		
Mild (GDS 5–9points)							1.36	1.10–1.67	.004
Moderate to severe (GDS ≥ 10)							1.84	1.41–2.39	<.001
Emotional support									
Available							1.00		
Not available							0.85	0.58–1.24	.394
Instrumental support									
Available							1.00		
Not available							0.71	0.46–1.11	.132
Frequency of meeting friends									
≥2 times/wk							1.00		
1 time/wk							1.12	0.86–1.48	.396
1–3times/wk							1.00	0.78–1.27	.970
A few times a year or less							1.17	0.92–1.48	.196
IADL									
Not decline							1.00		
Decline							3.06	2.39–3.91	<.001

Missing values were imputed by using a multivariate normal imputation method.

Supplementary Table 5
The Weibull Survival Analysis for the Incidence of Functional Disability Between the Cohorts (2010–2013 vs 2016–2019) in 75 Year-Olds and Older

	≥75 years (n = 20344)								
	Model 1			Model 2			Model 3		
	HR	95% CI	*P*	HR	95% CI	*P*	HR	95% CI	*P*
Cohorts									
2010–2013 cohort	1.00			1.00			1.00		
2016–2019 cohort	0.73	0.67–0.80	<.001	0.75	0.69–0.82	<.001	0.95	0.87–1.04	.300
Sex									
Men	1.00			1.00			1.00		
Women	0.82	0.74–0.90	<.001	0.83	0.75–0.92	<.001	0.69	0.61–0.77	<.001
Age, y									
75–79	1.00			1.00			1.00		
80–84	2.08	1.86–2.32	<.001	2.02	1.81–2.25	<.001	1.79	1.60–2.00	<.001
≥85	4.85	4.34–5.42	<.001	4.47	4.00–5.01	<.001	3.32	2.95–3.73	<.001
Community participation									
No participation				1.00			1.00		
Participation				0.61	0.55–0.68	<.001	0.85	0.75–0.96	.010
Work									
No working				1.00			1.00		
Working				0.67	0.56–0.81	<.001	0.76	0.64–0.92	.004
Educational attainment, y									
≥10	1.00			1.00			1.00		
<10	1.13	1.03–1.24	.009	1.09	0.99–1.20	.068	1.02	0.93–1.12	.724
Equivalent income									
≥$20,000	1.00			1.00			1.00		
<$20,000	1.05	0.95–1.17	.346	1.03	0.92–1.14	.631	0.96	0.86–1.07	.433
Marital status									
Married	1.00			1.00			1.00		
Unmarried	1.17	1.05–1.29	.004	1.15	1.04–1.28	.007	1.12	1.01–1.24	.040
Self-reported medical conditions									
No illness	1.00			1.00			1.00		
Illness	1.19	1.04–1.37	.013	1.16	1.01–1.33	.038	1.08	0.93–1.24	.310
Smoking									
No Smoking							1.00		
Smoking							1.17	0.99–1.38	.070
Alcohol consumption									
No drinking							1.00		
Ddrinking							0.81	0.72–0.91	.001
Walking time per day, min									
≥60							1.00		
30–59							1.26	1.10–1.45	.001
<30							1.63	1.43–1.86	<.001
Frequency of going outdoors									
≥2 times/wk							1.00		
Less than once/wk							1.24	1.08–1.42	.002
<once/wk							1.38	1.21–1.58	<.001
Depressive symptoms									
No symptoms (GDS < 5)							1.00		
Mild (GDS 5–9 points)							1.25	1.13–1.39	<.001
Moderate to severe (GDS ≥10)							1.34	1.16–1.55	<.001
Emotional support									
Available							1.00		
Not available							0.94	0.79–1.12	.508
Instrumental support									
Available							1.00	0.76–1.20	
Not available							0.96		.704
Frequency of meeting friends									
≥2 times/wk							1.00		
1 time/wk							1.12	0.97–1.30	.125
1–3 times/mo							1.14	0.99–1.31	.062
A few times a year or less							1.23	1.07–1.40	.003
IADL									
Not decline							1.00		
Decline							2.32	2.08–2.59	<.001

Missing values were imputed by using a multivariate normal imputation method.