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Reduced long-term care cost by social participation among older Japanese adult: A eleven-year follow-up study in JAGES

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Abstract

Objectives: Reducing costs related to functional disabilities and long-term care (LTC) is necessary in aging societies. We evaluated the differences in the cumulative cost of public long-term care insurance (LTCI) services by social participation.

Design: Prospective observational study.

Setting: Our baseline survey was conducted in March 2006 among people aged 65 or older who were not eligible for public LTCI benefits were selected using a complete survey in Tokoname City, Japan. We followed up with their LTC services costs over a period of 11 years. Social participation was assessed by the frequency of participation in clubs for hobbies, sports, or volunteering. We adopted a classical linear regression analysis and an inverse probability weighting (IPW), with multiple imputation of missing values

Participants: 5,377 older adults.

Primary outcome measures: The cumulative cost of public LTCI services for 11 years.

Results: Even when adjusting for the confounding variables, social participation at the baseline was negatively associated with the cumulative cost of LTCI services. The IPW model showed that for respondents who participated in clubs for hobbies or sports once a week or more, the cost of LTCI services was lower: approximately 3,500 USD and 6,000 USD for 11 years per person, in comparison to non-participants.

Conclusions: Older adults' participation in community organizations may help reduce future LTC costs. Promoting participation opportunities in the community could ensure the financial stability of LTCI services.

Strengths and limitations of this study

- To our knowledge, this is the first to demonstrate that social participations among older adults might help lower subsequent LTCI costs.
- Our findings are based on eleven-years prospective observational study using public LTCI receipt data in Japan.
- Selection bias might have occurred because of the 53% response rate to the base-line survey.
- The measurements of social participation rely on self-reported questionnaire.

Main text

Introduction

Across the globe, costs related to functional disabilities and long-term care (LTC) are rapidly increasing in societies with aging populations. Expenses are greater among those with more severe impairments.[1] In Japan, one of the countries experiencing the highest rate of aging, the proportion of older people is currently 27.3% and is predicted to reach around 40% by 2065.[2] Under these circumstances, the costs for long-term care insurance (LTCI) are expected to rise from 10 billion USD in 2016 to 21 billion USD by 2025.

Lowering these costs requires building a sustainable, healthy aging society. The Japanese government implemented a public nursing care insurance law that includes an LTC prevention policy.[3] For this policy, a population approach as primary prevention was proposed rather than a high-risk one which was grounded in risk screening based on intervention targeting. Promoting social participation is considered an effective intervention regarding the population approach, which focuses on the entire group of older adults in a community.

Although social participation is an ambiguous concept, it can be categorized into three types: collective, productive, and political.[4] We view this idea as collective social activities in the local community. Social participation helps maintain social networks, support, and roles, raises self-esteem and self-efficacy, and facilitates access to various kinds of information. Several systematic reviews and meta-analyses have reported on the physical, psychological, and social benefits of social participation among older people.[5-10] Previous observational studies in Japan found that collective social participation activities such as volunteering, sports clubs, and hobbies among older adults lowered the risk of developing depressive symptoms,[11-13] the incidence of functional disabilities,[14-16] cognitive decline or dementia,[17,18] falls,[19] and immature death.[20-23]

If social participation extends healthy life expectancy and reduces the time spent in intensive nursing care, then the cumulative cost of LTCI services should be lower among the participants; however, to our knowledge, there is no evidence that social participation lessens it. In addition to health promotion, the cost of LTCI services is one of the

most important issues for the public sector as an insurer. The evidence for contributing to cost-saving has been useful for recent intervention financing schemes that provide economic incentives to service providers; for instance, social impact bonds (SIBs). In this paper, using data from a follow-up study that took place over a period of 11 years and tracked older Japanese adults, we assessed the cost containment effect of LTCI services via social participation.

Methods

Study design

The Japan Gerontological Evaluation Study (JAGES) conducted a self-administered questionnaire in March 2006 as a baseline; 5,483 respondents who were 65 years or older, physically and cognitively independent, and not eligible for public LTCI benefits were selected using a complete survey; they live in the city of Tokoname in Aichi Prefecture (response rate=53.4%). Afterward, we obtained receipt data on LTCI benefits over a period of 11 years after the baseline survey. After eliminating respondents who lacked information on sex and age (n=42), who had moved out of their residence (n=38), and who had been certified for LTCI before the baseline survey (n=26), 5,377 respondents were linked to the LTCI receipt dataset (**Figure 1**). Out of this amount, 30.4% had used LTCI services at least once, and 28.4% passed away during the follow-up period. This study was performed based on a collaborative research agreement with the local municipality. The ethics board at Nihon Fukushi University gave ethical permission (No. 16-29).

Measurements

Outcome variables; the costs of LTCI services

We obtained the LTC costs of insured services across forty-four points every three months (April, July, October, January) over a period of 11 years. We summed them up after tripling these monthly costs in order to calculate an approximate value of the overall cost for the follow-up period. We used the currency exchange rate of 100JPY to 1USD.

In addition, Japanese LTCI operates based on social insurance principles. Only services are provided, not cash allowances, and recipients can choose their services and providers.[24] The receipt data includes information about using insured services such as home visits, day, short-stay, residential, or in-facility services. The data do not include costs, which are not covered by insurance (such as food, housing, and diaper expenses). In general, 10% of these costs are co-payments (the municipality, which acts as an insurer, pays 90%), although there is a upper limit to the amount of monthly insurance

benefits, which differs depending on the needed level of care. People with certifications for LTC and who need (levels 1 to 5) or require support (levels 1 or 2) can use LTCI services. Those higher levels of care can utilize more LTCI services through insurance coverage. The cumulative cost of such care in the following cases is zero: deceased individuals who did not have functional disabilities, respondents who did not have proper certification, and non-service users.

Explanatory variables: Social participation

We focused on the frequency of participation in three major kinds of social groups among older Japanese adults: hobbies, sports, and volunteering. Please note that participating in volunteer activities is not necessarily "voluntary" in Japan. We categorized it to the four frequencies; *never*; *a few times a year*; *once or twice a month*; and *once a week or more*.

Covariates

For potential confounding variables we chose sex, age, the presence of disease or impairment, educational attainment, equivalent income (USD), marital status, living situation, and self-rated health for the baseline survey. We used age as a continuous variable (73.4±6.2). We dichotomized the presence of disease or impairment, and we categorized years of education as *<6*, *6-9*, *10-12*, and *13+*. We equalized household income by the square root of the numbers and classified it as *<20.0*, *20.0-39.9*, and *40.0+* thousand USD. Marital status consisted of *married*, *widowed*, *divorced*, and *never married*. We classified living situation as *living alone*, *with one's spouse only*, *with a child*, or *with others* such as grandchildren, siblings, and relatives. We assessed self-rated health using four categories: *excellent*, *good*, *fair*, and *poor*.

Statistical analysis

After calculating the descriptive statistics, we conducted four regression analyses. First, we adopted a classical linear regression (ordinary linear squares [OLS]) model, controlling the above potential confounding variables. We handled the missing value in each control variable as a dummy variable. Second, we predicted the marginal effects, adopting a generalized linear model (GLM)[25] with Gamma distribution, as well as the

log link and robust variance estimator, because our dependent variable is not normally distributed. Next, we performed a multiple imputation technique by chained equations under the missing at random assumption. We created twenty imputed datasets. Using each dataset, we first estimated the OLS model with the robust variance estimator. Finally, to estimate the causal treatment effect from observational data, we adopted the inverse probability weighting (IPW) model[26, 27] using the imputed data sets. We calculated the generalized propensity scores using multinomial regression analysis, employing all previously listed potential confounders. For reference, we only examined the same model among the deceased, who passed away during the follow-up period. The LTCI costs for the deceased indicates the "lifetime cost" of LTCI because they did not use LTCI services at the baseline. We performed analyses using STATA 15.1 (STATA Corp LP, College Station, Texas, USA).

Results

Table 1 shows the characteristics of the respondents; the mean age at the baseline was 73.4; 52.0% of the respondents were male. The average of the cumulative cost of LTCI services during the follow-up period was 13.7 thousand USD. There were significant differences in the average duration for the level of care required for social participation during the follow-up period (**Table 2**). Non-participants in groups for hobbies, sports, and volunteering had a longer duration of certification for LTC at all levels, level two and above, and level four and above. For example, among participants who took part in the group for hobbies, the average duration for non-participants was 14.1 (standard deviation [SD]=25.8) months, whereas that of those who participated "once a week or more" was 10.6 (SD=21.6) months.

The classical regression model showed that in comparison to non-participants, respondents who participated in the group for hobbies once a week produced a cost containment in 3.6 (95% confidence interval [CI]: 6.0 to 1.3) thousand USD, which was lower per person for LTCI cumulative costs over the 11-year period (**Table 3**). Likewise, participating in a sports club was also significantly associated with lower LTCI costs: the category of those who took part "once a week or more" was 4.9 [95% CI: 6.9 to 2.8] thousand USD less per person. However, in the volunteer group, only less frequent participation was associated with lower costs; for individuals in the category of "a few times a year" this figure was 4.1 [95% CI: 7.1 to 1.0] thousand USD less per person. When we changed the estimation method to GLM, and when we adopted OLS after multiple imputation, the major results and trends were similar to the above, although some point estimations in GLM were higher in the categories that had a small sample size (please see **Supplementary File 1**).

The average treatment effects of IPW showed similar outcomes. In comparison to non-participants, going to a group for hobbies once a week or more resulted in a cost that was reduced by approximately 3.5 [95% CI: 6.2 to 0.8] thousand USD; for sports clubs, this lowered figure was approximately 6.1 [95% CI: 9.3 to 2.8] thousand USD. The significant relationship with less frequent participation in the volunteer group dis-

appeared, but the direction of the association and point estimations did not largely change (the C statistics in these models are shown in **Supplementary File 2**).

In addition, in comparison to non-participants, for deceased individuals during the follow-up period, joining a group for hobbies (once a week+) or sports (once a week+) led to a reduced cost of approximately 3.9 to 5.7 thousand USD, and 9.4 to 11.4 thousand USD, respectively (please see **Supplementary File 3**). These outcomes are preliminary because there were very few analyzed subjects (especially the sports and volunteer groups).

Discussions

During the 11-year follow-up period, compared to non-participants, respondents who took part in the group for hobbies or sports once a week produced lower costs for LTCI services (approximately 3.5 and 6.1 thousand USD per person).

These findings are consistent with those of previous research. Most investigations suggest that social participation decreases the incidence of physical disability risk. In an intervention study examining the effect of community salons in Japan, among the participants, the incidence of physical disability risk fell by 51% over five years;[28] cognitive disability risk also declined by around 30% over seven years[29]. Several trajectory analyses showed that attending leisurely activities is related to "functional maintenance,"[30] while a low frequency of going out was related to being "persistently disabled."[31] Another longitudinal study showed that a low frequency of going out was associated with tooth loss[32] and revealed that older adults with 20 teeth had a longer healthy life expectancy (men: +92 day, women: +70 day) compared to edentulous people.[33]

This study adds evidence to the current literature, suggesting that social participation may be effective not only for preventing functional deterioration, but also in terms of reducing LTC costs. Our findings illustrate that the more the respondents took part in each type of community activity, the less time they spent in intensive nursing care. Therefore, differences in LTCI costs may have arisen due to the extension of healthy life expectancy or a reduction in the period of functional disability, rather than restrictions on using required services. Lifetime LTCI cost, which was estimated among deceased individuals, showed similar trends. This suggests that postponing the onset of functional disabilities or death did not cause differences in costs.

On the other hand, for volunteer activities, less frequent (rather than very frequent) participation resulted in lower LTCI costs. In Japan, it is often mentioned that part of participants in volunteer activities is experiencing an excessive burden. Official Japanese statistics revealed that half of older adults preferred volunteer activities that do not constrain their time or term.[34] Our results suggest that taking part in volunteer activities by force, which is not the original meaning of volunteering, might not

necessarily protect their health, although participating in and of itself is preventive.

This study has public health implications. One systematic review mentioned that most local and national public health interventions are substantially cost saving.[35] Our results suggest that promoting participation in community activities might have a non-ignorable cost containment effect. That is, 21.8% and 12.7% of the respondents, or about 2,240 and 1,300 people, in this municipality may have been participating in a group for hobbies or sports at least once a week. If the number of these people increased by 10% (around 220 and 130 people), it may have been possible to reduce the cumulative cost of LTCI services by approximately 780 to 800, and 630 to 790 thousand USD, respectively, over the 11-year period. It is important that each activity in this paper is not a special program and is already prevalent in Japan, and that the expenditure to be borne by the public sector is comparatively inexpensive. Furthermore, our findings might be an underestimation, because less frequent categories for each type of social participation tended to result in a higher mortality rate.

Our study has several limitations and strengths. First, due to accessibility to data, we could not analyze medical care costs. A previous study mentioned that medical care and LTC expenditures have a weak, but negative, relationship.[36] However, to our knowledge, our study is the first to demonstrate that social participations among older adults might help lower subsequent LTCI costs. Second, generalizability is limited by the fact that our study was conducted in one municipality. However, our findings have high representativeness because we used public receipt data, which have a higher achievement rate, and the proportion of older adults and of certified LTC levels is roughly the same between the subject area and the national average. Third, it is possible that our measurement of social participation does not reflect actual activities correctly due to the self-reported questionnaire. To assess the frequency and role of these groups, future research should examine interactions among participating members using objective indicators.

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Competing interests None declared.

Ethics approval This study was performed on the basis of collaborative research agreement with municipality. Ethical permission (No. 16-29) was provided by the Ethics Board at Nihon Fukushi University.

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References

1. W Greysen SR., Stijacic Cenzer I., & Boscardin WJ., (2017) Functional impairment: an unmeasured marker of medicare costs for postacute care of older adults. *J Am Geriatr Soc.* 65(9): 1996-2002.
2. National Institute of Population and. Social Security Research (2017) *Population Projections for Japan: 2016-2065 (With long-range Population Projections: 2066-2115)*. (http://www.ipss.go.jp/pp-zenkoku/j/zenkoku2017/pp29_ReportALL.pdf)
3. Ministry of Health, Labour and Welfare (2017) *Long-Term Care, Health and Welfare Services for the Elderly.* (http://www.mhlw.go.jp/english/policy/care-welfare/care-welfare-elderly/index.html
4. Bukov A, Maas I, Lampert T. (2002) Social participation in very old age: cross-sectional and longitudinal findings from BASE. Berlin Aging Study. *J Gerontol B Psychol Sci Soc Sci.* 57(6): P510-P517.
5. Stuck AE., Walthert JM., & Nikolaus T., et al. (1999) Risk factors for functional status decline in community-level elderly people; a systematic literature review. *Soc Sci Med,* 48: 445-469.
6. Holt-Lunstad J. Smith TB. & Layton JB. (2010) Social relationships and mortality risk: a meta-analytic review. *PLoS Medicine*. 7(7): e1000316. doi:10.1371.
7. Cattan M. (2010) *Preventing social isolation and loneliness among older people: effectiveness of*

health promotion interventions. Saarbrücken: Lambert academic publishing.
8. Dickens AP. Richards SH. & Greaves CJ. et al. (2011) Interventions targeting social isolation in older people: a systematic review. *BMC Public Health.* 11:647.
9. Douglas H., Georgiou A., Westbrook J., (2017) Social participation as an indicator of successful aging: an overview of concepts and their associations with health. *Australian Health Review,* 41: 455-462.
10. Webber M., & Fendt-Newlin M., (2017) A review of social participation interventions for people with mental health problems. *Soc Psychiatr Epidemiol,* 52: 369-380.
11. Takagi D., Kondo K., & Kawachi I., et al. (2013) Social participation and mental health; moderating effects of gender, social role and rurality. *BMC Public Health.* 13: 701
12. Tsuji T, Sasaki Y, & Matsuyama Y et al. (2017) Reducing depressive symptoms after the Great East Japan Earthquake in older survivors through group exercise participation and regular walking:a prospective observational study. *BMJ Open,* 7(3): e013706.
13. Shiba K., Kondo N., & Kondo K. et al. (2017) Retirement and mental health: does social participation mitigate the association? A fixed-effects longitudinal analysis. *BMC Public Health.* 17(1): 526
14. Hirai H., Kondo K., Ojima T., et al. (2009) Examination of risk factors for onset of certification of long-term care insurance in community-dwelling older people : AGES project 3-year follow-up study. *Jpn J Public Health,* 56(8), 501-512 (in Japanese with English abstract)
15. Kanamori, S., Kai, Y., & Kondo, K., et al. (2012) Participation in sports organizations and the prevention of functional disability in older Japanese: the AGES cohort study. *PLoSOne,* 7(11): e51061.
16. Kanamori S., Kai Y., & Aida J. et al. (2014) Social participation and the prevention of functional disability in older Japanese: the JAGES cohort study. *PLoS One.* 9(6): e99638.
17. Takeda T., Kondo K., & Hirai H., et al. (2010) Psychosocial risk factors involved in progressive dementia-associated senility among the elderly residing at home AGES Project–Three year cohort longitudinal study. *Jpn J Public Health,* 57(12): 1054-1065 (in Japanese with English abstract).
18. Saito T., Murata C., & Saito M, et al. (2018) Influence of social relationship domains and their combinations on incident dementia: a prospective cohort study. *J Epidemiol Community Health,* 72(1): 7-12.
19. Hayashi T., Kondo K., & Suzuki K., et al. (2014) Factors associated with falls in community-dwelling older people with focus on participation in sport organizations; the Japan Gerontological Evaluation Study Project. *BioMed Research International,* 537614.
20. Noda H., Iso H., Toyoshima H., et al., (2005) Walking and sports participation and mortality from coronary heart disease and stroke. *Journal of the American College of Cardiology*, 46(9): 1761-1767.
21. Saito, M., Kondo, N., & Kondo, K., et al. (2012) Gender differences on the impacts of social exclusion on mortality among older Japanese: AGES cohort study. *Soc Sci Med,* 75, 940-945.
22. Ishikawa Y., Kondo N., & Kondo K, et al. (2016) Social participation and mortality: does social position in civic groups matter? *BMC Public Health.* 16(1): 394.
23. Ashida T., Kondo N., & Kondo K (2016) Social participation and the onset of functional disability by socioeconomic status and activity type; the JAGES cohort study. *Prev Med,* 89: 121-128.
24. Tamiya T., Noguchi H., Nishi A., et al. (2011) Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet,* 378(9797): 1183-1192
25. McCullagh P., & Nelder JA., (1989) *Generalized Liner Modelrs, second ed.* CRC Press.
26. Hoshino T., & Okada K., (2006) Estimation of causal effect using propensity score methods in clinical medicine, epidemiology, pharmacoepidemiology and public health; a review. *J. Natl. Inst. Public Health,* 55(3): 230-243 (in Japanese with English abstract).
27. Brookhart MA., Schneeweiss S., & Rothman KJ., et al. (2006) Variable selection for propensity score models. *Am J Epidemiol.* 163(12):1149-1156
28. Hikichi H., Kondo N., & Kondo K, et al. (2015) Effect of community intervention program promoting social interactions on functional disability prevention for older adults; propensity score matching and instrumental variable analyses, JAGES Taketoyo study. *J Epidemiol Community Health,* 69(9):905-910.
29. Hikichi H., Kondo K., & Takeda T, et al. (2017) Social interaction and cognitive decline; results

of a 7-year community intervention. *Alzheimers Dement (N Y)*, 3: 23-32
30. Yu HW., Chiang TL., & Chen DR., et al. (2016) Trajectories of Leisure Activity and Disability in Older Adults Over 11 Years in Taiwan. *J Appl Gerontol.* 1: 733464816650800
31. Saito J., Kondo N., Saito M., et al. (2018) Exploring 2.5-year trajectories of functional decline in older adults by applying a growth mixture model and the frequency of outings as a predictor: 2010–2013 JAGES longitudinal study. *J Epidemiol,* (in press).
32. Koyama S., Aida J., & Kondo K, et al. (2016) Does poor dental health predict becoming homebound among older Japanese? *BMC Oral Health.* 16(1): 51.
33. Matsuyama Y., Aida J., & Watt RG. et al. (2017) Dental status and compression of life expectancy with disability. *J. dent. res*. 96(9): 1006-1013.
34. Cabinet Office (2011) *Results of survey on attitude toward the senior citizens' economic life* (in Japanese) (http://www8.cao.go.jp/kourei/ishiki/h23/sougou/zentai/index.html)
35. Masters R., Anwar E., & Collins B., et al. (2017) Return on investment of public health interventions: a systematic review. *J Epidemiol Community Health,* 71: 827-834
36. Suzuki W., Iwamoto Y., & Yuda M., et al. (2012) The distribution patterns of medical care and long-term care expenditures. *Jpn. J. Health Econ. Policy. (Iryo-Keizai Kenkyu)*, 24(2): 86-107 (in Japanese with English abstract).

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure 1. Flow chart of respondent selection.
Table S1. Differences of cumulative cost in LTCI services by OLS with MI, and GLM
Table S2. C statistics by multinominal regression model
Table S3. Differences of lifetime cost in LTCI services by social participation among deceased person

Tab.1 Characteristics of respondents

	Total	Cumulative cost of LTCI services in 11 years (1000USD) [b]	
	%	Mean ± SD	*p*
Sex [a]			
Male	52.0	7.7 ± 24.8	
Female	48.0	18.7 ± 44.8	<.001
Age [a]			
(Mean±SD)	(73.4±6.2)		
65-74	61.3	6.3 ± 25.2	
75-84	33.3	23.0 ± 47.2	
85+	5.4	39.1 ± 56.4	<.001
Disease and/or impairment [a]			
None	27.2	10.9 ± 35.5	
Presence	64.6	14.3 ± 37.8	
Missing	8.3	17.7 ± 39.7	=.001
Years of education [a]			
<6	2.7	30.7 ± 57.6	
6-9	41.9	12.4 ± 34.9	
10-12	24.8	13.1 ± 37.2	
13+	32.2	11.1 ± 33.3	
Missing	10.7	23.2 ± 48.8	<.001
Equivalent income (1000USD) [a]			
<20.0	36.0	12.2 ± 36.5	
20.0-39.9	27.3	9.5 ± 30.5	
40.0+	6.8	12.0 ± 35.5	
Missing	29.9	19.6 ± 43.6	<.001
Marital status [a]			
Married	69.2	9.2 ± 29.7	
Widowed	21.4	24.8 ± 50.2	
Divorced	1.7	11.0 ± 27.9	
Never married	2.0	27.4 ± 60.1	
Missing	5.7	22.7 ± 45.9	<.001
Living situation [a]			
Living alone	10.7	23.8 ± 50.9	
With spouse only	36.5	9.6 ± 30.1	
With child	22.7	12.9 ± 35.9	
With others	25.6	14.6 ± 39.7	
Missing	4.6	21.3 ± 41.6	<.001
Self rated health [a]			
Excellent	6.0	7.9 ± 30.5	
good	61.7	11.5 ± 34.5	
Fair	22.5	18.2 ± 43.0	
Poor	5.1	21.7 ± 45.6	
Missing	4.7	18.9 ± 39.9	<.001
TOTAL	100.0	13.7 ± 37.4	

a) These variables are based on baseline questionnaire survey.

Tab.2 Average duration of care giving at follow-up period by social participation [a)]

	n	ALL Mean (SD)	Care Lv2+ Mean (SD)	Care Lv4+ Mean (SD)
Hobby activities group				
Never	2833	14.1 (25.8)	7.1 (17.6)	2.2 (8.5)
A few times a year	259	9.0 (19.4)	3.5 (9.9)	1.2 (5.3)
Once or twice a month	524	10.7 (21.8)	4.6 (14.4)	1.6 (7.5)
Once a week +	972	10.6 (21.8)	4.1 (13.2)	1.0 (6.0)
		p <.001	p <.001	p <.001
Sports group or club				
Never	3716	13.7 (25.1)	6.6 (17.0)	2.1 (8.4)
A few times a year	91	7.5 (19.6)	4.8 (16.5)	1.2 (5.5)
Once or twice a month	125	6.0 (17.3)	2.7 (12.5)	0.5 (2.6)
Once a week +	572	7.2 (18.1)	2.4 (9.8)	0.5 (3.4)
		p <.001	p <.001	p <.001
Volunteer group				
Never	3899	12.9 (24.4)	6.1 (16.4)	1.9 (7.9)
A few times a year	194	7.1 (17.3)	2.9 (11.1)	1.1 (7.7)
Once or twice a month	193	9.9 (21.6)	4.3 (13.3)	1.1 (7.2)
Once a week +	122	6.4 (17.5)	3.1 (10.9)	0.8 (3.2)
		p <.001	p <.001	p =.019

Unit: month SD: Standard deviation

Tab.3 Differences of cumulative cost in LTCI services in a 11-years follow-up period by social participation

	n	Mean	OLS [a,b)] Coef. (95%CI)	IPW with MI [c,d)] Coef. (95%CI)	Mortality
Hobby activities group					
Never	2833	14.6	*ref.*	*ref.*	30.8
A few times a year	259	6.6	- 3.2† (-6.7 to 0.2)	- 3.5 (-8.1 to 1.2)	28.0
Once or twice a month	524	10.2	- 2.8† (-5.8 to 0.7)	- 2.2 (-5.6 to 1.2)	21.7
Once a week +	972	9.4	- 3.6** (-6.0 to -1.3)	- 3.5* (-6.2 to -0.8)	19.5
Sports group or club					
Never	3716	13.9	*ref.*	*ref.*	29.1
A few times a year	91	9.3	2.5 (-4.9 to 9.9)	1.8 (-5.8 to 9.4)	18.7
Once or twice a month	125	4.8	- 3.3 (-7.6 to 9.4)	- 4.2 (-10.7 to 2.3)	16.1
Once a week +	572	5.2	- 4.9*** (-6.9 to -2.8)	- 6.1*** (-9.3 to -2.8)	18.6
Volunteer group					
Never	3899	12.7	*ref.*	*ref.*	28.4
A few times a year	194	4.8	- 4.1** (-7.1 to -1.0)	- 3.9 (-9.1 to 1.3)	20.7
Once or twice a month	193	10.0	1.9 (-2.9 to 6.7)	1.5 (-3.8 to 6.7)	12.7
Once a week +	122	5.9	- 0.7 (-4.5 to 3.1)	- 1.4 (-7.9 to 5.1)	11.5

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000USD

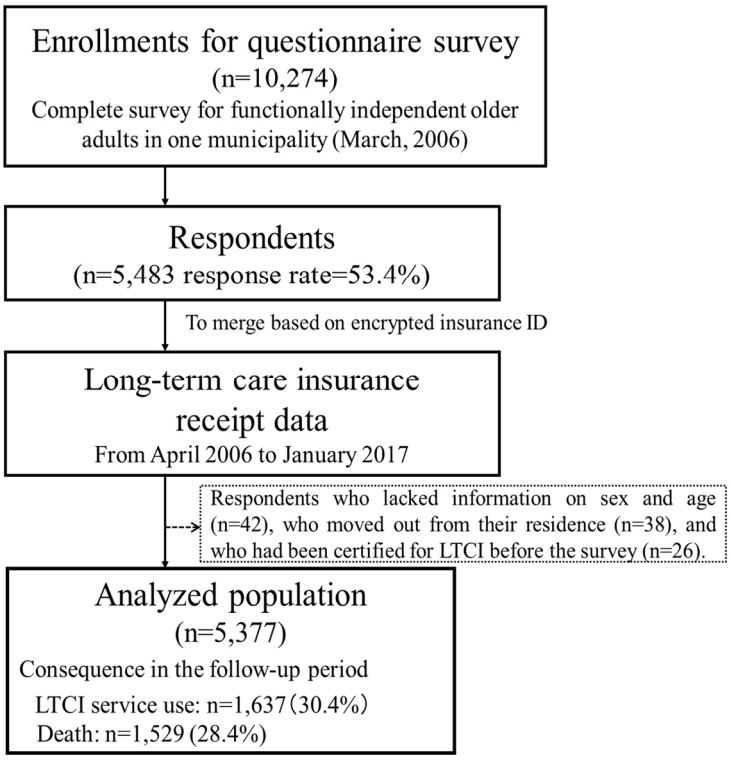
OLS: Ordinal least squares, IPW: Inverse probability weighting, MI: Multiple imputation, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) The result was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

d) The generalized propensity scores were calculated using multinominal regression analysis using all previously listed potential confounders: sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health.



Flow chart of respondent selection.

Table S1. Differences of cumulative cost in LTCI services by OLS with MI, and GLM

	n	GLM [a,b)] Marginal effect (95%CI)	OLS with MI [b,c)] Coef. (95%CI)
Hobby activities group			
Never	2833		*ref.*
A few times a year	259	- 1.9 (-11.0 to 7.2)	- 3.1† (-6.6 to 0.3)
Once or twice a month	524	- 3.3 (-8.7 to 2.2)	- 2.9† (-5.8 to 0.1)
Once a week +	972	- 3.5† (-7.3 to 0.3)	- 3.7* (-6.0 to -1.3)
Sports group or club			
Never	3716		*ref.*
A few times a year	91	10.9 (-14.3 to 36.1)	2.7 (-4.6 to 10.0)
Once or twice a month	125	- 5.0 (-17.8 to 7.9)	- 3.5 (-7.8 to 0.7)
Once a week +	572	- 7.0** (-11.2 to -2.9)	- 4.9*** (-6.9 to -2.9)
Volunteer group			
Never	3899		*ref.*
A few times a year	194	- 9.4*** (-14.1 to -4.6)	- 4.3** (-7.3 to -1.2)
Once or twice a month	193	2.3 (-8.9 to 13.6)	1.9 (-2.9 to 6.8)
Once a week +	122	- 2.8 (-11.1 to 5.6)	- 0.5 (-4.4 to 3.3)

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000 USD

GLM: Generalized linear model, OLS: Ordinal least squares, MI: Multiple imputation, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) Each model was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

Table S2. C statistics by multinominal regression model

	Hobby activi-ties group	Sports group or club	Volunteer group
A few times a year vs Never	0.664	0.757	0.637
Once or twice a month vs Never	0.665	0.695	0.681
Once a week + vs Never	0.662	0.645	0.713

C statistics by multinominal regression model in order to calculate generalized propensity scores were not high: hobby activities group=.662 to .665, sports group or club=.645 to .757, volunteer group=.637 to 713. However, it is not necessarily to mean undesirable model, because the goal of a propensity score model is to efficiently control confounding, not to predict treatment or exposure.[28]

Table S3. Differences of lifetime cost in LTCI services by social participation among deceased person

	n	Mean	OLS [a,b)]	GLM [a,b)]	After Multiple Imputation [c)]	
					OLS [b)]	IPW [d)]
			Coef. (95%CI)	Marginal effect (95%CI)	Coef. (95%CI)	Coef. (95%CI)
Hobby activities group						
Never	861	19.2	*ref.*		*ref.*	*ref.*
A few times a year	72	9.7	- 6.0* (-11.9 to - 0.1)	- 5.6 (-14.9 to 3.8)	- 5.6† (-11.6 to 0.3)	- 4.7 (-13.7 to 4.4)
Once or twice a month	113	15.8	- 2.0 (-9.1 to 5.1)	- 0.9 (-9.3 to 7.6)	- 2.1 (-9.2 to 4.9)	- 2.4 (-9.8 to 4.9)
Once a week +	188	12.2	- 5.3* (-10.1 to -0.4)	- 3.9 (-7.3 to 0.3)	- 5.4* (-10.2 to -0.5)	- 5.7† (-11.6 to 0.3)
Sports group or club						
Never	1066	19.1	*ref.*		*ref.*	*ref.*
A few times a year	17	4.3	- 8.9*** (-13.7 to -4.1)	- 17.8*** (-22.8 to -12.8)	- 8.6** (-14.1 to -3.0)	- 9.4 (-27.3 to 8.4)
Once or twice a month	20	4.0	- 8.6** (-14.8 to -2.4)	- 18.5*** (-24.0 to -13.0)	- 9.1** (-15.3 to -2.8)	- 10.1 (-26.6 to 6.4)
Once a week +	105	5.4	- 9.7*** (-13.8 to -5.7)	- 11.4** (-17.8 to -4.9)	- 9.4*** (-13.4 to -5.4)	- 11.1** (-18.6 to -3.5)
Volunteer group						
Never	1091	16.9	*ref.*		*ref.*	*ref.*
A few times a year	40	11.2	- 1.8 (-12.4 to 8.8)	- 5.9 (-18.8 to 7.0)	- 1.7 (-12.6 to 9.2)	- 2.0 (-13.7 to 9.8)
Once or twice a month	24	20.6	6.2 (-14.9 to 27.2)	10.2 (-22.5 to 42.9)	7.1 (-13.9 to 28.0)	7.6 (-7.4 to 22.7)
Once a week +	14	9.3	- 4.6 (-16.8 to 7.7)	- 12.5** (-20.4 to -4.7)	- 5.1 (-18.1 to 7.8)	- 3.4 (-23.0 to 16.2)

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000USD

OLS: Ordinal least squares, GLM: Generalized linear model, IPW: Inverse probability weighting, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) Each model was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

d) The generalized propensity scores were calculated using multinominal regression analysis using all previously listed potential confounders: sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health. C statistics were as follows: hobby activities group=.640 to .665, sports group or club=.645 to 757, volunteer group=.637 to 713.

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cohort reporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Study design	#4	Present key elements of study design early in the paper	6
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	6

	#6b	For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6
Bias	#9	Describe any efforts to address potential sources of bias	12
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6-7
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	7-8
	#12b	Describe any methods used to examine subgroups and interactions	8
	#12c	Explain how missing data were addressed	8
	#12d	If applicable, explain how loss to follow-up was addressed	6
	#12e	Describe any sensitivity analyses	8
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	6
	#13b	Give reasons for non-participation at each stage	6
	#13c	Consider use of a flow diagram	6
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential	9

		confounders. Give information separately for exposed and unexposed groups if applicable.	
	#14b	Indicate number of participants with missing data for each variable of interest	9
	#14c	Summarise follow-up time (eg, average and total amount)	6
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	N/A
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
	#16b	Report category boundaries when continuous variables were categorized	N/A
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10
Key results	#18	Summarise key results with reference to study objectives	11
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	12
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	11-12
Generalisability	#21	Discuss the generalisability (external validity) of the study results	12
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

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Reduced long-term care cost by social participation among older Japanese adult: A prospective follow-up study in JAGES

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Abstract

Objectives: Reducing costs related to functional disabilities and long-term care (LTC) is necessary in aging societies. We evaluated the differences in the cumulative cost of public long-term care insurance (LTCI) services by social participation.

Design: Prospective observational study.

Setting: Our baseline survey was conducted in March 2006 among people aged 65 or older who were not eligible for public LTCI benefits were selected using a complete enumeration in Tokoname City, Japan. We followed up with their LTC services costs over a period of 11 years. Social participation was assessed by the frequency of participation in clubs for hobbies, sports, or volunteering. We adopted a classical linear regression analysis and an inverse probability weighting (IPW), with multiple imputation of missing values

Participants: Functionally independent 5,377 older adults.

Primary outcome measures: The cumulative cost of public LTCI services for 11 years.

Results: Even when adjusting for the confounding variables, social participation at the baseline was negatively associated with the cumulative cost of LTCI services. The IPW model showed that respondents who participated in hobby activities once a week or more, the cumulative cost of LTCI services for 11 years was lower approximately 3,500 USD per person, in comparison to non-participants. Similary, that in respondents who participated in sports group or clubs was lower approximately 6,000 USD than non-participants.

Conclusions: Older adults' participation in community organizations may help reduce future LTC costs. Promoting participation opportunities in the community could ensure the financial stability of LTCI services.

Strengths and limitations of this study

- To our knowledge, this is the first to demonstrate that social participations among older adults might help lower subsequent LTCI costs.
- Our findings are based on eleven-years prospective observational study using public LTCI receipt data in Japan.
- Selection bias might have occurred because of the 53% response rate to the base-line survey.
- The measurements of social participation rely on self-reported questionnaire.

Main text

Introduction

Across the globe, costs related to functional disabilities and long-term care (LTC) are rapidly increasing in societies with aging populations. Expenses are greater among those with more severe impairments.[1] In Japan, one of the countries experiencing the highest rate of aging, the proportion of older people is currently 27.3% and is predicted to reach around 40% by 2065.[2] Under these circumstances, the costs for long-term care insurance (LTCI) are expected to rise from 100 billion USD in 2016 to 210 billion USD by 2025.

Lowering these costs requires building a sustainable and healthy aging society which means developing and maintaining the functional ability that enables well-being in older age. The Japanese government implemented a public nursing care insurance law that includes an LTC prevention policy.[3] For this policy, a population approach as primary prevention was proposed rather than a high-risk one which was grounded in risk screening based on intervention targeting. Promoting social participation is considered an effective intervention regarding the population approach, which focuses on the entire group of older adults in a community.

Although social participation is an ambiguous concept, Bukov (2002) distinguished three types of participation: collective, productive, and political.[4] In this paper, we focused on involvement in collective activities in formal and informal societal groups at local community. Social participation helps maintain social networks, support, and roles, raises self-esteem and self-efficacy, and facilitates access to various kinds of information. Several international systematic reviews and meta-analyses have reported on the physical, psychological, and social benefits of social participation among older people.[5-10] For instance, meta-analysis across 148 articles mentioned active engagement in social activities could reduce risk for mortality. In particular, previous observational studies in Japan also found that collective social participation activities such as volunteering, sports clubs, and hobbies among older adults lowered the risk of developing depressive symptoms,[11-13] the incidence of functional disabilities,[14-16] cognitive decline or dementia,[17,18] falls,[19] and immature death.[20-23]

We hypothesize that if social participation extends healthy life expectancy and reduces the time spent in intensive nursing care, then the cumulative cost of LTCI services might be lower among the participants; however, to our knowledge, there is no evidence that social participation lessens it. In addition, Japanese LTCI services are provided mainly when people aged 65 and over come to require care or support, based on investigation for certification and doctor's written opinion. The cost of LTCI services is one of the most important issues for the public sector as an insurer. The evidence for contributing to cost-saving has been useful for recent intervention financing schemes that provide economic incentives to service providers; for instance, social impact bonds (SIBs). In this paper, using data from a follow-up study that took place over a period of 11 years and tracked older Japanese adults, we assessed the differences of the duration period of requiring care level and of the cumulative cost of LTCI services by frequency of social participation in baseline survey.

Methods

Study design

The Japan Gerontological Evaluation Study (JAGES) conducted a self-administered questionnaire in March 2006 as a baseline; 5,483 respondents who were 65 years or older, physically and cognitively independent, and not eligible for public LTCI benefits were selected using a complete enumeration; they live in the city of Tokoname in Aichi Prefecture (response rate=53.4%: 5,483 / 10,274). In addition, our subjects were more healthy or active older adults at baseline, because Japanese LTCI certifies the people included mild care needs, not only severe care level. Afterward, we obtained receipt data on LTCI benefits over a period of 11 years after the baseline survey, from government database of public LTCI. After eliminating respondents who lacked information on sex and age (n=42), who had moved out of their residence (n=38), and who had been certified for LTCI before the baseline survey (n=26), 5,377 respondents were linked to the LTCI receipt dataset (**Figure 1**). Out of this amount, 30.4% had used LTCI services at least once, and 28.4% passed away during the follow-up period.

Measurements

Outcome variables; the costs of LTCI services

Primary outcome variable is the cumulative cost of LTCI services at follow-up period. We obtained the LTC costs of insured services across forty-four points every three months (April, July, October, January) over a period of 11 years. We summed them up after tripling these monthly costs in order to calculate an approximate value of the overall cost for the follow-up period. We used the currency exchange rate of 100JPY to 1USD. As closely related variable, we calculated the number of months which was eligible for LTCI benefit across the whole population, from care level 5 which signifies the highest level of requirement for LTC to any care or support level.

In addition, Japanese LTCI operates based on social insurance principles. Only services are provided, not cash allowances, and recipients can choose their services and providers.[24] The receipt data includes information about using insured services such as home visits, day, short-stay, residential, or in-facility services. The data do not include

costs, which are not covered by insurance (such as food, housing, and diaper expenses). In general, 10% of these costs are co-payments (the municipality, which acts as an insurer, pays 90%), although there is a upper limit to the amount of monthly insurance benefits, which differs depending on the needed level of care. People with certifications for LTC and who need (levels 1 to 5) or require support (levels 1 or 2) can use LTCI services. Those higher levels of care can utilize more LTCI services through insurance coverage. The cumulative cost of such care in the following cases is zero: deceased individuals who did not have functional disabilities, respondents who did not have proper certification, and non-service users.

Explanatory variables: Social participation

The indicator of social participation was taken from the Japanese General Social Survey,[25] and categorized organizations into following eight types: hobby activities group, sports group or club, volunteer group, neighborhood association, senior citizen club/fire-fighting team, religious group, political organization or group, industrial or trade association, and citizen or consumer group. We focused on the three groups/organizations previously identified as being associated with lower risks for functional disabilities; hobby activities group,[17,26] sports group or club,[15,26] and volunteer group.[27,28] According to principal components analysis, these community activities were categorized to horizontal organizations.[29,30] Respondents were asked how often they took part in these activities. We categorized them to the four frequencies, respectively; *never; a few times a year; once or twice a month;* and *once a week or more*.

Covariates

Demographic variables included sex, age, educational attainment, equivalent income (USD), marital status, and living situation at the baseline survey. Age was a continuous variable (73.4±6.2). Years of education was categorized as *<6*, *6-9*, *10-12*, and *13+*. We equalized household income by the square root of the numbers and classified it as *<20.0*, *20.0-39.9*, and *40.0+* thousand USD. Marital status consisted of *married*, *widowed*, *divorced*, and *never married*. Living situation was categorized as *living alone*, *with one's spouse only*, *with a child*, or *with others* such as grandchildren, siblings, and relatives.

In order to account for the health status at the baseline, the presence of disease or impairment and self-rated health were considered. The presence of disease or impairment was based on self-reported medical condition (no illness, having illness but need no treatment, having illness but discontinued treatment, and receiving some treatment). We dichotomized it; that is, no illness or not. We assessed self-rated health using four categories: *excellent*, *good*, *fair*, and *poor*.

Statistical analysis

After calculating the descriptive statistics, we conducted four regression analyses. First, we adopted a classical linear regression (ordinary linear squares [OLS]) model, controlling covariates at baseline survey. We handled the missing value in each control variable as a dummy variable. Second, as one of robustness check, we predicted the marginal effects, adopting a generalized linear model (GLM)[31] with Gamma distribution, as well as the log link and robust variance estimator, because our dependent variable (the cumulative cost of LTCI services) is not normally distributed. Next, we performed a multiple imputation technique by chained equations under the missing at random assumption, which means there might be systematic differences between the missing and observed values. We created twenty imputed datasets. Using each dataset, we first estimated the OLS model with the robust variance estimator. Finally, in order to estimate the potential outcomes after conditioning on the covariates, we adopted the inverse probability weighting (IPW) model[32, 33] using the imputed data sets. We calculated the generalized propensity scores using multinomial regression analysis, employing all previously listed covariates. For reference, we only examined the same model among the deceased, who passed away during the follow-up period. The LTCI costs for the deceased indicates the "lifetime cost" of LTCI because they did not use LTCI services at the baseline. We performed analyses using STATA 15.1 (STATA Corp LP, College Station, Texas, USA).

Patient and public involvement

No patient or the public was involved in the development of research question and de-

sign of this study. The results of this research will be disseminated to stakeholders such as local and central health government after being published in a scientific journal.

Results

Table 1 shows the characteristics of the respondents; the mean age at the baseline was 73.4; 52.0% of the respondents were male. The average of the cumulative cost of LTCI services during the follow-up period was 13.7 thousand USD. The distribution of that was skewed right. There were significant differences in the average duration for the level of care required for social participation across the whole population during the follow-up period (**Table 2**). Non-participants in groups for hobbies, sports, and volunteering had a longer duration of certification for LTC at all care levels. For example, among participants who took part in the group for hobbies, the average duration for non-participants was 14.1 (standard deviation [SD]=25.8) months, whereas that of those who participated "once a week or more" was 10.6 (SD=21.6) months.

The classical regression model showed that in comparison to non-participants, respondents who participated in the group for hobbies once a week produced a cost containment in 3.6 (95% confidence interval [CI]: 6.0 to 1.3) thousand USD, which was lower per person for LTCI cumulative costs over the 11-year period (**Table 3**). Likewise, participating in a sports club was also significantly associated with lower LTCI costs: the category of those who took part "once a week or more" was 4.9 [95% CI: 6.9 to 2.8] thousand USD less per person. However, in the volunteer group, only less frequent participation was associated with lower costs; for individuals in the category of "a few times a year" this figure was 4.1 [95% CI: 7.1 to 1.0] thousand USD less per person. When we changed the estimation method to GLM, and when we adopted OLS after multiple imputation, the major results and trends were similar to the above, although some point estimations in GLM were higher in the categories that had a small sample size (please see **Supplementary File 1**).

The estimations of IPW showed similar outcomes. In comparison to non-participants, going to a group for hobbies once a week or more resulted in a cost that was reduced by approximately 3.5 [95% CI: 6.2 to 0.8] thousand USD; for sports clubs, this lowered figure was approximately 6.1 [95% CI: 9.3 to 2.8] thousand USD. The significant relationship with less frequent participation in the volunteer group disappeared, but the

direction of the association and point estimations did not largely change (the C statistics in these models are shown in **Supplementary File 2**).

In addition, in comparison to non-participants, for deceased individuals during the follow-up period, joining a group for hobbies (once a week+) or sports (once a week+) led to a reduced cost of approximately 3.9 to 5.7 thousand USD, and 9.4 to 11.4 thousand USD, respectively (please see **Supplementary File 3**). These outcomes are preliminary because there were very few analyzed subjects (especially the sports and volunteer groups).

Discussions

According to the 11-year prospective cohort study for Japanese healthy older adults, compared to non-participants, respondents who took part in the group for hobbies or sports once a week produced lower costs for LTCI services (approximately 3.5 and 6.1 thousand USD per person), even after demographic variables and health status at baseline were controlled.

These findings are consistent with those of previous research. Several longitudinal studies showed that older adults who participate in social activities have lower risks of disability,[34] functional decline,[35,36] and mobility decline.[37,38] Moreover, it has been suggested that participation to hobby groups, sports club, and volunteer group might contribute to reduce the incidence of physical disability risk.[15,17,26-28] In an intervention study examining the effect of community salons in Japan, among the participants, the incidence of physical disability risk fell by 51% over five years;[39] cognitive disability risk also declined by around 30% over seven years.[40] Several trajectory analyses showed that attending leisurely activities is related to "functional maintenance,"[41] while a low frequency of going out was related to being "persistently disabled."[42]

This study adds evidence to the current literature, suggesting that social participation may be effective not only for preventing functional deterioration, but also in terms of reducing LTC costs. Our findings illustrate that the more the respondents took part in each type of community activity, the less time they spent in intensive nursing care. Therefore, differences in LTCI costs may have arisen due to the extension of healthy life expectancy or a reduction in the period of functional disability, rather than restrictions on using required services. Lifetime LTCI cost, which was estimated among deceased individuals, showed similar trends. This suggests that postponing the onset of functional disabilities or death did not cause differences in costs.

On the other hand, for volunteer activities, less frequent (rather than very frequent) participation resulted in lower LTCI costs. In Japan, it is often mentioned that part of participants in volunteer activities is experiencing an excessive burden. Official Japanese statistics revealed that half of older adults preferred volunteer activities that do not constrain their time or term.[43] Our results suggest that taking part in volunteer ac-

tivities by force, which is not the original meaning of volunteering, might not necessarily protect their health, although participating in and of itself is preventive.

This study has public health implications. One systematic review mentioned that most local and national public health interventions are substantially cost saving.[44] Our results suggest that promoting participation in community activities might have a non-ignorable cost containment effect. That is, 21.8% and 12.7% of the respondents, or about 2,240 and 1,300 people, in this municipality may have been participating in a group for hobbies or sports at least once a week. If the number of these people increased by 10% (around 220 and 130 people), it may have been possible to reduce the cumulative cost of LTCI services by approximately 780 to 800, and 630 to 790 thousand USD, respectively, over the 11-year period. It is important that each activity in this paper is not a special program and is already prevalent in Japan, and that the expenditure to be borne by the public sector is comparatively inexpensive. Furthermore, our findings might be an underestimation, because less frequent categories for each type of social participation tended to result in a higher mortality rate.

Our study has several limitations and strengths. First, due to accessibility to data, we could not analyze medical care costs. A previous study mentioned that medical care and LTC expenditures have a weak, but negative, relationship.[45] However, to our knowledge, our study is the first to demonstrate that social participations among older adults might help lower subsequent LTCI costs. Second, we assessed social participation variables and covariates only at the baseline. Our study analyzed healthy older adults; we excluded those with physically and cognitively disabilities at baseline; we controlled for multiple health dimensions and other covariates, adopting several statistical techniques. However, we cannot deny the possibility of reverse causation. Third, generalizability might be limited by the fact that our study was conducted in one municipality, although the proportion of older adults and of certified LTC levels is roughly the same between the subject area and the national average. Selection bias might have occurred because the response rate in baseline survey was not high (53.4%). However, there was important meanings to analyze the merged individual data from a questionnaire concerning social life and a public receipt data concerning LTC services. Fourth,

there might be measurement bias about social participation because it derived from the self-reported questionnaire. Although our indicators have been often used in previous survey, it is possible that it does not reflect actual activities correctly since the self-reported one. To assess the frequency and role of these groups, future research should examine interactions among participating members using objective indicators.

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Competing interests None declared.

Ethics approval This study was performed on the basis of collaborative research agreement with municipality. Ethical permission (No. 16-29) was provided by the Ethics Board at Nihon Fukushi University.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement We can NOT publish our dataset. The dataset has ethical or legal restrictions because it includes human participants.

References

1. W Greysen SR., Stijacic Cenzer I., & Boscardin WJ., (2017) Functional impairment: an unmeasured marker of medicare costs for postacute care of older adults. *J Am Geriatr Soc.* 65(9): 1996-2002.
2. National Institute of Population and. Social Security Research (2017) *Population Projections for Japan: 2016-2065 (With long-range Population Projections: 2066-2115)*. (http://www.ipss.go.jp/pp-zenkoku/j/zenkoku2017/pp29_ReportALL.pdf)
3. Ministry of Health, Labour and Welfare (2017) *Long-Term Care, Health and Welfare Services for the Elderly.* (http://www.mhlw.go.jp/english/policy/care-welfare/care-welfare-elderly/index.html
4. Bukov A, Maas I, Lampert T. (2002) Social participation in very old age: cross-sectional and longitudinal findings from BASE. Berlin Aging Study. *J Gerontol B Psychol Sci Soc Sci.* 57(6): P510-P517.
5. Stuck AE., Walthert JM., & Nikolaus T., et al. (1999) Risk factors for functional status decline in community-level elderly people; a systematic literature review. *Soc Sci Med,* 48: 445-469.
6. Holt-Lunstad J. Smith TB. & Layton JB. (2010) Social relationships and mortality risk: a meta-analytic review. *PLoS Medicine*. 7(7): e1000316. doi:10.1371.

7. Cattan M. (2010) *Preventing social isolation and loneliness among older people: effectiveness of health promotion interventions*. Saarbrücken: Lambert academic publishing.
8. Dickens AP. Richards SH. & Greaves CJ. et al. (2011) Interventions targeting social isolation in older people: a systematic review. *BMC Public Health.* 11:647.
9. Douglas H., Georgiou A., Westbrook J., (2017) Social participation as an indicator of successful aging: an overview of concepts and their associations with health. *Australian Health Review,* 41: 455-462.
10. Webber M., & Fendt-Newlin M., (2017) A review of social participation interventions for people with mental health problems. *Soc Psychiatr Epidemiol,* 52: 369-380.
11. Takagi D., Kondo K., & Kawachi I., et al. (2013) Social participation and mental health; moderating effects of gender, social role and rurality. *BMC Public Health.* 13: 701
12. Tsuji T, Sasaki Y, & Matsuyama Y et al. (2017) Reducing depressive symptoms after the Great East Japan Earthquake in older survivors through group exercise participation and regular walking:a prospective observational study. *BMJ Open,* 7(3): e013706.
13. Shiba K., Kondo N., & Kondo K. et al. (2017) Retirement and mental health: does social participation mitigate the association? A fixed-effects longitudinal analysis. *BMC Public Health.* 17(1): 526
14. Hirai H., Kondo K., Ojima T., et al. (2009) Examination of risk factors for onset of certification of long-term care insurance in community-dwelling older people : AGES project 3-year follow-up study. *Jpn J Public Health,* 56(8), 501-512 (in Japanese with English abstract)
15. Kanamori, S., Kai, Y., & Kondo, K., et al. (2012) Participation in sports organizations and the prevention of functional disability in older Japanese: the AGES cohort study. *PLoSOne,* 7(11): e51061.
16. Kanamori S., Kai Y., & Aida J. et al. (2014) Social participation and the prevention of functional disability in older Japanese: the JAGES cohort study. *PLoS One.* 9(6): e99638.
17. Takeda T., Kondo K., & Hirai H., et al. (2010) Psychosocial risk factors involved in progressive dementia-associated senility among the elderly residing at home AGES Project–Three year cohort longitudinal study. *Jpn J Public Health,* 57(12): 1054-1065 (in Japanese with English abstract).
18. Saito T., Murata C., & Saito M, et al. (2018) Influence of social relationship domains and their combinations on incident dementia: a prospective cohort study. *J Epidemiol Community Health,* 72(1): 7-12.
19. Hayashi T., Kondo K., & Suzuki K., et al. (2014) Factors associated with falls in community-dwelling older people with focus on participation in sport organizations; the Japan Gerontological Evaluation Study Project. *BioMed Research International,* 537614.
20. Noda H., Iso H., Toyoshima H., et al., (2005) Walking and sports participation and mortality from coronary heart disease and stroke. *Journal of the American College of Cardiology*, 46(9): 1761-1767.
21. Saito, M., Kondo, N., & Kondo, K., et al. (2012) Gender differences on the impacts of social exclusion on mortality among older Japanese: AGES cohort study. *Soc Sci Med,* 75, 940-945.
22. Ishikawa Y., Kondo N., & Kondo K, et al. (2016) Social participation and mortality: does social position in civic groups matter? *BMC Public Health.* 16(1): 394.
23. Ashida T., Kondo N., & Kondo K (2016) Social participation and the onset of functional disability by socioeconomic status and activity type; the JAGES cohort study. *Prev Med,* 89: 121-128.
24. Tamiya T., Noguchi H., Nishi A., et al. (2011) Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet,* 378(9797): 1183-1192
25. Osaka university commerce JGSS Research Center. Summary of Surveys. (http://jgss.daishodai.ac.jp/english/surveys/sur_top.html)
26. Ashida T., Kondo N., Kondo K. (2016) Social participation and the onset of functional disability by socioeconomic status and activity type: the JAGES cohort study. *Prev Med,* 89: 121-128.
27. Lum T.Y., & Lightfoot E. (2005) The effects of volunteering on the physical and menatl health of older people. *Res Aging,* 27(1): 31-55.
28. Musick M.A., & Wilson J. (2003) Volunteering and depression: the role of psychological and social resouces in different age group. *Soc Sci Med,* 56(2) 259-269.
29. Aida J., Hanibuchi T., & Nakade M., et al. (2009) The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis. Soc Sci Med. 69(4): 512-518

30. Yazawa A., Inoue Y., & Fujiwara T., et al. (2016) Association between social participation and hypertension among older people in Japan: the JAGES Study. *Hypertens Res.* 39(11):818-824.
31. McCullagh P., & Nelder JA., (1989) *Generalized Linear Models, second ed.* CRC Press.
32. Hoshino T., & Okada K., (2006) Estimation of causal effect using propensity score methods in clinical medicine, epidemiology, pharmacoepidemiology and public health; a review. *J. Natl. Inst. Public Health,* 55(3): 230-243 (in Japanese with English abstract).
33. Brookhart MA., Schneeweiss S., & Rothman KJ., et al. (2006) Variable selection for propensity score models. *Am J Epidemiol.* 163(12):1149-1156
34. Mendes de Leon C.F., Glass T.A., Berkman L.F. (2003) Social engagement and disability in a community population of older adults: the New Haven EPESE. *Am J Epidemiol.* 157(7): 633-642.
35. James B.D., Boyle P.A., Buchman A.S., et al. (2011) Relation of late-life social activity with incident disability among community-dwelling older adults. *J Gerontol A Biol Sci Med Sci,* 66A(4):467-473
36. Thomas PA. (2011) Trajectories of social engagement and limitations in late life. *J Health Soc Behav,* 52(4): 430-443.
37. Avlund K., Vass M., & Hendriksen C. (2003) Onset of mobility disability among community-dwelling old men and women: the role of tiredness in daily activities. *Age Ageing* 32(6): 579-584
38. Buchman A.S., Boyle P.A., & Wilson R.S., et al. (2009) Association between late-life social activity and motor decline in older adults. *Arch Intern Med,* 169(12): 1139-1146.
39. Hikichi H., Kondo N., & Kondo K, et al. (2015) Effect of community intervention program promoting social interactions on functional disability prevention for older adults; propensity score matching and instrumental variable analyses, JAGES Taketoyo study. *J Epidemiol Community Health,* 69(9):905-910.
40. Hikichi H., Kondo K., & Takeda T, et al. (2017) Social interaction and cognitive decline; results of a 7-year community intervention. *Alzheimers Dement (N Y)*, 3: 23-32
41. Yu HW., Chiang TL., & Chen DR., et al. (2016) Trajectories of Leisure Activity and Disability in Older Adults Over 11 Years in Taiwan. *J Appl Gerontol.* 1: 733464816650800
42. Saito J., Kondo N., Saito M., et al. (2018) Exploring 2.5-year trajectories of functional decline in older adults by applying a growth mixture model and the frequency of outings as a predictor: 2010–2013 JAGES longitudinal study. *J Epidemiol,* (in press).
43. Cabinet Office (2011) *Results of survey on attitude toward the senior citizens' economic life* (in Japanese)
(http://www8.cao.go.jp/kourei/ishiki/h23/sougou/zentai/index.html)
44. Masters R., Anwar E., & Collins B., et al. (2017) Return on investment of public health interventions: a systematic review. *J Epidemiol Community Health,* 71: 827-834
45. Suzuki W., Iwamoto Y., & Yuda M., et al. (2012) The distribution patterns of medical care and long-term care expenditures. *Jpn. J. Health Econ. Policy. (Iryo-Keizai Kenkyu)*, 24(2): 86-107 (in Japanese with English abstract).

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure 1. Flow chart of respondent selection.
Table S1. Differences of cumulative cost in LTCI services by OLS with MI, and GLM
Table S2. C statistics by multinominal regression model
Table S3. Differences of lifetime cost in LTCI services by social participation among deceased person

Tab.1 Characteristics of respondents

	Total	Cumulative cost of LTCI services in 11 years (1000USD) [b]	
	%	Mean ± SD	*p*
Sex [a]			
Male	52.0	7.7 ± 24.8	
Female	48.0	18.7 ± 44.8	<.001
Age [a]			
(Mean±SD)	(73.4±6.2)		
65-74	61.3	6.3 ± 25.2	
75-84	33.3	23.0 ± 47.2	
85+	5.4	39.1 ± 56.4	<.001
Disease and/or impairment [a]			
None	27.2	10.9 ± 35.5	
Presence	64.6	14.3 ± 37.8	
Missing	8.3	17.7 ± 39.7	=.001
Years of education [a]			
<6	2.7	30.7 ± 57.6	
6-9	41.9	12.4 ± 34.9	
10-12	24.8	13.1 ± 37.2	
13+	32.2	11.1 ± 33.3	
Missing	10.7	23.2 ± 48.8	<.001
Equivalent income (1000USD) [a]			
<20.0	36.0	12.2 ± 36.5	
20.0-39.9	27.3	9.5 ± 30.5	
40.0+	6.8	12.0 ± 35.5	
Missing	29.9	19.6 ± 43.6	<.001
Marital status [a]			
Married	69.2	9.2 ± 29.7	
Widowed	21.4	24.8 ± 50.2	
Divorced	1.7	11.0 ± 27.9	
Never married	2.0	27.4 ± 60.1	
Missing	5.7	22.7 ± 45.9	<.001
Living situation [a]			
Living alone	10.7	23.8 ± 50.9	
With spouse only	36.5	9.6 ± 30.1	
With child	22.7	12.9 ± 35.9	
With others	25.6	14.6 ± 39.7	
Missing	4.6	21.3 ± 41.6	<.001
Self rated health [a]			
Excellent	6.0	7.9 ± 30.5	
good	61.7	11.5 ± 34.5	
Fair	22.5	18.2 ± 43.0	
Poor	5.1	21.7 ± 45.6	
Missing	4.7	18.9 ± 39.9	<.001
TOTAL	100.0	13.7 ± 37.4	

a) These variables are based on baseline questionnaire survey.

Tab.2 Average duration of care giving at follow-up period by social participation [a)]

	n	ALL[a)] Mean (SD)	Care Lv1+ Mean (SD)	Care Lv2+ Mean (SD)	Care Lv3+ Mean (SD)	Care Lv4+ Mean (SD)	Care Lv5 Mean (SD)
Hobby activities group							
Never	2833	14.1 (25.8)	9.8 (21.4)	7.1 (17.6)	4.0 (12.5)	2.2 (8.5)	0.8 (4.6)
A few times a year	259	9.0 (19.4)	5.6 (15.7)	3.5 (9.9)	1.8 (6.4)	1.2 (5.3)	0.6 (4.1)
Once or twice a month	524	10.7 (21.8)	6.1 (16.6)	4.6 (14.4)	2.7 (10.2)	1.6 (7.5)	0.6 (3.7)
Once a week +	972	10.6 (21.8)	6.2 (16.6)	4.1 (13.2)	2.2 (9.3)	1.0 (6.0)	0.4 (3.0)
		p <.001	p <.001	p <.001	p <.001	p =.019	p =.026
Sports group or club							
Never	3716	13.7 (25.1)	9.3 (20.7)	6.6 (17.0)	3.8 (12.1)	2.1 (8.4)	0.8 (4.6)
A few times a year	91	7.5 (19.6)	5.6 (18.4)	4.8 (16.5)	2.8 (12.0)	1.2 (5.5)	0.8 (5.0)
Once or twice a month	125	6.0 (17.3)	3.3 (13.4)	2.7 (12.5)	1.4 (6.9)	0.5 (2.6)	0.2 (1.4)
Once a week +	572	7.2 (18.1)	3.8 (12.8)	2.4 (9.8)	1.0 (5.4)	0.5 (3.4)	0.1 (1.0)
		p <.001	p <.001	p <.001	p <.001	p <.001	p =.005
Volunteer group							
Never	3899	12.9 (24.4)	8.6 (20.0)	6.1 (16.4)	3.5 (11.6)	1.9 (7.9)	0.7 (4.3)
A few times a year	194	7.1 (17.3)	3.9 (12.8)	2.9 (11.1)	1.6 (8.3)	1.1 (7.7)	0.7 (5.6)
Once or twice a month	193	9.9 (21.6)	6.1 (17.0)	4.3 (13.3)	2.0 (8.9)	1.1 (7.2)	0.4 (2.7)
Once a week +	122	6.4 (17.5)	3.9 (12.4)	3.1 (10.9)	1.6 (6.9)	0.8 (3.2)	0.2 (1.5)
		p <.001	p <.001	p <.001	p <.001	p =.019	p =.165

Unit: month SD: Standard deviation

a) This is including certification for long-term care level from support level 1 to care level 5.

Tab.3 Differences of cumulative cost in LTCI services in a 11-years follow-up period by social participation

	n	Mean	OLS [a,b)] Coef. (95%CI)	IPW with MI [c,d)] Coef. (95%CI)	Mortality
Hobby activities group					
Never	2833	14.6	*ref.*	*ref.*	30.8
A few times a year	259	6.6	- 3.2† (-6.7 to 0.2)	- 3.5 (-8.1 to 1.2)	28.0
Once or twice a month	524	10.2	- 2.8† (-5.8 to 0.7)	- 2.2 (-5.6 to 1.2)	21.7
Once a week +	972	9.4	- 3.6** (-6.0 to -1.3)	- 3.5* (-6.2 to -0.8)	19.5
Sports group or club					
Never	3716	13.9	*ref.*	*ref.*	29.1
A few times a year	91	9.3	2.5 (-4.9 to 9.9)	1.8 (-5.8 to 9.4)	18.7
Once or twice a month	125	4.8	- 3.3 (-7.6 to 9.4)	- 4.2 (-10.7 to 2.3)	16.1
Once a week +	572	5.2	- 4.9*** (-6.9 to -2.8)	- 6.1*** (-9.3 to -2.8)	18.6
Volunteer group					
Never	3899	12.7	*ref.*	*ref.*	28.4
A few times a year	194	4.8	- 4.1** (-7.1 to -1.0)	- 3.9 (-9.1 to 1.3)	20.7
Once or twice a month	193	10.0	1.9 (-2.9 to 6.7)	1.5 (-3.8 to 6.7)	12.7
Once a week +	122	5.9	- 0.7 (-4.5 to 3.1)	- 1.4 (-7.9 to 5.1)	11.5

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000USD

OLS: Ordinal least squares, IPW: Inverse probability weighting, MI: Multiple imputation, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) The result was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

d) The generalized propensity scores were calculated using multinominal regression analysis using all previously listed potential confounders: sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health.

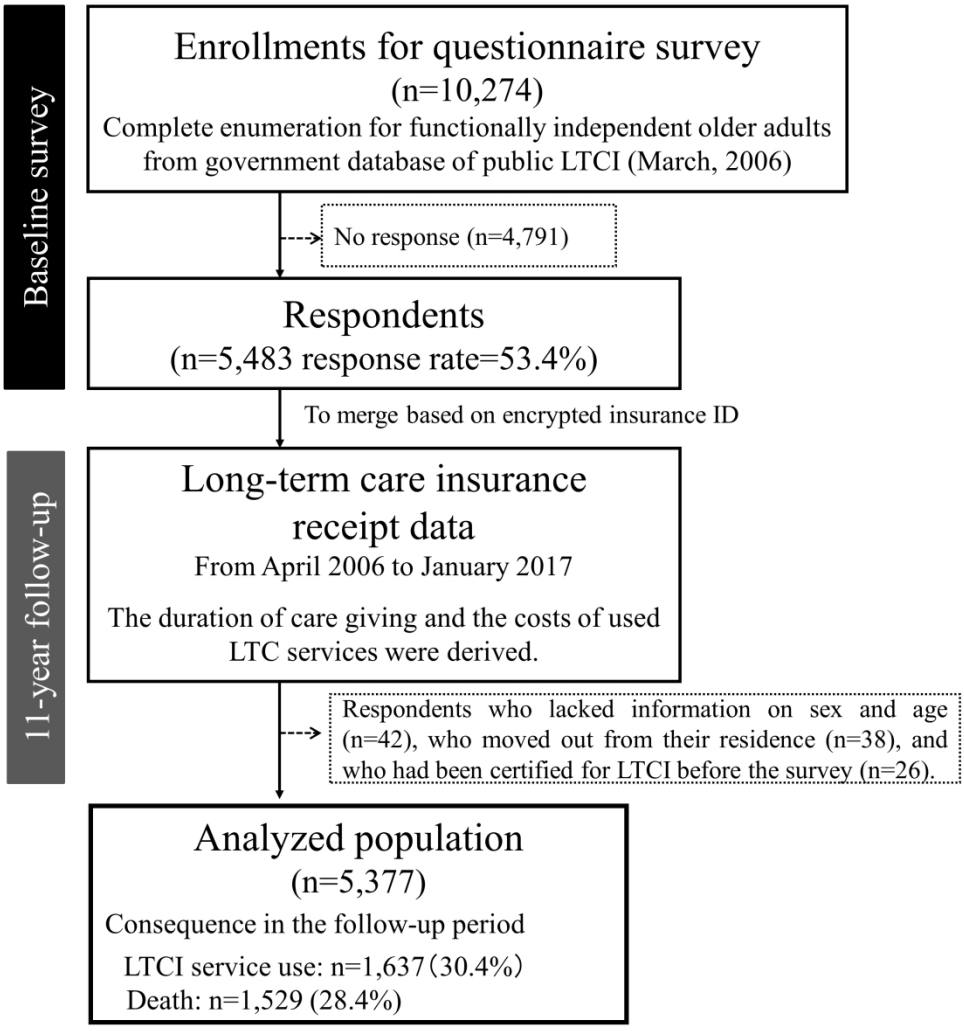

Figure 1: Flow chart of respondent selection.

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Table S1. Differences of cumulative cost in LTCI services by OLS with MI, and GLM

	n	GLM [a,b)] Marginal effect (95%CI)	OLS with MI [b,c)] Coef. (95%CI)
Hobby activities group			
Never	2833		*ref.*
A few times a year	259	- 1.9 (-11.0 to 7.2)	- 3.1† (-6.6 to 0.3)
Once or twice a month	524	- 3.3 (-8.7 to 2.2)	- 2.9† (-5.8 to 0.1)
Once a week +	972	- 3.5† (-7.3 to 0.3)	- 3.7* (-6.0 to -1.3)
Sports group or club			
Never	3716		*ref.*
A few times a year	91	10.9 (-14.3 to 36.1)	2.7 (-4.6 to 10.0)
Once or twice a month	125	- 5.0 (-17.8 to 7.9)	- 3.5 (-7.8 to 0.7)
Once a week +	572	- 7.0** (-11.2 to -2.9)	- 4.9*** (-6.9 to -2.9)
Volunteer group			
Never	3899		*ref.*
A few times a year	194	- 9.4*** (-14.1 to -4.6)	- 4.3** (-7.3 to -1.2)
Once or twice a month	193	2.3 (-8.9 to 13.6)	1.9 (-2.9 to 6.8)
Once a week +	122	- 2.8 (-11.1 to 5.6)	- 0.5 (-4.4 to 3.3)

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000 USD

GLM: Generalized linear model, OLS: Ordinal least squares, MI: Multiple imputation, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) Each model was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

Table S2. C statistics by multinominal regression model

	Hobby activities group	Sports group or club	Volunteer group
A few times a year vs Never	0.664	0.757	0.637
Once or twice a month vs Never	0.665	0.695	0.681
Once a week + vs Never	0.662	0.645	0.713

C statistics by multinominal regression model in order to calculate generalized propensity scores were not high: hobby activities group=.662 to .665, sports group or club=.645 to .757, volunteer group=.637 to 713. However, it is not necessarily to mean undesirable model, because the goal of a propensity score model is to efficiently control confounding, not to predict treatment or exposure.[28]

Table S3. Differences of lifetime cost in LTCI services by social participation among deceased person

	n	Mean	OLS [a,b]	GLM [a,b]	After Multiple Imputation [c]	
					OLS [b]	IPW [d]
			Coef. (95%CI)	Marginal effect (95%CI)	Coef. (95%CI)	Coef. (95%CI)
Hobby activities group						
Never	861	19.2	*ref.*		*ref.*	*ref.*
A few times a year	72	9.7	- 6.0* (-11.9 to - 0.1)	- 5.6 (-14.9 to 3.8)	- 5.6† (-11.6 to 0.3)	- 4.7 (-13.7 to 4.4)
Once or twice a month	113	15.8	- 2.0 (-9.1 to 5.1)	- 0.9 (-9.3 to 7.6)	- 2.1 (-9.2 to 4.9)	- 2.4 (-9.8 to 4.9)
Once a week +	188	12.2	- 5.3* (-10.1 to -0.4)	- 3.9 (-7.3 to 0.3)	- 5.4* (-10.2 to -0.5)	- 5.7† (-11.6 to 0.3)
Sports group or club						
Never	1066	19.1	*ref.*		*ref.*	*ref.*
A few times a year	17	4.3	- 8.9*** (-13.7 to -4.1)	- 17.8*** (-22.8 to -12.8)	- 8.6** (-14.1 to -3.0)	- 9.4 (-27.3 to 8.4)
Once or twice a month	20	4.0	- 8.6** (-14.8 to -2.4)	- 18.5*** (-24.0 to -13.0)	- 9.1** (-15.3 to -2.8)	- 10.1 (-26.6 to 6.4)
Once a week +	105	5.4	- 9.7*** (-13.8 to -5.7)	- 11.4** (-17.8 to -4.9)	- 9.4*** (-13.4 to -5.4)	- 11.1** (-18.6 to -3.5)
Volunteer group						
Never	1091	16.9	*ref.*		*ref.*	*ref.*
A few times a year	40	11.2	- 1.8 (-12.4 to 8.8)	- 5.9 (-18.8 to 7.0)	- 1.7 (-12.6 to 9.2)	- 2.0 (-13.7 to 9.8)
Once or twice a month	24	20.6	6.2 (-14.9 to 27.2)	10.2 (-22.5 to 42.9)	7.1 (-13.9 to 28.0)	7.6 (-7.4 to 22.7)
Once a week +	14	9.3	- 4.6 (-16.8 to 7.7)	- 12.5** (-20.4 to -4.7)	- 5.1 (-18.1 to 7.8)	- 3.4 (-23.0 to 16.2)

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000USD

OLS: Ordinal least squares, GLM: Generalized linear model, IPW: Inverse probability weighting, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) Each model was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

d) The generalized propensity scores were calculated using multinominal regression analysis using all previously listed potential confounders: sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health. C statistics were as follows: hobby activities group=.640 to .665, sports group or club=.645 to 757, volunteer group=.637 to 713.

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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In your methods section, say that you used the STROBE cohort reporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Study design	#4	Present key elements of study design early in the paper	6
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	6

	#6b	For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6
Bias	#9	Describe any efforts to address potential sources of bias	13
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6-8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	8
	#12b	Describe any methods used to examine subgroups and interactions	8
	#12c	Explain how missing data were addressed	8
	#12d	If applicable, explain how loss to follow-up was addressed	6
	#12e	Describe any sensitivity analyses	8
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	6
	#13b	Give reasons for non-participation at each stage	6
	#13c	Consider use of a flow diagram	6
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential	10

		confounders. Give information separately for exposed and unexposed groups if applicable.	
	#14b	Indicate number of participants with missing data for each variable of interest	6
	#14c	Summarise follow-up time (eg, average and total amount)	6
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	N/A
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
	#16b	Report category boundaries when continuous variables were categorized	N/A
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10
Key results	#18	Summarise key results with reference to study objectives	12
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	13
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12-13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	13
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

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Reduced long-term care cost by social participation among older Japanese adult: A prospective follow-up study in JAGES

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Abstract

Objectives: Reducing costs related to functional disabilities and long-term care (LTC) is necessary in aging societies. We evaluated the differences in the cumulative cost of public long-term care insurance (LTCI) services by social participation.

Design: Prospective observational study.

Setting: Our baseline survey was conducted in March 2006 among people aged 65 or older who were not eligible for public LTCI benefits were selected using a complete enumeration in Tokoname City, Japan. We followed up with their LTC services costs over a period of 11 years. Social participation was assessed by the frequency of participation in clubs for hobbies, sports, or volunteering. We adopted a classical linear regression analysis and an inverse probability weighting (IPW), with multiple imputation of missing values

Participants: Functionally independent 5,377 older adults.

Primary outcome measures: The cumulative cost of public LTCI services for 11 years.

Results: Even when adjusting for the confounding variables, social participation at the baseline was negatively associated with the cumulative cost of LTCI services. The IPW model showed that respondents who participated in hobby activities once a week or more, the cumulative cost of LTCI services for 11 years was lower approximately 3,500 USD per person, in comparison to non-participants. Similary, that in respondents who participated in sports group or clubs was lower approximately 6,000 USD than non-participants.

Conclusions: Older adults' participation in community organizations may help reduce future LTC costs. Promoting participation opportunities in the community could ensure the financial stability of LTCI services.

Strengths and limitations of this study

- To our knowledge, this is the first to demonstrate that social participations among older adults might help lower subsequent LTCI costs.
- Our findings are based on eleven-years prospective observational study using public LTCI receipt data in Japan.
- Selection bias might have occurred because of the 53% response rate to the baseline survey.
- The measurements of social participation rely on self-reported questionnaire.

Main text

Introduction

Across the globe, costs related to functional disabilities and long-term care (LTC) are rapidly increasing in societies with aging populations. Expenses are greater among those with more severe impairments.[1] In Japan, one of the countries experiencing the highest rate of aging, the proportion of older people is currently 27.3% and is predicted to reach around 40% by 2065.[2] Under these circumstances, the costs for long-term care insurance (LTCI) are expected to rise from 100 billion USD in 2016 to 210 billion USD by 2025. Lowering these costs requires building a sustainable and healthy aging society which means developing and maintaining the functional ability that enables well-being in older age. The Japanese government implemented a public nursing care insurance law that includes an LTC prevention policy.[3] For this policy, a population approach as primary prevention was proposed rather than a high-risk one which was grounded in risk screening based on intervention targeting. Promoting social participation is considered an effective intervention regarding the population approach, which focuses on the entire group of older adults in a community.

Although social participation is an ambiguous concept, Bukov (2002) distinguished three types of participation: collective, productive, and political.[4] In this paper, we focused on involvement in collective activities in formal and informal societal groups at local community. Social participation helps maintain social networks, support, and roles, raises self-esteem and self-efficacy, and facilitates access to various kinds of information. Several international systematic reviews and meta-analyses have reported on the physical, psychological, and social benefits of social participation among older people.[5-10] For instance, meta-analysis across 148 articles mentioned active engagement in social activities could reduce risk for mortality. In particular, previous observational studies in Japan also found that collective social participation activities such as volunteering, sports clubs, and hobbies among older adults lowered the risk of developing depressive symptoms,[11-13] the incidence of functional disabilities,[14-16] cognitive decline or dementia,[17,18] falls,[19] and immature death.[20-23]

We hypothesize that if social participation extends healthy life expectancy and reduces

the time spent in intensive nursing care, then the cumulative cost of LTCI services might be lower among the participants; however, to our knowledge, there is no evidence that social participation lessens it. In addition, Japanese LTCI services are provided mainly when people aged 65 and over come to require care or support, based on investigation for certification and doctor's written opinion. The cost of LTCI services is one of the most important issues for the public sector as an insurer. The evidence for contributing to cost-saving has been useful for recent intervention financing schemes that provide economic incentives to service providers; for instance, social impact bonds (SIBs). In this paper, using data from a follow-up study that took place over a period of 11 years and tracked older Japanese adults, we assessed the differences of the duration period of requiring care level and of the cumulative cost of LTCI services by frequency of social participation in baseline survey.

Methods

Study design

The Japan Gerontological Evaluation Study (JAGES) conducted a self-administered questionnaire in March 2006 as a baseline; 5,483 respondents who were 65 years or older, physically and cognitively independent, and not eligible for public LTCI benefits were selected using a complete enumeration; they live in the city of Tokoname in Aichi Prefecture (response rate=53.4%: 5,483 / 10,274). In addition, our subjects were more healthy or active older adults at baseline, because Japanese LTCI certifies the people included mild care needs, not only severe care level. Afterward, we obtained receipt data on LTCI benefits over a period of 11 years after the baseline survey, from government database of public LTCI. After eliminating respondents who lacked information on sex and age (n=42), who had moved out of their residence (n=38), and who had been certified for LTCI before the baseline survey (n=26), 5,377 respondents were linked to the LTCI receipt dataset (**Figure 1**).

Measurements

Outcome variables; the costs of LTCI services

Primary outcome variable is the cumulative cost of LTCI services at follow-up period. We obtained the LTC costs of insured services across forty-four points every three months (April, July, October, January) over a period of 11 years. We summed them up after tripling these monthly costs in order to calculate an approximate value of the overall cost for the follow-up period. We used the currency exchange rate of 100JPY to 1USD. As closely related variable, we calculated the number of months which was eligible for LTCI benefit across the whole population, from care level 5 which signifies the highest level of requirement for LTC to any care or support level.

In addition, Japanese LTCI operates based on social insurance principles. Only services are provided, not cash allowances, and recipients can choose their services and providers.[24] The receipt data includes information about using insured services such as home visits, day, short-stay, residential, or in-facility services. The data do not include costs, which are not covered by insurance (such as food, housing, and diaper expenses).

In general, 10% of these costs are co-payments (the municipality, which acts as an insurer, pays 90%), although there is a upper limit to the amount of monthly insurance benefits, which differs depending on the needed level of care. People with certifications for LTC and who need (levels 1 to 5) or require support (levels 1 or 2) can use LTCI services. Those higher levels of care can utilize more LTCI services through insurance coverage. The cumulative cost of such care in the following cases is zero: deceased individuals who did not have functional disabilities, respondents who did not have proper certification, and non-service users.

Explanatory variables: Social participation

As mentioned above, social participation is an ambiguous concept. The indicator of social participation was taken from the Japanese General Social Survey,[25] and categorized organizations into following eight types as collective social participation activities: hobby activities group, sports group or club, volunteer group, neighborhood association, senior citizen club/fire-fighting team, religious group, political organization or group, industrial or trade association, and citizen or consumer group. We focused on the three groups/organizations previously identified as being associated with lower risks for functional disabilities; hobby activities group,[17,26] sports group or club,[15,26] and volunteer group.[27,28] According to principal components analysis, these community activities were categorized to horizontal organizations.[29,30] Respondents were asked how often they took part in these activities. We categorized them to the four frequencies, respectively; *never; a few times a year; once or twice a month;* and *once a week or more*.

Covariates

Demographic variables included sex, age, educational attainment, equivalent income (USD), marital status, and living situation at the baseline survey. It is well known that these are basic variables as social determinants of health. Age was a continuous variable (73.4±6.2). Years of education was categorized as *<6*, *6-9*, *10-12*, and *13+*. We equalized household income by the square root of the numbers and classified it as *<20.0*, *20.0-39.9*, and *40.0+* thousand USD. Marital status consisted of *married*, *widowed*, *divorced*, and *never married*. Living situation was categorized as *living alone*, *with one's spouse only*, *with a child*, or *with others* such as grandchildren, siblings, and relatives.

In order to account for the health status at the baseline, the presence of disease or impairment and self-rated health were considered. The presence of disease or impairment was based on self-reported medical condition (no illness, having illness but need no treatment, having illness but discontinued treatment, and receiving some treatment). We dichotomized it; that is, no illness or not. We assessed self-rated health using four categories: *excellent*, *good*, *fair*, and *poor*.

Statistical analysis

After calculating the descriptive statistics, we conducted four regression analyses. First, we adopted a classical linear regression (ordinary linear squares [OLS]) model, controlling covariates at baseline survey. We handled the missing value in each control variable as a dummy variable. Second, as one of robustness check, we predicted the marginal effects, adopting a generalized linear model (GLM)[31] with Gamma distribution, as well as the log link and robust variance estimator, because our dependent variable (the cumulative cost of LTCI services) is not normally distributed. Next, we performed a multiple imputation technique by chained equations under the missing at random assumption, which means there might be systematic differences between the missing and observed values. We created twenty imputed datasets. Using each dataset, we first estimated the OLS model with the robust variance estimator. Finally, in order to estimate the potential outcomes after conditioning on the covariates, we adopted the inverse probability weighting (IPW) model[32, 33] using the imputed data sets. We calculated the generalized propensity scores using multinomial regression analysis, employing all previously listed covariates. For reference, we only examined the same model among the deceased, who passed away during the follow-up period. The LTCI costs for the deceased indicates the "lifetime cost" of LTCI because they did not use LTCI services at the baseline. We performed analyses using STATA 15.1 (STATA Corp LP, College Station, Texas, USA).

Patient and public involvement

No patient or the public was involved in the development of research question and design

of this study. The results of this research will be disseminated to stakeholders such as local and central health government after being published in a scientific journal.

Results

Table 1 shows the characteristics of the respondents; the mean age at the baseline was 73.4; 52.0% of the respondents were male. Out of this amount, 30.4% had used LTCI services at least once, and 28.4% passed away during the follow-up period. The average of the cumulative cost of LTCI services during the follow-up period was 13.7 thousand USD. The distribution of that was skewed right. There were significant differences in the average duration for the level of care required for social participation across the whole population during the follow-up period (**Table 2**). Non-participants in groups for hobbies, sports, and volunteering had a longer duration of certification for LTC at all care levels. For example, among participants who took part in the group for hobbies, the average duration for non-participants was 14.1 (standard deviation [SD]=25.8) months, whereas that of those who participated "once a week or more" was 10.6 (SD=21.6) months.

The classical regression model showed that in comparison to non-participants, respondents who participated in the group for hobbies once a week produced a cost containment in 3.6 (95% confidence interval [CI]: 6.0 to 1.3) thousand USD, which was lower per person for LTCI cumulative costs over the 11-year period (**Table 3**). Likewise, participating in a sports club was also significantly associated with lower LTCI costs: the category of those who took part "once a week or more" was 4.9 [95% CI: 6.9 to 2.8] thousand USD less per person. However, in the volunteer group, only less frequent participation was associated with lower costs; for individuals in the category of "a few times a year" this figure was 4.1 [95% CI: 7.1 to 1.0] thousand USD less per person. When we changed the estimation method to GLM, and when we adopted OLS after multiple imputation, the major results and trends were similar to the above, although some point estimations in GLM were higher in the categories that had a small sample size (please see **Supplementary Table S1**).

The estimations of IPW showed similar outcomes. In comparison to non-participants, going to a group for hobbies once a week or more resulted in a cost that was reduced by approximately 3.5 [95% CI: 6.2 to 0.8] thousand USD; for sports clubs, this lowered figure was approximately 6.1 [95% CI: 9.3 to 2.8] thousand USD. The significant

relationship with less frequent participation in the volunteer group disappeared, but the direction of the association and point estimations did not largely change (the C statistics in these models are shown in **Supplementary Table S2**).

In addition, in comparison to non-participants, for deceased individuals during the follow-up period, joining a group for hobbies (once a week+) or sports (once a week+) led to a reduced cost of approximately 3.9 to 5.7 thousand USD, and 9.4 to 11.4 thousand USD, respectively (please see **Supplementary Table S3**). These outcomes are preliminary because there were very few analyzed subjects (especially the sports and volunteer groups).

Discussions

According to the 11-year prospective cohort study of healthy Japanese older adults, compared to non-participants, respondents who took part in hobby groups or sports activities once a week incurred lower costs for long-term care insurance (LTCI) services (approximately 3.5 and 6.1 thousand USD, respectively, per person), even after demographic variables and health status at baseline were controlled.

These findings are consistent with those of previous research in which several longitudinal studies have shown that older adults who participate in social activities have lower risks of disability,[34] functional declines,[35,36] and mobility declines.[37,38] Moreover, it has been suggested that participation in hobby groups, sports clubs, and volunteer groups might contribute to reducing the incidence of physical disability risks.[15,17,26-28] In an intervention study examining the effect of community salons in Japan, it was reported that the incidence of physical disability risks among participants fell by 51% over five years[39] and that cognitive disability risks declined by around 30% over seven years.[40] Several trajectory analyses have shown that attending leisure activities is related to "functional maintenance,"[41] while a low frequency of going outside the home was related to being "persistently disabled."[42]

This study adds evidence to the current literature suggesting that social participation may be effective not only for preventing functional deterioration but also in terms of reducing LTC costs. Our findings also illustrate that the more the respondents took part in each type of community activity, the less time they spent in intensive nursing care. Although the mechanisms behind the relationship between collective social participation and LTCI costs are not fully understood, participating in community activities might contribute to the promotion of physical activities, the maintenance of social role and social networks, and the acquisition of important health-related information. Therefore, differences in LTCI costs may have arisen due to extensions to healthy life expectancy or reductions in the periods of functional disability, rather than restrictions on the use of the required services. Lifetime LTCI costs, which were estimated among deceased individuals, showed similar trends. This suggests that postponing the onset of functional disabilities or death did not cause the differences in costs.

On the other hand, for volunteer activities, less frequent (rather than very frequent) participation resulted in lower LTCI costs. In Japan, it has often been mentioned that a portion of those participating in volunteer activities shoulder excessive burdens in terms of supporting those activities, and official Japanese statistics have revealed that half of older adults preferred volunteer activities that do not constrain their time.[43] Our results also suggest that being forced to take part in volunteer activities, which is counter to the intended meaning of volunteering, might not necessarily protect the participant's health, even though participating in and of itself has preventive effects.

It is clear that this study has public health implications. For example, one systematic review mentioned that most local and national public health interventions are aimed at cost saving,[44] and our results suggest that promoting participation in community activities might have a non-ignorable cost-containment effect. More specifically, 21.8% and 12.7% of the respondents, or about 2,240 and 1,300 people, in this municipality may have been participating in hobby or sports groups at least once a week. If those numbers were 10% higher (approximately 220 and 130 people), it may have been possible to reduce the cumulative cost of LTCI services by approximately 780 to 800, and 630 to 790 thousand USD, respectively, over an 11-year period. It is important to note that each activities discussed in this paper are not special programs, and that all of them are already common in Japan. Hence, the additional expenditures to be borne by the public sector would be comparatively minor. It is also suggested that an accumulation of cost impact analyses might be meaningful in terms of public health and community work research. Furthermore, our findings might even be an underestimation because less frequent categories for each type of social participation tend to result in higher mortality rates.

Our study has several limitations and strengths. First, due to restricted data accessibility, we could not analyze medical care costs, which is significant because a previous study mentioned that medical care and LTC expenditures have a weak, but negative, relationship.[45] However, to the best of our knowledge, our study is the first to demonstrate that social participations among older adults might help lower subsequent LTCI costs. Second, we assessed social participation variables and covariates only at the baseline. More specifically, our study only analyzed healthy older adults, excluding

those with physically and cognitively disabilities. We also controlled for multiple health dimensions and other covariates by adopting several statistical techniques. However, since the baseline survey was based on a self-reported questionnaire, we cannot deny the possibility of reverse causation. Third, generalizability might be limited by the fact that our study was conducted in one municipality, even though the proportions of older adults and certified LTC levels between the subject area and the national average are roughly the same. Furthermore, selection bias might have occurred because the response rate in our baseline survey was not high (53.4%). However, there are important conclusions that can be drawn from an analysis of merged individual data from this questionnaire regarding social life and public receipt data as they pertain to LTC services. Fourth, there might be measurement bias regarding the actual social participation levels because the data were derived solely from responses to the self-reported questionnaire. Although our indicators have often been used in previous surveys, it is possible that the self-reported activities do not reflect actual participation levels. To assess the frequency and role of these groups, future research should examine interactions among participating members using more objective indicators.

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Author Contributions All authors contributed to the conception and design of this study. Data collection was primarily conducted by MS, YO and KK. Analyses were performed by MS and supported by JA, NK, JS and HK. MS prepared the initial manuscript and JA, NK, JS, HK, AA, and KK significantly contributed to revising it. All authors read and approved the final manuscript.

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Competing interests None declared.

Ethics approval This study was performed on the basis of collaborative research agreement with municipality. Ethical permission (No. 16-29) was provided by the Ethics Board at Nihon Fukushi University.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Data is not open for public due to ethical concerns. Data are from the JAGES study whose authors may be contacted at data management committee: dataadmin@jages.net. The data set has ethical or legal restrictions because it includes human participants.

References

1. W Greysen SR., Stijacic Cenzer I., & Boscardin WJ., (2017) Functional impairment: an unmeasured marker of medicare costs for postacute care of older adults. *J Am Geriatr Soc.* 65(9): 1996-2002.
2. National Institute of Population and. Social Security Research (2017) *Population Projections for Japan: 2016-2065 (With long-range Population Projections: 2066-2115)*. (http://www.ipss.go.jp/pp-zenkoku/j/zenkoku2017/pp29_ReportALL.pdf)
3. Ministry of Health, Labour and Welfare (2017) *Long-Term Care, Health and Welfare Services for the Elderly.* (http://www.mhlw.go.jp/english/policy/care-welfare/care-welfare-elderly/index.html
4. Bukov A, Maas I, Lampert T. (2002) Social participation in very old age: cross-sectional and longitudinal findings from BASE. Berlin Aging Study. *J Gerontol B Psychol Sci Soc Sci.* 57(6): P510-P517.
5. Stuck AE., Walthert JM., & Nikolaus T., et al. (1999) Risk factors for functional status decline in community-level elderly people; a systematic literature review. *Soc Sci Med,* 48: 445-469.
6. Holt-Lunstad J. Smith TB. & Layton JB. (2010) Social relationships and mortality risk: a meta-analytic review. *PLoS Medicine*. 7(7): e1000316. doi:10.1371.

7. Cattan M. (2010) *Preventing social isolation and loneliness among older people: effectiveness of health promotion interventions*. Saarbrücken: Lambert academic publishing.
8. Dickens AP. Richards SH. & Greaves CJ. et al. (2011) Interventions targeting social isolation in older people: a systematic review. *BMC Public Health.* 11:647.
9. Douglas H., Georgiou A., Westbrook J., (2017) Social participation as an indicator of successful aging: an overview of concepts and their associations with health. *Australian Health Review,* 41: 455-462.
10. Webber M., & Fendt-Newlin M., (2017) A review of social participation interventions for people with mental health problems. *Soc Psychiatr Epidemiol,* 52: 369-380.
11. Takagi D., Kondo K., & Kawachi I., et al. (2013) Social participation and mental health; moderating effects of gender, social role and rurality. *BMC Public Health.* 13: 701
12. Tsuji T, Sasaki Y, & Matsuyama Y et al. (2017) Reducing depressive symptoms after the Great East Japan Earthquake in older survivors through group exercise participation and regular walking:a prospective observational study. *BMJ Open,* 7(3): e013706.
13. Shiba K., Kondo N., & Kondo K. et al. (2017) Retirement and mental health: does social participation mitigate the association? A fixed-effects longitudinal analysis. *BMC Public Health.* 17(1): 526
14. Hirai H., Kondo K., Ojima T., et al. (2009) Examination of risk factors for onset of certification of long-term care insurance in community-dwelling older people : AGES project 3-year follow-up study. *Jpn J Public Health,* 56(8), 501-512 (in Japanese with English abstract)
15. Kanamori, S., Kai, Y., & Kondo, K., et al. (2012) Participation in sports organizations and the prevention of functional disability in older Japanese: the AGES cohort study. *PLoSOne,* 7(11): e51061.
16. Kanamori S., Kai Y., & Aida J. et al. (2014) Social participation and the prevention of functional disability in older Japanese: the JAGES cohort study. *PLoS One.* 9(6): e99638.
17. Takeda T., Kondo K., & Hirai H., et al. (2010) Psychosocial risk factors involved in progressive dementia-associated senility among the elderly residing at home AGES Project–Three year cohort longitudinal study. *Jpn J Public Health,* 57(12): 1054-1065 (in Japanese with English abstract).
18. Saito T., Murata C., & Saito M, et al. (2018) Influence of social relationship domains and their combinations on incident dementia: a prospective cohort study. *J Epidemiol Community Health,* 72(1): 7-12.
19. Hayashi T., Kondo K., & Suzuki K., et al. (2014) Factors associated with falls in community-dwelling older people with focus on participation in sport organizations; the Japan Gerontological Evaluation Study Project. *BioMed Research International,* 537614.
20. Noda H., Iso H., Toyoshima H., et al., (2005) Walking and sports participation and mortality from coronary heart disease and stroke. *Journal of the American College of Cardiology*, 46(9): 1761-1767.
21. Saito, M., Kondo, N., & Kondo, K., et al. (2012) Gender differences on the impacts of social exclusion on mortality among older Japanese: AGES cohort study. *Soc Sci Med,* 75, 940-945.
22. Ishikawa Y., Kondo N., & Kondo K, et al. (2016) Social participation and mortality: does social position in civic groups matter? *BMC Public Health.* 16(1): 394.
23. Ashida T., Kondo N., & Kondo K (2016) Social participation and the onset of functional disability by socioeconomic status and activity type; the JAGES cohort study. *Prev Med,* 89: 121-128.
24. Tamiya T., Noguchi H., Nishi A., et al. (2011) Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet,* 378(9797): 1183-1192
25. Osaka university commerce JGSS Research Center. Summary of Surveys. (http://jgss.daishodai.ac.jp/english/surveys/sur_top.html)
26. Ashida T., Kondo N., Kondo K. (2016) Social participation and the onset of functional disability by socioeconomic status and activity type: the JAGES cohort study. *Prev Med,* 89: 121-128.
27. Lum T.Y., & Lightfoot E. (2005) The effects of volunteering on the physical and menatl health of older people. *Res Aging,* 27(1): 31-55.
28. Musick M.A., & Wilson J. (2003) Volunteering and depression: the role of psychological and social resouces in different age group. *Soc Sci Med,* 56(2) 259-269.

29. Aida J., Hanibuchi T., & Nakade M., et al. (2009) The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis. Soc Sci Med. 69(4): 512-518
30. Yazawa A., Inoue Y., & Fujiwara T., et al. (2016) Association between social participation and hypertension among older people in Japan: the JAGES Study. *Hypertens Res.* 39(11):818-824.
31. McCullagh P., & Nelder JA., (1989) *Generalized Linear Models, second ed.* CRC Press.
32. Hoshino T., & Okada K., (2006) Estimation of causal effect using propensity score methods in clinical medicine, epidemiology, pharmacoepidemiology and public health; a review. *J. Natl. Inst. Public Health,* 55(3): 230-243 (in Japanese with English abstract).
33. Brookhart MA., Schneeweiss S., & Rothman KJ., et al. (2006) Variable selection for propensity score models. *Am J Epidemiol.* 163(12):1149-1156
34. Mendes de Leon C.F., Glass T.A., Berkman L.F. (2003) Social engagement and disability in a community population of older adults: the New Haven EPESE. *Am J Epidemiol.* 157(7): 633-642.
35. James B.D., Boyle P.A., Buchman A.S., et al. (2011) Relation of late-life social activity with incident disability among community-dwelling older adults. *J Gerontol A Biol Sci Med Sci,* 66A(4):467-473
36. Thomas PA. (2011) Trajectories of social engagement and limitations in late life. *J Health Soc Behav,* 52(4): 430-443.
37. Avlund K., Vass M., & Hendriksen C. (2003) Onset of mobility disability among community-dwelling old men and women: the role of tiredness in daily activities. *Age Ageing* 32(6): 579-584
38. Buchman A.S., Boyle P.A., & Wilson R.S., et al. (2009) Association between late-life social activity and motor decline in older adults. *Arch Intern Med,* 169(12): 1139-1146.
39. Hikichi H., Kondo N., & Kondo K, et al. (2015) Effect of community intervention program promoting social interactions on functional disability prevention for older adults; propensity score matching and instrumental variable analyses, JAGES Taketoyo study. *J Epidemiol Community Health,* 69(9):905-910.
40. Hikichi H., Kondo K., & Takeda T, et al. (2017) Social interaction and cognitive decline; results of a 7-year community intervention. *Alzheimers Dement (N Y)*, 3: 23-32
41. Yu HW., Chiang TL., & Chen DR., et al. (2016) Trajectories of Leisure Activity and Disability in Older Adults Over 11 Years in Taiwan. *J Appl Gerontol.* 1: 733464816650800
42. Saito J., Kondo N., Saito M., et al. (2018) Exploring 2.5-year trajectories of functional decline in older adults by applying a growth mixture model and the frequency of outings as a predictor: 2010–2013 JAGES longitudinal study. *J Epidemiol,* (in press).
43. Cabinet Office (2011) *Results of survey on attitude toward the senior citizens' economic life* (in Japanese) (http://www8.cao.go.jp/kourei/ishiki/h23/sougou/zentai/index.html)
44. Masters R., Anwar E., & Collins B., et al. (2017) Return on investment of public health interventions: a systematic review. *J Epidemiol Community Health,* 71: 827-834
45. Suzuki W., Iwamoto Y., & Yuda M., et al. (2012) The distribution patterns of medical care and long-term care expenditures. *Jpn. J. Health Econ. Policy. (Iryo-Keizai Kenkyu)*, 24(2): 86-107 (in Japanese with English abstract).

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure 1. Flow chart of respondent selection.

Table S1. Differences of cumulative cost in LTCI services by OLS with MI, and GLM

Table S2. C statistics by multinominal regression model

Table S3. Differences of lifetime cost in LTCI services by social participation among deceased person

Tab.1 Characteristics of respondents

	Total	Cumulative cost of LTCI services in 11 years (1000USD) [b]	
	%	Mean ± SD	*p*
Sex [a]			
Male	52.0	7.7 ± 24.8	
Female	48.0	18.7 ± 44.8	<.001
Age [a]			
(Mean±SD)	(73.4±6.2)		
65-74	61.3	6.3 ± 25.2	
75-84	33.3	23.0 ± 47.2	
85+	5.4	39.1 ± 56.4	<.001
Disease and/or impairment [a,b]			
None	27.2	10.9 ± 35.5	
Presence [b]	64.6	14.3 ± 37.8	
Missing	8.3	17.7 ± 39.7	=.001
Years of education [a]			
<6	2.7	30.7 ± 57.6	
6-9	41.9	12.4 ± 34.9	
10-12	24.8	13.1 ± 37.2	
13+	32.2	11.1 ± 33.3	
Missing	10.7	23.2 ± 48.8	<.001
Equivalent income (1000USD) [a]			
<20.0	36.0	12.2 ± 36.5	
20.0-39.9	27.3	9.5 ± 30.5	
40.0+	6.8	12.0 ± 35.5	
Missing	29.9	19.6 ± 43.6	<.001
Marital status [a]			
Married	69.2	9.2 ± 29.7	
Widowed	21.4	24.8 ± 50.2	
Divorced	1.7	11.0 ± 27.9	
Never married	2.0	27.4 ± 60.1	
Missing	5.7	22.7 ± 45.9	<.001
Living situation [a]			
Living alone	10.7	23.8 ± 50.9	
With spouse only	36.5	9.6 ± 30.1	
With child	22.7	12.9 ± 35.9	
With others	25.6	14.6 ± 39.7	
Missing	4.6	21.3 ± 41.6	<.001
Self rated health [a]			
Excellent	6.0	7.9 ± 30.5	
good	61.7	11.5 ± 34.5	
Fair	22.5	18.2 ± 43.0	
Poor	5.1	21.7 ± 45.6	
Missing	4.7	18.9 ± 39.9	<.001
TOTAL	100.0	13.7 ± 37.4	

a) These variables are based on baseline questionnaire survey.

b) A breakdown of proportion was as follows: one=32.1%, two=15.2%, three=4.2%, four and over=1.9%, unknown=11.2%These variables are based on baseline questionnaire survey.

Tab.2 Average duration of care giving at follow-up period by social participation [a)]

	n	ALL[a)] Mean (SD)	Care Lv1+ Mean (SD)	Care Lv2+ Mean (SD)	Care Lv3+ Mean (SD)	Care Lv4+ Mean (SD)	Care Lv5 Mean (SD)
Hobby activities group							
Never	2833	14.1 (25.8)	9.8 (21.4)	7.1 (17.6)	4.0 (12.5)	2.2 (8.5)	0.8 (4.6)
A few times a year	259	9.0 (19.4)	5.6 (15.7)	3.5 (9.9)	1.8 (6.4)	1.2 (5.3)	0.6 (4.1)
Once or twice a month	524	10.7 (21.8)	6.1 (16.6)	4.6 (14.4)	2.7 (10.2)	1.6 (7.5)	0.6 (3.7)
Once a week +	972	10.6 (21.8)	6.2 (16.6)	4.1 (13.2)	2.2 (9.3)	1.0 (6.0)	0.4 (3.0)
		p <.001	p <.001	p <.001	p <.001	p =.019	p =.026
Sports group or club							
Never	3716	13.7 (25.1)	9.3 (20.7)	6.6 (17.0)	3.8 (12.1)	2.1 (8.4)	0.8 (4.6)
A few times a year	91	7.5 (19.6)	5.6 (18.4)	4.8 (16.5)	2.8 (12.0)	1.2 (5.5)	0.8 (5.0)
Once or twice a month	125	6.0 (17.3)	3.3 (13.4)	2.7 (12.5)	1.4 (6.9)	0.5 (2.6)	0.2 (1.4)
Once a week +	572	7.2 (18.1)	3.8 (12.8)	2.4 (9.8)	1.0 (5.4)	0.5 (3.4)	0.1 (1.0)
		p <.001	p <.001	p <.001	p <.001	p <.001	p =.005
Volunteer group							
Never	3899	12.9 (24.4)	8.6 (20.0)	6.1 (16.4)	3.5 (11.6)	1.9 (7.9)	0.7 (4.3)
A few times a year	194	7.1 (17.3)	3.9 (12.8)	2.9 (11.1)	1.6 (8.3)	1.1 (7.7)	0.7 (5.6)
Once or twice a month	193	9.9 (21.6)	6.1 (17.0)	4.3 (13.3)	2.0 (8.9)	1.1 (7.2)	0.4 (2.7)
Once a week +	122	6.4 (17.5)	3.9 (12.4)	3.1 (10.9)	1.6 (6.9)	0.8 (3.2)	0.2 (1.5)
		p <.001	p <.001	p <.001	p <.001	p =.019	p =.165

Unit: month SD: Standard deviation

a) This is including certification for long-term care level from support level 1 to care level 5.

Tab.3 Differences of cumulative cost in LTCI services in a 11-years follow-up period by social participation

	n	Mean	OLS [a,b)] Coef. (95%CI)	IPW with MI [c,d)] Coef. (95%CI)	Mortality
Hobby activities group					
Never	2833	14.6	*ref.*	*ref.*	30.8
A few times a year	259	6.6	- 3.2† (-6.7 to 0.2)	- 3.5 (-8.1 to 1.2)	28.0
Once or twice a month	524	10.2	- 2.8† (-5.8 to 0.7)	- 2.2 (-5.6 to 1.2)	21.7
Once a week +	972	9.4	- 3.6** (-6.0 to -1.3)	- 3.5* (-6.2 to -0.8)	19.5
Sports group or club					
Never	3716	13.9	*ref.*	*ref.*	29.1
A few times a year	91	9.3	2.5 (-4.9 to 9.9)	1.8 (-5.8 to 9.4)	18.7
Once or twice a month	125	4.8	- 3.3 (-7.6 to 9.4)	- 4.2 (-10.7 to 2.3)	16.1
Once a week +	572	5.2	- 4.9*** (-6.9 to -2.8)	- 6.1*** (-9.3 to -2.8)	18.6
Volunteer group					
Never	3899	12.7	*ref.*	*ref.*	28.4
A few times a year	194	4.8	- 4.1** (-7.1 to -1.0)	- 3.9 (-9.1 to 1.3)	20.7
Once or twice a month	193	10.0	1.9 (-2.9 to 6.7)	1.5 (-3.8 to 6.7)	12.7
Once a week +	122	5.9	- 0.7 (-4.5 to 3.1)	- 1.4 (-7.9 to 5.1)	11.5

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000USD

OLS: Ordinal least squares, IPW: Inverse probability weighting, MI: Multiple imputation, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) The result was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

d) The generalized propensity scores were calculated using multinominal regression analysis using all previously listed potential confounders: sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health.

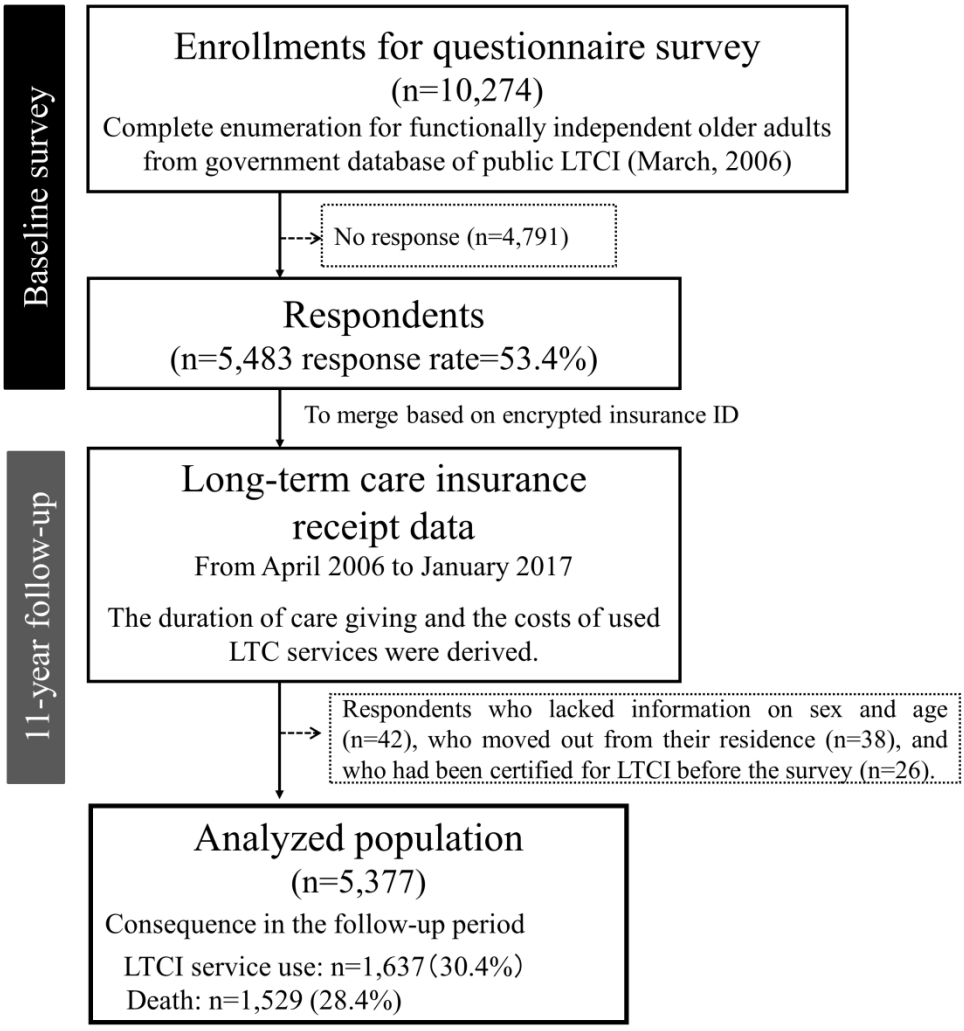

Figure 1: Flow chart of respondent selection.

242x261mm (300 x 300 DPI)

Table S1. Differences of cumulative cost in LTCI services by OLS with MI, and GLM

	n	GLM [a,b)] Marginal effect (95%CI)	OLS with MI [b,c)] Coef. (95%CI)
Hobby activities group			
Never	2833		*ref.*
A few times a year	259	- 1.9 (-11.0 to 7.2)	- 3.1† (-6.6 to 0.3)
Once or twice a month	524	- 3.3 (-8.7 to 2.2)	- 2.9† (-5.8 to 0.1)
Once a week +	972	- 3.5† (-7.3 to 0.3)	- 3.7* (-6.0 to -1.3)
Sports group or club			
Never	3716		*ref.*
A few times a year	91	10.9 (-14.3 to 36.1)	2.7 (-4.6 to 10.0)
Once or twice a month	125	- 5.0 (-17.8 to 7.9)	- 3.5 (-7.8 to 0.7)
Once a week +	572	- 7.0** (-11.2 to -2.9)	- 4.9*** (-6.9 to -2.9)
Volunteer group			
Never	3899		*ref.*
A few times a year	194	- 9.4*** (-14.1 to -4.6)	- 4.3** (-7.3 to -1.2)
Once or twice a month	193	2.3 (-8.9 to 13.6)	1.9 (-2.9 to 6.8)
Once a week +	122	- 2.8 (-11.1 to 5.6)	- 0.5 (-4.4 to 3.3)

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000 USD

GLM: Generalized linear model, OLS: Ordinal least squares, MI: Multiple imputation, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) Each model was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

Table S2. C statistics by multinominal regression model

	Hobby activities group	Sports group or club	Volunteer group
A few times a year vs Never	0.664	0.757	0.637
Once or twice a month vs Never	0.665	0.695	0.681
Once a week + vs Never	0.662	0.645	0.713

C statistics by multinominal regression model in order to calculate generalized propensity scores were not high: hobby activities group=.662 to .665, sports group or club=.645 to .757, volunteer group=.637 to 713. However, it is not necessarily to mean undesirable model, because the goal of a propensity score model is to efficiently control confounding, not to predict treatment or exposure.[28]

Table S3. Differences of lifetime cost in LTCI services by social participation among deceased person

	n	Mean	OLS [a,b]	GLM [a,b]	After Multiple Imputation [c]	
					OLS [b]	IPW [d]
			Coef. (95%CI)	Marginal effect (95%CI)	Coef. (95%CI)	Coef. (95%CI)
Hobby activities group						
Never	861	19.2	*ref.*		*ref.*	*ref.*
A few times a year	72	9.7	- 6.0* (-11.9 to - 0.1)	- 5.6 (-14.9 to 3.8)	- 5.6† (-11.6 to 0.3)	- 4.7 (-13.7 to 4.4)
Once or twice a month	113	15.8	- 2.0 (-9.1 to 5.1)	- 0.9 (-9.3 to 7.6)	- 2.1 (-9.2 to 4.9)	- 2.4 (-9.8 to 4.9)
Once a week +	188	12.2	- 5.3* (-10.1 to -0.4)	- 3.9 (-7.3 to 0.3)	- 5.4* (-10.2 to -0.5)	- 5.7† (-11.6 to 0.3)
Sports group or club						
Never	1066	19.1	*ref.*		*ref.*	*ref.*
A few times a year	17	4.3	- 8.9*** (-13.7 to -4.1)	- 17.8*** (-22.8 to -12.8)	- 8.6** (-14.1 to -3.0)	- 9.4 (-27.3 to 8.4)
Once or twice a month	20	4.0	- 8.6** (-14.8 to -2.4)	- 18.5*** (-24.0 to -13.0)	- 9.1** (-15.3 to -2.8)	- 10.1 (-26.6 to 6.4)
Once a week +	105	5.4	- 9.7*** (-13.8 to -5.7)	- 11.4** (-17.8 to -4.9)	- 9.4*** (-13.4 to -5.4)	- 11.1** (-18.6 to -3.5)
Volunteer group						
Never	1091	16.9	*ref.*		*ref.*	*ref.*
A few times a year	40	11.2	- 1.8 (-12.4 to 8.8)	- 5.9 (-18.8 to 7.0)	- 1.7 (-12.6 to 9.2)	- 2.0 (-13.7 to 9.8)
Once or twice a month	24	20.6	6.2 (-14.9 to 27.2)	10.2 (-22.5 to 42.9)	7.1 (-13.9 to 28.0)	7.6 (-7.4 to 22.7)
Once a week +	14	9.3	- 4.6 (-16.8 to 7.7)	- 12.5** (-20.4 to -4.7)	- 5.1 (-18.1 to 7.8)	- 3.4 (-23.0 to 16.2)

*** p<.001 ** p<.01 * p<.05 † p<.10 Unit: 1000USD

OLS: Ordinal least squares, GLM: Generalized linear model, IPW: Inverse probability weighting, CI: Confidential interval

a) Missing values in control variables were included as a dummy variable.

b) Each model was controlled by sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline.

c) Multiple imputation by chained equations was performed using sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health at baseline (m=20).

d) The generalized propensity scores were calculated using multinominal regression analysis using all previously listed potential confounders: sex, age, disease and/or impairment, years of education, equivalent income, marital status, living situation, self rated health. C statistics were as follows: hobby activities group=.640 to .665, sports group or club=.645 to 757, volunteer group=.637 to 713.

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cohort reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Study design	#4	Present key elements of study design early in the paper	6
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	6

	#6b	For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6
Bias	#9	Describe any efforts to address potential sources of bias	13
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6-8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	8
	#12b	Describe any methods used to examine subgroups and interactions	8
	#12c	Explain how missing data were addressed	8
	#12d	If applicable, explain how loss to follow-up was addressed	6
	#12e	Describe any sensitivity analyses	8
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	6
	#13b	Give reasons for non-participation at each stage	6
	#13c	Consider use of a flow diagram	6
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential	10

		confounders. Give information separately for exposed and unexposed groups if applicable.	
	#14b	Indicate number of participants with missing data for each variable of interest	6
	#14c	Summarise follow-up time (eg, average and total amount)	6
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	N/A
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
	#16b	Report category boundaries when continuous variables were categorized	N/A
	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10
Key results	#18	Summarise key results with reference to study objectives	12
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	13
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12-13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	13
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14