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Intensity of community-based programs by long-term care insurers and the likelihood of frailty: Multilevel analysis of older Japanese adults

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ABSTRACT

The World Health Organization (WHO) argues that governments can postpone declining capacity of older adults by providing sufficient support. Yet, to our knowledge, no study has focused on the role of local governments for realizing healthy ageing. This study examined the association between the intensity of community-based programs for frailty postponement by long-term care insurers (as municipalities) and the likelihood of frailty. We analyzed repeated cross-sectional data of three waves (2010-11, 2013, and 2016) from the Japan Gerontological Evaluation Study (JAGES). Participants included 375,400 older adults aged 65 years or older (M = 74.1) living in a total of 81 regions covered by insurers in Japan. Frailty was assessed by a governmental standardized index, the Kihon Check List (KCL; a basic function check list in Japanese). Estimations were obtained using a multilevel logistic model with random slopes. We found that every social activity per hundred older people organized by a long-term care insurer was significantly associated with an 11% reduction of the likelihood of frailty (Odds ratio = 0.89; 95% credible interval = 0.81, 0.99). Although the main effect of educational events was not significant, the point estimate was slightly larger for people with lower levels of education than for those with higher education. The results also suggested that insurer-organized social activities could be more beneficial in communities with few opportunities for civic participation. The variation in intensity of community-based programs by long-term care insurers may explain part of a disparity in the likelihood of frailty between municipalities.

1. Introduction

The World Health Organization (WHO) defines “healthy aging” as “the process of developing and maintaining the functional ability that enables wellbeing in older age” (World Health Organization, 2015). Interventions targeting frailty and deterring disability are essential to promote healthy aging. Frailty is an age-related physiological syndrome that puts older people at a greater risk for adverse health outcomes such as falls, institutionalization, hospitalization, and death (Fried et al., 2001; Kan et al., 2008). It should be noted that there are still some debates on the definition of frailty (Clegg et al., 2013; Collard et al., 2012). While Rockwood and colleagues defined frailty as cumulative deficits including disabilities, diseases, symptoms, signs, and laboratory abnormalities (Jones et al., 2004; Mitnitski et al., 2001; Peña et al., 2014; Rockwood and Mitnitski, 2007; Rockwood et al., 2005), Fried and colleagues defined it as a physical phenotype and argued that researchers should distinguish frailty from disability and comorbidity (Fried et al., 2004; Fried et al., 2001). Although the two definitions are somewhat overlapped (Cigolle et al., 2009; Rockwood et al., 2007), the latter seems more practical because each condition (namely, frailty, disability, and comorbidity) needs different medical and long-term care services (Fried et al., 2004). Moreover, the latter view fits better into

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the context of aiming at healthy aging and attracts policy makers' attention to frailty as a good target for interventions, given that frailty is a reversible condition and a precursor of disability (Fried et al., 2004; Kan et al., 2008; Lang et al., 2009; Vermeulen et al., 2011). The WHO also argues that governments can reverse or slow declining capacity of older people by providing sufficient support (World Health Organization, 2015). Despite the important role of governments, to our knowledge, no study has focused on the responsibility of local governments for postponement of frailty.

Many interventions for frailty such as exercise (Clegg et al., 2012; de Vries et al., 2012; Theou et al., 2011), nutritional support (Halfon et al., 2015; Kim and Lee, 2013; Maggio et al., 2013), cognitive training (Ng et al., 2015), comprehensive geriatric assessment (Ellis et al., 2017), and their combinations (Kim et al., 2012; Luger et al., 2016; Ng et al., 2015) have been proposed and substantiated. Most of these interventions target those who are already frail or pre-frail. These approaches, however, can help only a limited number of people. One study estimated that the prevalence of frailty is 11.3% in Japan (Shimada et al., 2013), which corresponds to over 5 million people. As frailty is such a common condition among older people, community-based strategies for decreasing frailty in the general population should be developed (Sacha et al., 2017). As the most rapidly aging society in the world, insurers of long-term care insurance (LTCI) in Japan (where an insurer is a single municipality in general, though some small municipalities administer the LTCI jointly) have developed various community-based programs that seem beneficial for decreasing frailty.

One of the potential strategies for postponement of frailty is the encouragement of social participation. The town of Taketoyo, Japan, has created community centers called "salons," in which older residents gather and engage in various social activities (e.g., light exercise, singing, playing games, drinking tea). Researchers have revealed that participants in the salon programs have better self-rated health and lower likelihood of functional and cognitive disability than non-participants, addressing endogeneity through the use of an instrumental variable (the distance between a house and the nearest salon) (Hikichi et al., 2017, 2015; Ichida et al., 2013). Motivated by the example of Taketoyo, many insurers now provide older citizens with public spaces such as community centers, libraries, or classrooms in local schools to help them hold social activities. Another means of social participation—volunteering—may also help older people maintain their robustness. Previous studies have shown that volunteering is associated with better psychosocial, physical, and cognitive outcomes in older people (Anderson et al., 2014; Jung et al., 2010). LTCI insurers train residents and send them as volunteers to nursing homes, households of elderly people living alone, and neighborhood watch programs. Some insurers incentivize older residents to participate in volunteering by rewarding them with "volunteer points," which participants can use to shop at local shopping malls and exchange as payment for LTCI. Encouragement of social participation thus seems promising, but there is a drawback to consider. Sex, health status, socioeconomic status (SES), and social connection are known determinants of participation in social activities and volunteering (Hikichi et al., 2017; Niebuur et al., 2018). Consequently, if people who have poor health, low SES, and are isolated are less likely to participate in such activities, interventions focusing on social participation may widen the disparity in healthy aging.

Another approach to decreasing frailty is providing education and training (World Health Organization, 2017). Many insurers arrange educational events for postponement of frailty, in which older people learn how to maintain their robustness through healthy behaviors such as physical activity, following a nutritious diet, oral care, and cognitive exercise. Yet, the effect of such educational programs on the general population is still unclear (Albrecht et al., 2016; Ebrahim et al., 2011; Schoberer et al., 2016).

Insurers can use funding from LTCI for initiating measures to encourage social participation and organize educational events. Nevertheless, the intensity of these measures differs across the nation; some insurers arrange social activities for older residents 10,000 to 40,000 times in a year, while others organize such activities only once or never. Thus, we hypothesize that the variation in intensity of interventions by insurers can explain part of the regional disparity that exists in the likelihood of frailty. In other words, our research question is whether older people under insurers dedicated to measures for postponement of frailty are less likely to be frail than those under less-dedicated insurers.

This study used a large amount of data from a nationwide study on older Japanese adults to examine associations between the number of times that an insurer organized educational events and social activities on the one hand, and the likelihood of frailty among community-dwelling older adults on the other. Moreover, by including variables of SES (as educational attainment) and social capital (defined as "resources that are accessed by individuals as a result of their membership of a network or a group"; Kawachi and Berkman, 2014), we evaluated whether the community-based strategies could shrink the disparity among people of different SES and between communities in the likelihood of frailty. Although we did not directly assess individual participation in the programs and thus could not infer causality, this study is the first to explore the association between intensity of community-based intervention efforts by insurers and decrease in frailty, given the important role of local governments in achieving healthy aging, as highlighted by the WHO.

2. Method

2.1. Study participants

We used repeated cross-sectional data from the Japan Gerontological Evaluation Study (JAGES). The JAGES is a large observational study, including natural experiment (Hikichi et al., 2016) and community intervention (Hikichi et al., 2017, 2015; Ichida et al., 2013), of Japanese people aged 65 or older who are physically and cognitively independent (that is, not certified as needing long-term care). Our data came from three waves of the study conducted in 2010–2011, 2013, and 2016. In each wave, 22, 25, and 34 insurers of the LTCI participated, respectively. Self-reported questionnaires were mailed to eligible residents; random sampling methods were used by 42 large insurers, while a census of all eligible residents was conducted in 39 smaller insurers. In the large insurers, participants who answered a questionnaire in a previous wave were oversampled in the following wave. In the three waves, questionnaires were collected from 112,123, 137,736, and 196,438 participants, respectively, corresponding to response rates of 66.3%, 71.1%, and 70.2%, respectively. Participants who reported depending on others for activities of daily living (ADL) (n = 37,207) were excluded from the analysis because we considered frailty as the previous stage of disability (Fried et al., 2004; Kan et al., 2008; Vermeulen et al., 2011). Participants whose sex and age could not be confirmed or were reported in error (n = 33,690) were also excluded. This study was reviewed and approved by ethics committees at the University of Tokyo, Nihon Fukushi University, National Centre for Geriatrics and Gerontology, and Chiba University. We acquired permission to use the data from the JAGES investigators.

2.2. Frailty measure

Frailty was assessed by a governmental standardized index named the Kihon Check List (KCL, a basic function checklist in Japanese). The KCL was originally developed by Japan's Ministry of Health, Labour, and Welfare (MHLW) to identify those who are at high risk of disability. The JAGES incorporates the KCL into its questionnaire. The KCL consists of 25 questions in the domains of physical, oral, social, and cognitive functions, nutritional status, and depressive mood (see Appendix Table A1). The most widely used definition of frailty is the Fried criteria (Fried et al., 2001) that features five phenotypes (shrinking, exhaustion,

low levels of activity, weakness, and slowness). Under these criteria, frailty, pre-frailty, and robustness are defined as when an individual meets ≥3, 1–2, and 0 of the five phenotypes, respectively. In a clinical setting, Satake et al. (2016) verified that an individual's total KCL score is closely correlated with the number of Fried's phenotypes that describe him or her (ρ = 0.655; c-statistic was 0.81 for pre-frailty and 0.92 for frailty) and proposed to define states with a KCL value of 4 and over as pre-frailty (sensitivity 70.3%; specificity 78.3%) and of 8 and over as frailty (sensitivity 89.5%; specificity 80.7%). We adopted these cut-off values and constructed binary variables indicating the status of pre-frailty (assigning the value of 1 to those who scored 4 and over, thus also including those who were frail in this category) and of frailty (those who scored 8 and over). Then, we conducted logistic regressions on the two outcomes with separated samples.

2.3. Predictors and other covariates

Our primary predictor was the annual number of times that an insurer took measures for postponement of frailty per hundred older adults. The MHLW categorizes the measures into (1) educational events and (2) promotion of social activity. Educational events include consultation events and seminars for postponement of frailty. For the promotion of social activity, insurers train older volunteers and arrange their activities. They also provide public spaces where older citizens can congregate and encourage them to participate in social activities. The number of times that an insurer organized educational events and social activities was extracted from the Report on Preventive Long-Term Care Service, into which reports from insurers are compiled by the MHLW, corresponding to the years of the JAGES investigations. It was divided by the population aged 65 or older insured by each insurer, using data from the Basic Resident Register administrated by Japan's Ministry of Internal Affairs and Communications.

Secondary predictors were educational attainment and social capital. For educational attainment, we categorized participants into three groups: low (9 years or less), middle (10–12 years), and high (13 years or more) levels of education. To measure social capital, we used three scales consisting of civic participation, social cohesion, and reciprocity validated by Saito et al. (2016). The previous study validated community-level social capital, which is equal to the average score of each of these three scales within a school district (it often represents the unit of a former village, and community activities such as senior citizens clubs, agricultural cooperatives, and local festivals take place within each district). Civic participation was measured as the number of the following groups engaged in per month: volunteer groups, sports groups, and hobby groups. Social cohesion was measured as the number of participants who answered “strongly/moderately agree” on three questions about community trust, norms of reciprocity, and community attachment. Reciprocity was measured as the number of participants who answered “any one or more” on three questions about receiving and providing emotional support and receiving instrumental support. Each variable ranged from 0 to 3, and we included both individual- and community-level scores at level 1 in our three-level models described later because previous studies showed that individual social capital cannot fully explain disparities in the onset of functional decline, and community social capital affects it contextually (Aida et al., 2013; Fujihara et al., 2019). To examine whether the community-based interventions could shrink disparities in frailty, we included interaction terms—that is, the number of interventions, along with educational attainment and scores of social capital in our model.

We also adjusted for sex, age, annual equivalized household income (low (≤1.9), middle (2.0–3.9), and high (≥4.0) million Japanese Yen (JPY, 1US$ = approximately 108JPY in November 2019), marital status (married, widowed, divorced, and never married), employment status (employed or not), and fixed effects of the year of investigation (2013 or 2016).

2.4. Statistical analysis

Considering the heterogeneity of regions covered by insurers, we used multilevel logistic models to evaluate associations between the number of interventions and the likelihood of frailty and pre-frailty. The data was a repeated cross-sectional design and structured in three levels; individuals at level 1 were nested within the years of investigation at level 2, nested within insurers at level 3. The number of interventions and fixed effects of the years of investigation are variables at level 2; all of the other covariates were measured at level 1. We included random slopes of the year of investigation at level 3 to allow time-variant effects of interventions to be heterogeneous across insurers. Estimates were obtained using Markov Chain Monte Carlo (MCMC) methods (Browne, 2017). To mitigate potential biases caused by these missing values, we adopted multiple imputations under the missing at random (MAR) assumption. Incomplete variables were imputed by a multivariate normal model using all the covariates as explanatory variables: sex, age, years of education, equivalized household income, marital status, employment status, the 25 items of the KCL, year of the investigation, municipality of residence, and the three items of civic participation, social cohesion, and reciprocity. We created 10 imputed datasets, and the estimates were combined. Multilevel analyses were performed with MLwiN, version 3.02 (Centre for Multilevel Modelling, University of Bristol) via Stata, version 14.2 (Stata Corp, College Station, TX) (Charlton et al., 2017; Leckie and Charlton, 2013). All other analyses were conducted using Stata.

3. Results

3.1. Participant characteristics

As shown in Table 1, there was a declining trend for the prevalence of pre-frailty and frailty (pre-frailty: 2010–2011: 59.9%; 2013: 47.3%; 2016: 38.5%, frailty: 2010–2011: 25.1%; 2013: 16.1%; 2016: 9.9%). It may reflect a trend that Japanese people aged 65 and over now score 5–10 years younger in physical and psychological health than they used to 10–20 years ago (Ouchi et al., 2017). In the descending waves, the social capital scores of civic participation and reciprocity had improved at both the individual and community level.

Between insurers, there were variations of the prevalence of pre-frailty and frailty. The prevalence of pre-frailty ranged from 52.2% to 73.2% in 2010–2011, from 39.0% to 61.1% in 2013, and from 29.0% to 44.9% in 2016. For the same years, the prevalence of frailty ranged from 18.6% to 37.2%, from 12.2% to 24.4%, and from 7.1% to 14.3%, respectively. On average, insurers arranged educational events from 2.09 to 3.63 times per hundred older adults per year and social activities from 1.74 to 3.49 times. The number of interventions also varied by insurer; some insurers arranged interventions more than 10 times the average, whereas others arranged none.

3.2. Multilevel analysis

Table 2 shows the results of our multilevel logistic analyses. Social capital may act as a mediator because interventions can promote social capital. Thus, we ran regressions excluding social capital related variables in Model 1 and then added them in Model 2. We found that each social activity per hundred older people was significantly associated with an 11% reduction of the likelihood of frailty (*OR* = 0.89; 95% credible interval [*CI*] = 0.81, 0.99) in Model 2. Comparing to Model 1, the estimated associations of interventions with outcomes got stronger rather than weaker after adjusting for social capital. Hence, social capital appeared to act as a confounder, rather than a mediator.

We also checked whether educational attainment and social capital act as effect modifiers. Although the main effect of educational events on the likelihood of frailty was negative but non-significant, an interaction term with a dummy variable indicating a low level of education

Table 1
Participant characteristics.

	2010–2011	2013	2016	*p*-value
Individual				
N	97,745	119,947	157,708	
Pre-frailty (%)	59.9	47.3	38.5	< 0.001
Frailty (%)	25.1	16.1	9.9	< 0.001
Male (%)	46.3	46.6	46.3	0.10
Age (*M* (*SD*))	74.0 (6.14)	73.7 (6.10)	73.8 (6.05)	< 0.001
Education (%)				< 0.001
Low (≤9 years)	47.6	41.0	31.6	
Middle (10–12 years)	34.7	38.1	41.8	
High (≥13 years)	17.8	20.9	26.6	
Equivalized household income (%)				< 0.001
Low (≤1.9 million JPY)	50.7	50.8	48.4	
Middle (2.0–3.9 million JPY)	38.4	38.4	40.2	
High (≥4.0 million JPY)	10.9	10.8	11.5	
Marital status (%)				< 0.001
Married	72.3	73.4	73.6	
Widowed	22.4	20.9	19.0	
Divorced	3.3	3.5	4.5	
Never married	2.1	2.3	3.0	
Employed (%)	23.2	24.6	29.6	< 0.001
Individual social capital (*M* (*SD*))				
Civic participation score	0.65 (0.87)	0.66 (0.89)	0.79 (0.99)	< 0.001
Social cohesion score	2.12 (1.06)	2.03 (1.09)	2.03 (1.09)	< 0.001
Reciprocity score	2.82 (0.55)	2.83 (0.53)	2.85 (0.50)	< 0.001
Community social capital (*M* (*SD*))				
Civic participation score	0.70 (0.15)	0.71 (0.15)	0.83 (0.16)	< 0.001
Social cohesion score	2.10 (0.18)	2.01 (0.17)	2.01 (0.16)	< 0.001
Reciprocity score	2.81 (0.06)	2.82 (0.06)	2.83 (0.06)	< 0.001
Insurer				
N	22	25	34	
Pre-frailty (%) (Min-Max)	52.2–73.2	39.0–61.1	29.0–44.9	
Frailty (%) (Min-Max)	18.6–37.2	12.2–24.4	7.1–14.3	
Educational events per hundred older adults				
M (*SD*)	2.96 (3.46)	3.63 (7.24)	2.09 (4.73)	0.55
Min-Max	0.0–15.3	0.0–36.7	0.03–27.4	
Social activities per hundred older adults				
M (*SD*)	1.74 (4.43)	3.43 (8.59)	3.49 (8.28)	0.66
Min-Max	0.0–21.1	0.0–36.3	0.0–43.3	

Note. p-values for χ^2 test and one-way ANOVA across the waves are displayed. M = Mean; SD = standard deviation; JPY = Japanese Yen (1US$ = approximately 108JPY in November 2019).

showed a negative significance. The difference in point estimates was very slight (for those with a high level of education: *OR* = 0.92; 95% *CI* = 0.78, 1.08, while for those with a low level of education: *OR* = 0.91; 95% *CI* = 0.77, 1.08 in Model 2), but the significance of the interaction term suggests that educational interventions might fill a gap in knowledge and the likelihood of frailty. By contrast, an interaction term between social activity and a low level of education showed a positive significance, though the point estimate for those with a low level of education was still negative and narrowly missed conventional significance (*OR* = 0.90; 95% *CI* = 0.81, 1.004). Interaction terms with community-level social capital, educational event–social cohesion and social activity–civic participation were significantly positive, which suggests that the interventions' effects on decreasing frailty were larger for those who lived in a community where such social capital was inadequate. Yet, the interaction term between educational event and community civic participation was statistically significant, which suggests that education-based interventions might be more effective in communities where civic participation is more active. In contrast to frailty, few variables were associated with the likelihood of pre-frailty (see Fig. 1).

4. Discussion

To our knowledge, this study is the first to explore the association between intensity of community-based intervention efforts by LTCI insurers and decrease in frailty. Using multilevel analysis, we found a reduced likelihood of frailty among older adults covered by insurers that organized more social activities. A previous randomized control trial revealed that social support alone was comparable to physical training and nutritional intervention and successfully decreased frailty (Luger et al., 2016). Taken together, our finding supports that providing opportunities for social interactions through community-based programs helps older adults maintain their capacity.

Although the main effect of educational events on frailty was not significant, it negatively interacted with an indicator of a lower level of education. This finding suggests that educational programs were more beneficial for people with lower levels of education, and thus might fill knowledge gaps between different socio-economic groups. By contrast, social activity positively interacted with the indicator of a low level of education (i.e., it was more effective among people with higher levels of education). Given that people with lower levels of education are less likely to participate in volunteering (Niebuur et al., 2018), those with lower education would be less benefited by interventions even if insurers provide opportunities for volunteering because they are less likely to participate in them. Another study, however, pointed out that they were more likely to participate in gathering at community centers than those with higher education (Hikichi et al., 2017). Further studies are thus needed to confirm relationships between educational attainment, participation in social activities, and the effect of community-based interventions.

Another important finding was the differential effects of the interventions by community-level social capital. Our findings suggest that social activities organized by insurers were more meaningful in communities with few opportunities for civic participation. From individualistic views, it has been known that participation in social activities (Hikichi et al., 2017, 2015; Ichida et al., 2013) and volunteering (Anderson et al., 2014; Jung et al., 2010) is salutary for older people. Yet, older people face difficulties in finding such opportunities in a community with insufficient social capital, which widens regional disparities in geriatric health. In health research, considering variation in community-level social capital is important because it can explain health outcomes even after adjusting for individual-level covariates (Koyama et al., 2016; Mohan et al., 2005; Sundquist et al., 2006). For example, a previous study found that lower levels of community social capital was associated with an elevated risk of functional disability among older women after adjusting for individual risk factors (Aida et al., 2013). Adding to the previous findings, the present study suggests that the creation of salons and the promotion of volunteering by insurers may facilitate social activities and mitigate disadvantages in communities with low stocks of social capital (e.g., few opportunities for civic participation). The WHO asserts that the environment older people inhabit is key to healthy aging as it can make up for their declining intrinsic capacity (both physical and mental) and maintain functional ability (World Health Organization, 2015). The present study makes a contribution to the promotion of healthy aging by suggesting that local governments can create environments where older people can continue participating in social activities and realize their potential.

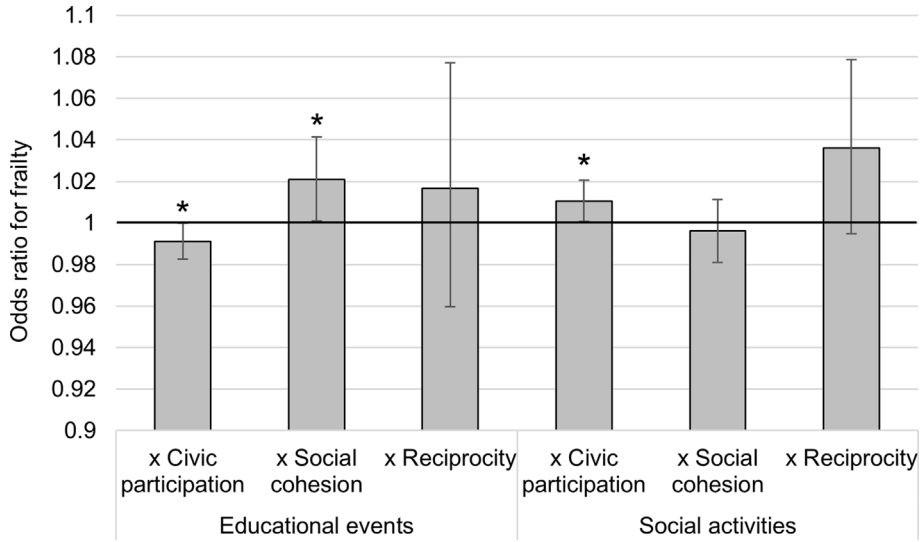
4.1. Limitations

The present study had several limitations. First, we measured an ecological effect of community-based interventions and could not determine from the JAGES data whether the participants actually took part in the educational events and social activities organized by insurers. Therefore, we are unable to conclusively infer if the lower risk of frailty was attributable to the programs. Our study was exploratory, which assumed that the more opportunities for community-based programs long-term care insurers provided, the more community-dwelling older adults would participate in them. Yet, if unobserved factors confounded the associations, our findings can be biased. Thus, it should

Table 2
The association between the number of times of interventions and the likelihood of pre-frailty and frailty.

Variables	Pre-frailty						Frailty					
	Model 1			Model 2			Model 1			Model 2		
	OR	95% *CI*		*OR*	95% *CI*		*OR*	95% *CI*		*OR*	95% *CI*	
Educational attainment												
Low education	1.57***	1.53	1.60	1.40***	1.36	1.43	1.69***	1.64	1.75	1.48***	1.43	1.53
Middle education	1.15***	1.13	1.18	1.11***	1.09	1.14	1.22***	1.18	1.26	1.17***	1.13	1.21
High education	ref.			ref.			ref.			ref.		
Individual SC												
Civic participation				0.74***	0.73	0.75				0.66***	0.65	0.67
Social cohesion				0.77***	0.76	0.77				0.73***	0.72	0.74
Reciprocity				0.61***	0.59	0.62				0.64***	0.62	0.65
Community SC												
Civic participation				0.93**	0.89	0.98				0.93*	0.87	0.99
Social cohesion				1.10*	1.02	1.18				1.06	0.97	1.16
Reciprocity				0.78*	0.65	0.94				0.85	0.66	1.09
Educational events	1.00	0.98	1.02	0.93	0.82	1.05	1.01	0.97	1.05	0.92	0.78	1.08
Interactions with education												
× Low education	1.00	1.00	1.01	1.00	1.00	1.01	0.99*	0.98	0.998	0.99*	0.98	0.999
× Middle education	1.00	1.00	1.01	1.00	1.00	1.01	0.99	0.98	1.00	0.99	0.98	1.00
× High education	ref.			ref.			ref.			ref.		
Interactions with individual SC												
× Civic participation				1.00	1.00	1.00				1.00	0.99	1.00
× Social cohesion				1.00	1.00	1.00				1.00	1.00	1.00
× Reciprocity				1.00	1.00	1.01				1.00	1.00	1.00
Interactions with community SC												
× Civic participation				1.00	0.99	1.01				0.99*	0.98	0.9999
× Social cohesion				1.01	1.00	1.03				1.02*	1.001	1.04
× Reciprocity				1.01	0.97	1.05				1.02	0.96	1.08
Social activities	0.98	0.96	1.00	0.96	0.89	1.03	0.98	0.93	1.03	0.89*	0.81	0.99
Interactions with education												
× Low education	1.00	1.00	1.00	1.00	1.00	1.00	1.01***	1.003	1.01	1.01**	1.002	1.01
× Middle education	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.01
× High education	ref.			ref.			ref.			ref.		
Interactions with individual SC												
× Civic participation				1.00	1.00	1.00				1.00	1.00	1.00
× Social cohesion				1.00	1.00	1.00				1.00	1.00	1.00
× Reciprocity				1.00	1.00	1.00				1.00	1.00	1.00
Interactions with community SC												
× Civic participation				1.00	1.00	1.01				1.01*	1.001	1.02
× Social cohesion				0.99	0.98	1.00				1.00	0.98	1.01
× Reciprocity				1.02	0.99	1.05				1.04	0.99	1.08
DIC	477808.3			457333.0			316951.5			297999.7		

Note. *$p < .05$; **$p < .01$; ***$p < .001$.
OR = odds ratio; SE = standard error; CI = credible interval; SC = social capital; DIC = the Bayesian Deviance Information Criterion.



Note. *$p < .05$

Fig. 1. Interaction terms between interventions and community-level social capital.

be tested in future studies whether the associations we found are causal. Second, we could not obtain detailed data on the salon or volunteering activities, such as the number of participants or content of the activities, from the report by the MHLW. We expect that future studies will reveal what types of social activities are more effective on decreasing frailty and how older adults can be motivated to participate in them. Third, the JAGES modified the original KCL slightly when it incorporated the KCL into its questionnaire (see Appendix Text A1 and Table A2 for more details). The modifications can cause a measurement error in outcomes that are not related to exposure (as non-differential misclassification), but we adjusted for the fixed effects of the year of investigation, and thus believe that this bias was reduced. Fourth, a sample selection bias may exist if respondents are more likely to participate in community-based programs and less likely to be frail than non-respondents. Nevertheless, the response rates in the JAGES are quite high (generally around 70% per wave) compared to other studies involving community-dwelling older adults (Santos-Eggimann et al., 2009) and is one of the strengths of the present study. Finally, participants are limited to those who are physically and cognitively independent. Hence, our findings cannot generalize to those who have been disabled.

5. Conclusions

In summary, the present study found a negative association between the promotion of social activities by LTCI insurers and the likelihood of frailty. The results also suggest that interventions by insurers can even compensate for lack of community-level social capital. It is our hope that this study will motivate local governments to promote community-based strategies for postponement of frailty in community-dwelling older adults.

Authorship contributions

KS conceived the design, performed the statistical analysis, and drafted the manuscript. KK and NK collected the data. TI, RW, NK, IK, and KK revised the manuscript critically. All authors approved the final version of the manuscript. There are no conflicts of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2019.112701.

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