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Social capital and pneumococcal vaccination (PPSV23) in community-dwelling older Japanese: a JAGES multilevel cross-sectional study

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ABSTRACT

Objective Inequalities exist between the 23-valent pneumococcal polysaccharide vaccination (PPSV23) rate in each municipality among Japanese older adults. Exploring individual-level and community-level intervenable factors is necessary to improve the vaccination rates. We examined the associations between community-level and individual-level social capital and the PPSV23 vaccination among older Japanese adults using multilevel Poisson regression analyses.

Design Cross-sectional study.

Setting We used data from the Japan Gerontological Evaluation Study, conducted between 3 October 2016 and 10 January 2017 in 631 districts, 39 municipalities and 18 prefectures.

Participants The target population comprised persons aged 65 years or older who are physically and cognitively independent (that is, not certified as needing long-term care). Further, 180 021 older adults from 39 Japanese municipalities were enrolled.

Primary outcome measure The primary outcome was the PPSV23 vaccination among the Japanese older adults aged 65 years or older who did not have physical or cognitive disabilities.

Results After adjusting for municipality-, community-, individual-levels effects with multiple imputation, 137 075 individuals who participated in one/more of the civic participation (participation of social groups), social cohesion (social tie), or reciprocity (mutual exchange of social support) were significantly associated with more vaccinations than those without the three social capitals among the 137 075 older adults (13.0% (95% CI 11.0% to 14.9%), 5.0% (95% CI 2.4% to 7.6%) or 33.9% (95% CI23.6% to 44.2%) increase, respectively, p>0.001 for all). The rich (≥+1 SD) community-level civic participation was significantly associated with 3.4% increase [95% CI 0.02% to 6.78%, p<0.05] of the PPSV23 vaccination among the older adults compared to those with the poor or standard one.

Conclusions Older adults with one/more of the three social capitals at the both levels received more PPSV23 vaccinations than those without those social capitals. Therefore, fostering of those social capitals may improve the inequality of the PPSV23 vaccination rate among older adults in each municipality.

Strengths and limitations of this study

- ► This is the first study to examine the associations between social capital and the PPSV23 vaccination among older adults aged ≥65 years after adjusting municipality-, community-,and individual-level effects.
- ► Almost 180 000 people aged 65 years or older participated in a large, nationwide population-based study.
- ► While this study had a large sample size, the measurements were self-reported data.
- ► This study was cross-sectional study; therefore, we did not determine causal pathways.

INTRODUCTION

It was estimated that lower respiratory infectious illnesses including pneumonia caused 1 080 958 deaths in older adults aged >70 years worldwide in 2016.[1] *Streptococcus pneumoniae* was the leading cause of morbidity and mortality of the illnesses globally, contributing to 1 189 937 deaths, which were more than all other etiologies combined in 2016.[1] The adult pneumonia study group—Japan estimated that 69.4% of adult pneumonia was occurred in older adults aged ≥65 years annually in Japan and *S. pneumoniae* was the leading bacterial etiological agent as related to 530 000 adult pneumonia cases in multicentre prospective surveillance conducted from September 2011 to January 2013.[2]

The 23-valent pneumococcal polysaccharide vaccination (PPSV23) and the 13-valent pneumococcal conjugate vaccine are effective for preventing pneumonia caused by *S. pneumoniae* strains in older adults aged ≥65 years.[3 4] The following epidemiological determinants have been reported to be associated with coverage of the PPSV23 or the both vaccinations: age,[5 6] sex,[6 7] education,[6 8] income,[9] marital status,[8] household structure,[8] self-rated health,[10] health literacy,[9] smoking,[6] general practitioner,[10] high-risk diseases for pneumonia including diabetes, heart diseases, chronic respiratory

diseases,[6 7] out-of-pocket amounts after subtracting the subsidy of municipalities from the vaccination costs.[11 12]

In Japan, the PPSV23 vaccination (PNEUMOVAX NP, MSD) has been incorporated into a national immunisation programme for adults aged ≥65 years since October 2014. Public subsidies for the PPSV23 vaccination are available in most developed countries, including Japan.[13] In almost all the municipalities in Japan, PPSV23 vaccination payment is partly subsidised by the municipality and the remaining out-of-pocket cost is undertaken by the individual.[14]

Recently, Naito and colleagues estimated that the 5 years cumulative vaccination coverage was 49% across Japan in 2018 since the PPSV23 vaccination was started in 2014 as the national immunisation programme.[15] The immunisation programme is intended for older adults who aged ≥65 years, and those who aged 60–64 and have extremely restricted daily activity due to a disorder in their heart/kidney/respiratory function or immune function because of HIV infection. However, Murakami *et al* reported that there was the remarkable inequality in the PPSV23 vaccination rate (median, 5;95 percentiles of the vaccination rate: 41.8%, 13.6%, and 62.5%) in 1010 Japanese municipalities.[14] Murakami's group also reported that the out-of-pocket cost and the number of direct mail notifications from a municipality were negatively and positively associated, respectively, with the municipality-level PPSV23 vaccination rate.[11] Murakami's reports suggest that municipality-provided subsidies and implementations can improve the PPSV23 vaccination rate among the older adults at the municipality level[11] . However, municipalities may not be able to subsidize or implement the tools for encouraging the PPSV23 vaccination depending on circumstances (e.g. financial reason). Therefore, it is important to pursue individual-level or community-level intervenable factors for improving the vaccination rate among older adults

Social capital is one such factor that has undergone multilevel analyses to examine the contextual effects of group-level social capital in many studies in the field of public health[16–19]. A few reports show associations between individual-, group, or community-level social capital and paediatric vaccinations.[20 21] However, to the best of our knowledge, no study has yet assessed associations between individual-, community-level social capital, and vaccination among older adults. Fostering social capital may improve the inequality in PSSV23 vaccination rate among older adults if social capital is related to the vaccination among them.

We analysed associations between the individual and community-level social capital measures including civic participation (social participation), social cohesion (social tie) and reciprocity (mutual exchange of social support). The three social capital measures have been developed and validated as an instrument to measure community-level social capital based on data derived from older community dwellers in Japan.[17] Besides, the three measures at the two-levels have been most frequently shown to be associated with health-related outcomes among Japanese older adults aged ≥65 years.[16 17 22–27] So, we evaluated whether the three measures of social capital were associated with the PPSV23 vaccination adjusting with municipality, community- and individuallevel effects among community-dwelling older adults aged ≥65 years.

METHODS

Study population

This study had a cross-sectional design and used data from the Japan Gerontological Evaluation Study (JAGES). The JAGES was designed to describe the health status and social determinants of people who are physically and cognitively independent (not certified as needing long-term care). We used the 2016 wave of JAGES, a cross-sectional dataset obtained from self-reported questionnaires mailed to community-dwelling individuals in 39 municipalities. In the 2016 wave, 196, 438 of 279, 661 individuals (70.2%) responded to the survey. After excluding data from older adults who had been certified as needed the long-term care at the survey, those who aged <65 years, and those who did not answer any question at all, the number of participants in the 'JAGES2016' data attributed to 180 021. The questionnaires comprised basic items and eight optional modules. We used data concerning the basic items that included questions about PPSV23 vaccination and three social capital measures. The data were nested in 631 communities essentially based on elementary or junior high school district because a school district reflects a geographical scale wherein older Japanese people can move on foot or bike,[17] and the communities were further nested in the 39 municipalities.

PPSV23 vaccination

The outcome variable was the PPSV23 vaccination in the last 5 years. This was assessed by asking the respondents, 'Did you get a pneumococcal vaccination in the last 5 years? They chose from the following options: (1) no, (2) yes, I used my municipality's subsidy and (3) Yes, but I did not use my municipality's subsidy. We considered the no.2 and 3 as those who received the PPSV23 vaccination.

Measurements of individual- and community-level social capital

To assess community-level social capital, each response was aggregated to the elementary or junior high school distinct. These school districts can be interpreted as units at the community level for the following reasons: First, the district represents a geographical area wherein people can walk easily from home, interact with each other on a daily basis, and organise community activities.[17] Second, previous studies used the district as a unit for the community level to assess the effect of community-level social capital on health outcomes among community-dwelling older adults.[16 17 28] The value of the aggregated responses was scaled so that the effect of a one-unit increase or decrease can be interpreted as the effect of an 1 SD increase or decrease.

Civic participation, social cohesion and reciprocity were evaluated as measurements of individual- and community-level social capital.[16] Civic participation was assessed as participation in the following five social groups: sports groups/clubs, volunteer groups, hobby activity groups, study/cultural groups and groups that conduct activities to teach skills/pass on experiences to others. Individual-level civic participation was scored '1' if respondents participated in any of the five social groups once a month or more often and scored '0' if respondents participated in these social groups less than once a month. Community-level civic participation was determined by summing the participation proportions of the five social groups in each community. Social cohesion was assessed with the following questions: 'Do you think people living in your area can be trusted in general?'; 'Do you think most people in your community aid others?'; and 'How strong is your attachment to your place of residence?'. Individual-level social cohesion was scored '1' if respondents answered 'very' or 'moderately' to at least one of the three questions and scored '0' if respondents did not answer 'very' or 'moderately' to any of the questions. Community-level social cohesion was determined by summing the proportions of those who answered 'very' or 'moderately' to the questions in each community. Reciprocity was assessed with questions related to emotional or instrumental social support as follows: 'Do you have someone who listens to your concerns and complaints?'; 'Do you listen to someone's concerns and complaints?' and 'Do you have someone who looks after you when you are sick for a few days?'. Individual-level reciprocity was scored '1' if respondents answered 'any one or more' to any of the questions and scored '0' if respondents answered 'nobody' to all of the three questions. Community-level reciprocity was determined by summing the proportions of those who answered 'any one or more' to the questions in each community.

Covariates

Age was categorised into two groups: 65–74 years and ≥75 years. Educational attainment was categorised into five groups: <6 years (less than elementary school course completion), 6–9 years (elementary school course completion to middle/completion of junior-high school), 10–12 years (junior high school completion to middle/completion of high school), ≥13 years (middle/completion of university course, or more) and others that varied from these four categories. Equivalised income was calculated by standardising household gross income divided by the square root of the number of household members and was categorised into five groups: <¥0.5 million, ¥0.50–¥0.99 million, ¥1.00–¥1.99 million, ¥2.00–¥3.99 million and ≥¥4.00 million. Marital status was classified into five groups: married, widowed, divorced, never married and others. Household structure was assessed by asking the respondents 'Who do you live with?'. They were asked to choose from the following options: 'no one,' 'spouse,' 'son,' 'daughter,' 'spouse of child,' 'grandchild,' 'brother or sister', 'father,' 'mother,' 'father-in-law,' 'mother-in-law' and 'the other'. The responses were categorised into six households: living alone, living with a spouse, living with offspring, living with a spouse and offspring, living in a three-generation household, and the others. The first five categorisations mirrored the five major households among adults aged ≥65 years in Japan.[29] The longest job that have ever had was assessed by asking the responders 'What is the type of the occupation that you have taken the longest in your life?' and they were asked to choose from the following options: professional/technical, managerial, clerical, sales/service, skilled labour, agriculture, forestry/fisheries, self-employment other than agriculture/forestry/fisheries, the other, I have never had a job.

Statistical analyses

We created the Directed Acyclic Graph (DAG) to identify a Minimal Sufficient Adjustment Sets (MSAS) of the potential confounders for estimating the total effects of social capital on the PSSV23 vaccination. We used an on-line tool, DAGitty V.3.0 (http://www.dagitty.net) to create the DAG. The DAG analysis revealed that the MSAS for estimating the effects were age, sex, education, income, marital status, household structure and municipality (figure 1). The data consisting of the 180 021 participants had missing in most of the characteristics including the PPSV23 vaccination, three social capitals, sex, educational attainment, equivalised income, marital status (online supplemental table 1). For handling the missing data, we performed multiple imputation (MI) among 180 021 participants including the PSSV23 vaccination, the three social capital measures, and all the MSAS except for the community and municipality dummy variables, age, and household structure. There was no missing data in the age, household structure, and municipality dummy variables. The community dummy variable had missing data, however, we did not impute the variable with the MI because the numbers for each community were assigned for convenience only, and there was no relationship between the numbers and the characteristics of the regions, and no regular distribution among them to enable MI. We generated five imputed datasets with MI by Chained Equations method.[30] To meet the assumption that data were missing at random and improve the quality of the imputed values, we included the longest jobs that have ever had and the community dummy variable as auxiliary variables associated with missing data and the PPSV23 vaccination. We confirmed that the two auxiliary variables did not bias on estimating the effects of social capital on the vaccination even if those were included in the estimation (figure 1).

χ^2 test was performed for categorical data. A multilevel Poisson regression model with a random intercept was used to calculate a coefficient and 95% CI as the effect of community- and individual-level social capital measure on the PPSV23 vaccination. Unadjusted coefficient and 95% CI were calculated in multivariate Poisson regression with a fixed

intercept and no covariate adjustment. Only the PPSV23 vaccination variable with quantitative variables after the MI was converted to a binary variable for the Poisson regression analyses. The imputed values <1 were converted to 0, and 1 or more converted to 1. The other imputed variables were not converted for the regression analyses at all. Coefficients and 95% CI were adjusted with the MSAS and the auxiliary variables were also input in the model as the Stef. van Buuren's recommendation.[31] We estimated the effect to social capital on the PSSV23 vaccination from each imputed dataset with combining the results by using Rubin's rules.[32] We performed a sensitivity analysis with the complete data set without missing data in the multilevel Poisson regression same as performed in the imputed data sets. All p values were two tailed and the significance was set at 5%. P values lower than 0.05 were considered statistically significant. We used Stata V.14.1 (Lightstone) for all analyses.

Respondents were informed that participation was voluntary and that returning the self-administered questionnaire would be deemed as consent to participate.

Patient and public involvement

No patients were involved in the development of the research question, study design, or data interpretation in this study.

RESULTS

Table 1 shows the individual- and community-level characteristics of the 180021 older adults who received PPSV23 vaccination and those who did not the vaccination with the MI data sets. A greater percentage of older adults who had individual-level civic participation, social cohesion or reciprocity received the vaccination compared with those without the social capitals. A greater percentage of older adults who had the rich (≥1 SD) of the community-level civic participation or social cohesion received the vaccination compared with the standard (>−1SD, <+1SD) or poor (≤−1SD) of the two social capitals. A greater percentage of the older adults with the standard community-level reciprocity received the vaccination compared with the other two. A greater percentage of adults who were women, aged ≥75 years, had

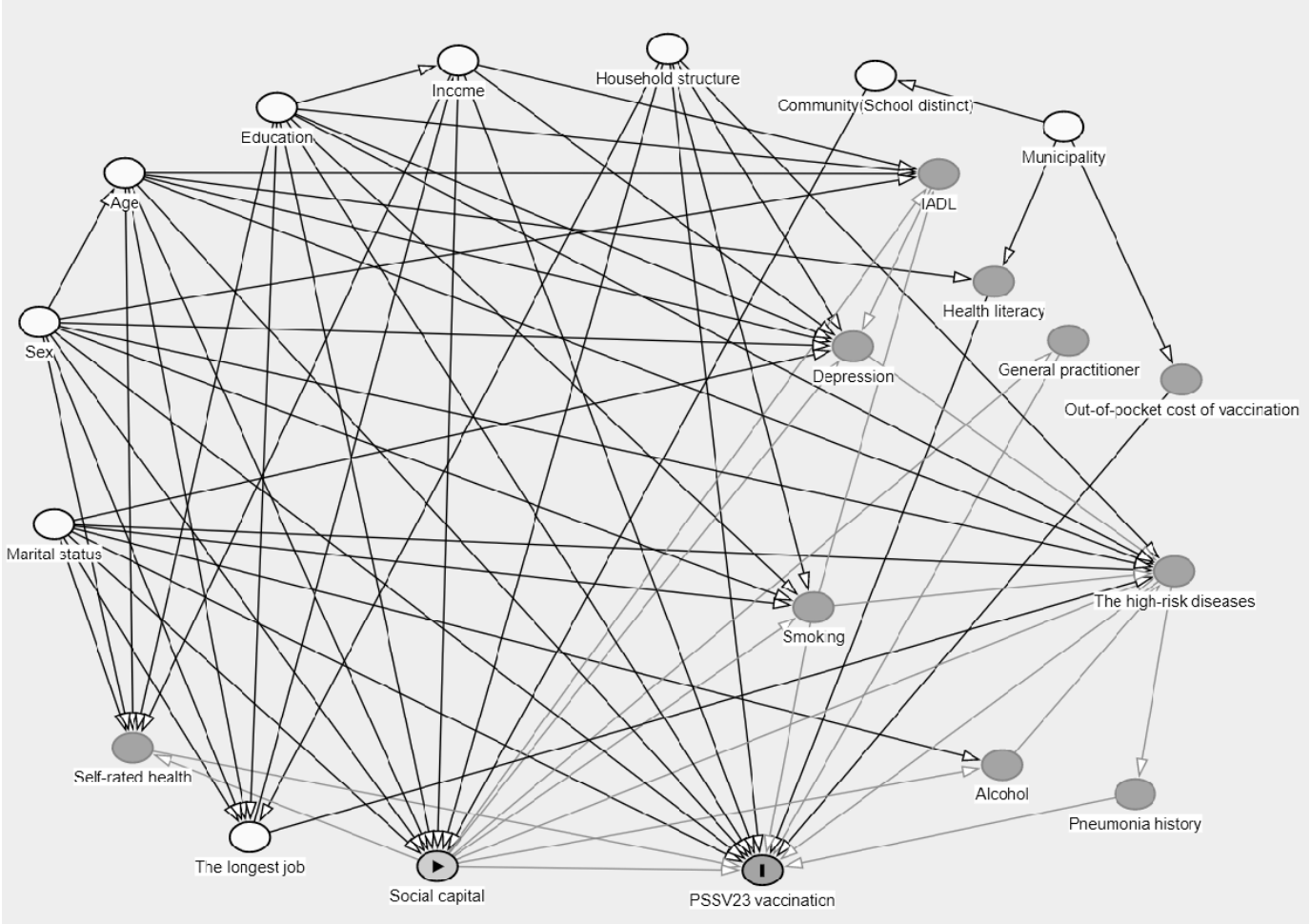

Figure 1 The DAG for estimating effects of social capital on the PPSV23 vaccination. The DAG shows the outcome (the PPSV23 vaccination), the exposure (social capital), the ancestors of the outcome and exposure including the MSAS and the auxiliary variables (white coloured) and ancestors of the outcome (grey coloured). The MSAS consists of age, sex, education, household structure, income, marital status and municipality. The auxiliary variables consist of the longest job and community.[6–11 16 17 24 25 35–41] DAG, Directed Acyclic Graph; MSAS, Minimal Sufficient Adjustment Sets; PPSV23, 23-valent Pneumococcal Polysaccharide Vaccination. IADL, Instrumental Activities of Daily Living

Table 1 Basic characteristics of the community-dwelling older adults aged 65 years and over (N=180 021)

		PPSV23						
		No			Yes			P value*
Individual-level social capital variables		n§	%	SD†	n	%	SD	
Civic participation	No participation	69 876	60.9	42.31	44 878	39.1	24.9	
	Any participation	36 167	55.4	37.50	29 100	44.6	32.3	<0.001
Social cohesion	Not cohesive	16 980	63.3	29.06	9847	36.7	17.2	
	Cohesive	89 063	58.1	34.23	64 131	41.9	45.3	<0.001
Reciprocity	No support	4701	68.2	16.9	2196	31.8	23.2	
	Any support	101 342	58.5	43.3	71 782	41.5	33.2	<0.001
Community-level social capital variables								
Civic participation	>-1SD, <+1SD	80 633	58.7	775.8	56 800	41.3	440.9	
	≥+1SD	8387	55.6	110.0	6703	44.4	72.2	
	≤−1SD	17 063	62.1	790.0	10 435	37.9	397.6	<0.001
Social cohesion	>-1SD, <+1SD	79 353	58.9	589.9	55 314	41.1	235.0	
	≥+1SD	14 267	58.5	320.5	10 125	41.5	139.0	
	≤−1SD	12 453	59.4	275.8	8509	40.6	95.5	<0.001
Reciprocity	>-1SD, <+1SD	84 383	58.5	267.7	59 871	41.5	143.1	
	≥+1SD	12 667	59.4	291.9	8666	40.6	141.6	
	≤−1SD	9023	62.5	241.9	5411	37.5	80.5	<0.001
The other covariates								
Age groups, years	65–74	65 681	65.0	-‡	35 350	35.0	35.0	
	≥75	40 362	51.1	–	38 628	48.9	–	<0.001
Sex	Male	49 720	60.4	19.9	32 556	39.6	21.1	
	Female	56 323	57.6	18.8	41 422	42.4	20.2	<0.001
Educational attainment, years	<6	1291	63.8	8.0	731	36.2	6.6	
	6–9	35 225	60.1	27.1	23 351	39.9	16.2	
	10–12	42 368	58.2	35.5	30 407	41.8	31.7	
	≥13	26 486	58.2	5.4	19 040	41.8	12.0	
	Others	673	60.0	2.1	449	40.0	1.6	<0.001
Equivalised income, million yen	<0.5	6395	58.0	48.3	4630	42.0	23.6	
	0.50–0.99	17 478	58.7	61.1	12 316	41.3	37.8	
	1.00–1.99	37 084	58.5	79.9	26 294	41.5	77.6	
	2.00–3.99	31 736	59.6	48.4	21 530	40.4	87.7	
	≥4.00	13 350	59.2	75.3	9209	40.8	39.8	<0.01
Marital status	Married	75 883	58.7	11.3	53 399	41.3	20.0	
	Widowed	20 052	55.6	7.7	16 007	44.4	18.0	
	Divorced	5464	67.7	8.3	2606	32.3	7.8	
	Never married	3740	70.9	1.2	1538	29.1	3.6	
	Other	904	67.9	0.8	428	32.1	5.7	<0.001
Household structure	Living with a spouse	44 598	58.1	–	32 148	41.9	–	
	By alone	10 952	61.0	–	7014	39.0	–	
	Living with offspring	8048	59.7	–	5441	40.3	–	
	Living with a spouse and offspring	15 802	61.3	–	9981	38.7	–	
	Living in three-generation household	11 529	55.1	–	9406	44.9	–	
	The other house structures	15 115	60.2	–	9987	39.8	–	<0.001

Continued

Table 1 Continued

Individual-level social capital variables		PPSV23 No n§	%	SD†	Yes n	%	SD	P value*
The longest job that have ever had								
	Professional/technical	19910	59.5	51.7	13574	40.5	32.0	
	Managerial	7551	56.1	47.7	5914	43.9	18.2	
	Clerical	18891	55.9	44.9	14923	44.1	18.2	
	Sales/service	20354	61.5	64.3	12759	38.5	52.8	
	Skilled labour	13795	60.0	33.2	9195	40.0	30.5	
	Agriculture, forestry or fisheries	5651	60.5	24.1	3694	39.5	25.6	
	Self-employment other than agriculture, forestry and fisheries	3769	61.1	69.1	2405	38.9	26.1	
	The other	9502	60.2	42.4	6294	39.8	11.0	
	I have never had a job	6622	55.9	24.6	5220	44.1	12.8	<0.001

*χ^2 test was performed for the categorical data.
†SD of the five mutated data sets.
‡No imputed data because of no missing data.
§The numbers were average of the five imputed data sets.
PPSV23, 23-valent pneumococcal polysaccharide vaccination.

higher education, lower equivalised income or widowed received the vaccination compared with those in the other categories. A greater percentage of older adults who lived in a three-generation household received the vaccination than those in the other household structures. A greater percentage of older adults who had ever had clerical or never had a job received the PPSV23 vaccination compared with those who had the other job.

Table 2 shows the associations between individual-, community-level social capital and PPSV23 vaccination among the 137075 community-dwelling older adults after adjusting for all the MSAS and inputting the auxiliary variables. The individual-level civic participation, social cohesion, or reciprocity was significantly associated with 13.0% (95% CI 11.0% to 14.9%), 5.0% (95% CI 2.4% to 7.6%) or 33.9% increase (95% CI 23.6% to 44.2%) of the PPSV23 vaccination among the older adults, respectively. The rich (≥+1 SD) community-level civic participation was significantly associated with 3.4% increase (95% CI 0.02% to 6.78%) of the PPSV23 vaccination among the older adults, although the other two community-level social capital were not significantly associated with the vaccination. We performed a sensitivity analysis with the complete data set and the results was almost same as the one with the imputed data set (online supplemental table 2). The both results showed that the three individual-level social capitals and community-level civic participation were significantly associated with the vaccination (table 2 and online supplemental table 2). At first glance, the estimations of community-level social participation in the imputed data sets and the complete data set look different as the poor (≤−1SD) community-level one was significantly associated with 4.6% decrease (95% CI −8.3% to −0.1%) of the PSSV23 vaccination in the complete data set (online supplemental table 2). However, the two estimates were consistent in that community-level social participation was significantly associated with the vaccination.

DISCUSSION

Inequalities have been shown to exist between the PPSV23 vaccination rate among the older adults.[11 14] We analysed associations between individual-, community-level social capital and the PPSV23 vaccination among community-dwelling older adults aged ≥65 years. After adjusting for all the covariates and inputting the auxiliary variables in the imputed data sets, our analyses showed that one or more individual-level civic participation, social cohesion or reciprocity was significantly associated with a greater likelihood of vaccination among the older adults than those with the lack of these social capitals (table 2). The rich community-level civic participation was associated with more vaccination than the standard or poor social capital among older adults (table 2). These results suggest that older adults with the higher individual-level civic participation, social cohesion or reciprocity receive the PPSV23 vaccination greater than those without these social capitals, and that older adults living in districts with the rich community-level civic participation receive more vaccinations than those living in districts with the standard or poor community-level social capital.

Several groups reported an association between municipality-provided subsidies and the PPSV23 vaccination as ecological studies at the municipality or nation level.[11 12 15]

Table 2 Coefficients and 95% CI of associations between the PSSV23 vaccination and individual-level and community-level social capital among the community-dwelling older adults (N=137 075)

Individual-level social capital variables		Unadjusted coefficient	Unadjusted 95% CI	Adjusted coefficient	Adjusted 95% CI
Civic participation	No participation	Reference	Reference	Reference	Reference
	≥1 participation	**0.136*** **	**0.120 to 0.152**	**0.130*** **	**0.110 to 0.149**
Social cohesion	No social cohesion	Reference	Reference	Reference	Reference
	≥1 social cohesion	**0.089*** **	**0.066 to 0.112**	**0.050*** **	**0.024 to 0.076**
Reciprocity	No reciprocity	Reference	Reference	Reference	Reference
	≥1 reciprocity	**0.457*** **	**0.372 to 0.542**	**0.339*** **	**0.236 to 0.442**
Community-level social capital variables					
Civic participation	**Less than 1 SD difference**	Reference	Reference	Reference	Reference
	≥+1 SD	**0.062*** **	**0.033 to 0.091**	**0.034* **	**0.0002 to 0.068**
	≤ −1 SD	**−0.082*** **	**−0.106 to −0.057**	−0.007	−0.040 to 0.026
Social cohesion	Less than 1 SD difference	Reference	Reference	Reference	Reference
	≥+1 SD	**0.025* **	**0.00004 to 0.049**	−0.022	−0.049 to 0.006
	≤ −1 SD	**0.042** **	**0.017 to 0.067**	0.001	−0.029 to 0.031
Reciprocity	Less than 1 SD difference	Reference	Reference	Reference	Reference
	≥+1 SD	**−0.041*** **	**−0.068 to −0.013**	−0.004	−0.031 to 0.023
	≤ −1 SD	**−0.101*** **	**−0.101 to −0.710**	−0.008	−0.043 to 0.027

The coefficients and 95% CIs were calculated in multivariate Poisson regression with random intercepts and adjusted with the MSAS (age group, sex, educational attainment, equivalised income, marital status, household structure and municipality) together with auxiliary variables (the longest jobs that have ever had and community dummy variable). The municipality and community dummy variables were included in the regression model as the random intercepts (municipality variable: level 3 and community variable: level 2). Unadjusted coefficient and 95% CI were calculated in multivariate Poisson regression with a fixed intercept and no adjustment. We estimated the effect of social capital on the PSSV23 vaccination from each imputed dataset with combining the results by using Rubin's rules. The significant associations are shown in bold.

*P<0.05; **p<0.01; ***p<0.001.

MSAS, Minimal Sufficient Adjustment Sets; PPSV23, 23-Valent Pneumococcal polysaccharide Vaccination.

In contrast, this study was conducted to assess the associations between social capital and the PPSV23 vaccination among Japanese adults aged ≥65 at individual, community and municipality-levels. After adjusting for all the covariates, the individual-level civic participation, social cohesion, reciprocity and community-level civic participation were significantly associated with the PPSV23 vaccination than in the lack of these social capitals (table 2). Our results suggest that fostering individual- and community-level social capital may improve the inequality of the vaccination among older adults. Thereby, recommending a policy to mitigate the inequality of PPSV23 vaccination in municipalities among Japanese older adults.

A few reports show associations between social capital and influenza vaccination among older adults.[33 34] However, these studies solely assessed associations between individual-level social capital and vaccination. Contrastingly, we assessed associations between multilevel (community and individual) social capital and PPSV23 vaccination among older adults (table 2). Our results suggest that both of the individual- and community-level social capitals were associated with the PPSV23 vaccination among older adults. Moreover, our study indicates the importance of such multilevel analyses. However, it is unclear why the three social capitals were associated with higher vaccination receipt, and how the three social capitals were associated with the PPSV23 vaccination among older adults. Future studies should address this issue.

Nawa and Fujiwara recently reported associations between individual and community-level social cohesion and the second dose of measles vaccination among Japanese children.[20] Our results showed that the individual-level social cohesion but not community level's one was significantly associated with PPSV23 vaccination among older adults (table 2). This suggests that the social cohesion had an effect on the two vaccinations similarly but at different levels.

The present study has two strengths. First, to our best knowledge, this is the first study to show associations between the PPSV23 vaccination and individual- or community-level social capital among older adults aged 65 years, although there have been a few studies that showed associations between paediatric vaccinations, individual-, and community-level social capital,[20 21] or associations between influenza

vaccination and only individual-level social capital among older adults.[33 34] Second, our result suggests that the individual- and community-level social capital may be one of intervenable factors which can ameliorate the inequality of the PPSV23 vaccination rates among a large population of community-dwelling older adults.

There are some limitations to our study. First, we only analysed the epidemiological association between social capital and PPSV23 vaccination among older adults; we did not determine causal pathways owing to cross-sectional nature of the data at the survey. Second, our findings cannot be generalised to people who had been certified as needed the long-term care because the participants were limited to those who were physically and cognitively independent. Third, a recall bias may have occurred in the survey for the PPSV23 vaccination. The question asked participants the vaccination status in the last 5years, which they might not have remembered the vaccination if they had got it several years before the survey. The impact of this potential bias is unknown. Forth, we could not analyse the associations between individual-level, community-level social capital and the PSSV23 vaccination among the community-dwelling older adults who information of the school district was missing because we did not perform the MI for the community-dummy variable (see statistical analysis in the 'Methods' section).

CONCLUSION

Individual- and community-level intervenable factors are necessary to improve the inequality of the PPSV23 vaccination among older adults. We assessed associations between individual-, community-level social capitals and the PSSV23 vaccination among community-dwelling older adults aged ≥65 years. Our results show that civic participation, social cohesion or reciprocity at the individual level was associated with the vaccination, and that the rich civic participation at community level was associated with more vaccinations among older adults living in communities than those in communities with the standard or poor social capital. Our findings suggest that older adults with individual- or community-level social capitals receive more vaccinations than those without such social capitals. Therefore, fostering social capital is recommended as a policy to ameliorate the inequality of PPSV23 vaccination among older adults in Japanese municipalities.

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