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Associations of social capital and health at a city with high aging rate and low population density

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ABSTRACT

Maintaining physical and mental health of older people is one of the important issues to be addressed in the aging society. Social capital, defined as the resources available to members of social groups, has recently attracted attention as a factor influencing public health. Most of the previous studies targeted various communities having different aging rates or population densities at once to examine the associations of social capital and health outcomes. However, the results of those studies are not always consistent. Moreover, because few studies have targeted a particular advanced aging society, associations of social capital and health at such societies have remained unknown. This study examined how social capital associates with health at a particular city having a very high aging rate and low population density. We targeted Iwamizawa city, Hokkaido, Japan, which is one of the most advanced aging areas, with an aging rate of 36.6% and a population density of 165/km^2. We analyzed self-administered questionnaire data obtained from "HELLO (HEalth, Lifestyle, and LOcal community of Iwamizawa citizen) Study" in 2018. The sample comprised 1237 individuals aged 65 and older. Following previous studies, we regarded three items—social cohesion, reciprocity, and civic participation—as social capital indices, and targeted two health outcomes: self-rated health (SRH) and degree of depression. Multilevel Poisson regression analyses were used to calculate prevalence ratios (PRs). We found that at the individual-level, the PR (95% confidence interval) of having poor SRH among those with more civic participation was 0.81 (0.71–0.93), and that of being depressed among those with more social cohesion was 0.32 (0.21–0.51), even after adjusting for compositional factors. We also found that the community-level civic participation significantly correlated with aging rate. Our findings indicate that social capital positively associates with older people's health at the advanced aging city.

1. Introduction

Aging population is the global trend. World Health Organization (WHO) has reported that the number and proportion of people aged 60 years and older in the population is increasing. By 2030, the share of the population aged 60 years and over will increase from 1 billion in 2020 to 1.4 billion. By 2050, the world's population of people aged 60 years and older will double, 2.1 billion (WHO, 2021). In Japan, more than 28 percent of the population is over 65 years old, the highest proportion in the world (Ministry of Internal Affairs and Communications, Japan). Population has been declining since 2008, and it has been estimated that by 2040, one in every three people will be 65 or older. This rapidly aging and declining population has a direct impact on economic growth by reducing the labor force. The United Nations Population Division reported that Japan has the highest old-age dependency ratio (OADR), defined as the number of old-age dependents (persons aged 65 years or over) per 100 persons of working age (aged 20–64 years), in the world, with the value of 51 in 2019 (The United Nations, 2019), and it is predicted that the number will reach 81 in 2050. Progress of aging has also put increased financial pressure on older people long-term care services, so that Japan's healthcare policy for elderly has focused not only on providing services but also on preventing long-term care (Ministry of Health, Labour and Welfare, Japan). In addition, declining population has accelerated depopulation of rural areas, and caring living conditions of older people in such areas is important to maintain the physical and mental health of them (Sakamoto et al., 2004). However, health and

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living conditions of older people are not yet well understood.

Several studies have pointed out that social participation and interpersonal interactions are key factors for maintaining the health of older people (Aida et al., 2011; Holt-Lunstad et al., 2010). Growing recognition of the social determinants of health has stimulated research on social capital and health (Campbell, 2019; Ehsan et al., 2019; Rodgers, Valuev, Hswen, & Subramanian, 2019). In the field of public health, social capital is defined as resources that are accessed by individuals as a result of their membership in a network or group (Villalonga-Olives & Kawachi, 2015). As population ages, the relationship between the older people and social capital has been drawing attention because access to social capital could enable them to maintain productive and independent. Studies have pointed out that the availability of social capital within communities will become an important ingredient of successful aging (Cannuscio et al., 2003; Cagney & Wen, 2008). There are two ways of understanding social capital (Kim & Kawachi, 2006). One is considering social capital as individual-level resources that are embedded in the social networks (Giordano & Lindstrom, 2010), and the other is considering it as community-level cohesiveness influencing public health through its contextual effect (Kawachi et al., 1999; Putnam, 2000, pp. 326–335). From both points of view, studies have pointed out that having more social capital can be associated with better health (Moore & Kawachi, 2017; Villalonga-Olives & Kawachi, 2015; Choi et al., 2014; Legh-Jones, H. and Moore, S. 2012; Nyqvist et al., 2014). For example, it is reported that interpersonal trust and civic participation could be determinants of self-rated health (Nieminen et al., 2010; Kawachi et al., 1999; Giordano & Lindstrom, 2010). Associations between social capital and mental health have also been studied, and it is reported that social capital helps prevent mental illness (De Silva, 2006; Fujiwara & Kawachi, 2008; Hamano et al., 2010). However, importantly, there are studies pointing out negative association between social capital and health outcomes (Villalonga-Olives & Kawachi, 2017; Campos-Matos et al., 2016; Takagi et al., 2013). For example, studies in Japan have reported that trust among neighbors might negatively affect the self-rated health of the residents in a Japanese suburban city (Murayama et al., 2012), and that stronger social cohesion increased depressive symptoms for residents whose hometown of origin differed from the communities where they currently resided (Takagi et al., 2013). Thus, the results of previous studies that examined how social capital influences public health are not always consistent, and evidence on how various aspects of social capital affect health outcomes remains unclear (Ehsan et al., 2019). Most of the previous studies targeted various communities across municipalities (Fujihara et al., 2019; Hamano et al., 2010; Saito et al., 2017) or even countries (Campos-Matos et al., 2016) at once. However, to our knowledge, there have not been many studies on social capital and health focusing on a society having the characteristics of advanced aging and depopulation, and associations of social capital and health at such societies have remained unknown.

This study examined how community-level and individual-level social capital are related to older people health at an advancing depopulation city having very high aging rate and low population density. Following previous studies (Saito et al., 2017; Fujihara et al., 2019), we regarded three items—social cohesion, reciprocity, and civic participation—as social capital indices. Social cohesion and reciprocity are called cognitive social capital referring to trust in others and reciprocity between individuals, respectively, while civic participation is called structural social capital referring to participation in a society (Harpham, 2008). These two kinds of social capital may differentially affect health outcome as pointed out in previous studies (De Silva, 2006; Saito et al., 2017; Fujihara et al., 2019). We targeted two health outcomes, self-rated health (SRH) and degree of depression, which are valid predictors of mortality regardless of other medical, behavioral, or psychosocial factors (Idler & Benyamini, 1997; Royall et al., 2007), and examined whether associations exist with social capital.

2. Methods

2.1. Data

We targeted Iwamizawa city, Hokkaido, Japan, which is one of the most advanced aging and depopulation areas in the country, with an aging rate of 36.6% and a population density of 165/km^2. The data were obtained from "HELLO (HEalth, Lifestyle, and LOcal community of Iwamizawa citizen) Study 2018." The study was designed to survey the awareness of health and living conditions of citizens and intended to be used to develop health promoting policies. The city is divided in 10 junior high school districts (Table 1). Between August and October, a total of 9947 residents (14.3% of the population) aged from 18 to 103 were randomly selected and mailed a self-administered questionnaire which included items on social capital and health outcomes. A total of 3161 people responded (response rate, 31.8%). Although social capital could be evaluated at various levels of aggregations, such as municipality, prefecture, and country levels, we selected the junior high school districts as the unit of community in this study for the following reasons pointed out in the previous studies (Fujihara et al., 2019; Saito et al., 2017). First, older people can easily traverse such districts on foot or by bicycle, and the activities of community organizations are conducted within the districts. Second, using junior high school districts as the sampling unit, we could evaluate regional variability. Third, it is the smallest area size in which we could maintain sufficient precision of the aggregated information, in terms of the number of samples within each community. We excluded a community (District 6 in Table 1) due to the small number of participants there (only 21 responses), and 1476 responses of people less than 65 years old because they were not asked to respond to items related to social capital. We further excluded 427 participants having missing values for any of health outcomes and social capital indices. Thus, the final participants consisted of 1237 valid responses from people living in 9 communities. A flow diagram of the study subjects selection process is shown in Fig. 1.

2.2. Measures

We selected three social capital indices—social cohesion, reciprocity, and civic participation— which were derived from data obtained in the Japan Gerontological Evaluation Study (JAGES) (Fujihara et al., 2019; Koyama et al., 2016; Saito et al., 2017). These have been used to study the relationship between social capital and health of older people in Japan. Social cohesion, an index of cognitive social capital, was assessed using the following questions: "Would you say that people in your local area can be trusted?" "Would you say that people in your local area can be helpful for others?" "Do you have an attachment to your local area?" The questions were rated on a 5-point scale, from "1: yes, very much" to "5: no, not at all." We then dichotomized the responses as 1 if they were "1: yes, very much" or "2: yes," and 0 otherwise to calculate a score raging from 0.0 to 2.4 (Saito et al., 2017).

Reciprocity, another index of cognitive social capital, was assessed by the following questions: "How many family members or relatives do you have whom you meet or talk to at least once a month?" "How many family members or relatives do you have whom you can comfortably talk to on private issues?" "How many family members or relatives do you have whom you can ask any help intimately?" "How many friends do you have whom you can comfortably talk to on private issues?" "How many friends do you have whom you can ask any help intimately?" "How many friends do you have whom you meet or talk to at least once a month?" The responses were "1: none," "2: one," "3: two," "4: three or four," "5: five to eight," and "6: nine or more." We then calculated the abbreviated Lubben Social Network Scale (LSNS-6) ranging from 6 to 36, which is used worldwide to measure social isolation in elderly individuals (Lubben et al., 2006).

Civic participation, an index of structural social capital, was assessed by asking the respondents the following questions: "Do you participate

Table 1
Demographics of 10 junior high school districts and survey participants.

District	Population	Selected		Responded						Average Age	SD
		Total	%	Total	%	Male	%	Female	%		
1	3825	527	13.8	184	34.9	86	46.7	98	53.3	65.2	16.6
2	16,305	2390	14.7	782	32.7	321	41.0	461	59.0	60.9	18.1
3	2943	462	15.7	174	37.7	82	47.1	92	52.9	63.8	17.0
4	8624	1202	13.9	325	27.0	147	45.2	178	54.8	61.5	16.1
5	11,890	1701	14.3	483	28.4	205	42.4	278	57.6	59.9	17.5
6	460	56	12.2	21	37.5	10	47.6	11	52.4	69.0	13.6
7	6088	880	14.5	290	33.0	142	49.0	148	51.0	65.1	15.4
8	2233	298	13.3	118	39.6	52	44.1	66	55.9	64.1	15.1
9	7762	1062	13.7	359	33.8	173	48.2	186	51.8	62.6	16.2
10	9516	1369	14.4	425	31.0	192	45.2	233	54.8	64.2	15.8
Total	69,646	9947	14.3	3161	31.8	1410	44.6	1751	55.4	62.4	16.9

SD: Standard Deviation. The population of Iwamizawa at the time of the survey was 69,646. A total of 9947 residents aged from 18 to 103 were randomly selected and mailed a self-administered questionnaire, and 3161 people responded. District 6 was excluded due to the small number of participants in the analyses.

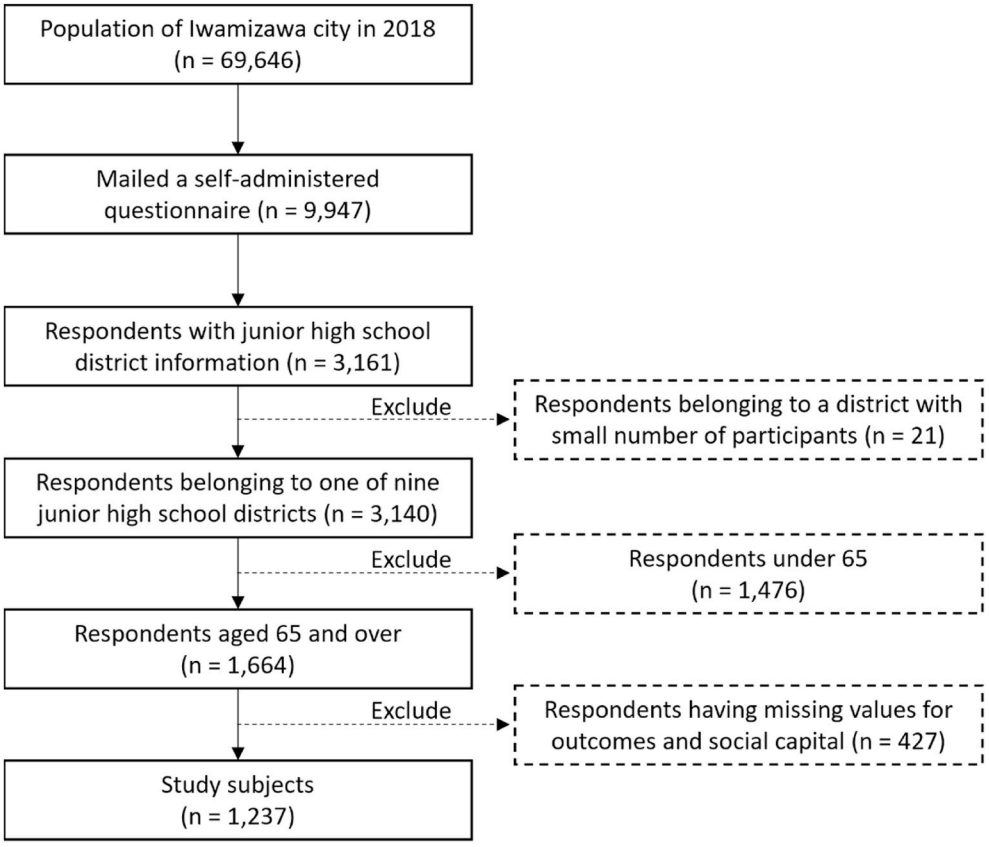

Fig. 1. Flow diagram for study subjects selection.

in any local festivals or events?" "Are you active in neighbourhood association?" "Can you take care of people as the organizer in neighbourhood associations or in any group activities?" "Do you do any volunteer activities?" The responses were scored 1 or 0 if they were "yes" or "no," respectively, and used to calculate a score raging from 0 to 4 following the Japan Science and Technology Agency Index of Competence (JST-IC) (Iwasa et al., 2015, 2018).

To consider the contextual effect of social capital, we aggregated individual response to the community level (Kawachi et al., 2008; Hamano et al., 2010) after dichotomizing the responses (Fujihara et al., 2019). That is, for social cohesion, we dichotomized the response as "yes" if there was at least one "1: yes, very much" or "2: yes" for the three questions, and "no" otherwise. For reciprocity, the response was dichotomized as "yes" if the number of people was one or more for at least one of the six questions, and "no" otherwise. For civic participation, we dichotomized the response as "yes" if there was "yes" answer for at least one of the four questions, and "no" otherwise. We then calculated the percentage of respondents in the "yes" category for the three social capital indices to define community-level social cohesion, reciprocity, and civic participation for each community.

The outcome variable SRH was assessed using the following question: "How do you feel about your recent health condition?" The responses were "excellent," "good," "fair," or "poor." The response was dichotomized as "good" if it was "excellent" or "good" and as "poor" if it was "fair" or "poor" (Saito et al., 2017).

The other health-related outcome, the degree of depression, was assessed using the Patient Health Questionnaire-9 (PHQ-9) that was developed as a self-administered questionnaire to evaluate the degree of

depression (Kroenke et al., 2001). The respondents were asked the following question regarding nine depressive symptoms: "How often have you suffered the following symptoms? 1: unable to enjoy things, 2: being nervous, 3: unable to sleep well or sleep too much, 4: feel tired, 5: have no appetite or overeat, 6: feel inferior, 7: have difficulty concentrating on reading newspapers or watching TV, 8: your motion became slow or restless enough that others may notice, 9: thought you should die or tried to hurt yourself." As a severity measure the PHQ-9 score can range from 0 to 27, since each of the nine items can be scored from 0 (never) to 3 (nearly every day). We then dichotomized the responses as "depressed" if the PHQ-9 score was $\geq$10 and otherwise as "not depressed" (Kroenke et al., 2001).

Potential confounding factors included demographic variables, health status, and behavior. Following previous studies that explored social determinants of health (Campos-Matos et al., 2016; Fujihara et al., 2019; Hamano et al., 2010; Nakaya et al., 2014), these variables included age (65–69, 70–74, 75–79, 80–84, or $\geq$ 85), sex, smoking habit (never-, ex-, or current-smoker), alcohol drinking (never-, ex-, or current-drinker), educational attainment (years $\leq$9 (junior high school), 10–12 (high school), 13–14 (two-year college), or 15 $\leq$ (university or higher)), working (yes/no), medical history (yes/no for cancer, cerebral cardiovascular diseases (CVD), hypertension, diabetes, depression), physical activity (categorized as low-, moderate-, and high-activity following the short version of the International Physical Activity Questionnaire (IPAQ) based on the responses for "vigorous activity such as carrying heavy baggage, climbing a slope by bicycle, jogging, or playing tennis," "moderate activity such as carrying light baggage, playing tag with kids, or swimming slowly," and "keeping on walking continuously more than 10 min"), and marital status (married, widowed, divorced, or never married).

2.3. Statistical analysis

Subjects with poor SRH were not uncommon, 285 of 1237 (23.0%), so the odds ratio derived from the logistic regression was unable to approximate the prevalence ratio (Barros & Hirakata, 2003; Zhang & Yu, 1998). Therefore, multilevel Poisson regression analysis was used to examine the associations between social capital and health outcomes. The prevalence ratios (PRs) of being in poor health were calculated with 95% confidence intervals (CIs).

We first evaluated the community-level disparities of health outcomes using two-level Poisson regression models with no predictors ("null" models) for each health outcome. Then, three models were sequentially fitted. Model 1 incorporated community-level social capital measures to assess the contextual effect without adjustment. Model 2 added individual-level social capital measures. This model examined the existence of association between individual-level and/or community-level social capital and health outcomes without adjustment. Model 3 added variables of compositional factors: age, sex, smoking habit, alcohol drinking, educational attainment, working, medical history, frequency of physical activity, and marital status. The model assessed whether community-level and individual-level social capital associate with health outcomes after adjusting for compositional factors. We calculated the Variance Inflation Factors (VIF) for each variable included in the models and confirmed that most of the values were less than 2.0 (maximum 2.9) and there was no multicollinearity between the variables. Missing values in predictor variables were dealt with multiple imputation method (Multivariate Imputation by Chained Equations) in the analyses. Community level variance σ^2 was reported for each model. All statistical analyses were performed using R version 4.0.2.

3. Results

Table 2 provides descriptive statistics for individual-level variables used in the models. The average age was 74.4 (standard deviation (SD) was 7.0), and the number decreases with age. At the individual level, those with poor SRH and being depressed had significantly lower scores for each of the three social capital indices. For social cohesion, the average scores were 1.7 for those with good SRH and 1.6 for those with poor SRH ($p < 0.005$), and 1.7 for those who were not depressed and 1.2 for those depressed ($p < 0.001$). For reciprocity, the average scores were 20.8 for those with good SRH and 18.4 for those with poor SRH ($p < 0.001$), and 20.5 for those who were not depressed and 17.4 for those depressed ($p < 0.001$). For civic participation, the average scores were 1.9 for those with good SRH and 1.0 for those with poor SRH ($p < 0.001$), and 1.7 for those who were not depressed and 1.0 for those depressed ($p < 0.001$). The percentages of being poor SRH and depressed increased with age. Never- and ex-drinkers compared to current-drinkers, those in the "no" category for working compared to those in the "yes" category, those with low and moderate physical activities compared to those with high activities, and those in the "yes" category of medical history for cancer compared to those in the "no" category reported poor SRH with higher percentages. Females compared to males, current-smokers compared to never- and ex-smokers, those who graduated only junior high school compared to those with other educational background, and those in the "yes" category of medical history for CVD compared to those in the "no" category reported that they were depressed with higher percentages.

Table 3 shows descriptive statistics for community-level social capital and correlation coefficients between aging rate, population density, and population of community. The percentage of reporting "yes" categories for social cohesion, reciprocity, and civic participation were shown. The community-level civic participation was significantly correlated with aging rate positively, and negatively with population density and population.

Table 4 shows the results of the multilevel Poisson regression analyses. For SRH, the null model, which had no predictors, showed very small community-level variation, $\sigma^2 = 0.006$, indicating almost no community-level disparity of the health outcome. Community-level social capital, added on all the models, had no significant association with the individual-level health outcome. Model 2 found that individual-level reciprocity and civic participation significantly associated with poor SRH (PR = 0.97, 95% CI: 0.95–0.99 and PR = 0.76, 95% CI: 0.69–0.84, respectively). In Model 3, we still found significant association between individual-level civic participation and poor SRH (PR = 0.81, 95% CI: 0.71–0.93) even after adjusting for compositional factors.

For the degree of depression, the null model showed that there is a community-level disparity ($\sigma^2 = 0.047$). Adding community-level social capital reduced the variance drastically ($\sigma^2 < 0.001$, Model 1). As in SRH, community-level social capital, added on all the models, had no significant association with the individual-level health outcome. Model 2 found that individual-level social cohesion, reciprocity, and civic participation significantly associated with degree of depression (PR (95% CI) = 0.62 (0.49–0.79), 0.95 (0.92–0.99), and 0.78 (0.65–0.93), respectively). In Model 3, we still found significant association between individual-level social cohesion and depression (PR = 0.32, 95% CI: 0.21–0.51) even after adjusting for compositional factors.

4. Discussion

This study examined whether associations exist between social capital and health outcomes at an advanced aging city that has very high aging rate and low population density in Japan. To our knowledge, there have not been many studies on social capital and health focusing on such a society having the characteristics of advanced aging and depopulation. The data showed significant positive associations between individual-level social capital and health outcomes. Though community-level social capital did not associate with individual health directly, we found that community-level civic participation was significantly lower in communities with lower aging rates and higher population densities.

At the individual level, those with poor SRH and being depressed had significantly lower scores for each three social capital indices. Our

Table 2
Descriptive statistics of individual-level variables.

Individual-Level (n = 1237)	SRH				Depression				Total	
	Good (n = 952)		Poor (n = 285)		Not Depressed (n = 1153)		Depressed (n = 84)			
	n	%	n	%	n	%	n	%	n	%
Age										
65–69	322	84.1	61	15.9	367	95.8	16	4.2	383	31.0
70–74	253	80.8	60	19.2	296	94.6	17	5.4	313	25.3
75–79	201	77.0	60	23.0	243	93.1	18	6.9	261	21.1
80–84	103	69.1	46	30.9	135	90.6	14	9.4	149	12.0
85≤	73	55.7	58	44.3	112	85.5	19	14.5	131	10.6
Sex										
Male	463	77.0	138	23.0	570	94.8	31	5.2	601	48.6
Female	489	76.9	147	23.1	583	91.7	53	8.3	636	51.4
Smoking Habit										
Never	699	78.1	196	21.9	837	93.5	58	6.5	895	72.4
Ex	104	72.2	40	27.8	135	93.8	9	6.3	144	11.6
Current	92	72.4	35	27.6	115	90.6	12	9.4	127	10.3
Missing Value	57	80.3	14	19.7	66	93.0	5	7.0	71	5.7
Alcohol Drinking										
Never	346	72.7	130	27.3	441	92.6	35	7.4	476	38.5
Ex	87	63.0	51	37.0	126	91.3	12	8.7	138	11.2
Current	421	84.2	79	15.8	475	95.0	25	5.0	500	40.4
Missing Value	98	79.7	25	20.3	111	90.2	12	9.8	123	9.9
Education										
Junior High School	174	71.9	68	28.1	213	88.0	29	12.0	242	19.6
High School	498	80.5	121	19.5	588	95.0	31	5.0	619	50.0
Two-Year College	113	77.9	32	22.1	138	95.2	7	4.8	145	11.7
University or Higher	142	74.7	48	25.3	179	94.2	11	5.8	190	15.4
Missing Value	25	61.0	16	39.0	35	85.4	6	14.6	41	3.3
Working										
No	671	74.0	236	26.0	845	93.2	62	6.8	907	73.3
Yes	261	88.8	33	11.2	279	94.9	15	5.1	294	23.8
Missing Value	20	55.6	16	44.4	29	80.6	7	19.4	36	2.9
Medical History										
Cancer										
No	436	82.7	91	17.3	499	94.7	28	5.3	527	42.6
Yes	389	70.5	163	29.5	511	92.6	41	7.4	552	44.6
Missing Value	127	80.4	31	19.6	143	90.5	15	9.5	158	12.8
CVD										
No	766	77.8	219	22.2	926	94.0	59	6.0	985	79.6
Yes	59	62.8	35	37.2	84	89.4	10	10.6	94	7.6
Missing Value	127	80.4	31	19.6	143	90.5	15	9.5	158	12.8
Hypertension										
No	685	77.9	194	22.1	822	93.5	57	6.5	879	71.0
Yes	140	70.0	60	30.0	188	94.0	12	6.0	200	16.2
Missing Value	127	80.4	31	19.6	143	90.5	15	9.5	158	12.8
Diabetes										
No	787	77.5	229	22.5	953	93.8	63	6.2	1016	82.1
Yes	38	60.3	25	39.7	57	90.5	6	9.5	63	5.1
Missing Value	127	80.4	31	19.6	143	90.5	15	9.5	158	12.8
Depression										
No	819	76.8	248	23.2	999	93.6	68	6.4	1067	86.2
Yes	6	50.0	6	50.0	11	91.7	1	8.3	12	1.0
Missing Value	127	80.4	31	19.6	143	90.5	15	9.5	158	12.8
Physical Activity										
Low	323	76.9	97	23.1	394	93.8	26	6.2	420	34.0
Moderate	177	77.0	53	23.0	222	96.5	8	3.5	230	18.6
High	351	85.6	59	14.4	391	95.4	19	4.6	410	33.1
Missing Value	101	57.1	76	42.9	146	82.5	31	17.5	177	14.3
Marital Status										
Married	680	80.0	170	20.0	803	94.5	47	5.5	850	68.7
Widowed	179	72.5	68	27.5	224	90.7	23	9.3	247	20.0
Divorced	28	66.7	14	33.3	38	90.5	4	9.5	42	3.4
Never Married	31	66.0	16	34.0	42	89.4	5	10.6	47	3.8
Missing Value	34	66.7	17	33.3	46	90.2	5	9.8	51	4.1
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)		
Social Cohesion	1.7	(0.8)	1.6	(0.9)	1.7	(0.8)	1.2	(1.0)		
Reciprocity	20.8	(5.8)	18.4	(5.7)	20.5	(5.8)	17.4	(5.7)		
Civic Participation	1.9	(1.5)	1.0	(1.3)	1.7	(1.5)	1.0	(1.3)		

SD: Standard Deviation, CVD: Cerebral Cardiovascular Disease. Missing values in predictor variables were dealt with multiple imputation method in the analyses. CVD includes stroke, myocardial infarction, and angina pectoris.

Table 3
Descriptive statistics of community-level social capital indices and correlation coefficients between demographics of community.

Community-Level (n = 9)	Median (min–max)	Correlation Coefficients		
		Aging Rate	Population Density	Population
Social Cohesion	89.8 (82.8–95.0)	0.37	−0.31	−0.30
Reciprocity	99.3 (96.2–100.0)	−0.37	0.15	0.05
Civic Participation	69.5 (60.3–80.0)	**0.67***	**−0.86****	**−0.93****

*p < 0.05, **p < 0.01.

findings also show that individuals having more civic participation have decreased prevalence of having poor SRH (PR = 0.81, 95% CI: 071.–0.93), and those having more social cohesion have decreased prevalence of being depressed (PR = 0.32, 95% CI: 0.21–0.51) even after adjusting for compositional factors (Model 3). In Model 2, we found that other social capital indices also significantly associated with the health outcomes. These results are in line with previous studies reporting that individual-level cognitive social capital as well as structural social capital were positively associated with self-rated health and mental health (Nieminen et al., 2010; Giordano & Lindstrom, 2010).

We observed little community-level disparity in SRH, and community-level social capital had no contextual effect on the health outcome. We found that individual-level structural social capital, measured by civic participation, significantly associated with SRH, while cognitive social capital, measured by social cohesion, did not. This is in line with the results of some previous studies on the relationship among trust, social capital, and health targeting Japanese society (Aida et al., 2011; Yamagishi & Yamagishi, 1994; Carpiano & Fitterer, 2014). Those studies pointed out that Japanese respondents see more utility rather than trust in dealing with others through personal relations, and this may have resulted in no significant associations between cognitive social capital and health. In contrast, many previous studies conducted in the US or Europe reported that SRH was associated with trust (Nieminen et al., 2010; Kawachi et al., 1999; Giordano & Lindstrom, 2010). Our result might reflect the characteristics of Japanese communities, which might have closer social ties but lower generalized trust (Yamagishi & Yamagishi, 1994).

The drastic decrease of community-level variances σ^2 of degree of depression in Model 1 indicates that the disparity between communities can be explained by differences in the community-level social capital. However, community-level social capital, added on all the models, had no significant association with the individual-level health outcome. These indicate that though community-level social capital may associate with community-level degree of depression, it does not with individual-level directly. We found that individual-level social cohesion positively associated with the health outcome even after adjusting for the compositional factors (Model 3). This finding is consistent with some previous studies reporting that cognitive social capital, measured by trust, is positively associated with mental health (De Silva, 2006; Hamano et al., 2010). Model 2 found that not only social cohesion but also reciprocity and civic participation significantly associated with degree of depression. This indicates that social participation and interpersonal interactions among people significantly associated with their degree of depression.

We found no contextual effect of community-level social capital on either SRH or degree of depression. However, previous studies have pointed out that community-level social capital did impact SRH or mental health (Hamano et al., 2010; Kim et al., 2011). These studies selected larger or smaller size of areas, country or neighbourhood, as a unit of community, while in the present study, we selected junior high school district as a unit of community. Selecting different sizes and numbers of communities may result in different associations between community-level social capital and health. As a study suggested that smaller area social capital might be more important for individual health (Snelgrove et al., 2009), we need further studies clarifying the association between community-level social capital and health.

Regarding civic participation, 69.5% of respondents reported that they are in the "yes" category. This percentage is much higher than those reported in previous studies we followed (Fujihara et al., 2019; Saito et al., 2017). The difference could be caused by the fact that we focused on an advanced aging society with depopulation while these previous studies targeted a much larger number of individuals from various municipalities in Japan. Saito et al. targeted 123,760 people aged 65 years or older selected from 30 municipalities, and Fujihara et al. targeted 30,587 people from 24 municipalities. This higher percentage of civic participation indicates that contrary to our possible beliefs that older people tend to be socially isolated in an advanced aging society like that of Iwamizawa city, they might actively participate in any neighbourhood activities and have more interpersonal interactions. This voluntary belonging to and active participation in neighbourhood associations could be a reason why we did not observe negative associations between social capital and health outcomes. If people feel any burden or suffer from a sense of duty, such as the need to attend meetings regularly or to assume managerial or supervisory roles in neighbourhood associations, in other words, if membership in such associations is less voluntary, social capital might fail to present its positive association with health (De Silva, 2006; Villalonga-Olives & Kawachi, 2017; Campos-Matos et al., 2016; Takagi et al., 2013).

We found significant correlations between community-level civic participation and aging rate, population density, and population

Table 4
Estimated prevalence ratios from multilevel Poisson analysis.

	Poor SRH						**Depressed**					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	PR	(95% CI)	PR	(95% CI)	PR	(95% CI)	PR	(95% CI)	PR	(95% CI)	PR	(95% CI)
Community-Level												
Social Cohesion	1.05	(0.98–1.11)	1.06	(0.99–1.12)	1.09	(0.10–1.20)	1.01	(0.95–1.18)	1.08	(0.97–1.20)	1.11	(0.91–1.34)
Reciprocity	0.96	(0.80–1.15)	0.96	(0.79–1.16)	0.93	(0.67–1.29)	0.78	(0.59–1.04)	0.81	(0.60–1.09)	0.66	(0.36–1.19)
Civic Participation	0.98	(0.96–1.01)	0.99	(0.97–1.01)	0.98	(0.95–1.02)	0.97	(0.93–1.01)	0.98	(0.94–1.12)	1.00	(0.92–1.08)
Individual-Level												
Social Cohesion			0.94	(0.82–1.08)	0.85	(0.70–1.04)			**0.62****	(0.49–0.79)	**0.32****	(0.21–0.51)
Reciprocity			**0.97****	(0.95–0.99)	0.99	(0.96–1.02)			**0.95***	(0.92–0.99)	0.97	(0.91–1.03)
Civic Participation			**0.76****	(0.69–0.84)	**0.81****	(0.71–0.93)			**0.78****	(0.65–0.93)	1.00	(0.75–1.33)
Community-Level Variance σ^2	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	

PR: Prevalence Ratio, CI: Confidence Interval, SRH: Self-Rated Health. *p < 0.05, **p < 0.01. Community-level variances σ^2 of null models for SRH and depression were 0.006 and 0.047, respectively. Missing values in predictor variables were dealt with multiple imputation method in the analyses.

(Table 3). This indicates that older people living in communities with lower aging rates and higher population densities have lower civic participation. In other words, older people living in the central area of Iwamizawa tend to be socially isolated and have little interpersonal interaction, while those in a non-central area might communicate well with each other. This is the opposite what we might have expected, as in the central area many services are readily available, people have many opportunities to get out of their homes and meet other people, and people can easily get any information including health-related topics. Our finding is in line with a previous study reporting that community age and degree of urbanization were associated with many of the social capital indicators (Hanibuchi et al., 2012). In terms of developing social capital interventions for public health, it has been very difficult to design feasible policies (Villalonga-Olives et al., 2018). For example, a study has reported that though promoting social capital among older people significantly reduced their loneliness and decreased their depressive symptoms, it failed to change their SRH (Coll-Planas et al., 2017). It has, however, been suggested that community-based health promotion programs focused on increasing social interactions among older adults could be effective in preventing the onset of disability (Hikichi et al., 2015). Moreover, based on the association between population density of communities and all-cause mortality at the community level, it has also been suggested that health promotion policies should direct interventions towards reducing mortality in densely populated neighbourhoods (Nakaya et al., 2014). Our data showed that individual-level civic participation positively associated with individual health, though community-level social capital did not directly. We think that interventions that increase the community-level civic participation of older people living in densely populated communities on a priority basis could promote individual-level civic participation and result in enhancing individual health.

Our study has several limitations. First, its cross-sectional design might have resulted in reverse causality of the association between social capital and health. That is, the individuals with better health status might have shown more civic participation or social cohesion, rather than the other way round. To verify the causality, further studies, including the coming follow-up survey on health and living conditions must be required. Second, both our outcome variables and social capital variables were self-reported. This would lead to possible biases such as social desirability. Moreover, since the survey was conducted via mail, there may have been people who could not respond for various health-related reasons. That is, the study sample could be made up of a relatively healthy group. It is necessary to develop a method for more easily measuring anyone's social capital quantitatively. We could make use of smartphone and social networking service (SNS) data to measure social capital (Bae, 2019; Choi, 2019). If the interest is on measuring social capital in closed groups, such as those in nursing homes or at any events of neighbourhood associations, wearable technologies, which can capture face-to-face interaction quantitatively, could be applied (Watanabe et al., 2014). Third, our data contained not very large numbers of individual and community samples. Especially, relatively low response rate of the survey (31.8%) might have caused a selection bias, and data collected could be insufficient to infer the older people health conditions. To exclude the selection bias, we should redesign the questionnaire to be easier to respond, let the residents know more about the survey before delivering the questionnaire, give them any incentives (e.g., coupons) to motivate them to respond the survey, and then conduct additional survey at Iwamizawa to confirm our results.

5. Conclusion

We examined the relationship between social capital and health of older people at an advanced aging city having a very high aging rate and low population density. The strength of our study is the finding indicating that social capital could be a social determinant of older people health in the advanced aging society with depopulation. This could help develop community-based interventions to promote social interactions and enhance the health of older people living in advanced aging societies.

Author contributions

Conceived and designed the experiments: TK, AT. Performed the experiments: TK, AT. Analyzed the data: JW, TK. Contributed to materials and analysis tools: TK, AT, TN, DS, TT. Wrote the paper: JW. All authors approved the final version of the manuscript.

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Ethical statement

The respondents were advised that participation in the study was voluntary and that completing and returning the self-administered questionnaire indicated consent to participation in the study. This study was approved by the internal review board of Research & Development Group of Hitachi, Ltd., and that of Faculty of Medicine, Hokkaido University. All procedures were in line with the Declaration of Helsinki in its latest version.

Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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