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Community-level social capital and subsequent health and well-being among older adults in Japan: An outcome-wide longitudinal approach

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ABSTRACT

There is inconsistent evidence on the association between community-level social capital and the health or well-being of older adults. This study examined the association between community-level social capital and multidimensional health and well-being outcomes using an outcome-wide approach. We used data from the Japan Gerontological Evaluation Study, a nationwide cohort study of Japanese older adults (analytic samples: 47,227 for outcomes obtained from the long-term care insurance registry and 34,183 for other outcomes). We assessed three aspects of school-district-level community social capital in 2016 (civic participation, social cohesion, and reciprocity) and 41 subsequent health and well-being outcomes through 2019. We performed either a modified multilevel Poisson regression or a multilevel logistic regression analysis. We adjusted for pre-baseline characteristics, prior outcome values, and individual-level social capital from the 2013 wave. Even after Bonferroni correction, we found that community-level social capital was associated with some subsequent social well-being and physical/cognitive health. For example, community-level reciprocity was associated with a higher prevalence of taking a social role (Prevalence ratio [PR] = 1.03, 95% confidence interval [CI] = 1.02, 1.04) and undergoing health screening (PR = 1.03, 95% CI: 1.01, 1.04). There was modest evidence that community-level civic participation was associated with a higher competency of intellectual activity (PR = 1.01, 95% CI: 1.01, 1.02) and community-level social cohesion was associated with a reduced onset of functional disability (PR = 0.94, 95% CI: 0.90, 0.98). Community-level social capital may promote social well-being and some physical/cognitive health outcomes.

1. Introduction

Maintaining and improving health and well-being among older adults are critical public health issues (Zuidberg et al., 2020). Well-being is a complex concept encompassing many domains, and health is an essential aspect of well-being (Centers for Disease Control and Prevention, 2018; VanderWeele, 2017a). Although health and well-being are inherently multidimensional, existing empirical studies, including those in the field of public health, have examined a limited range of outcomes (e.g., a single disease) and failed to capture a holistic picture of the exposure effect on broad well-being (VanderWeele, 2017a). Evaluating one's health based only on the presence/absence of disease or disability might underestimate the human capacity to cope autonomously with the physical, emotional, and social challenges of life: highlighting a disease might label people with chronic diseases and disabilities as definitively ill (Huber et al., 2011). Therefore, it is necessary to capture health and well-being among older adults from a holistic perspective, which includes social health and other aspects (e.g., eudaimonic well-being, such as purpose in life) (Ryff et al., 2021). To this end, scholars have introduced the concept of human flourishing—a state in which all aspects of a person's life are good. This concept comprises the following five domains of human well-being: 1) happiness and life satisfaction, 2) mental

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and physical health, 3) meaning and purpose, 4) character and virtue, and 5) close social relationships. Human flourishing is a broader more comprehensive concept than psychological well-being, unique in that it includes health and virtue as components of well-being (VanderWeele, 2017a).

Social capital has been studied as a factor that affects multidimensional health and well-being among older adults, both positively and negatively (Kawachi and Berkman, 2014). Social capital is defined as "resources that are accessed by individuals as a result of their membership of a network or a group" (Kawachi and Berkman, 2014). Conceptually, social capital encompasses both individual- and community-level attributes. Individual-level social capital involves an egocentric social network, whereas community-level social capital reflects contextual effects derived from a membership of community (Kawachi and Subramanian, 2006). It is crucial to study community-level social capital because it can affect population health, regardless of individual-level social capital (Kawachi et al., 2008). Despite its potential health benefits, community-level social capital can also be detrimental to individuals' health through several pathways (e.g., excess claims on group members, such as peer pressure) (Portes, 1998; Amemiya et al., 2019; Haseda et al., 2018). Previous empirical studies have reported mixed results regarding the relationship between community-level social capital and health/well-being. In these studies, the aforementioned appeared beneficial for physical health and well-being (Murayama et al., 2012; Nyqvist et al., 2013; Rodgers et al., 2019), but to adversely impact risk behaviors and self-rated health (Villalonga-Olives and Kawachi, 2017). Mental health such as depression was both positively and negatively affected by community-level social capital (Ehsan and Silva, 2015; Villalonga-Olives and Kawachi, 2017). Essentially, community-level social capital may have differential and potentially conflicting effects across outcomes. Therefore, it is necessary to holistically examine how community-level social capital affects a broad range of health and well-being outcomes.

Although the results are mixed across studies examining different health and well-being outcomes, the comparison of results across such studies remains challenging owing to differences in the following aspects: 1) study design (cross-sectional vs. longitudinal), 2) study population, 3) number and types of confounding factors, and 4) methods for measuring exposure (Kim et al., 2020). Some studies measure community-level social capital in terms of perceptions of social capital, such as trust in the community (Young et al., 2004), whereas others measure structural social capital, such as the number of elections attended (Sundquist et al., 2014). Moreover, community-level social capital has heterogeneous effects based on gender and socioeconomic status (Uphoff et al., 2013). The impact of community-level social capital on the improvement of long-term care varies depending on the gender and social participation status of individuals (Amemiya et al., 2019).

To address the abovementioned gaps, we adopted an outcome-wide approach to examine the association between community-level social capital and health/well-being outcomes using a large longitudinal dataset of community-dwelling older adults in Japan. The health and well-being outcomes were assessed using five domains and 41 health and well-being outcomes based on the human flourishing framework (VanderWeele, 2017a). The outcome-wide approach enabled us to understand the association between community-level social capital and well-being from a holistic perspective (Vanderweele, 2017b). This approach also enabled us to assess the potentially differential effects of community-level social capital across outcomes by standardizing the following aspects: 1) study design, 2) study population, 3) covariates, and 4) exposure (VanderWeele et al., 2020). We also investigated the heterogeneous effects of community-level social capital on health and well-being according to individual socio-demographic characteristics, including gender and socioeconomic status (SES).

2. Methods

2.1. Study population

Data were obtained from the Japan Gerontological Evaluation Study (JAGES), a nationwide survey involving Japanese older adults aged 65 years and above (Kondo and Rosenberg, 2018). In this study, self-administered questionnaires were mailed to older adults without functional disabilities (i.e., those not certified as requiring public long-term care). We used data obtained from the 2013, 2016, and 2019 JAGES surveys. The participants were selected from 26 municipalities (n = 178,201). In the 14 large municipalities, the respondents selected in the previous wave (2010) through a multi-stage random sampling approach based on their officially registered residents and newly randomly sampled participants were selected. On the other hand, in the 12 small municipalities, all eligible individuals were included. The participants responded to the questionnaires in the 2013 survey (n = 126,474; response rate = 71.0%). In 2016, a follow-up survey was conducted (n = 79,049; follow-up rate: 62.5%). Exposure was community-level social capital, assessed in the 2016 survey. We obtained two analytical samples by linking these 79,049 individuals to the second follow-up wave of the survey in 2019 (n = 34,183) or to the public long-term care insurance (LTCI) registry, including information on the onset of death, dementia, and functional disability between 2016 and 2019 (n = 47,227) (Supplemental methods). Outcomes were assessed using the 2019 survey or the public LTCI registry. Respondents who provided inconsistent answers regarding age or gender, height, or weight between surveys were excluded (n = 2635). Items for the loneliness measure, one of our outcomes, were available only in the submodule questionnaire in 2019 which was distributed to a randomly selected 12.5% of the participants in 21 follow-up municipalities (n = 21,010) and responded to by 15,054 individuals. In the final analytical sample, respondents who received and answered the 2019 submodule questionnaire including the loneliness sample were 4384. Items for ikigai (ikigai is broadly defined as "what makes life worth living", originates from Japanese culture and is widely accepted within it [Mathews, 1996]), another outcome variable in this study, were available only in the submodule questionnaire in 2013, which was distributed to a randomly selected 12.5% of the participants (n = 35,888) and responded to by 24,383 individuals. In the final analytical sample, respondents who received and answered the 2013 submodule questionnaire including ikigai were 6832.

2.2. Measures

2.2.1. Community-level social capital

Our exposure of interest was community social capital in 2016, defined at the school district level. We used a scale that was previously developed and validated using the JAGES data (Saito et al., 2017) and assessed three components of community social capital: civic participation, social cohesion, and reciprocity. Community-level social capital was calculated by aggregating the responses of individuals who participated in the 2013 and 2016 surveys. We focused on the school district as a geographical unit for the following four reasons: 1) This scale was validated using it as the geographic unit, 2) it is a daily living area for many older adults, 3) it often represents the socio-geographic area of a former village, and community activities such as senior citizens' clubs, agricultural cooperatives, and local festivals are organized within each district, 4) it represents the smallest geographic unit where we could maintain adequate precision of aggregated information, based on the sample size within each community (Saito et al., 2017; Noguchi et al., 2019; Ministry of HealthLabor and Welfare, 2017).

Civic participation reflects the structural dimensions of social capital (Islam et al., 2006). Community-level civic participation was defined as a measure of social participation in five groups (hobby, sports, volunteering, study or cultural groups, and activities to teach skills or pass on

experiences to others). Community-level civic participation was assessed by summing the proportions of individuals participating in each group by school district (score range: 0–5). Individual-level participation in each group was defined as participation once a month or more (versus participation less than once a month or never).

Social cohesion reflects subjective attitudes, such as trust, perception of others' intentions to help, and attachment within the community. Community-level social cohesion was assessed by summing the proportions of individuals who answered "very" or "moderately" to the following three items: community trust ("Do you think that people living in your area can be trusted, in general?), perception of others' intentions to help ("Do you think that people living in your area try to help others in most situations?), and attachment to the residential area ("How attached are you to the area where you live?") (score range: 0–3). We defined individual-level social cohesion as the responses of each individual to community trust, perception of others' intentions to help, and attachment to a residential area.

Community-level reciprocity reflects the aspect of community social capital that facilitates the exchange of individual social support. Community-level reciprocity was assessed by summing the proportions of individuals who answered "yes" to each of the following three items: receiving emotional support ("Do you have someone who listens to your concerns and complaints?"), providing emotional support ("Do you listen to someone's concerns and complaints?"), and receiving instrumental support ("Do you have someone who looks after you when you are sick and confined to a bed for a few days?) (score range: 0–3). We defined individual-level reciprocity as the responses of each individual to receiving emotional support, providing emotional support, and receiving instrumental support. The details of each item and option are listed in Supplementary Table S1. All the community-level social capital was standardized, and a one-unit change in the exposure corresponded to 1-SD change across the three social capital domains.

2.2.2. Outcome variables

We chose 41 outcomes based on the multidimensional concept of human flourishing as a framework (VanderWeele, 2017a) and referred to previous studies (Nakagomi et al., 2022, 2023; Okuzono et al., 2022).

We examined outcomes including dimensions of 1) physical/cognitive, and mental health (no natural remaining teeth, self-rated health, instrumental independence, intellectual activity, body mass index (BMI), self-reported chronic diseases (hypertension, diabetes, dyslipidemia, stroke, heart disease, respiratory disease), depressive symptoms, hopeless, loneliness, death, dementia, and functional disability (any levels; level 2 or above), 2) subjective well-being (happiness, life satisfaction, and ikigai), 3) social well-being (participation in hobby, sports, senior, learning or cultural groups, community trust, perception of others' intentions to help, attachment to the residential area, higher frequency of meeting friends, number of friends seen within a month, receiving emotional social support/instrumental social support, and social roles), 4) pro-social/altruistic behaviors (participation in volunteer groups and activities to teach skills or pass on experiences to others), and 5) health behavior (current smoking/drinking status, eating vegetables and fruit, longer walking time, housebound [lower frequency of going out], and health screening). Outcomes from the LTCI registry (death, dementia, and functional disability) were assessed for outcome incidence during the 3-year follow-up period (from 2016 and through 2019). Other outcomes were assessed in the 2019 survey—three years later from the baseline wave. In this study, all outcomes were converted into binary values because some continuous variables were not normally distributed, and making it easier to interpret the estimated associations. Supplementary Table S1 shows further details about each outcome.

2.2.3. Covariates

We adjusted for individual socio-demographic and community-level factors as potential confounders. All covariates were taken from the pre-baseline wave (the 2013 survey), which ensured the temporal order between the covariates and community social capital exposure and helped mitigate the risk of adjusting for potential mediators (VanderWeele et al., 2020).

Individual-level socio-demographic factors included age (continuous), gender (men or women), employment (current worker versus non-worker), years of education ($<$ high school [9 years or less] versus $\geq$ high school [ten years or more]), and equivalized household income ($<$2 million yen or $\geq$ 2 million yen), with reference to previous studies (Murata et al., 2008; Haseda et al., 2018). They also included marital status (married, single, or others), living alone or not, and ADL (dependent or independent; whether the patient receives care or assistance for walking, bathing, or toileting in their daily life). Community-level variables included population density (rural; $<$1000 people/km2, suburban; 1000–1500 people/km2, urban; $>$1500 people/km2) (Koyama et al., 2016; Noguchi et al., 2019, 2022).

To reduce the possibility of reverse causation, we also controlled for the pre-baseline values of all outcomes in 2013, except for death and three other outcomes for which pre-baseline data were unavailable (dementia, functional disability, and loneliness).

The target of our effect estimates was the contextual effects of community-level social capital. Therefore, individual responses in 2013 were adjusted to remove compositional effects. Items of pre-baseline individual social capital included the outcomes in 2013, except for perceived emotional support.

2.3. Statistical analysis

We used an outcome-wide analytical approach that enabled the holistic assessment of the impact of a single exposure on a range of outcomes (VanderWeele, 2017b). The data included individuals (first level) nested in 672 school districts for the panel data and 449 school districts for the LTCI-based registry (second level). There were no large differences between the two analytic samples on the distribution of community-level social capital (Supplementary Table S2).

We assessed each outcome in separate multilevel regression models, assuming the random intercepts for school districts and adjusting for all covariates. We conducted multilevel modified Poisson regression for non-rare binary outcomes (Zou, 2004) with a prevalence of $\geq$10%. We conducted multilevel logistic regression for rare binary outcomes with a prevalence of $<$10%. Modified Poisson regression estimates the prevalence ratios, whereas logistic regression for rare outcomes estimates the odds ratios approximating the prevalence ratios. To account for multiple testing, we used Bonferroni correction in which we divided the usual significance levels of the test (0.05) by the number of tests and determined the more conservative p-value threshold for Bonferroni adjustment as $\alpha = 0.0012$ (0.05/41).

Additionally, to assess the heterogeneity of the effects of social capital across demographics, we conducted a subgroup analysis based on gender and SES. We defined low SES as reporting both low education (9 years or less) and low equivalized income (2 million yen/year or less) in 2013. We defined high SES as others (either high education [ten years or more] or high equivalized income [$>$2 million yen/year]), following previous research in Japan (Murata et al., 2008; Haseda et al., 2018; Okuzono et al., 2022). We used the same significance levels described above ($\alpha = 0.0012$ [0.05/41]).

We adopted multiple imputations under the missing at random assumption. After generating ten imputed datasets, we performed the above analyses using each dataset and combined the effect estimations across imputations.

We performed three sensitivity analyses. First, the analyses were performed on respondents who answered at two time points (2013 and 2016 surveys: n = 76,414) because the respondents who could respond to the entire three-wave survey included many healthy people who survived for six years and could answer a similar questionnaire three times, which may have caused bias. Non-responses to questions and outcomes of persons who did not participate in the 2019 survey were

imputed. Second, we used different categories for years of education (<6, 6–9, 10–12 or ≥ 13 years) and income (continuous) to assess the differences in outcomes resulting from changes in sociodemographic factor divisions. Third, to evaluate the robustness of the observed associations to unadjusted confounding, we calculated the E-value for each exposure-outcome association. E-value quantifies the minimum strength of the association on the risk ratio scale that an unmeasured confounder would need to have with both the exposure and outcomes above and beyond the adjusted covariate to explain away the observed association (VanderWeele and Ding, 2017). All analyses were performed using STATA, version 17.0 (STATA Corp LLC, College Station, Texas, USA).

3. Results

The analytical samples included 34,183 individuals (17,702 women and 16,481 men) from 672 school districts in 21 municipalities for the 2019 survey and 47,227 individuals (25,630 women and 21,597 men) from 449 school districts in 19 municipalities for the LTCI registry (Fig. 1).

Table 1 shows the pre-baseline characteristics and prior outcome values of the respondents of the study sample linked to the 2019 survey (n = 34,183). Participants' mean age was 72.0 (SD = 4.9), and 51.8% were female. Similar trends were found for the pre-baseline characteristics and prior outcomes of the study sample linked to the LTCI registry (n = 47,277), the sample that received and answered the 2013 submodule questionnaire including ikigai (n = 6832), and those who received and answered the 2019 submodule questionnaire including loneliness (n = 4384) (Supplementary Table S3).

Table 2 shows the estimated associations between the baseline community social capital exposures and each outcome after adjusting for pre-baseline confounders. Higher community-level civic participation was associated with higher prevalence of participation in the hobby group (Prevalence ratio [PR] = 1.035, 95% confidence interval [CI]: 1.021, 1.050), sports group (PR = 1.047, 95% CI: 1.031, 1.063), learning or cultural group (Odds ratio [OR] = 1.104, 95% CI: 1.049, 1.154), and volunteering (PR = 1.064, 95% CI: 1.039, 1.090) and was associated with a lower risk of death (OR = 0.906, 95% CI: 0.862, 0.953). Higher community-level social cohesion was associated with higher levels of community trust at the individual level (PR = 1.027, 95% CI: 1.020, 1.033), perception of others' intentions to help (PR = 1.041, 95% CI: 1.031, 1.051), and attachment to the residential area (PR = 1.016, 95% CI: 1.010, 1.021). Individuals who lived in communities with higher levels of reciprocity were more likely to receive instrumental social support (PR = 1.122, 95% CI: 1.068, 1.178), health screening (PR = 1.025, 95% CI: 1.013, 1.036), and to take on social roles (OR = 1.030, 95 % CI: 1.018, 1.041). After the Bonferroni correction, these associations remained below the statistically significant threshold (α < 0.05/41).

We also found modest evidence of several other exposure-outcome associations in some aspects of well-being, such as physical/cognitive health, social well-being, and health behavior. First, higher community-level civic participation was associated with the prevalence of instrumental independence (OR = 1.055, 95% CI: 1.006, 1.106), having competency in intellectual activity (PR = 1.011, 95% CI: 1.004, 1.018), and participation in activities to teach skills or pass on experiences to others (OR = 1.088, 95% CI: 1.031, 1.148) as well as lower prevalence of currently smoking (OR = 0.922, 95% CI: 0.855, 0.994) and taking social roles (PR = 0.982, 95% CI: 0.970, 0.995). Second, higher community-level social cohesion was associated with lower prevalence of no natural teeth remaining (OR = 0.916, 95% CI: 0.851, 0.987), self-reported diabetes (PR = 0.975, 95% CI: 0.957, 0.995), functional disability of both any levels (PR = 0.941, 95% CI: 0.904, 0.979) and level 2 or above (OR = 0.919, 95% CI: 0.864, 0.977), having competency in intellectual activity (PR = 0.992, 95% CI: 0.984, 1.000), and being housebound (lower frequency of going out) (OR = 0.915, 95% CI: 0.848, 0.987). Third, higher community-level reciprocity was associated with higher levels of the frequency of eating vegetables and fruits (PR = 1.005, 95% CI: 1.001, 1.010), lower prevalence of participating in volunteering (PR = 0.974, 95% CI: 0.952, 0.990), and feeling attachment to the residential area (PR = 0.995, 95% CI: 0.991, 0.999). However, after the Bonferroni correction, these associations were not below the threshold (α < 0.05/41).

There was little evidence of an association between community-level social capital and mental health. For example, we did not observe clear evidence of the associations between depressive symptoms and community-level civic participation (PR = 1.001, 95% CI: 0.982, 1.020),

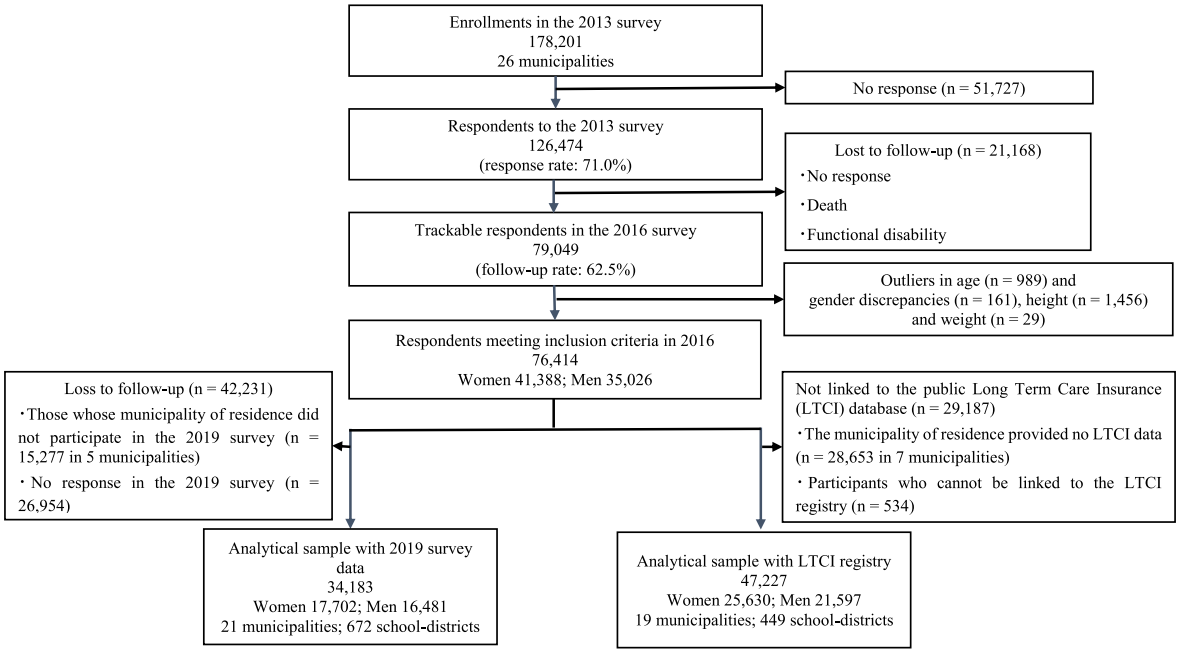


Fig. 1. Flow of sample selection (n = 34,183 in 21 municipalities for the outcomes in the 2019 survey and n = 47,277 in 19 municipalities for the outcomes based on the long-term care insurance registry).

Table 1
Pre-baseline characteristics and prior outcomes in 2013 stratified by gender of the analytical sample linked to the 2019 survey (n = 34,183).

	Overall (n = 34,183)	Women (n = 17,702)	Men (n = 16,481)
Characteristic			
Age, mean (SD)	71.99 (4.90)	71.93 (4.86)	72.06 (4.95)
Education, n (%)			
≤9 years	10,795 (31.58)	6246 (35.28)	4549 (27.60)
≥10 years	22,973 (67.21)	11,221 (63.39)	11,752 (71.31)
missing	415 (1.21)	235 (1.33)	180 (1.09)
Household income, n (%)			
>2 million yen	13,378 (39.14)	7012 (39.61)	6366 (38.63)
≤2 million yen	16,277 (47.62)	7719 (43.61)	8558 (51.93)
missing	4528 (13.25)	2971 (16.78)	1557 (9.45)
Marital status, n (%)			
widowed/divorced/single/others	7520 (22.00)	5777 (32.63)	1743 (10.58)
married	26,258 (76.82)	11,660 (65.87)	14,598 (88.57)
missing	405 (1.18)	265 (1.50)	140 (0.85)
Employment, n (%)			
non-worker	23,474 (68.67)	12,771 (72.14)	10,703 (64.94)
Current worker	8559 (25.04)	3422 (19.33)	5137 (31.17)
missing	2150 (6.29)	1509 (8.52)	641 (3.89)
Living with someone, n (%)			
no	4573 (13.38)	3205 (18.11)	1368 (8.30)
yes	28,304 (82.80)	13,702 (77.40)	14,602 (88.60)
missing	1306 (3.82)	795 (4.49)	511 (3.10)
Activities of daily living, n (%)			
dependent	253 (0.74)	143 (0.81)	110 (0.67)
independent	32,976 (96.47)	17,058 (96.36)	15,918 (96.58)
missing	954 (2.79)	501 (2.83)	453 (2.75)
Prior outcomes			
1. Physical/cognitive and mental health			
No natural teeth remaining, n (%)	2135 (6.25)	1001 (5.65)	1134 (6.88)
missing	781 (2.28)	491 (2.77)	290 (1.76)
Good self-rated health, n (%)	29,718 (86.94)	15,484 (87.47)	14,234 (86.37)
missing	793 (2.32)	466 (2.63)	327 (1.98)
Normal BMI, n (%)	24,515 (71.72)	12,720 (71.86)	11,795 (71.57)
missing	375 (1.10)	240 (1.36)	135 (0.82)
Instrumental independence, n (%)	29,656 (86.76)	16,697 (94.32)	12,959 (78.63)
missing	561 (1.64)	253 (1.43)	308 (1.87)
Having competency in intellectual activity, n (%)	25,865 (75.67)	13,723 (77.52)	12,142 (73.67)
missing	729 (2.13)	438 (2.47)	291 (1.77)
Self-reported hypertension, n (%)	14,230 (41.63)	7039 (39.76)	7191 (43.63)
missing	2193 (6.42)	1255 (7.09)	938 (5.69)
Self-reported diabetes, n (%)	3841 (11.24)	1429 (8.07)	2412 (14.64)
missing	2193 (6.42)	1255 (7.09)	938 (5.69)
Self-reported dyslipidemia, n (%)	4911 (14.37)	2996 (16.92)	1915 (11.62)
missing	2193 (6.42)	1255 (7.09)	938 (5.69)
Self-reported stroke, n (%)	738 (2.16)	220 (1.24)	518 (3.14)
missing	2193 (6.42)	1255 (7.09)	938 (5.69)
Self-reported heart disease, n (%)	2968 (8.68)	1036 (5.85)	1932 (11.72)
missing	2193 (6.42)	1255 (7.09)	938 (5.69)
Self-reported respiratory disease, n (%)	1376 (4.03)	646 (3.65)	730 (4.43)
missing	2193 (6.42)	1255 (7.09)	938 (5.69)
Depressive symptoms (GDS), n (%)	5811 (17.00)	2866 (16.19)	2945 (17.87)
missing	4595 (13.44)	2988 (16.88)	1607 (9.75)
Hopeless, n (%)	4369 (12.78)	2198 (12.42)	2171 (13.17)
missing	742 (2.17)	480 (2.71)	262 (1.59)
2. Subjective well-being			
High happiness level, n (%)	8520 (24.92)	5029 (28.41)	3491 (21.18)
missing	688 (2.01)	465 (2.63)	223 (1.35)
Life satisfaction, n (%)	28,729 (84.04)	15,055 (85.05)	13,674 (82.97)
missing	531 (1.55)	318 (1.80)	213 (1.29)
3. Social well-being			
Participation in a hobby group, n (%)	12,236 (35.80)	7384 (41.71)	4852 (29.44)
missing	4036 (11.81)	2279 (12.87)	1757 (10.66)
Participation in sports group, n (%)	9823 (28.74)	5556 (31.39)	4267 (25.89)
missing	4380 (12.81)	2598 (14.68)	1782 (10.81)
Participation in learning or cultural group, n (%)	3666 (10.72)	2484 (14.03)	1182 (7.17)
missing	4591 (13.43)	2676 (15.12)	1915 (11.62)
Participation in the senior group, n (%)	2575 (7.53)	1438 (8.12)	1137 (6.90)
missing	4251 (12.44)	2452 (13.85)	1799 (10.92)
Higher levels of community trust, n (%)	24,348 (71.23)	12,339 (69.70)	12,009 (72.87)
missing	527 (1.54)	305 (1.72)	222 (1.35)
Perception of others' intentions to help, n (%)	18,034 (52.76)	9343 (52.78)	8691 (52.73)
missing	706 (2.07)	429 (2.42)	277 (1.68)
Attachment to the resident area, n (%)	27,598 (80.74)	14,212 (80.28)	13,386 (81.22)
missing	443 (1.30)	258 (1.46)	185 (1.12)

(*continued on next page*)

Table 1 (*continued*)

	Overall (n = 34,183)	Women (n = 17,702)	Men (n = 16,481)
Receiving emotional social support, n (%)	32,161 (94.08)	17,171 (97.00)	14,990 (90.95)
missing	541 (1.58)	235 (1.33)	306 (1.86)
Receiving instrumental social support, n (%)	32,306 (94.51)	16,664 (94.14)	15,642 (94.91)
missing	533 (1.56)	326 (1.84)	207 (1.26)
Higher frequency of meeting friends, n (%)	12,846 (37.58)	7739 (43.72)	5107 (30.99)
missing	1154 (3.38)	699 (3.95)	455 (2.76)
A large number of friends seen within a month, n (%)	13,600 (39.79)	7584 (42.84)	6016 (36.50)
missing	1122 (3.28)	658 (3.72)	464 (2.82)
Taking on social roles, n (%)	19,690 (57.60)	11,631 (65.70)	8059 (48.90)
missing	821 (2.40)	475 (2.68)	346 (2.10)
4. Pro-social/altruistic behaviors			
Volunteering, n (%)	4552 (13.32)	2403 (13.57)	2149 (13.04)
missing	4770 (13.95)	2820 (15.93)	1950 (11.83)
Sharing skills and experience, n (%)	2182 (6.38)	1230 (6.95)	952 (5.78)
missing	4612 (13.49)	2700 (15.25)	1912 (11.60)
5. Health behavior			
Current smoking status, n (%)	3088 (9.03)	541 (3.06)	2547 (15.45)
missing	380 (1.11)	214 (1.21)	166 (1.01)
Current drinking status, n (%)	13,796 (40.36)	3431 (19.38)	10,365 (62.89)
missing	368 (1.08)	205 (1.16)	163 (0.99)
Higher levels of eating vegetables and fruits, n (%)	27,819 (81.38)	15,420 (87.11)	15,420 (75.23)
missing	178 (1.01)	178 (1.01)	203 (1.23)
Longer walking time, n (%)	27,314 (79.27)	14,032 (79.27)	13,282 (80.59)
missing	455 (1.33)	266 (1.50)	189 (1.15)
Housebound (lower frequency of going out), n (%)	513 (1.50)	246 (1.39)	267 (1.62)
missing	374 (1.09)	181 (1.02)	193 (1.17)
Receiving health screening, n (%)	22,290 (65.21)	11,514 (65.04)	10,776 (65.38)
missing	625 (1.83)	384 (2.17)	241 (1.46)

Abbreviations: SD, standard deviation; BMI, Body Mass Index; GDS, Geriatric depression scale.
See Supplementary Table S1 for the definition of outcome and exposure variables.

community-level social cohesion (PR = 0.993, 95% CI: 0.973, 1.013), and community-level reciprocity (PR = 1.004, 95% CI: 0.987, 1.018).

When conducting a subgroup analysis based on gender, the results were generally similar between men and women for most outcomes. However, there was some modest evidence of effect modification based on gender (Supplementary Table S4). For example, higher community-level civic participation was associated with a lower prevalence of taking on social roles among men but not among women (P for interaction <0.001). Higher community-level social cohesion was more clearly associated with higher prevalence of currently smoking among women than men (P for interaction = 0.040). Additionally, we found some modest effect modifications of SES between community-level social capital and some social well-being outcomes, although this was not clear (Supplementary Table S5). For example, for the low SES group, the effect sizes of the association between community-level civic participation and participation in hobby and sports groups were larger than those for the high SES group.

In the sensitivity analyses, we used data from those who responded to only the 2013 and 2016 surveys (n = 76,414) and imputed the outcomes in 2019. No substantial differences in demographics were found compared with the analytical sample, who answered all the 2013, 2016, and 2019 surveys (Supplementary Table S6). These results were also similar to the main results obtained using data from individuals who responded to the three waves (Supplementary Table S7). Similar results were also obtained in models with different years of education and income categories (Supplementary Table S8). Moreover, the E-values showed some robustness in the observed associations between community-level social capital and subsequent health and well-being. For example, to explain the observed association between community-level reciprocity and taking on social roles, an unmeasured confounder needs to be associated with both exposure and outcomes, after controlling for the adjusted covariates, by a risk ratio of 1.204-fold each and by a risk ratio of 1.153-fold to shift the CI to include the null value (Table 3).

4. Discussion

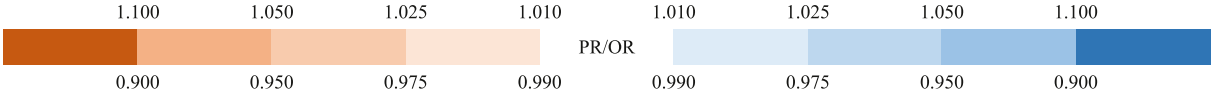
To the best of our knowledge, this is the first study to examine the associations between community-level social capital and multidimensional health and well-being using an outcome-wide longitudinal design. This study has four main findings. First, community-level social capital is associated with certain dimensions of human well-being, including physical/cognitive health and health behavior. However, the observed associations were modest or mixed, according to the outcomes and dimensions of social capital. For example, community-level civic participation was positively associated with lower risk of death and higher competency in intellectual activity, whereas community-level social cohesion was negatively associated with lower competency in intellectual activity. Second, we found that higher community-level civic participation, social cohesion, and reciprocity were associated with several positive aspects of subsequent social well-being and pro-social/altruistic behaviors according to the subtypes of social capital. Third, there was little evidence of an association between community-level social capital, mental health, and subjective well-being. Finally, there was a modest effect modification based on gender and SES on the association between community-level social capital and social well-being, whereas the exposure-outcome associations were comparable across groups for most outcomes.

Some of our results are consistent with the trends from previous studies, but there are some differences. This might be due to methodological differences from other studies, including 1) study design, 2) measurement of community-level social capital, 3) number and types of covariates controlled, 4) sample composition, and 5) adjustments for all the pre-baseline outcomes. Previous studies have shown that social capital has protective effects on mental health, subjective well-being, and health behaviors, such as alcohol use (De Silva et al., 2005; Ehsan and Silva, 2015; Nyqvist et al., 2013; Bryden et al., 2013). However, these results were not observed in this study, possibly due to the study design. A previous systematic review showed that community (ecological)-level social capital was associated with a reduced risk of common mental disorders in a cross-sectional study. However, no longitudinal

Table 2
Association between community-level social capital and subsequent health and well-being in 2019.

	Community-level social capital					
	Civic participation		Social cohesion		Reciprocity	
	RR	(95%CI:PR) [95%CI:OR]	RR	(95%CI:PR) [95%CI:OR]	RR	(95%CI:PR) [95%CI:OR]
1. Physical/cognitive and mental health						
No natural teeth remaining	0.973	[0.892, 1.062]	0.916*	[0.851, 0.987]	1.028	[0.961, 1.099]
Self-rated health	1.002	(0.998, 1.007)	1.003	(0.999, 1.008)	0.999	(0.995,1.003)
BMI	0.992	(0.977, 1.007)	1.004	(0.988, 1.020)	0.998	(0.986,1.011)
Instrumental independence	1.055*	[1.006, 1.106]	0.991	[0.945, 1.039]	1.003	[0.958, 1.050]
Having competency in Intellectual activity	1.011**	(1.004, 1.018)	0.992*	(0.985, 1.000)	1.003	(0.997,1.010)
Self-reported hypertension	0.992	(0.982, 1.003)	1.006	(0.996, 1.016)	1.006	(0.998, 1.015)
Self-reported diabetes	1.011	(0.990, 1.032)	0.975*	(0.957, 0.995)	1.012	(0.994, 1.030)
Self-reported dyslipidemia	1.024	(0.998, 1.050)	0.998	(0.972, 1.024)	1.001	(0.979, 1.024)
Self-reported stroke	1.001	[0.906, 1.105]	0.931	[0.839, 1.033]	1.041	[0.959, 1.129]
Self-reported heart disease	0.991	(0.964, 1.018)	0.990	(0.964, 1.017)	1.007	(0.982, 1.033)
Self-reported respiratory disease	1.016	[0.958, 1.078]	1.001	[0.943, 1.063]	0.984	[0.931, 1.039]
Depressive symptoms	1.001	(0.982, 1.020)	0.993	(0.973, 1.013)	1.002	(0.987, 1.018)
Hopeless	0.986	(0.959, 1.013)	0.998	(0.970, 1.028)	1.000	(0.978, 1.023)
Loneliness	0.985	(0.941, 1.030)	1.003	(0.965, 1.043)	1.004	(0.971, 1.038)
Death	0.906***	[0.862, 0.953]	1.004	[0.952, 1.059]	0.997	[0.948, 1.048]
Dementia	0.955	[0.848, 1.075]	0.935	[0.834, 1.048]	1.020	[0.910, 1.143]
Functional disability (any level)	1.014	(0.975, 1.054)	0.941**	(0.904, 0.979)	0.994	(0.964, 1.024)
Functional disability (≥ level 2)	1.013	[0.952, 1.079]	0.920**	[0.865, 0.979]	1.049	[0.995, 1.106]
2. Subjective well-being						
High happiness level	0.989	(0.978, 1.001)	1.010	(0.998, 1.021)	1.001	(0.991, 1.012)
Life satisfaction	0.998	(0.994, 1.002)	1.002	(0.997, 1.007)	0.999	(0.995, 1.003)
Having ikigai	0.998	(0.988, 1.008)	1.009	(0.997, 1.021)	1.002	(0.992, 1.011)
3. Social well-being						
Participation in hobby group	1.035***	(1.021, 1.050)	1.001	(0.988, 1.015)	0.993	(0.982, 1.004)
Participation in sports group	1.047***	(1.031, 1.063)	0.993	(0.977, 1.010)	1.004	(0.991, 1.017)
Participation in learning or cultural group	1.104***	[1.054, 1.156]	0.992	[0.946, 1.040]	0.974	[0.937, 1.014]
Participation in senior citizens club	0.998	(0.958, 1.038)	1.056*	(1.008, 1.107)	1.021	(0.983, 1.059)
Higher levels of community trust	0.999	(0.992, 1.006)	1.027***	(1.020, 1.033)	0.998	(0.991, 1.004)
Perception of others' intentions to help	0.997	(0.988, 1.006)	1.041***	(1.031, 1.051)	0.999	(0.990, 1.008)
Attachment to the residential area	1.000	(0.995, 1.005)	1.016***	(1.010, 1.021)	0.995*	(0.991, 0.999)
Higher frequency of meeting friends	1.007	(0.989, 1.026)	0.997	(0.982, 1.026)	1.010	(0.996, 1.024)
A large number of friends seen within a month	1.007	(0.995, 1.020)	1.009	(0.997, 1.022)	1.007	(0.995, 1.018)
Receiving emotional social support	0.954	[0.895, 1.018]	1.044	[0.978, 1.115]	1.050	[0.998, 1.105]
Receiving instrumental social support	0.996	[0.929, 1.069]	1.027	[0.961, 1.098]	1.122***	[1.068, 1.178]
Taking on social roles	0.983**	(0.970, 0.995)	1.007	(0.994, 1.021)	1.030***	(1.018,1.041)
4. Pro-social/altruistic behaviors						
Volunteering	1.064***	(1.039, 1.090)	0.999	(0.973, 1.026)	0.971**	(0.952, 0.990)
Sharing skills and experience	1.088**	[1.031, 1.148]	1.018	[0.958, 1.083]	0.967	[0.916, 1.020]

5. Health behavior						
Current smoking status	0.922*	[0.855, 0.994]	1.062	[0.980, 1.152]	0.999	[0.935, 1.068]
Current drinking status	1.001	(0.990, 1.011)	0.999	(0.989, 1.009)	0.997	(0.988, 1.006)
Higher levels of eating vegetables and fruits	1.004	(0.999, 1.010)	1.000	(0.995, 1.006)	1.005*	(1.001, 1.010)
Longer walking time	1.007	(0.999, 1.014)	1.001	(0.994, 1.008)	0.996	(0.990, 1.001)
Housebound (lower frequency of going out)	1.004	[0.933, 1.081]	0.915*	[0.848, 0.987]	1.017	[0.955, 1.083]
Receiving health screening	0.994	(0.980, 1.007)	1.005	(0.992, 1.019)	1.025***	(1.014, 1.036)



Abbreviations: RR, risk ratio; PR; prevalence ratio; OR, odds ratio; CI, confidence interval; BMI, Body Mass Index
*p < 0.05 before Bonferroni correction; **p < 0.01 before Bonferroni correction; ***p < 0.05 after Bonferroni correction (the p-value cutoff for Bonferroni correction is α= 0.05/41 = 0.0012)
Three aspects of community-level social capital were standardized.
The estimates for the rare (< 10%) binary outcomes (Outcomes in the 2019 survey: no natural teeth remaining, instrumental independence, self-reported stroke, respiratory disease, participation in learning or cultural groups, emotional social support, instrumental social support, sharing skills and experience, current smoking status, and being housebound; Outcomes for long-term care insurance registry: death, dementia, functional disability [> level 2]) were odds ratios estimated using multilevel logistic regression.
The estimates for the other outcomes were prevalence ratios estimated using modified multilevel Poisson regression.
All models were controlled for sociodemographic factors (age, gender, education, household income, employment, marital status, living alone, population density), baseline activities of daily living, and prior outcome values, except for death, dementia, functional disability, and loneliness.
The analytical sample size was n=34,183 for the 2019 survey and n = 47,227 for the following outcomes: death, functional disabilities, and dementia.
We colored the columns using the legend above based on the magnitude of estimates.

study has observed this relationship (Ehsan and Silva, 2015), which is similar to our results. Additionally, a previous study published in the JAGES demonstrated that community-level civic participation was associated with depressive symptoms; however, this association disappeared after adjusting for individual-level civic participation (Yamaguchi et al., 2019). In our analysis, each domain of pre-baseline individual social capital was adjusted so that we would have similarly found no association. Additionally, no studies in the systematic review of subjective well-being and social capital have used multilevel analysis (Nyqvist et al., 2013). Therefore, it is possible that they would have observed similar trends if they were using the same design and variables to be adjusted. Furthermore, previous studies on physical health outcomes (Sundquist et al., 2014) and previous studies on the JAGES (Nakagomi et al., 2019; Noguchi et al., 2019; Noguchi et al., 2022; Aida et al., 2013; Fujihara et al., 2019) showed a positive association between social capital and physical/cognitive health, such as death, functional ability, cognitive function, and chronic diseases (e.g., heart disease, diabetes, and stroke). In this study, community-level civic participation was associated with reduced mortality. However, other associations were modest and mixed. For example, there were modest associations between community-level civic participation and higher competency in intellectual activity, community-level social cohesion, functional disability, and diabetes, which may be due to the measurement of community-level social capital and adjustment for all the pre-baseline outcomes. In a previous study conducted in Sweden, community-level social capital was associated with all-cause mortality and cause-specific mortality (e.g., heart disease, diabetes, and stroke) (Sundquist et al., 2014). This Swedish study measured social capital via a single neighborhood voting rate. This study used a validated composite community-level social capital indicator, which may have affected the differences in the results.

Potential mechanisms linking community-level social capital to subsequent health and well-being may be explained by 1) social contagion, 2) good access to services and amenities, and 3) good community coalitions.

Social contagion is the concept in which habits and behaviors spread through a close social network (Kawachi and Berkman, 2014). In the case of physical/cognitive health, individuals with higher civic participation may be more intellectually active as they are exposed to various media to obtain information about activities and common topics of conversation in their communities, which might prevent dementia and other diseases (Murayama et al., 2018). This may result in reduced risk of death. Communities with high reciprocity could provide and receive social support and take on social roles in the community.

Good access to services and amenities may facilitate social well-being (Kawachi and Berkman, 2000). Communities with high civic participation may have more facilities, systems, and services for engaging in social activities and gathering information. Easier access to such resources through social participation might have played a role in potentially mitigating the decline in intellectual activities and a decrease in mortality.

According to the community coalition action theory, community coalition is defined as bringing people together, expanding available resources, and focusing on community concerns that will improve community capacities and social outcomes (Butterfoss, 2013). In this study, it could be thought that the community context of high community-level social capital enhances the quality of community coalitions, such as community care meetings and regional councils formed by the administration, municipalities, and community residents. As a result, social capacity could be improved by enriching social resources and services to improve the health of residents living in the community, which might influence social outcomes, such as individual social participation, perceptions of community trust, and attachment.

However, evidence of a protective association between community-level social capital and subsequent physical/cognitive health was limited or modest. The potential mechanisms of social capital and its

Table 3
Robustness to unmeasured confounding (E-values) of associations between community-level social capital and subsequent health and well-being in 2019.

	E-values					
	Community-level social capital					
	Civic participation		Social cohesion		Reciprocity	
	Effect estimate	CI limit	Effect estimate	CI limit	Effect estimate	CI limit
1. Physical/cognitive and mental health						
No natural teeth remaining	1.196	1.000	1.407	1.128	1.197	1.000
Self-rated health	1.050	1.000	1.061	1.000	1.031	1.000
BMI	1.096	1.000	1.067	1.000	1.046	1.000
Instrumental independence	1.295	1.080	1.105	1.000	1.058	1.000
Having competency in Intellectual activity	1.117	1.067	1.096	1.002	1.060	1.000
Self-reported hypertension	1.096	1.000	1.085	1.000	1.087	1.000
Self-reported diabetes	1.116	1.000	1.186	1.080	1.123	1.000
Self-reported dyslipidemia	1.180	1.000	1.047	1.000	1.036	1.000
Self-reported stroke	1.030	1.000	1.357	1.000	1.247	1.000
Self-reported heart disease	1.105	1.000	1.111	1.000	1.092	1.000
Self-reported respiratory disease	1.144	1.000	1.030	1.000	1.147	1.000
Depressive symptoms	1.036	1.000	1.094	1.000	1.051	1.000
Hopeless	1.137	1.000	1.041	1.000	1.019	1.000
Loneliness	1.142	1.000	1.057	1.000	1.069	1.000
Death	1.441	1.275	1.069	1.000	1.060	1.000
Dementia	1.271	1.000	1.343	1.000	1.161	1.000
Functional disability (any level)	1.133	1.000	1.322	1.172	1.086	1.000
Functional disability ($\geq$ level 2)	1.130	1.000	1.395	1.171	1.275	1.000
2. Subjective well-being						
High happiness level	1.151	1.000	1.108	1.000	1.040	1.000
Life satisfaction	1.049	1.000	1.049	1.000	1.030	1.000
Having ikigai	1.048	1.000	1.101	1.000	1.042	1.000
3. Social well-being						
Participation in hobby group	1.227	1.166	1.040	1.000	1.092	1.000
Participation in sports group	1.269	1.209	1.091	1.000	1.069	1.000
Participation in learning or cultural group	1.442	1.293	1.100	1.000	1.191	1.000
Participation in senior citizens club	1.052	1.000	1.301	1.098	1.165	1.000
Higher community trust	1.037	1.000	1.192	1.163	1.051	1.000
Perception of others' intentions to help	1.053	1.000	1.248	1.211	1.033	1.000
Higher attachment to the residential area	1.006	1.000	1.142	1.113	1.076	1.026
Higher frequency of meeting friends	1.091	1.000	1.060	1.000	1.111	1.000
Large number of friends seen within a month	1.094	1.000	1.105	1.000	1.089	1.000
Receiving emotional social support	1.271	1.000	1.259	1.000	1.280	1.000
Receiving instrumental social support	1.064	1.000	1.194	1.000	1.492	1.339
Taking on social roles	1.152	1.073	1.093	1.000	1.204	1.153
4. Pro-social/altruistic behaviors						
Volunteering	1.326	1.239	1.033	1.000	1.207	1.111
Sharing skills and experience	1.383	1.187	1.132	1.000	1.196	1.000
5. Health behavior						
Current smoking status	1.388	1.086	1.320	1.000	1.029	1.000
Current drinking status	1.023	1.000	1.028	1.000	1.062	1.000
Higher levels of eating vegetables and fruits	1.072	1.000	1.021	1.000	1.077	1.028
Longer walking time	1.088	1.000	1.026	1.000	1.072	1.000
Housebound (lower frequency of going out)	1.068	1.000	1.412	1.126	1.147	1.000
Receiving health screening	1.085	1.000	1.079	1.000	1.184	1.132

Abbreviation: CI, confidence interval; BMI. Body Mass Index.
For information on the calculation of E-values, see VanderWeele and Ding(2017) for the formula.

effects on physical, cognitive, and mental health include 1) health behaviors and 2) psychosocial processes (Kawachi and Berkman, 2000). Higher community-level social capital may have promoted 1) higher individual-level social participation and 2) reduced stress owing to cohesion, which may have reduced the risk of lower IADL, self-reported diabetes, and functional disability. In communities with high levels of social cohesion, community residents may make efforts to maintain their health. This might be because they may not want to cause trouble for other residents or feel embarrassed if seen as unhealthy or functionally dependent, which reflects the cohesive nature of Japanese society. Another potential reason why these associations were not evident is that the follow-up period was too short (three years) and not enough for the effects of community-level social capital to manifest. In this study, we observed a clear association between community-level social capital and physical health only for death. If there is an association between social capital and death, it could be through the mechanism described above, but the other associations with physical health are modest. Therefore, the results must be interpreted carefully.

This study found modest and potentially harmful associations between community-level social capital and several outcomes. For example, higher community-level social cohesion and being housebound (lower frequency of going out), higher community-level reciprocity and a lower probability of volunteering. Regarding social contagion, both positive and adverse health effects of community factors can spread (Christakis and Fowler, 2008). Solid connections and cohesion might harm some aspects of older adults' health. Specifically, the exclusion of outsiders (those who are not integrated into such communities) might cause them to go out less. However, a negative association with an outcome does not necessarily imply that the outcome has a truly harmful association with health. Higher reciprocity usually involves the norm of helping each other within the community and may not be considered volunteering.

Moreover, the direction of the effect could be opposite, depending on the aspects of social capital. For example, competency in intellectual activity was positively associated with community-level civic participation but negatively associated with social cohesion. Additionally, taking on social roles was negatively associated with community-level civic participation but positively associated with reciprocity. This difference may be explained by the different properties of each aspect of social capital. Previous studies on the JAGES have also indicated that different aspects of community-level social capital may have opposing associations with outcomes (Saito et al., 2017; Fujihara et al., 2019). When considering social capital, it is important to consider its negative influences as well.

We observed almost homogeneous associations between community-level social capital and well-being outcomes based on gender or SES. However, we observed some heterogeneous associations in several outcomes. One possible mechanism for the heterogeneity based on gender and SES is social exclusion (Portes, 1998). In this study, the association between higher community-level civic participation and a lower prevalence of taking on social roles was more evident among men than among women. According to our data, men were less likely to participate in social activities in the pre-baseline than women were. Men who are less involved in such social activities might be marginalized in the community and have fewer opportunities to engage with neighboring friends and younger people. Another possible mechanism is social contagion owing to strong community ties (Villalonga-Olives and Kawachi, 2017). The association between community-level social cohesion and the risk of smoking was observed only among women, which may have been more strongly influenced by smokers in more cohesive communities where women have greater networks compared to men. Moreover, for some social well-being outcomes, such as participation in hobby and sports groups, participants with low SES might be more positively affected by community-level social capital. In communities with higher social capital, health-related information and behaviors may spread to individuals with low SES. Individuals with low SES were more likely to be affected by community-level social capital than those with high SES by compensating for health-affecting factors associated with low SES. For example, individuals with low SES might lack available resources and information compared to those with high SES (Adler and Ostrove, 1999). Community-level social capital may have facilitated information contagion to individuals with low SES and buffered the health disparities associated with SES.

This study has some strengths. First, this is the first study to use an outcome-wide longitudinal approach to assess the association between community-level social capital and holistic health and well-being. Second, we utilized a large-scale nationwide longitudinal cohort, including over 30,000 analytical samples, rich in survey items encompassing physical, mental, and social factors. The longitudinal study design enabled us to ensure the temporal ordering between exposure and outcomes and adjust for pre-baseline covariates controlling for confounding while avoiding the overadjustment of potential mediators. Third, the comprehensive data allowed us to adjust for a broad range of pre-baseline potential confounders. Such adjusted covariates include pre-baseline outcome values, which addresses reverse causality, at least partially. Lastly, our geographically diverse sample and large sample size per community enabled us to use the validated scale of community-level social capital.

This study has several limitations. First, our results on the effects of community-level social capital may be conservative because the three-year follow-up period may not be sufficiently long for community-level factors to manifest. Moreover, community-level social capital might have a small effect size, which may not have been detected owing to the lack of statistical power and a more conservative threshold for statistical significance after multiple testing corrections. Second, most of the outcomes were self-reported and may have been susceptible to information bias. However, this study also included objectively measured outcomes from LTCI registry, which are less susceptible to information bias. Third, we did not set a criterion for the number of individuals included in the school districts in this study. The number of individuals within the school districts we included in this study ranged from eight to 1308, with an average of 108 people for the sample who answered the 2013 and 2016 surveys from which community-level social capital was calculated (Supplementary Table S2). This suggested that the small number of individuals within the school districts might have reduced the accuracy of the estimates. We did not establish criteria to prevent selection bias by excluding participants and ensuring that the sample was as large as possible. Furthermore, it is important to note that school districts may not necessarily be appropriate geographical units. It remains unclear whether similar results would be obtained if this scale were applied to a community defined by an alternative geographic unit. Fourth, we did not adjust for the pre-baseline levels of the exposure because community-level social capital could be relatively stable over time and had limited variability between the pre-baseline and baseline waves. In this case, the estimated effects corresponded to the cumulative exposure to community social capital rather than the incident changes at the baseline. Fifth, the response rate of the target population was approximately 70%, and the follow-up rate was approximately 30–40%, leaving the possibility of selection bias owing to selective attrition. However, we reviewed the demographics and pre-baseline outcome values of the participants who were lost to the follow-up in 2019 and confirmed that they were nearly the same as those of the analytical samples (Supplementary Table S9). We also conducted a sensitivity analysis with imputed outcomes for the respondents who answered in the two waves of the 2013 and 2016 surveys. These results were similar to the main results (Supplementary Table S7). Sixth, the study adjusted for a comprehensive set of covariates. However, because it used observational data, the possibility of unmeasured confounders remained. The results of the E-value analyses were somewhat robust to the unmeasured confounders, although some of the E-values were not sufficiently large to deny the existence of unmeasured confounders that could explain the observed results. Thus, it is crucial to recognize that our statistical findings from the observational data may not necessarily indicate the causal effect of community social capital. Seventh, we divided SES into only two categories using educational status and household income, which may have prevented us from observing clear heterogeneity. To assess heterogeneity in detail, it is necessary to approach SES from a more multidimensional perspective (e.g., occupational status) or use another method, such as a machine learning-based approach (Athey et al., 2019). Eighth, the outcome-wide approach addresses a broad range of outcomes and does not allow for an in-depth discussion of each outcome individually (VanderWeele et al., 2020). Contrarily, the conventional approach of assessing a single outcome does not provide insights into the impacts of exposure on a holistic range of well-being outcomes and has other methodological limitations, such as p-hacking and publication bias (VanderWeele, 2017b). These approaches play complementary roles in promoting our understanding of social capital and health. Finally, the findings were based on a limited population of Japanese older adults aged 65 years and above who responded to the survey in multiple waves. The results may vary depending on differences in social and cultural context, such as age and social norms. It should be noted that the results might not be generalizable to other populations.

5. Conclusion

Community-level social capital may promote social well-being and some aspects of physical and cognitive health, such as reducing the risk of death and functional disability among older adults, regardless of gender and SES. Therefore, fostering community-level social capital may improve individual-level social well-being and physical and cognitive health without increasing health inequality. Meanwhile, community-level social capital did not show clear associations with most aspects of physical, cognitive, and mental health, subjective well-being, and health behaviors. Depending on the type of social capital, community-

level social capital may have detrimental effects on several health outcomes. Therefore, to maximize well-being among older adults, especially to improve aspects not associated with or negatively associated with community-level social capital in this study, additional implementations in the social environments may be necessary. Further studies are required to examine the heterogeneous and long-term effects of community-level social capital in more detail.

Data availability statement

The data underlying this article were provided by the JAGES data administration office by permission. Data will be shared on request to the corresponding author with the permission of the JAGES data administration office (https://www.jages.net/data_application/).

Ethical approvals

The ethics committees of Kyoto University (R3153-2), Nihon Fukushi University (13–14), and Chiba University (2493; 3442) approved this study.

CRediT authorship contribution statement

Sho Takeda: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Writing – original draft, Writing – review & editing. **Maho Haseda:** Conceptualization, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Koryu Sato:** Methodology, Supervision, Writing – review & editing. **Koichiro Shiba:** Formal analysis, Methodology, Writing – review & editing. **Atsushi Nakagomi:** Formal analysis, Methodology, Project administration, Writing – review & editing. **Kazushige Ide:** Formal analysis, Methodology, Project administration, Writing – review & editing. **Naoki Kondo:** Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None declared.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2024.103336.

References

Adler, N.E., Ostrove, J.M., 1999. Socioeconomic status and health: what we know and what we don't. In: Annals of the New York Academy of Sciences. New York Academy of Sciences, pp. 3–15. https://doi.org/10.1111/j.1749-6632.1999.tb08101.x.

Aida, J., Kondo, K., Kawachi, I., Subramanian, S.V., Ichida, Y., Hirai, H., Kondo, N., Osaka, K., Sheiham, A., Tsakos, G., Watt, R.G., 2013. Does social capital affect the incidence of functional disability in older Japanese? A prospective population-based cohort study. J. Epidemiol. Community Health 67 (1978), 42–47. https://doi.org/10.1136/jech-2011-200307.

Amemiya, A., Saito, J., Saito, M., Takagi, D., Haseda, M., Tani, Y., Kondo, K., Kondo, N., 2019. Social capital and the improvement in functional ability among older people in Japan: a multilevel survival analysis using JAGES data. Int. J. Environ. Res. Publ. Health 16. https://doi.org/10.3390/ijerph16081310.

Athey, S., Tibshirani, J., Wager, S., 2019. Generalized random forests. Ann. Stat. 47, 1179–1203. https://doi.org/10.1214/18-AOS1709.

Bryden, A., Roberts, B., Petticrew, M., McKee, M., 2013. A systematic review of the influence of community level social factors on alcohol use. Health Place 21, 70–85. https://doi.org/10.1016/j.healthplace.2013.01.012.

Butterfoss, F.D., 2013. Toward a comprehensive understanding of community coalitions: moving from practice to theory. In: Emerging Theories in Health Promotion Practice and Research, second ed. Jossey-Bass.

Centers for Disease Control and Prevention, 2018. Well-Being Concepts. https://www.cdc.gov/hrqol/wellbeing.htm. (Accessed 12 June 2023).

Christakis, N.A., Fowler, J.H., 2008. The collective dynamics of smoking in a large social network. N. Engl. J. Med. 358, 2249–2258. https://doi.org/10.1056/NEJMsa0706154.

De Silva, M.J., McKenzie, K., Harpham, T., Huttly, S.R.A., 2005. Social capital and mental illness: a systematic review. J. Epidemiol. Community Health. https://doi.org/10.1136/jech.2004.029678, 1978.

Ehsan, A.M., Silva, D., 2015. Social capital and common mental disorder: a systematic review. J. Epidemiol. Community Health 69, 1021–1028. https://doi.org/10.1136/jech.

Fujihara, S., Tsuj, T., Miyaguni, Y., Aida, J., Saito, M., Koyama, S., Kondo, K., 2019. Does community-level social capital predict decline in instrumental activities of daily living? A JAGES prospective cohort study. Int. J. Environ. Res. Publ. Health 16. https://doi.org/10.3390/ijerph16050828.

Haseda, M., Kondo, N., Ashida, T., Tani, Y., Takagi, D., Kondo, K., 2018. Community social capital, built environment, and income-based inequality in depressive symptoms among older people in Japan: an ecological study from the JAGES project. J. Epidemiol. 28, 108–116. https://doi.org/10.2188/jea.JE20160216.

Huber, M., André Knottnerus, J., Green, L., Van Der Horst, H., Jadad, A.R., Kromhout, D., Leonard, B., Lorig, K., Loureiro, M.I., Van Der Meer, J.W.M., Schnabel, P., Smith, R., Van Weel, C., Smid, H., 2011. How should we define health? BMJ (Online) 343. https://doi.org/10.1136/bmj.d4163.

Islam, M.K., Merlo, J., Kawachi, I., Lindström, M., Gerdtham, U.G., 2006. Social capital and health: does egalitarianism matter? A literature review. Int. J. Equity Health. https://doi.org/10.1186/1475-9276-5-3.

Kawachi, I., Berkman, L.F., 2014. Social capital, social cohesion, and health. In: Berkman, L.F., Kawachi, I., Glymour, M.M. (Eds.), Social Epidemiology, second ed. Oxford University Press, pp. 290–319.

Kawachi, I., Subramanian, S.V., 2006. Measuring and modeling the social and geographic context of trauma: a multilevel modeling approach. J. Trauma Stress 195–203. https://doi.org/10.1002/jts.20108.

Kawachi, I., Subramanian, S.V., Kim, D., 2008. Social capital and health: a decade of progress and beyond. In: Kawachi, I., Subramanian, S.V., Kim, D. (Eds.), Social Capital and Health, first ed. Springer, pp. 1–26.

Kawachi, I., Berkman, L., 2000. Social cohesion, social capital, and health. In: Berkman, L.F., Kawachi, I. (Eds.), Social Epidemiology. Oxford University Press, pp. 174–190.

Kim, E.S., Chen, Y., Kawachi, I., VanderWeele, T.J., 2020. Perceived neighborhood social cohesion and subsequent health and well-being in older adults: an outcome-wide longitudinal approach. Health Place 66. https://doi.org/10.1016/j.healthplace.2020.102420.

Kondo, K., Rosenberg, M., 2018. Advancing Universal Health Coverage through Knowledge Translation for Healthy Ageing: Lessons Learnt from the Japan

Gerontological Evaluation Study. World Health Organization, Geneva. https://apps.who.int/iris/handle/10665/279010.
Koyama, S., Aida, J., Saito, M., Kondo, N., Sato, Y., Matsuyama, Y., Tani, Y., Sasaki, Y., Kondo, K., Ojima, T., Yamamoto, T., Tsuboya, T., Osaka, K., 2016. Community social capital and tooth loss in Japanese older people: a longitudinal cohort study. BMJ Open 6, 10768. https://doi.org/10.1136/bmjopen-2015.
Mathews, G., 1996. What Makes Life Worth Living? How Japanese and Americans Make Sense of Their Worlds. University of California Press.
Ministry of Health, Labor and Welfare, 2017. Long-Term Care, Health and Welfare Services for the Elderly. https://www.mhlw.go.jp/english/policy/care-welfare/care-welfare-elderly/index.html. (Accessed 12 June 2023).
Murata, C., Kondo, K., Hirai, H., Ichida, Y., Ojima, T., 2008. Association between depression and socio-economic status among community-dwelling elderly in Japan: the Aichi Gerontological Evaluation Study (AGES). Health Place 14, 406–414. https://doi.org/10.1016/j.healthplace.2007.08.007.
Murayama, H., Fujiwara, Y., Kawachi, I., 2012. Social capital and health: a review of prospective multilevel studies. J. Epidemiol. https://doi.org/10.2188/jea.JE20110128.
Murayama, H., Sugiyama, M., Inagaki, H., Okamura, T., Miyamae, F., Ura, C., Edahiro, A., Motokawa, K., Awata, S., 2018. Is community social capital associated with subjective symptoms of dementia among older people? A cross-sectional study in Japan. Geriatr. Gerontol. Int. 18, 1537–1542. https://doi.org/10.1111/ggi.13519.
Nakagomi, A., Shiba, K., Kawachi, I., Ide, K., Nagamine, Y., Kondo, N., Hanazato, M., Kondo, K., 2022. Internet use and subsequent health and well-being in older adults: an outcome-wide analysis. Comput. Hum. Behav. 130 https://doi.org/10.1016/j.chb.2021.107156.
Nakagomi, A., Tsuji, T., Saito, M., Ide, K., Kondo, K., Shiba, K., 2023. Social isolation and subsequent health and well-being in older adults: a longitudinal outcome-wide analysis. Soc. Sci. Med. 327 https://doi.org/10.1016/j.socscimed.2023.115937.
Nakagomi, A., Tsuji, T., Hanazato, M., Kobayashi, Y., Kondo, K., 2019. Association between community-level social participation and self-reported hypertension in older Japanese: a JAGES multilevel cross-sectional study. Am. J. Hypertens. 32, 503–514. https://doi.org/10.1093/ajh/hpz028.
Noguchi, T., Kondo, K., Saito, M., Nakagawa-Senda, H., Suzuki, S., 2019. Community social capital and the onset of functional disability among older adults in Japan: a multilevel longitudinal study using Japan Gerontological Evaluation Study (JAGES) data. BMJ Open 9. https://doi.org/10.1136/bmjopen-2019-029279.
Noguchi, T., Murata, C., Hayashi, T., Watanabe, R., Saito, M., Kojima, M., Kondo, K., Saito, T., 2022. Association between community-level social capital and frailty onset among older adults: a multilevel longitudinal study from the Japan Gerontological Evaluation Study (JAGES). J. Epidemiol. Community Health 76 (1978), 182–189. https://doi.org/10.1136/jech-2021-217211.
Nyqvist, F., Forsman, A.K., Giuntoli, G., Cattan, M., 2013. Social capital as a resource for mental well-being in older people: a systematic review. Aging Ment. Health 17, 394–410. https://doi.org/10.1080/13607863.2012.742490.
Okuzono, S.S., Shiba, K., Kim, E.S., Shirai, K., Kondo, N., Fujiwara, T., Kondo, K., Lomas, T., Trudel-Fitzgerald, C., Kawachi, I., Vanderweele, T.J., 2022. Ikigai and subsequent health and wellbeing among Japanese older adults: longitudinal outcome-wide analysis. Lancet Reg Health West Pac 21, 100391. https://doi.org/10.1016/j.
Portes, A., 1998. Social capital: its origins and applications in modern sociology. Annu. Rev. Sociol. 24 https://doi.org/10.1146/annurev.soc.24.1.1.
Rodgers, J., Valuev, A.V., Hswen, Y., Subramanian, S.V., 2019. Social capital and physical health: an updated review of the literature for 2007–2018. Soc. Sci. Med. https://doi.org/10.1016/j.socscimed.2019.112360.
Ryff, C.D., Boylan, J.M., Krisch, J.A., 2021. Eudaimonic and hedonic well-being: an integrative perspective with linkages to sociodemographic factors and health. In: Lee, M.T., Kubzansky, L.D., VanderWeele, T.J. (Eds.), Measuring Well-Being: Interdisciplinary Perspectives from the Social Science and the Humanities. Oxford University Press, pp. 92–135.
Saito, M., Kondo, N., Aida, J., Kawachi, I., Koyama, S., Ojima, T., Kondo, K., 2017. Development of an instrument for community-level health related social capital among Japanese older people: the JAGES project. J. Epidemiol. 27, 221–227. https://doi.org/10.1016/j.je.2016.06.005.
Sundquist, K., Hamano, T., Li, X., Kawakami, N., Shiwaku, K., Sundquist, J., 2014. Linking social capital and mortality in the elderly: a Swedish national cohort study. Exp. Gerontol. 55, 29–36. https://doi.org/10.1016/j.exger.2014.03.007.
Uphoff, E.P., Pickett, K.E., Cabieses, B., Small, N., Wright, J., 2013. A systematic review of the relationships between social capital and socioeconomic inequalities in health: a contribution to understanding the psychosocial pathway of health inequalities. Int. J. Equity Health 12, 54. https://doi.org/10.1186/1475-9276-12-54.
VanderWeele, T.J., 2017a. On the promotion of human flourishing. Proc. Natl. Acad. Sci. USA 114, 8148–8156. https://doi.org/10.1073/pnas.1702996114.
Vanderweele, T.J., 2017b. Outcome-wide epidemiology. Epidemiology 28, 399–402. https://doi.org/10.1097/EDE.0000000000000641.
VanderWeele, T.J., Ding, P., 2017. Sensitivity analysis in observational research: introducing the E-value. Ann. Intern. Med. 167, 268. https://doi.org/10.7326/M16-2607.
VanderWeele, T.J., Mathur, M.B., Chen, Y., 2020. Outcome-wide longitudinal designs for causal inference: a new template for empirical studies. Stat. Sci. 35 https://doi.org/10.1214/19-sts728.
Villalonga-Olives, E., Kawachi, I., 2017. The dark side of social capital: a systematic review of the negative health effects of social capital. Soc. Sci. Med. 194, 105–127. https://doi.org/10.1016/j.socscimed.2017.10.020.
Yamaguchi, M., Inoue, Y., Shinozaki, T., Saito, M., Takagi, D., Kondo, K., Kondo, N., 2019. Community social capital and depressive symptoms among older people in Japan: a multilevel longitudinal study. J. Epidemiol. 29, 363–369. https://doi.org/10.2188/jea.JE20180078.
Young, A.F., Russell, A., Powers, J.R., 2004. The sense of belonging to a neighbourhood: can it be measured and is it related to health and well being in older women? Soc. Sci. Med. 59, 2627–2637. https://doi.org/10.1016/j.socscimed.2004.05.001.
Zou, G., 2004. A modified Poisson regression approach to prospective studies with binary data. Am. J. Epidemiol. 159, 702–706. https://doi.org/10.1093/aje/kwh090.
Zuidberg, M.R.J., Shriwise, A., De Boer, L.M., Johansen, A.S., 2020. Assessing progress under health 2020 in the European region of the world health organization. Eur. J. Publ. Health 30, 1072–1077. https://doi.org/10.1093/eurpub/ckaa091.