Association Between Community-Level Social Participation and Self-reported Hypertension in Older Japanese: A JAGES Multilevel Cross-sectional Study

Atsushi Nakagomi,[1] Taishi Tsuji,[2] Masamichi Hanazato,[2] Yoshio Kobayashi,[1] and Katsunori Kondo[2,3]

BACKGROUND
Many factors are associated with hypertension development. We focused on social participation as an aspect of social capital and investigated the contextual relationship between community-level social participation and hypertension using multilevel regression analyses.

METHODS
We used cross-sectional data from the 2016 Japan Gerontological Evaluation Study—a population-based study of functionally independent adults aged 65 years or older. The sample comprised 116,013 participants nested in 818 communities. Hypertension and social capital were defined by questionnaires. Social capital was assessed at both the individual and the community levels in 3 dimensions: civic participation (as an index of social participation), social cohesion, and reciprocity.

RESULTS
The prevalence rate of hypertension was 43.7%, and 44.1% of the respondents were involved in civic participation. Community-level civic participation, but not social cohesion or reciprocity, was negatively associated with hypertension in the total population (prevalence ratio (95% confidence interval): 0.98 (0.96–0.99), $P = 0.004$) and female group (0.97 (0.95–0.99), $P = 0.015$), and the association neared significance in the male group (0.98 (0.96–1.005), $P = 0.13$) after adjustment for individual-level social capital dimensions including civic participation, individual-level covariates, and population density as a community-level covariate. The interaction between community-level civic participation and sex in relation to hypertension was significant ($P = 0.012$).

CONCLUSIONS
We found a contextual preventive relationship between community-level civic participation and hypertension. The design of the contextual characteristics of communities by the promotion of social participation may help reduce the prevalence of hypertension in older people.

Keywords: blood pressure; hypertension; multilevel analysis; sex differences; social capital; social participation.

doi:10.1093/ajh/hpz028

Worldwide, the number of people with hypertension is on the rise and is estimated to reach 1.56 billion by 2025.[1] In Japan, more than 60% of people ≥60 years of age have hypertension, and the number of hypertension patients is also expected to increase owing to rapid aging.[2] A wide range of risk factors is associated with hypertension development. Among them, behavioral factors such as unhealthy diet, excessive alcohol consumption, smoking, and physical inactivity have been targeted in many studies and public policies.[3] However, individuals' interaction with others and their surrounding environment has not been investigated sufficiently as a possible approach to reducing hypertension. Recently, Yazawa et al.[4] focused on social participation and showed that people who participated in community organizations were less likely to be hypertensive than people who did not participate. Social participation, which is considered a key component for action on healthy aging,[5] could be one of the multidisciplinary strategies against hypertension.

Social participation can be recognized as social capital, which was defined as "resources that are accessed by individuals as a result of their membership of a network or a group" by Kawachi and Berkman.[6] Social capital is classified into cognitive and structural social capital.[7] Cognitive social capital includes individuals' attitudes, perceptions, and cognitions about the group to which they belong. Social participation is included in structural social capital and refers to the externally observable aspects of a social organization. Furthermore, social capital can be analyzed at the individual and group levels,[6] and multilevel analyses have been conducted to examine the contextual effects of group-level social capital in many studies in the field of public health.[8,9] Several studies have suggested

Correspondence: Atsushi Nakagomi (bay2item@yahoo.co.jp).

Initially submitted December 1, 2018; date of first revision January 14, 2019; accepted for publication February 19, 2019; online publication February 22, 2019.

[1]Department of Cardiovascular Medicine, Chiba University Graduate School of Medicine, Chiba, Japan; [2]Center for Preventive Medical Sciences, Chiba University, Chiba, Japan; [3]Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Obu, Aichi, Japan.

that group-level cognitive social capital has beneficial contextual effects on hypertension.[10–12] However, little is known regarding the effects of group-level structural social capital on hypertension. Ahern et al.[13] reported that group-level structural social capital was related to the presence of hypertension in the US population. In that study, however, both social participation and reciprocity were integrated to create an index of social capital. Additionally, the number of participants in that study was small (n = 769), and multilevel analyses were not employed for the assessment.

The aim of the present study was, therefore, to investigate the contextual relationship between community-level social participation and hypertension even after adjustment for individual-level social participation by performing community- and individual-level multilevel analyses in older Japanese people. Determining the contextual effects of social participation on hypertension is important because it can be a proposal for a population approach in which we may be able to reduce hypertension throughout a community by promoting social participation programs and designing a community to provide easy access to social participation.

METHODS

Study population

We used cross-sectional data from the 2016 wave of the Japan Gerontological Evaluation Study (JAGES).[14] The JAGES is the nationwide survey of community-dwelling older adults in Japan. It takes a social epidemiological approach to examine the causes of health problems. In the JAGES 2016 wave, self-administered questionnaires were mailed to functionally independent adults aged 65 years or older, who did not receive benefits from public long-term care insurance, across Japan, between September 2016 and January 2017. The respondents included 180,021 residents (response rate = 70.2%), and they were nested in 857 communities essentially based on elementary or junior high school districts because a school district reflects a geographical scale wherein older Japanese people can move on foot or by bike.[15] We excluded responses without valid values for key variables including age (n = 262), sex (n = 30), hypertension (n = 8,482), social participation (n = 46,404), and the population density of school districts (n = 8,527). Communities with ≤30 respondents (n = 303) were excluded to avoid non-precise community-level values due to small sample size. The final sample comprised 116,013 respondents (58,420 females and 57,593 males) nested in 818 communities. The JAGES participants were informed that participation in the present study was voluntary and that returning the questionnaire with responses indicated the provision of consent to participate. Ethical approval for the study was obtained from the Ethics Committee at the National Center for Geriatrics and Gerontology (approval no. 992) and Chiba University (approval no. 2493).

Dependent variable

We defined hypertension using the questionnaire because, in general, self-reports on diseases that are clearly defined and easily diagnosed, such as hypertension, have good agreement with medical record data.[16] All respondents were asked, "Are you receiving medical treatment for the diseases listed below?" All the respondents who answered yes to "hypertension" were categorized as having hypertension. Thus, the definition of hypertension in this study was self-reported hypertension on treatment; people who had hypertension but did not receive treatment were excluded.

Assessment of social capital

Based on a previous study that developed and validated a community-level social capital scale among older Japanese people from the 2013 JAGES,[8] we classified social capital into 3 dimensions: civic participation, social cohesion, and reciprocity. Civic participation was defined as an index of social participation using 5 organizations: (i) sports groups or clubs; (ii) volunteer groups; (iii) hobby activity groups; (iv) study or cultural groups; (v) activities to teach skills or pass on experiences to others. Individual-level civic participation was scored "1" if respondents participated in any of the 5 organizations once a month or more often and "0" if respondents participated in these organizations less than once a month. Community-level civic participation was defined as the sum of the participation proportions of the 5 organizations in each community. Three questions were used to assess social cohesion: "Do you think people living in your area can be trusted in general?"; "Do you think most people in your community offer assistance to others?"; "How strong is your attachment to your place of residence?". Individual-level social cohesion was scored "1" if respondents answered "very" or "moderately" to at least 1 of the 3 questions and "0" if respondents did not answer "very" or "moderately" to any of the questions. Community-level social cohesion was defined as the sum of the proportions of those who answered "very" or "moderately" to the 3 items. Three questions were used to assess reciprocity: "Do you have someone who listens to your concerns and complaints?"; "Do you listen to someone's concerns and complaints?"; "Do you have someone who looks after you when you are sick for a few days?". Individual- and community-level reciprocity was defined in the same way as social cohesion.

To examine the differences in the contextual associations with hypertension according to organization type, social participation was assessed in each of the 5 organizations involved in civic participation and 3 other organizations: (vi) nursing care prevention activities; (vii) senior citizen clubs; and (viii) community associations. Individual-level social participation was scored "1" if respondents participated in a certain organization once a month or more often and "0" if respondents participated in the organization less than once a month. Community-level social participation was defined as the participation proportion in a community.

All the community-level social capital indices were standardized in the analyses. If participants did not respond to the questions on social cohesion or reciprocity, corresponding observations were assigned to the "missing" categories.

Assessment of covariates

Demographic and physiological covariates included age, sex, and body mass index. Age was aggregated into 5 groups: 65–69, 70–74, 75–79, 80–84, and 85 years and older. Body mass index was calculated as the weight divided by the height squared (kg/m^2) and was divided into 4 categories: underweight (<18.5 kg/m^2); normal weight (18.5–24.9 kg/m^2); overweight (25–29.9 kg/m^2); and obese (≥30 kg/m^2).

Considering the effect of psychological stress on hypertension, depressive symptoms were assessed using the 15-item Geriatric Depression Scale as a psychological covariate. Respondents were classified into 3 groups: no depression (0–4), mild depression (5–9), and severe depression (10–15).

To assess the impacts of health behaviors, drinking and smoking status (none, past, or current) were classified by each answer choice. Physical activity was assessed by the frequency of going outside (<once a week; ≥once a week) and the average time spent walking each day (≤30 minutes; 30–59 minutes; and ≥60 minutes). The frequency of meeting friends (<once a week; ≥once a week) and eating status (eating alone or not) were used as psychosocial factors.

Socioeconomic status was evaluated by educational attainment (<10 or ≥10 years), marital status (married or single), occupational status (currently employed, formerly employed, and never employed), and annual equivalent income (<2,000,000; 2,000,000–3,999,999; or ≥4,000,000 yen).

Information on diabetes mellitus, dyslipidemia, cardiovascular diseases, and stroke was obtained from the questionnaire.

As a community-level covariate, we calculated the population density per square kilometer for each community using the 2010 census and Land Utilization Tertiary Mesh Data (as of 2010) of the National Land Numerical Information from the Ministry of Land, Infrastructure, Transport and Tourism in Japan. These calculations excluded nondeveloped areas (e.g., rivers, lakes, forest, and wasteland) and nonresidential land (farms and industrial districts).[17] Population density was stratified into quartiles. We used the ArcGIS 10.3 software for all spatial calculations.

If participants did not respond to these covariates, corresponding observations were assigned to the "missing" categories.

Statistical analysis

All data were analyzed using STATA 15.1 software (STATA Corp. LLC, College Station, TX). Continuous variables were assessed by *t*-test. Pearson's chi-square test was used to analyze categorical variables. The correlations between the prevalence of civic participation and population density were assessed by linear regression analyses.

Two-level Poisson regression analyses with random intercepts and fixed slopes were applied to investigate the contextual relationship between community-level social participation and individual-level hypertension. A total of 116,013 respondents (first level) were nested within 818 communities (second level). The multilevel prevalence ratios (PRs) and their 95% confidence intervals were calculated. In model 1, both individual- and community-level social capital indices and cross-level interaction terms between individual- and community-level civic participation were included. In model 2, all individual- and community-level covariates were added. Analyses stratified by sex were performed because the cross-level interaction between community-level civic participation and sex was significant ($P = 0.014$). In this study, logistic regression analysis was not appropriate because of the high prevalence of hypertension (43.7%).[18]

All *P* values were 2 tailed. *P* values lower than 0.05 were considered statistically significant.

RESULTS

Table 1 shows the descriptive characteristics of the 818 communities. Community-level civic participation, which was the sum of the participation proportions of the 5 organizations used to define civic participation, was 1.03 (the possible range of values was between 0 and 5). The sum of the proportions of those who answered "very" or "moderately" to the 3 questions about social cohesion and reciprocity was 2.00 and 2.80, respectively (the possible range of values was between 0 and 3). Community-level civic participation was significantly positively correlated with population density ($r = 0.36$, $P < 0.001$). The baseline characteristics of the respondents and crude PRs for hypertension are shown in Table 2. The mean ages of the total, male, and female populations were 73.5 ± 6.1, 73.4 ± 6.0, and 73.5 ± 6.2 years, respectively. The prevalence of hypertension was 43.7% in the total population, 44.4% among males, and 43.0% among females. In the total population, 44.1% of respondents were involved in civic participation, and a larger number of females participated in the organizations of civic participation than males (males: 40.0%; females: 48.1%; $P < 0.001$).

The results of the multilevel Poisson regression analyses are shown in Table 3. In model 1, both individual- and community-level civic participation were associated with a lower incidence of hypertension in all the groups. After

Table 1. Descriptive characteristics of the communities

Community-level variables	Mean	SD	Minimum	Maximum
Community-level social capital (unstandardized value[a])				
Civic participation	1.03	0.23	0.29	1.76
Social cohesion	2.00	0.18	1.32	2.67
Reciprocity	2.80	0.07	2.40	3.00
Population density, persons per kilometer squared of inhabitable area				
First quartile (*n* = 205)	3,032.7	10,71.5	795.8	4,773.8
Second quartile (*n* = 204)	7,017.5	1,281.5	4,801.0	9,024.7
Third quartile (*n* = 205)	10,587.9	908.8	9,043.9	12,156.6
Fourth quartile (*n* = 204)	14,734.5	3,022.1	12,189.8	37,915.6

The number of communities was 818.
[a]These values were standardized in the Poisson regression analysis.

Table 2. Participant characteristics and the prevalence of hypertension

	Total			Male			Female		
Variables	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)
Total	116,013	50,669 (43.7)		57,593	25,571 (44.4)		58,420	25,098 (43.0)	
Civic participation									
No participation	64,906	29,387 (45.3)	Reference	34,580	15,550 (45.0)	Reference	30,326	13,837 (45.6)	Reference
Any participation	51,107	21,282 (41.6)	0.92*** 0.91–0.93)	23,013	10,021 (43.5)	0.97** (0.95–0.99)	28,094	11,261 (40.1)	0.88*** (0.86–0.90)
Social cohesion									
Not cohesive	16,213	7,008 (43.2)	Reference	7,635	3,331 (43.6)	Reference	8,578	3,677 (42.9)	Reference
Cohesive	97,222	42,567 (43.8)	1.01 (0.99–1.03)	48,833	21,744 (44.5)	1.02 (0.99–1.05)	48,389	20,823 (43.0)	1.00 (0.98–1.03)
Missing	2,578	1,094 (42.4)	0.98 (0.94–1.03)	1,125	496 (44.1)	1.01 (0.94–1.08)	1,453	598 (41.2)	0.96 (0.90–1.03)
Reciprocity									
No support	1,477	618 (41.8)	Reference	1,134	476 (42.0)	Reference	343	142 (41.4)	Reference
Any support	112,324	49,126 (43.7)	1.05 (0.98–1.11)	55,403	24,655 (44.5)	1.06 (0.99–1.14)	56,921	24,471 (43.0)	1.04 (0.92–1.18)
Missing	2,212	925 (41.8)	1.00 (0.92–1.08)	1,056	440 (41.7)	0.99 (0.90–1.10)	1,156	485 (42.0)	1.01 (0.88–1.17)
Age, years									
65–69	39,187	14,712 (37.5)	Reference	19,459	7,935 (40.8)	Reference	19,728	6,777 (34.4)	Reference
70–74	31,994	13,862 (43.3)	1.15*** (1.13–1.17)	15,841	7,085 (44.7)	1.10*** (1.07–1.12)	16,153	6,777 (42.0)	1.22*** (1.19–1.25)
75–79	24,629	11,630 (47.2)	1.26*** (1.23–1.28)	12,282	5,719 (46.6)	1.14*** (1.11–1.17)	12,347	5,911 (47.9)	1.39*** (1.36–1.43)
80–84	13,476	6,926 (51.4)	1.37*** (1.34–1.40)	6,801	3,357 (49.4)	1.21*** (1.18–1.25)	6,675	3,569 (53.5)	1.56*** (1.51–1.60)
85 and older	6,727	3,539 (52.6)	1.40*** (1.37–1.44)	3,210	1,475 (46.0)	1.13*** (1.08–1.17)	3,517	2,064 (58.7)	1.71*** (1.65–1.77)
Body mass index, kg/m^2									
–18.4	8,280	2,150 (26.0)	Reference	2,782	685 (24.6)	Reference	5,498	1,465 (26.6)	Reference
18.5–24.9	79,747	32,392 (40.6)	1.56*** (1.51–1.62)	40,097	23,584 (58.8)	1.67*** (1.57–1.79)	39,650	23,771 (60.0)	1.50*** (1.44–1.57)
25.0–29.9	22,923	13,256 (57.8)	2.23*** (2.14–2.31)	12,687	5,427 (42.8)	2.32*** (2.17–2.48)	10,236	4,240 (41.4)	2.20*** (2.10–2.3)
30.0–	2,558	1,694 (66.2)	2.55*** (2.44–2.67)	1,059	388 (36.6)	2.57*** (2.38–2.79)	1,499	476 (31.8)	2.56*** (2.42–2.71)
Missing	2,505	1,177 (47.0)	1.81*** (1.71–1.91)	968	526 (54.3)	1.85*** (1.69–2.04)	1,537	802 (52.2)	1.79*** (1.68–1.92)
Smoking status									
Never	66,215	28,612 (43.2)	Reference	14,578	6,259 (42.9)	Reference	51,637	22,353 (43.3)	Reference
Past	35,284	16,303 (46.2)	1.07*** (1.05–1.08)	31,666	14,796 (46.7)	1.09*** (1.06–1.11)	3,618	1,507 (41.7)	0.96 (0.92–1.001)
Current	13,214	5,143 (38.9)	0.90*** (0.88–0.92)	10,756	4,246 (39.5)	0.92*** (0.89–0.95)	2,458	897 (36.5)	0.84*** (0.80–0.89)
Missing	1,300	611 (47.0)	1.09** (1.03–1.15)	593	270 (45.5)	1.06 (0.97–1.16)	707	341 (48.2)	1.11** (1.03–1.20)

Table 2. Continued

Variables	Total			Male			Female		
	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)
Alcohol intake									
Never	55,989	23,483 (41.9)	Reference	13,999	5,168 (36.9)	Reference	41,990	18,315 (43.6)	Reference
Past	12,523	5,173 (41.3)	0.98 (0.96–1.01)	8,800	3,577 (40.6)	1.10*** (1.07–1.14)	3,723	1,596 (42.9)	0.98 (0.95–1.02)
Current	45,347	21,058 (46.4)	1.11*** (1.09–1.12)	34,010	16,486 (48.5)	1.31*** (1.28–1.35)	11,337	4,572 (40.3)	0.92*** (0.90–0.95)
Missing	2,154	955 (44.3)	1.06* (1.01–1.11)	784	340 (43.4)	1.17*** (1.08–1.28)	1,370	615 (44.9)	1.03 (0.97–1.09)
Diabetes mellitus									
No	100,493	42,520 (42.3)	Reference	47,894	20,626 (43.1)	Reference	52,599	21,894 (41.6)	Reference
Yes	15,520	8,149 (52.5)	1.24*** (1.22–1.26)	9,699	4,945 (51.0)	1.18*** (1.16–1.21)	5,821	3,204 (55.0)	1.32*** (1.29–1.36)
Dyslipidemia									
No	99,939	41,948 (42.0)	Reference	51,430	21,837 (42.5)	Reference	48,509	20,111 (41.5)	Reference
Yes	16,074	8,721 (54.3)	1.29*** (1.27–1.31)	6,163	3,734 (60.6)	1.43*** (1.40–1.46)	9,911	4,987 (50.3)	1.21*** (1.19–1.24)
Cardiovascular disease									
No	104,440	44,717 (42.8)	Reference	50,121	21,839 (43.6)	Reference	54,319	22,878 (42.1)	Reference
Yes	11,573	5,952 (51.4)	1.20*** (1.18–1.22)	7,472	3,732 (49.9)	1.15*** (1.12–1.18)	4,101	2,220 (54.1)	1.29*** (1.25–1.32)
Stroke									
No	112,574	48,718 (43.3)	Reference	55,154	24,184 (43.8)	Reference	57,420	24,534 (42.7)	Reference
Yes	3,439	1,951 (56.7)	1.31*** (1.27–1.35)	2,439	1,387 (56.9)	1.30*** (1.25–1.34)	1,000	564 (56.4)	1.32*** (1.25–1.40)
Geriatric Depression Scale score									
0–4	77,617	33,215 (42.8)	Reference	39,684	17,407 (43.9)	Reference	37,933	15,808 (41.7)	Reference
5–9	17,229	7,951 (46.1)	1.08*** (1.06–1.10)	8,741	4,009 (45.9)	1.05** (1.02–1.07)	8,488	3,942 (46.4)	1.11*** (1.09–1.14)
10-	5,318	2,473 (46.5)	1.09*** (1.05–1.12)	2,876	1,329 (46.2)	1.05* (1.01–1.10)	2,442	1,144 (46.8)	1.12*** (1.08–1.17)
Missing	15,849	7,030 (44.4)	1.04*** (1.02–1.06)	6,292	2,826 (44.9)	1.02 (0.99–1.05)	9,557	4,204 (44.0)	1.06*** (1.03–1.08)
Marital status									
Single	29,054	13,251 (45.6)	Reference	7,932	3,483 (43.9)	Reference	21,122	9,768 (46.2)	Reference
Married	85,319	36,743 (43.1)	0.94*** (0.93–0.96)	48,853	21,767 (44.6)	1.01 (0.99–1.04)	36,466	14,976 (41.1)	0.89*** (0.87–0.91)
Missing	1,640	675 (41.2)	0.90** (0.85–0.96)	808	321 (39.7)	0.90* (0.83–0.99)	832	354 (42.5)	0.92* (0.85–1.00)
Living status									
Living with others	94,254	41,132 (43.6)	Reference	49,459	22,011 (44.5)	Reference	44,795	19,121 (42.7)	Reference
Living alone	16,376	7,033 (42.9)	0.98 (0.97–1.00)	5,811	2,488 (42.8)	0.96* (0.93–0.99)	10,565	4,545 (43.0)	1.01 (0.98–1.03)
Missing	5,383	2,504 (46.5)	1.07*** (1.03–1.10)	2,323	1,072 (46.1)	1.04 (0.99–1.08)	3,060	1,432 (46.8)	1.10*** (1.05–1.14)
Educational level									
≤9 years	34,526	16,665 (48.3)	Reference	15,557	7,231 (46.5)	Reference	18,969	9,434 (49.7)	Reference

Table 2. Continued

Variables	Total			Male			Female		
	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)	Total *n*	Prevalence of hypertension, *n* (%)	PR (95% CI)
>10 years	80,225	33,454 (41.7)	0.86*** (0.85–0.88)	41,538	18,110 (43.6)	0.94*** (0.92–0.96)	38,687	15,344 (39.7)	0.80*** (0.78–0.81)
Missing	1,262	550 (43.6)	0.90** (0.85–0.96)	498	230 (46.2)	0.99 (0.90–1.09)	764	320 (41.9)	0.84*** (0.77–0.92)
Employment									
Never	7,023	3,253 (46.3)	Reference	1,043	458 (43.9)	Reference	5,980	2,795 (46.7)	Reference
Past	65,055	28,482 (43.8)	0.95*** (0.92–0.97)	33,519	15,108 (45.1)	1.03 (0.96–1.10)	31,536	13,374 (42.4)	0.91*** (0.88–0.93)
Current	29,721	12,379 (41.7)	0.90*** (0.87–0.93)	18,071	7,804 (43.2)	0.98 (0.92–1.06)	11,650	4,575 (39.3)	0.84*** (0.81–0.87)
Missing	14,214	6,555 (46.1)	1.00 (0.97–1.03)	4,960	2,201 (44.4)	1.01 (0.94–1.09)	9,254	4,354 (47.0)	1.01 (0.97–1.04)
Annual equivalent income, yen									
<2,000,000	44,514	19,705 (44.3)	Reference	22,172	9,862 (44.5)	Reference	22,342	9,843 (44.1)	Reference
2.00,000-4,000,000	38,709	16,463 (42.5)	0.96*** (0.95–0.98)	20,603	9,089 (44.1)	0.99 (0.97–1.01)	18,106	7,374 (40.7)	0.92*** (0.90–0.95)
>4,000,000	11,404	4,840 (42.4)	0.96** (0.94–0.98)	6,015	2,670 (44.4)	1.00 (0.97–1.03)	5,389	2,170 (40.3)	0.91*** (0.88–0.95)
Missing	21,386	9,661 (45.2)	1.02* (1.002–1.04)	8,803	3,950 (44.9)	1.00 (0.98–1.04)	12,583	5,711 (45.4)	1.03* (1.01–1.06)
Walking									
0–29 minutes	31,389	14,814 (47.2)	Reference	15,520	7,280 (46.9)	Reference	15,869	7,534 (47.5)	Reference
30–59 minutes	41,155	17,815 (43.3)	0.92*** (0.90–0.93)	20,170	9,010 (44.7)	0.95*** (0.93–0.97)	20,985	8,805 (42.0)	0.88*** (0.86–0.90)
≥60 minutes	41,190	17,011 (41.3)	0.88*** (0.86–0.89)	20,929	8,845 (42.3)	0.90*** (0.88–0.92)	20,261	8,166 (40.3)	0.85*** (0.83–0.87)
Missing	2,279	1,029 (45.2)	0.96 (0.91–1.002)	974	436 (44.8)	0.95 (0.89–1.03)	1,305	593 (45.4)	0.96 (0.90–1.02)
Frequency of going outside									
<Once per week	4,653	2,215 (47.6)	Reference	2,409	1,086 (45.1)	Reference	2,244	1,129 (50.3)	Reference
≥Once per week	110,413	48,035 (43.5)	0.91*** (0.89–0.94)	54,674	24,264 (44.4)	0.98 (0.94–1.03)	55,739	23,771 (42.6)	0.85*** (0.81–0.88)
Missing	947	419 (44.2)	0.93 (0.86–1.004)	510	221 (43.3)	0.96 (0.86–1.07)	437	198 (45.3)	0.90 (0.81–1.01)
Eating alone									
No	89,212	39,028 (43.7)	Reference	46,877	20,905 (44.6)	Reference	42,335	18,123 (42.8)	Reference
Yes	26,801	11,641 (43.4)	0.99 (0.98–1.01)	10,716	4,666 (43.5)	0.98* (0.95–0.99)	16,085	6,975 (43.4)	1.01 (0.99–1.03)
Frequency of meeting someone									
<Once per week	61,129	26,715 (43.7)	Reference	34,055	15,055 (44.2)	Reference	27,074	11,660 (43.1)	Reference
≥Once per week	54,035	23,552 (43.6)	1.00 (0.98–1.01)	23,271	10,401 (44.7)	1.01 (0.99–1.03)	30,764	13,151 (42.7)	0.99 (0.97–1.01)
Missing	849	402 (47.3)	1.08 (1.01–1.16)	267	115 (43.1)	0.97 (0.85–1.12)	582	287 (49.3)	1.15 (1.05–1.24)

Abbreviations: PR, prevalence ratio; CI, confidence interval.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 3. Prevalence ratio (95% confidence interval) for hypertension: determined by multilevel Poisson regression analysis

	Total		Male		Female	
Variables	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
Fixed effects						
Community-level social capital						
Civic participation (per 1 SD)	0.95*** (0.93–0.96)	0.98** (0.96–0.99)	0.97*** (0.95–0.98)	0.98 (0.96–1.005)	0.92*** (0.91–0.94)	0.97* (0.95–0.99)
Social cohesion (per 1 SD)	1.01* (1.00–1.03)	1.00 (0.98–1.01)	1.00 (0.98–1.02)	0.99 (0.97–1.01)	1.02* (1.003–1.04)	1.00 (0.98–1.02)
Reciprocity (per 1 SD)	1.02* (1.00–1.03)	1.01 (0.99–1.02)	1.01 (0.99–1.03)	1.01 (0.99–1.03)	1.02* (1.000–1.05)	1.00 (0.98–1.03)
Individual-level social capital						
Civic participation (ref. “no participation”)						
Any participation	0.93*** (0.91–0.94)	0.94*** (0.92–0.95)	0.97* (0.95–0.996)	0.95*** (0.92–0.97)	0.89*** (0.87–0.91)	0.94*** (0.91–0.97)
Social cohesion (ref. “not cohesive”)						
Cohesive	1.02 (1.00–1.05)	1.02 (0.99–1.04)	1.02 (0.99–1.06)	1.02 (0.98–1.06)	1.02 (0.98–1.06)	1.01 (0.97–1.05)
Missing	1.00 (0.93–1.07)	0.99 (0.93–1.07)	1.06 (0.95–1.18)	1.05 (0.94–1.17)	0.97 (0.88–1.06)	0.95 (0.87–1.04)
Reciprocity (ref. “no support”)						
Any support	1.05 (0.97–1.13)	1.03 (0.94–1.11)	1.05 (0.96–1.16)	1.02 (0.92–1.12)	1.04 (0.89–1.23)	1.08 (0.91–1.28)
Missing	1.00 (0.9–1.11)	0.96 (0.86–1.07)	0.97 (0.84–1.11)	0.94 (0.81–1.09)	1.02 (0.84–1.23)	1.00 (0.83–1.21)
Cross-level interaction	0.98 (0.95–1.00)	0.98 (0.96–1.00)	0.98 (0.95–1.02)	0.98 (0.95–1.02)	0.98 (0.94–1.01)	0.98 (0.95–1.01)
Community-level covariate						
Population density (ref. “first quantile”)						
Second quartile		0.97* (0.95–0.998)		0.97 (0.94–1.003)		0.98 (0.95–1.02)
Third quartile		0.94*** (0.91–0.97)		0.95* (0.91–0.996)		0.93** (0.89–0.97)
Fourth quartile		0.91*** (0.88–0.94)		0.94** (0.90–0.98)		0.88*** (0.84–0.92)
Individual-level covariate						
Smoking status (ref. “never”)						
Past		1.03* (1.004–1.06)		1.04** (1.01–1.07)		0.99 (0.94–1.04)
Current		0.94*** (0.91–0.97)		0.94** (0.90–0.98)		0.93* (0.87–0.999)
Missing		1.05 (0.94–1.16)		1.06 (0.89–1.25)		1.05 (0.92–1.19)
Alcohol intake (ref. “never”)						
Past		0.98 (0.95–1.01)		1.07** (1.03–1.12)		1.00 (0.94–1.05)
Current		1.19*** (1.17–1.22)		1.35*** (1.31–1.4)		1.04* (1.01–1.08)
Missing		1.04 (0.96–1.12)		1.15 (0.999–1.32)		1.01 (0.92–1.10)
Geriatric Depression Scale score (ref. “0–4”)						
5–9		1.05** (1.02–1.07)		1.04* (1.01–1.08)		1.05** (1.02–1.09)
10–		1.05* (1.004–1.09)		1.06 (0.999–1.12)		1.04 (0.98–1.11)

Table 3. Continued

Variables	Total		Male		Female	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Missing		1.02 (0.99–1.05)		1.02 (0.98–1.07)		1.02 (0.98–1.05)
Marital status (ref. “single”)						
Married		0.95** (0.92–0.98)		0.99 (0.94–1.05)		0.96* (0.93–0.998)
Missing		0.88** (0.81–0.95)		0.88* (0.78–0.99)		0.91 (0.82–1.02)
Educational status (ref. “≤9 years”)						
>10 years		0.94*** (0.92–0.96)		0.95** (0.92–0.98)		0.93*** (0.90–0.96)
Missing		0.94 (0.86–1.03)		1.02 (0.90–1.17)		0.89* (0.79–0.99)
Walking (ref. “0–29 minutes”)						
30–59 minutes		0.96** (0.94–0.99)		0.96* (0.93–0.995)		0.96* (0.93–0.99)
≥60 minutes		0.94*** (0.92–0.96)		0.93*** (0.90–0.96)		0.95** (0.92–0.98)
Missing		0.97 (0.91–1.04)		0.98 (0.88–1.10)		0.96 (0.88–1.05)
Intercept (SE)		0.224 (0.013)		0.174 (0.016)		0.209 (0.021)
Random effects						
Community-level variance	0.0013 (0.0005)	<0.0001	<0.0001	<0.0001	0.0018 (0.0010)	<0.0001

The *P* value for interaction between community-level civic participation and sex was 0.014. In model 1, both individual-level and community-level social capital indices and cross-level interaction terms between individual- and community-level civic participation were included. In model 2, in addition to the variables listed in the table, age, sex, body mass index, diabetes, dyslipidemia, cardiovascular disease, stroke, living status, employment, annual equivalent income, frequency of going outside, eating alone, and frequency of meeting someone were included.

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

adjustment for individual- and community-level covariates in model 2, the association between community-level civic participation and hypertension remained significant in the total and female groups (total: PR = 0.98 (0.96–0.99), $P < 0.05$; females: PR = 0.97 (0.95–0.99), $P < 0.05$) and neared significance in the male group (males: PR = 0.98 (0.96–1.005), $P = 0.13$). The interaction between community-level civic participation and sex in relation to hypertension was significant ($P = 0.012$). No significant association was found in social cohesion and reciprocity at both the individual and community levels in model 2. In addition, we observed no statistically significant interaction between individual- and community-level civic participation in all the analyses.

Further analyses were performed to examine the differences in the contextual associations with hypertension according to organization type (Table 4). Instead of civic participation, each of the 8 organizations was used to create individual- and community-level social participation variables. Sports groups (total: PR = 0.98 (0.97–0.997), $P < 0.05$; females: PR = 0.98 (0.96–1.00), $P = 0.057$), hobby activity groups (total: PR = 0.98 (0.96–0.99), $P < 0.05$; females: PR = 0.98 (0.96–0.995), $P = 0.057$), and study or cultural groups (total: PR = 0.97 (0.95–0.999), $P < 0.05$; females: PR = 0.98 (0.94–1.01), $P = 0.19$) showed significant or near-significant contextual relationships with hypertension after adjusting for all the covariates in the total and female groups. In males, sports groups (males: PR = 0.98 (0.96–1.01), $P = 0.17$) and hobby activity groups (males: PR = 0.98 (0.96–1.001), $P = 0.07$) showed a near-significant contextual relationship with hypertension in model 2. On the other hand, participation in senior citizen clubs showed a positive (harmful) contextual relationship with hypertension in the total and female groups.

DISCUSSION

To the best of our knowledge, this is the first study to demonstrate the contextual relationship between community-level social participation and hypertension in older people. Civic participation, defined as participation in sports groups, volunteer groups, hobby activity groups, study or cultural groups, and activities to teach skills or pass on experiences to others, showed a beneficial contextual relationship with hypertension. We also found that the relationship varied by sex and organization type. The findings of this study suggest that promoting and organizing certain types of social activities in a community may be beneficial to the prevention of hypertension even in people who do not participate in such activities.

Several studies have reported that individual-level participation in horizontal organizations (characterized by nonhierarchical, egalitarian relationships) may be more beneficial to health than participation in vertical organizations (characterized by hierarchical relationships).[4,19] In this study, the 5 organizations involved in civic participation, and nursing care prevention activities were considered horizontal organizations. Senior citizen clubs and community associations were considered vertical organizations. In line with these, participation in horizontal organizations was beneficially associated with hypertension at the individual level. Furthermore, beneficial relationships with hypertension were also found with civic participation and some organizations comprising civic participation at the community level. This indicates that certain types of social participation, particularly the horizontal type, may have a beneficial group-level effect on hypertension. Although prospective investigations are required to confirm the causal effects, these findings are compelling because they suggest a population approach for reducing the prevalence of hypertension in communities through improvements in the contextual characteristics of communities. For example, promoting social participation programs, providing facilities for sports and hobby, and improving infrastructure for easy access may create a beneficial surrounding environment based on social participation. Residents of such communities can benefit from social participation not only by direct involvement but also through membership of the communities through their contextual effect.

Three group-level mechanisms are considered relevant to the pathways linking community-level social participation to hypertension: social contagion, informal social control, and collective efficacy.[6] Social contagion demonstrates that behaviors spread more quickly in a tightly knit network, through the diffusion of information or the transmission of behavioral norms. In communities in which many people participate in sports clubs, for example, residents who do not participate in sports club may begin exercising and walking owing to the behaviors of the people surrounding them. Informal social control was originally developed to refer to the ability of community members to suppress crime. However, this is also applicable to the prevention of harmful behaviors associated with hypertension such as smoking and excessive drinking. Older individuals may be encouraged by others to stop these harmful habits more often in communities with many participants engaged in social activities. In fact, adjustment for these individual-level factors mitigated the association between social participation and hypertension. However, the association of civic participation and participation in some organizations with hypertension remained significant, suggesting that other mechanisms also contribute to the linking pathway. Collective efficacy is the ability of the collective to mobilize collective action. Coleman referred to the term "appropriable social organizations" to explain the phenomenon that once a social organization is established for one purpose, it can be later adapted for a different purpose.[20] The opinions and actions of communities with widespread social participation may lead to the development of facilities, systems, and policies for health promotion.

In addition, a psychological factor can mediate the relationship between community-level social participation and hypertension. Community-level social participation, particularly in horizontal organizations, has been reported to have a protective relationship with individual-level depressive symptoms.[8,9] Because psychological stress is well-known to contribute to the development of hypertension,[21] residents of communities in which many people are involved

Table 4. Regression analysis showing prevalence ratio (95% confidence interval) of social participation-related indices for hypertension with treatment

Variables	Total		Male		Female	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Sports						
Community level (per 1 SD)	0.95*** (0.94–0.97)	0.98* (0.97–0.997)	0.97** (0.95–0.99)	0.98[a] (0.96–1.01)	0.93*** (0.92–0.95)	0.98[c] (0.96–1.00)
Individual level	0.92*** (0.90–0.94)	0.94*** (0.92–0.96)	0.97 (0.94–1.001)	0.95** (0.92–0.98)	0.88*** (0.86–0.91)	0.94*** (0.91–0.96)
Volunteer						
Community level (per 1 SD)	0.97* (0.95–0.99)	0.99 (0.97–1.01)	0.98 (0.95–1.01)	0.99 (0.96–1.02)	0.96* (0.93–0.99)	0.99 (0.96–1.02)
Individual level	0.93*** (0.91–0.96)	0.94*** (0.92–0.97)	0.98 (0.94–1.02)	0.96 (0.93–1.00)	0.89*** (0.86–0.93)	0.92*** (0.89–0.96)
Hobby						
Community level (per 1 SD)	0.95*** (0.94–0.96)	0.98** (0.96–0.99)	0.97*** (0.95–0.98)	0.98[b] (0.96–1.001)	0.93*** (0.91–0.95)	0.98* (0.96–0.995)
Individual level	0.94*** (0.93–0.96)	0.95*** (0.93–0.97)	0.98 (0.96–1.01)	0.96** (0.93–0.99)	0.92*** (0.89–0.94)	0.96** (0.93–0.99)
Study or cultural						
Community level (per 1 SD)	0.94*** (0.91–0.96)	0.97* (0.95–0.999)	0.96 (0.92–1.00)	0.97 (0.93–1.02)	0.92*** (0.89–0.95)	0.98[d] (0.94–1.01)
Individual level	0.91*** (0.88–0.94)	0.92*** (0.89–0.95)	0.99 (0.93–1.04)	0.97 (0.91–1.02)	0.87*** (0.84–0.91)	0.91*** (0.87–0.95)
Teach skills						
Community level (per 1 SD)	0.95** (0.92–0.99)	0.99 (0.96–1.02)	1.00 (0.95–1.04)	1.01 (0.97–1.06)	0.91*** (0.87–0.96)	0.97 (0.92–1.02)
Individual level	0.89*** (0.86–0.92)	0.90*** (0.87–0.94)	0.92** (0.87–0.97)	0.91** (0.87–0.96)	0.86*** (0.81–0.91)	0.90*** (0.85–0.95)
Nursing care						
Community level (per 1 SD)	1.01 (0.99–1.03)	1.01 (0.99–1.03)	1.00 (0.97–1.04)	1.01 (0.98–1.04)	1.01 (0.99–1.04)	1.01 (0.99–1.03)
Individual level	0.97 (0.93–1.004)	0.95* (0.92–0.99)	1.01 (0.95–1.08)	0.98 (0.92–1.05)	0.95* (0.91–0.998)	0.95* (0.90–0.99)
Senior citizen						
Community level (per 1 SD)	1.03*** (1.02–1.05)	1.02* (1.00–1.04)	1.02 (0.99–1.04)	1.01 (0.98–1.03)	1.05*** (1.03–1.08)	1.03* (1.01–1.06)
Individual level	1.07** (1.03–1.11)	1.00 (0.96–1.04)	1.06 (0.998–1.12)	1.01 (0.96–1.08)	1.08** (1.02–1.14)	0.98 (0.93–1.04)
Community association						
Community level (per 1 SD)	1.00 (0.98–1.02)	1.01 (0.99–1.03)	1.00 (0.98–1.02)	1.01 (0.98–1.03)	1.00 (0.97–1.03)	1.02 (0.99–1.05)
Individual level	0.99 (0.96–1.03)	1.00 (0.96–1.03)	0.98 (0.94–1.02)	0.98 (0.94–1.02)	1.00 (0.95–1.06)	1.01 (0.96–1.06)

The same variables as in Table 3 were included in models 1 and 2. Reference of individual-level social participation is “no participation.”
[a]$P = 0.17$; [b]$P = 0.07$; [c]$P = 0.057$; [d]$P = 0.19$.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

in horizontal-type organizations may be less likely to have hypertension through their alleviated mental stress.

In the present study, the beneficial relationship between community-level social participation and hypertension was stronger in females than males, although the overall trends were similar in both sexes. Although the reasons for the sex difference in the association are unclear, they may be partially explained by the differences in the strength of the reliance on the neighborhood for healthful resources. Antonucci and Akiyama reported that older females have larger networks and receive support from multiple sources, whereas males tend to rely on their spouses exclusively.[22] In addition, male respondents were likelier to have a job than their female counterparts (males: 31.4%; females: 19.9%, $P < 0.001$), and fewer male respondents engaged in civic participation. This suggests that males depend on other resources rather than the community to develop their social network.

Limitations

Our study has potential limitations. First, this is a cross-sectional study, so the possibility of reverse causation cannot be completely excluded. However, a reverse causal relationship does not seem reasonable in the explanation of the negative association between civic participation and hypertension, as hypertension patients are expected to participate more frequently in organizations such as sports groups to improve their blood pressure. It is not reasonable to avoid participation in social activities as a means to prevent hypertension. Second, we defined hypertension as "hypertension on treatment" based on a questionnaire. Although a good agreement between self-reported hypertension and medical record data was expected,[16] we could not include hypertension patients who were diagnosed at a checkup or clinic but did not receive treatment. However, the use of this definition is advantageous, in that we could exclude people for whom medical treatment was considered unnecessary because of the white-coat phenomenon, or as hypertension was controlled through lifestyle changes. Third, accessibility to medical facilities may have affected the results of this study because residents in large cities can usually access medical facilities more easily than those in small rural areas, which may have increased the number of patients with hypertension on treatment in large cities. However, the effect of accessibility probably led to the positive, rather than negative, association between community-level social participation and hypertension because the prevalence of civic participation was positively correlated with population density in this study. Fourth, selection bias may have affected the results because the survey response rate was 70.2%. Nonrespondents may have been likelier to be isolated from society and unhealthier than the respondents. In addition, there were several missing values, which may have led to systematic bias. Finally, it remains unknown whether the findings of this study can be extended to other populations. Particularly, the impact of organization type on the contextual effect of social participation probably varies by cultural background. However, basic concepts of this study (the contextual effect of social participation) seem to be generalizable and warrant further studies to be examined in other populations.

We found a contextual preventive relationship between community-level social participation and hypertension in older Japanese people. Females may derive a much stronger benefit from community-level social capital than males. In addition, the beneficial effects may vary by organization type. The design of the contextual characteristics of communities by promoting certain type of social participation and providing easy access to it may be an effective population approach to reduce the prevalence of hypertension among older people.

ACKNOWLEDGMENTS

This study was supported by grants from Chiba Foundation for Health Promotion and Disease Prevention. This study used data from the Japan Gerontological Evaluation Study (JAGES) supported by Japan Society for the Promotion of Science (JSPS) KAKENHI Grant Numbers (JP15H01972, JP15H04781, JP15H05059, JP15K03417, JP15K03982, JP15K16181, JP15K17232, JP15K18174, JP15K19241, JP15K21266, JP15KT0007, JP15KT0097, JP16H05556, JP16K09122, JP16K00913, JP16K02025, JP16K12964, JP16K13443, JP16K16295, JP16K16595, JP16K16633, JP16K17256, JP16K19247, JP16K19267, JP16K21461, JP16K21465, JP16KT0014, JP25253052, JP25713027, JP26285138, JP26460828, JP26780328), Health Labour Sciences Research Grants (H26-Choju-Ippan-006, H27-Ninchisyou-Ippan-001 H28- Choju-Ippan-002, H28- Ninchisyou-Ippan-002), the Research and Development Grants for Longevity Science from the Japan Agency for Medical Research and Development (AMED) (16dk0110017h0002, 16ls0110002h0001), and the Research Funding for Longevity Sciences from National Center for Geriatrics and Gerontology (24-17, 24-23). The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the respective funding organizations.

DISCLOSURE

The authors declared no conflict of interest.

REFERENCES

1. World Health Organization. *Global Status Report on Noncommunicable Diseases 2010.* <http://www.who.int/nmh/publications/ncd_report2010/en/>. Accessed 6 January 2019.
2. Miura K, Nagai M, Ohkubo T. Epidemiology of hypertension in Japan: where are we now? *Circ J* 2013; 77:2226–2231.
3. World Health Organization. *A Global Brief of Hypertension 2013.* <http://apps.who.int/iris/bitstream/10665/79059/1/WHO_DCO_WHD_2013.2_eng.pdf>. Accessed 6 January 2019.
4. Yazawa A, Inoue Y, Fujiwara T, Stickley A, Shirai K, Amemiya A, Kondo N, Watanabe C, Kondo K. Association between social participation and hypertension among older people in Japan: the JAGES Study. *Hypertens Res* 2016; 39:818–824.

5. Beard JR, Officer A, de Carvalho IA, Sadana R, Pot AM, Michel JP, Lloyd-Sherlock P, Epping-Jordan JE, Peeters GMEEG, Mahanani WR, Thiyagarajan JA, Chatterji S. The World report on ageing and health: a policy framework for healthy ageing. *Lancet* 2016; 387:2145–2154.
6. Berkman LF, Kawachi I, Glymour MM. *Social Epidemiology*, 2nd edn. Oxford University Press: New York, 2014, pp. 290–319.
7. Putnam RD. *Making Democracy Work: Civic Traditions in Modern Italy.* Princeton University Press: Princeton, NJ, 1993, pp. 167.
8. Saito M, Kondo N, Aida J, Kawachi I, Koyama S, Ojima T, Kondo K. Development of an instrument for community-level health related social capital among Japanese older people: the JAGES Project. *J Epidemiol* 2017; 27:221–227.
9. Tsuji T, Miyaguni Y, Kanamori S, Hanazato M, Kondo K. Community-level sports group participation and older individuals' depressive symptoms. *Med Sci Sports Exerc* 2018; 50:1199–1205.
10. Hamano T, Fujisawa Y, Yamasaki M, Ito K, Nabika T, Shiwaku K. Contributions of social context to blood pressure: findings from a multilevel analysis of social capital and systolic blood pressure. *Am J Hypertens* 2011; 24:643–646.
11. Oksanen T, Kawachi I, Jokela M, Kouvonen A, Suzuki E, Takao S, Virtanen M, Pentti J, Vahtera J, Kivimäki M. Workplace social capital and risk of chronic and severe hypertension: a cohort study. *J Hypertens* 2012; 30:1129–1136.
12. Fujino Y, Kubo T, Kunimoto M, Tabata H, Tsuchiya T, Kadowaki K, Nakamura T, Oyama I. A cross-sectional study of workplace social capital and blood pressure: a multilevel analysis at Japanese manufacturing companies. *BMJ Open* 2013; 3:e002215.
13. Ahern MM, Hendryx MS. Social capital and risk for chronic illnesses. *Chronic Illn* 2005; 1:183–190.
14. Kondo K. Progress in aging epidemiology in Japan: the JAGES project. *J Epidemiol* 2016; 26:331–336.
15. Takagi D, Kondo K, Kawachi I. Social participation and mental health: moderating effects of gender, social role and rurality. *BMC Public Health* 2013; 13:701.
16. Okura Y, Urban LH, Mahoney DW, Jacobsen SJ, Rodeheffer RJ. Agreement between self-report questionnaires and medical record data was substantial for diabetes, hypertension, myocardial infarction and stroke but not for heart failure. *J Clin Epidemiol* 2004; 57:1096–1103.
17. Fujiwara T, Takamoto I, Amemiya A, Hanazato M, Suzuki N, Nagamine Y, Sasaki Y, Tani Y, Yazawa A, Inoue Y, Shirai K, Shobugawa Y, Kondo N, Kondo K. Is a hilly neighborhood environment associated with diabetes mellitus among older people? Results from the JAGES 2010 study. *Soc Sci Med* 2017; 182:45–51.
18. Zhang J, Yu KF. What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA* 1998; 280:1690–1691.
19. Aida J, Hanibuchi T, Nakade M, Hirai H, Osaka K, Kondo K. The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis. *Soc Sci Med* 2009; 69:512–518.
20. Coleman J. *Foundations of Social Theory.* Harvard University Press: Cambridge, MA, 1990, pp. 300–321.
21. Hamer M, Steptoe A. Cortisol responses to mental stress and incident hypertension in healthy men and women. *J Clin Endocrinol Metab* 2012; 97:E29–E34.
22. Antonucci TC, Akiyama H. An examination of sex differences in social support among older men and women. *Sex Roles* 1987; 17:737–749.