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Complete List of Authors:	Koyama, Shihoko; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Aida, Jun; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Saito, Masashige; Nihon Fukushi University, Department of Social Welfare kondo, naoki; University of Tokyo School of Public Health, Department of Health Economics and Epidemiology Research Sato, Yukihiro; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Matsuyama, Yusuke; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Tani, Yukako; University of Tokyo School of Public Health, Department of Health Education and Health Sociology Sasaki, Yuri; Chiba University, Center for Preventive Medical Science Kondo, Katsunori; Chiba University, Center for Preventive Medical Science Ojima, Toshiyuki; Hamamatsu University School of Medicine, Department of Community Health and Preventive Medicine Yamamoto, Tatsuo; Graduate School of Dentistry, Kanagawa Dental University, Department of Oral Science Tsuboya, Toru; Tohoku university, School of Dentistry Osaka, Ken; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health
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Title

Community social capital and oral health in Japanese older people: longitudinal cohort study

Corresponding author: Jun Aida

Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry

4-1, Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8575, Japan Tel: +81-22-717-7639; Fax: +81-22-717-7644

E-mail: j-aida@umin.ac.jp

Shihoko. Koyama[1], Jun. Aida[1], Masashige Saito[2], Naoki Kondo[3], Yukihiro Sato[1], Yusuke Matsuyama[1], Yukako Tani[3], Yuri Sasaki[4], Katsunori Kondo[4], Toshiyuki Ojima[5], Tatsuo Yamamoto[6], Toru Tsuboya[1], Ken Osaka[1]

[1] Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry, Miyagi, Japan

[2] Department of Social Welfare, Nihon Fukushi University, Aichi, Japan

[3] Department of Health Education and Health Sociology, School of Public Health,
The University of Tokyo

[4] Center for Preventive Medical Science, Chiba University

[5] Department of Community Health and Preventive Medicine, Hamamatsu University School of Medicine, Shizuoka, Japan

[6] Division of Dental Sociology, Department of Oral Science, Graduate School of Dentistry, Kanagawa Dental University, Yokosuka City, Kanagawa, Japan

Key words: Social capital; Multilevel analysis; Tooth loss; Cohort study; Panel data

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ABSTRACT (242 words)

Objective: No study has prospectively examined the association of social capital in the community on oral health. The aim of this longitudinal cohort study was to examine the association between both community- and individual-level social capital (SC) and poor oral health in older Japanese.

Design: Prospective cohort study

Setting: We used data from the Japan Gerontological Evaluation Study (JAGES) performed in 2010 and 2013, conducted in 525 districts.

Participants: The target population was restricted to people aged 65 years or older who did not already have physical or cognitive disabilities. The participants were 51,280 people who responded in two surveys and had teeth at baseline.

Primary outcome measures: Loss of remaining teeth, measured by downward change of any category of remaining teeth, between baseline and follow-up.

Results: The mean age of the participants was 72.5 (SD=5.4). Further, 8.2% (n=4,180) lost one or more of their remaining teeth. Among 3 community-level social capital variables obtained from factor analysis, an indicator of civic participation significantly reduces the risk of tooth loss (OR: 0.93 [95% CI: 0.88–0.99]) in the fully adjusted model. In the model, individual-level social capital variable, "hobby activity participation" and "sports group participation" were also associated with a reduced risk of tooth loss (OR: 0.87 [95% CI: 0.80–0.95] and 0.90 [95% CI: 0.81–0.99]),

respectively).

Conclusions: Living in a community with rich social capital and individuals with good social capital predicted future maintenance of good oral health among older Japanese.

Strengths and limitations of this study

- This was the first prospective cohort study to examine the association between both community- and individual-level social capital and oral health.
- To consider wider range of community contextual characteristic, this study surveyed 525 communities around Japan.
- More than 50 thousand older population participated base-line and follow-up surveys.
- While this survey was large, the measurements used were self-reported, not clinical measurements.

INTRODUCTION

Higher prevalence of oral diseases causes not only individual burden, but also large social cost. Untreated caries in permanent teeth is the most prevalent condition, and severe periodontitis and untreated caries in deciduous teeth were the 6th and 10th most prevalent conditions of 291 diseases and injuries.[1] As a result of these diseases, tooth loss occurred, and severe tooth loss was the 36th most prevalent condition.[1] The direct and indirect global economic burden caused by oral diseases amounted to 442 billion US dollars in 2010.[2] In addition, oral health could affect general health conditions such as cardiovascular diseases,[3],[4] dementia,[5] incidence of falls,[6,7] and functional disability.[8]

Widespread inequalities in oral health are observed across the globe including in Japan[9], and which is associated with individual and social burdens. Social determinants of health are the most important cause of health inequalities.[10,11] Social capital, defined by Kawachi and Berkman[12] as "resources that are accessed by individuals as a result of their membership of a network or a group", is increasingly recognized as a determinant of population health as well as that of health inequalities.[13,14] Recently there has been an increased number of cross-sectional studies that have demonstrated the association between social capital and resources obtained from social capital on oral health.[15-18] In spite of large volume of cross-sectional studies focused on social capital and oral health outcomes, few studies used longitudinal

observation with community-level social capital, rather than individual-level measurements. Due to the possibility that a community's contextual social capital could affect the health of all residents, it is important to study population health. Although one prospective study in the United Kingdom suggests that the change in an individual's social capital corresponds to plausible changes in an older person's life course, this study did not use community-level social capital measurements.[19]

Questions regarding the association between community-level social capital and oral health based on longitudinal studies remain unclear. The aim of this longitudinal cohort study was to examine the association between community-level and individual-level social capital and poor oral health (reduction of remaining teeth) in Japanese elderly. We hypothesized that living in a high community-level social capital at baseline predicts a good oral health at follow-up even with considerations for individual-level social capital.

METHODS

Study setting

We used data from Japan Gerontological Evaluation Study (JAGES). The JAGES Project investigated social, behavioural, and health factors in people aged 65 years or older. The JAGES sample was restricted to people who did not already have physical or cognitive disabilities, which were defined as receiving long-term public care insurance benefits. This

longitudinal study used the panel data from 2 surveys. The baseline survey was conducted between August 2010 and January 2012 for 141,452 older people and 92,272 participated (response rate = 65.2%). The follow-up survey was conducted between October 2013 and December 2013, and 62,438 individuals completed the questionnaire in 2010 and 2013. Self-administered questionnaires were mailed to entire population in 10 municipalities, and in 14 municipalities, questionnaires were mailed to randomly selected population based on the official residential registers obtained from the municipal governments. Self-administered questionnaires used for the follow-up survey were subsequently mailed to the same municipalities and respondents.

Of these respondents, 4,466 were excluded because of a lack of information regarding oral health in 2010 and 2013. We excluded 6,541 individuals who had no natural teeth at baseline (2010), 151 individuals who were no information for their residential area. Finally, 51,280 respondents from 525 small districts were included in our analyses.

Outcome variable

The outcome variable used was dichotomous and "reduction of remaining teeth or not" between baseline to follow-up was measured. In both surveys, we asked for the number of remaining teeth by the following categories: "≥ 20 teeth"; "10-19 teeth"; "1-9 teeth"; "no natural teeth". At the follow-up survey, if respondents chose a category with a smaller number of

teeth compared to that of baseline, respondents were defined as a people who had reduced the number of their remaining teeth. Data on respondents who had no natural teeth at baseline were excluded from the multilevel analysis.

Predictor variables

Predictor variables used were individual-level social capital and community-level social capital, which were based on validated measurements by JAGES project data in 2013[20].

Individual-level social capital

Individual-level social capital used were participation in each community activity (volunteer groups, sports groups/clubs, hobby activity group), community trust, community attachment, and social support (receive emotional support, provide emotional support, receive instrumental support) in 2010.

The response categories used for community activity participation variables were “once or more per week” and “less than once per week”. Community trust was measured by using the two questions, first, “Do you trust people where live in your local area?”, second, “Do you think that to be helpful to other people in your local area?” to which respondents answered yes or no. Community attachment was measured by using the question, “Do you have attachment in your local area?” to which respondents answered yes or no. Social support was measured using three items: “Do you have someone

who listens to your concerns and complaints?" (categorized as 'receive emotional support'), "Do you listen to someone else's concerns and complaints?" (provide emotional support) and "Do you have someone who looks after you when you are sick for a few days?" (receive instrumental support).

Community-level social capital

We supposed that respondents lived in the same districts exposed to the same degree of community-level social capital. Community-level social capital variables were obtained from factor analysis. At first, rates of each individual-level social capital responses in each small district were calculated. Then, using 525 small districts as the analysis unit, factor analysis was conducted. As the result, three factors were obtained: civic participation (the participations in volunteer group; sports group; and hobby activity), social cohesion (community trust and attachment), reciprocity (received / provided emotional support; received instrumental support). Factor scores of each small district were used as the community-level social capital variables.

Covariate

As in the studies mentioned previously, the following questions regarding sociodemographic characteristics, baseline health status, and risk factors of oral health stats were included in the analyses as covariates: age,

sex, educational attainment, annual household income, comorbidity, smoking, density of dental office, population density, and number of teeth at baseline (2010). Age was grouped into quartiles: 65-69 years, 70-74 years, 75-79 years, 80-84 years, and 85 years or older. Educational attainment was categorized as follows: <6 years, 6–9 years, 10–12 years, and ≥13 years. Annual household income was categorized as follows: <$20,000 (<¥2,000,000), $20,000–$29,999 (¥2,000,000–¥2,999,999), $30,000–$39,999 (¥3,000,000–¥3,999,999), and ≥$40,000 (≥¥4,000,000) (US$1 = ¥100). Comorbidity was measured by using the question, "Do you receive treatment now?" (to which respondents answered yes or no). Smoking was categorized as follows: non-smoking, non-smoking now and quit more than 5 years ago, non-smoking now and quit within 4 years ago, and smoking now. We included density of dental office as a continuous variable in the models. Population density was categorized as follows: urban area (≥ 1500 people/km^2), suburban area (1,000-1,500 people/km^2), and rural area (< 1,000 people/km^2).

Data analysis

The data were analysed by multilevel logistic regression analyses. We calculated odds ratio (OR) and 95% confidence interval (CI) for respondents who had a reduction in the number of remaining teeth. Because 51,280 respondents were lived in 525 small districts, a two-level model (community-level and individual-level) was used. We put emphasize on the

theoretical importance of the covariates, we included all covariates into the multivariate model. If data were missing for explanatory variables, the corresponding observations were assigned to "missing" categories. The significance level was set at p-values < 0.05. We used SPSS version 19.0 for factor analysis and Stata version 13.1 for multilevel analysis.

Ethical issues

JAGES respondents were informed that participation in the study was voluntary, and that completing and returning the self-administered questionnaire by mail indicated their consent for participation in the study. Ethical approval was obtained from the Ethics Committee at Nihon Fukushi University.

RESULTS

Of 51,280 respondents, 21,652 men and 25,448 women were included in the analysis. The average age of the 51,280 respondents was 72.5 (SD=5.4). Among the respondents, 8.2% (n=4,180) who had a reduction in the number of their remaining teeth. Table 1 shows the descriptive statistics for each variable. Participants with older, lower education, lower income, living rural area, no emotional social support, having 10-19 teeth, or smoking tended to have higher incidence of tooth loss.

Table 2 shows the results of the multilevel logistic analysis. In the sex and age adjusted model, significant association of community-level social

capital and incidence of tooth loss was observed at 2 variables, "civic participation" and "social cohesion": OR: 0.84 [95% CI:0.80–0.89], and OR: 1.14 [95% CI:1.08–1.20], respectively. As the individual-level social capital variables, "hobby activity participation" and "sports group participation" were statistically significantly reduce the risk of tooth loss: OR: 0.81 [95% CI:0.76–0.88], and OR: 0.82 [95% CI:0.76–0.90], respectively. When all variables were included into a model, living in rich community-level social capital district at baseline and incident of tooth loss was observed at the variable "civic participation" (OR: 0.93 [95% CI: 0.88–0.99]). Individual-level social capital variables, "hobby activity participation" and "sports group participation" had still significant associations (OR: 0.87 [95% CI: 0.80–0.95]) (OR: 0.90 [95% CI: 0.81–0.99]).

DISCUSSION

To the best of our knowledge, this is the first study to examine the association between both community- and individual-level social capital and oral health by longitudinal data. The results suggest living in community with a higher density of civic participation, a measurement of community-level social capital, at baseline was associated with future low risk of tooth loss. This association was still significant even after adjustments for individual-level social participation variables that were also beneficial to oral health.

The results of the present longitudinal analysis were similar to

previous cross-sectional studies. In Japan, a previous study demonstrated a significant positive association between social participation and dental health status among older people. [21] Other cross-sectional study suggested that community-level horizontal social capital and vertical social capital have different effects on health; only the former had a contextual effect on dental status.[22] A review of the papers on social capital and oral health also reported the beneficial association of social capital and oral health. [16] However, the review pointed out the needs for longitudinal analysis. Present study added an evidence of social capital and oral health by cohort study.

There are numerous possible pathways between social capital and oral health. Rouxel et al. summarized the hypothesized pathways linking social capital and oral health: behavioural, psychosocial, via access to oral health services, and via policy development.[16] As the behavioural pathway, social capital is considered to affect health behaviours through social contagion and informal social control.[12] As an example, one study observed the contagion of smoking-cessation following the social network.[23] As the psychosocial pathway, social capital is considered to be associated with reducing psychosocial stress which is a possible risk of oral diseases.[24] Through collective efficacy community with rich social capital can be enable to establish health promoting policies.[12] Although population density of dental clinics was sparse during 1960th-1970th in Japan, establishment of dental clinic might be promoted in a community with rich social.

From the present results, social capital may contribute to

improvements in oral health. Previous intervention studies tried to promote health through enhancement of social capital. [25-27] The participation in the community salon contributed to the prevention of incident functional disability.[25,27] Hikichi et al. found that participation in the community salon contributed to the prevention of incident functional disability[27]. Although previous intervention studies related to social capital did not examine the effect on oral health, public health interventions enhancing social capital might improve oral health.

The strength of our study was its prospective cohort design that involved using panel data. This design was suitable for the inference of causality compared to previous cross-sectional studies. This is the first multilevel study of social capital and oral health using longitudinal data, including not only individual-level social capital but also community-level social capital. In addition, this study enabled to consider wider range of community contextual characteristic by surveying 525 communities around Japan with more than 50 thousand older people.

This study has a limitation that should be noted. While this survey was large, an oral health (number of remaining teeth) was self-reported, and even though the validity of this measure has been well established with respect to objective measures,[28-30] the longitudinal change of self-reported dental health was imprecise relative to clinical dental check-ups.

CONCLUSION

This large-scale covering wider areas cohort study has provided evidence that high community-level and individual-level social capital at baseline predicts lower incidence of tooth loss at follow-up in Japan older people.

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TABLES

Table 1. Characteristics of respondents for reduction of remaining teeth (n=51280)

		Reduction of remaining teeth (N, %)				
		No		Yes		Total
Sex	Man	21652	91%	2272	9%	23924
	Woman	25448	93%	1908	7%	27356
Age	65-69	16367	93%	1187	7%	17554
	70-74	14899	92%	1281	8%	16180
	75-79	10748	91%	1089	9%	11837
	80-84	2798	89%	346	11%	3144
	85+	1111	88%	152	12%	1263
Education	< 6 years	541	88%	77	12%	618
	6-9 years	19210	91%	1923	9%	21133
	10-12 years	16832	93%	1299	7%	18131
	≥13 years	8957	93%	702	7%	9659
Annual household income	< $10,000	4727	90%	504	10%	5231
	$10,000-$19,999	13758	92%	1208	8%	14966
	$20,000-$29,999	10198	92%	832	8%	11030
	$30,000-$39,999	6472	93%	502	7%	6974
	≥$40,000	4768	93%	364	7%	5132
Living area	Urban area	12844	93%	897	7%	13741
	Suburban area	22231	92%	1987	8%	24218
	-	12025	90%	1296	10%	13321
Hobby activity	Less than once per week	23139	91%	2207	9%	25346
	Once or more per week	16695	93%	1232	7%	17927
Sports group	Less than once per week	28213	92%	2596	8%	30809
	Once or more per week	10384	93%	756	7%	11140
Volunteer group	Less than once per week	32222	92%	2797	8%	35019
	Once or more per week	4688	92%	388	8%	5076

Community trust	No	12544	92%	1098	8%	13642
	Yes	32310	92%	2879	8%	35189
Community reciprocity	No	19386	92%	1657	8%	21043
	Yes	25252	92%	2294	8%	27546
Community attachment	No	7947	92%	709	8%	8656
	Yes	37904	92%	3356	8%	41260
Receive emotional support	No	2305	90%	268	10%	2573
	Yes	42452	92%	3677	8%	46129
Provide emotional support	No	2516	90%	295	10%	2811
	Yes	42015	92%	3622	8%	45637
Receive instrumental support	No	2127	92%	176	8%	2303
	Yes	42834	92%	3788	8%	46622
Number of teeth in 2010	≥20 teeth	19902	92%	1825	8%	21727
	10-19 teeth	13775	90%	1508	10%	15283
	1-9 teeth	13423	94%	847	6%	14270
Smoking	Non smoking	26527	93%	2045	7%	28572
	Non smoking now, quit before 5 years	10309	92%	941	8%	11250
	Non smoking now, quit within 4 years	2096	90%	240	10%	2336
	Smoking	4304	89%	551	11%	4855
Do you have hospital treatment?	Yes	32255	92%	2771	8%	35026
	No	11154	91%	1052	9%	12206

Table 2. Data are presented as odds ratios (95% confidence intervals), p value of reduction of remaining teeth of the respondents (n=51280)

		Sex and Age Analysis OR (95%CI), p value		Multivariate Analysis OR (95%CI), p value	
Sex (Ref: Woman)	Man			0.77 (0.71-0.83)	<0.001
Age (Ref: 65-69)	70-74			1.26 (1.16-1.37)	<0.001
	75-79			1.54 (1.41-1.69)	<0.001
	80-84			1.99 (1.74-2.27)	<0.001
	85+			2.26 (1.88-2.73)	<0.001
Education (Ref: ≥13 years)	< 6 years	1.67 (1.29-2.16)	<0.001	1.44 (1.11-1.86)	0.007
	6-9 years	1.31 (1.19-1.44)	<0.001	1.17 (1.06-1.29)	0.002
	10-12 years	1.04 (0.95-1.15)	0.412	1.01 (0.91-1.11)	0.911
Annual household income (Ref: ≥ $40,000)	< $10,000	1.42 (1.23-1.64)	<0.001	1.30 (1.13-1.51)	<0.001
	$10,000-$19,999	1.14 (1.01-1.29)	0.039	1.10 (0.97-1.24)	0.14
	$20,000-$29,999	1.05 (0.93-1.20)	0.426	1.04 (0.92-1.19)	0.53
	$30,000-$39,999	1.01 (0.87-1.16)	0.936	1.01 (0.88-1.16)	0.915
Living area (Ref: Rural area)	Urban area	0.63 (0.57-0.70)	<0.001	0.68 (0.57-0.82)	<0.001
	Suburban area	0.82 (0.76-0.90)	<0.001	0.87 (0.79-0.94)	0.001

Community-level social capital	Civic participation	0.84 (0.80-0.89)	<0.001	0.93 (0.88-0.99)	0.022
	Social cohesion	1.14 (1.08-1.20)	<0.001	1.06 (0.99-1.13)	0.111
	Reciprocity or Support	1.04 (0.97-1.11)	0.28	0.97 (0.90-1.05)	0.414
Density of dental office	Density of dental office per 10,000 people	0.87 (0.84-0.91)	<0.001	1.01 (0.94-1.08)	0.878
Individual-level social capital	Hobby activity	0.81 (0.76-0.88)	<0.001	0.87 (0.80-0.95)	0.002
	Sports group	0.82 (0.76-0.90)	<0.001	0.90 (0.81-0.99)	0.024
	Volunteer group	0.98 (0.88-1.10)	0.722	1.08 (0.96-1.21)	0.216
	Community trust	0.98 (0.91-1.05)	0.58	1.00 (0.93-1.08)	0.992
	Community reciprocity	1.00 (1.00-1.00)	0.914	1.00 (1.00-1.00)	0.477
	Community attachment	1.00 (1.00-1.00)	0.851	1.00 (1.00-1.00)	0.8
	Receive emotional support	1.00 (1.00-1.00)	0.426	1.00 (1.00-1.00)	0.73
	Provide emotional support	1.00 (1.00-1.00)	0.202	1.00 (1.00-1.00)	0.942

	Receive instrumental support	1.00 (1.00-1.00)	0.197	1.00 (1.00-1.00)	0.183
Number of teeth in 2010 (Ref: ≥20 teeth)	10-19 teeth	1.14 (1.06-1.23)	<0.001	1.06 (0.98-1.14)	0.127
	1-9 teeth	0.61 (0.56-0.66)	<0.001	0.53 (0.48-0.57)	<0.001
Smoking (Ref: Non smoking)	Non smoking now, quit before 5 years	0.98 (0.89-1.08)	0.665	1.04 (0.95-1.15)	0.387
	Non smoking now, quit within 4 years	1.30 (1.12-1.51)	0.001	1.39 (1.19-1.61)	<0.001
	Smoking	1.48 (1.32-1.66)	<0.001	1.58 (1.41-1.77)	<0.001
Do you have hospital treatment? (Ref: No)	Yes	1.17 (1.08-1.26)	<0.001	1.16 (1.07-1.25)	<0.001
Random-effects Parameters					
	Community-level variance Ωμ (standard error)			0.0037 (0.0062)	

FIGURE LEGENDS

Figure 1. Data for 51,280 respondents were included in the analysis.

Contributorship statement

Koyama and Aida participated in the acquired the data and the study design, performed the statistical analysis, and drafted the manuscript. Saito participated in the acquired the data and advised concept of study and statistical analysis and interpretation, and helped to draft the manuscript. N.Kondo, Sato, Matsuyama, Tani, Sasaki participated in the acquired the data and helped the analysis and interpretation, and helped to draft the manuscript. K.Kondo is the principal investigator of the JAGES project, helped to develop the idea of the study, participated in the acquired the data, advised the statistical analysis and interpretation, and revised the manuscript. Ojima, Yamamoto, Tsuboya, and Osaka participated in the data collection, advised the statistical analysis and interpretation, and revised the manuscript. All authors read and approved the final manuscript.

Competing interests

All author report no conflict of interest related to our manuscript.

Data sharing statement

Data are from the JAGES study. All enquiries are to be addressed at the data management committee via e-mail: dataadmin@jages.net. All JAGES datasets have ethical or legal restrictions for public deposition due to inclusion of sensitive information from the human participants.

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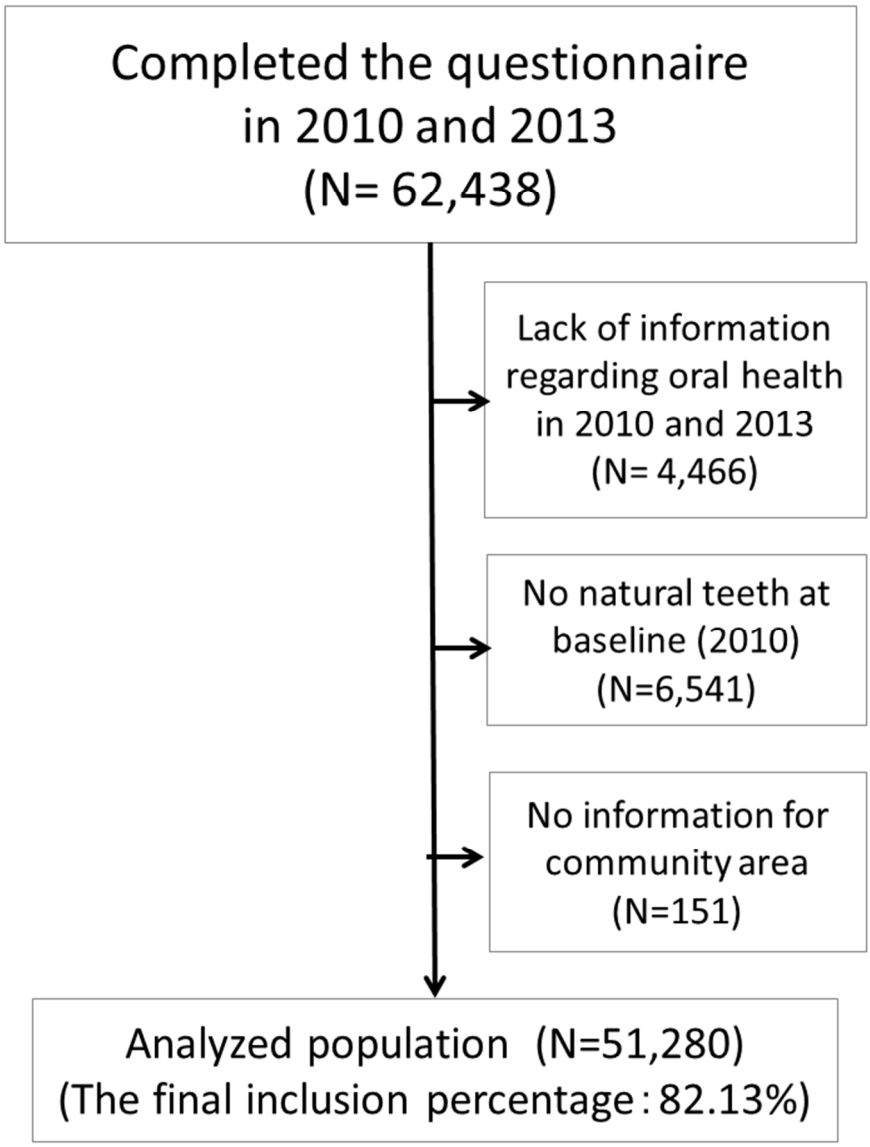

Data for 51,280 respondents were included in the analysis.
190x254mm (96 x 96 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title page #1 #3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Title page #3 #4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	#1 #2
Objectives	3	State specific objectives, including any prespecified hypotheses	#2
Methods			
Study design	4	Present key elements of study design early in the paper	#6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	#2 #3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	#2 #3
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	#3-#6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	#3-#6
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	#2 #3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	#3-#6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	#5 #6
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	#6 #7
		(*d*) If applicable, explain how loss to follow-up was addressed	#2 #3
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	#3 Figure 1
		(b) Give reasons for non-participation at each stage	#3 Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	#2 #3
		(b) Indicate number of participants with missing data for each variable of interest	#2 #3
		(c) Summarise follow-up time (eg, average and total amount)	#2 #3
Outcome data	15*	Report numbers of outcome events or summary measures over time	#7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	#7 #8
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	#8
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	#8-#10
Generalisability	21	Discuss the generalisability (external validity) of the study results	#8-#10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Community social capital and tooth loss in Japanese older people: a longitudinal cohort study

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Complete List of Authors:	Koyama, Shihoko; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Aida, Jun; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Saito, Masashige; Nihon Fukushi University, Department of Social Welfare kondo, naoki; University of Tokyo School of Public Health, Department of Health Economics and Epidemiology Research Sato, Yukihiro; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Matsuyama, Yusuke; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Tani, Yukako; University of Tokyo School of Public Health, Department of Health Education and Health Sociology Sasaki, Yuri; Chiba University, Center for Preventive Medical Sciences Kondo, Katsunori; Chiba University, Center for Preventive Medical Sciences Ojima, Toshiyuki; Hamamatsu University School of Medicine, Department of Community Health and Preventive Medicine Yamamoto, Tatsuo; Graduate School of Dentistry, Kanagawa Dental University, Department of Oral Science Tsuboya, Toru; Tohoku university, School of Dentistry Osaka, Ken; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health
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Secondary Subject Heading:	Epidemiology, Dentistry and oral medicine
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Title

Community social capital and tooth loss in Japanese older people: a longitudinal cohort study

Corresponding author: Jun Aida

Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry

4-1, Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8575, Japan Tel: +81-22-717-7639; Fax: +81-22-717-7644

E-mail: j-aida@umin.ac.jp

Shihoko Koyama[1], Jun Aida[1], Masashige Saito[2], Naoki Kondo[3], Yukihiro Sato[1], Yusuke Matsuyama[1], Yukako Tani[3], Yuri Sasaki[4], Katsunori Kondo[4], Toshiyuki Ojima[5], Tatsuo Yamamoto[6], Toru Tsuboya[1], Ken Osaka[1]

[1] Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry, Miyagi, Japan

[2] Department of Social Welfare, Nihon Fukushi University, Aichi, Japan

[3] Department of Health Education and Health Sociology, School of Public Health, The University of Tokyo

[4] Center for Preventive Medical Sciences, Chiba University

[5] Department of Community Health and Preventive Medicine, Hamamatsu University School of Medicine, Shizuoka, Japan

[6] Division of Dental Sociology, Department of Oral Science, Graduate

School of Dentistry, Kanagawa Dental University, Yokosuka City, Kanagawa, Japan

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ABSTRACT (245words)

Objective: To date, no study has prospectively examined the association between social capital (SC) in the community and oral health. The aim of this longitudinal cohort study was to examine the association between both community- and individual-level social capital and poor oral health in older Japanese people.

Design: Prospective cohort study

Setting: We utilized data from the Japan Gerontological Evaluation Study (JAGES) performed in 2010 and 2013 and conducted in 525 districts.

Participants: The target population was restricted to non-institutionalized people aged 65 years or older. Participants included 51,280 people who responded to two surveys and who had teeth at baseline.

Primary outcome measure: The primary outcome measure was loss of remaining teeth, measured by the downward change of any category of remaining teeth, between baseline and follow-up.

Results: The mean age of the participants was 72.5 years (SD=5.4). During the study period, 8.2% (n=4,180) lost one or more of their remaining teeth. Among 3 community-level social capital variables obtained from factor analysis, an indicator of civic participation significantly reduced the risk of tooth loss (OR: 0.93; 95% CI: 0.88–0.99). The individual-level social capital variables "hobby activity participation" and "sports group participation" were also associated with a reduced risk of tooth loss (OR: 0.87; 95% CI: 0.80–0.95 and OR: 0.90; 95% CI: 0.81–0.99, respectively).

Conclusions: Living in a community with rich social capital and individuals with good social capital is associated with the maintenance of good oral health among older Japanese people.

Strengths and limitations of this study

- This is the first prospective cohort study to examine the association between both community- and individual-level social capital and oral health.
- This study surveyed people from 525 communities around Japan in order to gain a wider range of community contextual characteristics.
- More than 50,000 people aged 65 and up participated in both baseline and follow-up surveys.
- Despite this large sample size, the measurements rely entirely on self-reported data.

INTRODUCTION

A higher prevalence of oral diseases causes not only individual burden, but also comes at a social cost. Untreated caries in permanent teeth represent the most prevalent condition, while severe periodontitis and untreated caries in deciduous teeth were the 6th and 10th most prevalent conditions of 291 diseases and injuries.[1] Tooth loss often occurs as a result of these diseases; in fact, severe tooth loss was the 36th most prevalent condition.[1] In 2010, the direct and indirect global economic burden caused by oral diseases amounted to US $442 billion.[2] In addition, oral health affects general health and can exacerbate conditions such as cardiovascular disease,[3, 4] dementia,[5] incidence of falls,[6, 7] and functional disability.[8]

Widespread inequalities in oral health are observed across the globe, including Japan,[9] and are associated with individual and social burdens. Social determinants of health are the most important cause of health inequalities.[10, 11] Social capital, defined by Kawachi and Berkman[12] as "resources that are accessed by individuals as a result of their membership of a network or a group", is increasingly recognized as a determinant of population health as well as that of health inequality.[13, 14] Recently, an increasing number of cross-sectional studies have demonstrated the association between social capital and resources obtained from social capital on oral health.[15-18] In spite of a large volume of cross-sectional studies focused on social capital and oral health outcomes, few studies have used longitudinal observation with community-level social capital, rather than

individual-level measurements. Due to the possibility that a community's contextual social capital could affect the health of all its residents, it is important to study population health. Although one prospective study from the United Kingdom suggests that the change in an individual's social capital corresponds to plausible changes in an older person's life course, this study did not use community-level social capital measurements.[19]

Questions regarding the association between community-level social capital and oral health based on longitudinal studies remain unanswered. The aim of this longitudinal cohort study was to examine the association between community-level and individual-level social capital and poor oral health (a reduction in remaining teeth) in elderly Japanese people. We hypothesized that living in high community-level social capital at baseline predicts good oral health at follow-up even when adjusting for individual-level social capital.

METHODS

Study setting

We utilized data from the Japan Gerontological Evaluation Study (JAGES). The JAGES Project investigated social, behavioural, and health factors in people aged 65 years or older. The JAGES sample was restricted to people who did not already have physical or cognitive disabilities, which were defined as receiving long-term public care insurance benefits. This longitudinal study used the panel data from 2 surveys. The baseline survey

was conducted between August 2010 and January 2012 among 141,452 older people. Self-administered questionnaires were mailed to the entire population of 10 municipalities, and in 14 municipalities, questionnaires were mailed to randomly selected members of the population, based on the official residential registers obtained from the respective municipal governments. A total of 92,272 people responded to the questionnaire (response rate = 65.2%). The follow-up survey was conducted between October 2013 and December 2013. Self-administered questionnaires used for the follow-up survey were subsequently mailed to the same municipalities and respondents. Collectively, 62,438 individuals completed both the 2010 and 2013 questionnaires.

Of these respondents, 4,466 were excluded because of a lack of information regarding oral health in 2010 and 2013. We excluded another 6,541 individuals who had no natural teeth at baseline (2010), and 151 individuals who gave no information for their residential area. Finally, 51,280 respondents from 525 districts were included in our analyses. (Figure 1)

Outcome variables

The outcome variable used was dichotomous and defined as a "reduction of remaining teeth or not" between baseline and follow-up. In both surveys, we asked for the number of remaining teeth by the following categories: "≥ 20 teeth"; "10-19 teeth"; "1-9 teeth"; "no natural teeth". At the

follow-up survey, if respondents chose a category with a smaller number of teeth compared to that of baseline, they were defined as people who had experienced a reduction in the number of their remaining teeth during the interim period. Data on respondents who had no natural teeth at baseline were excluded from multilevel analysis.

Predictor variables

Individual-level social capital

Individual-level social capital used was participation in each community activity (volunteer groups, sports groups/clubs, hobby activity group), community trust, community attachment, and social support (receive emotional support, provide emotional support, receive instrumental support) in 2010.

The response categories used for community activity participation variables were "once or more per week" and "less than once per week". Community trust was measured by asking two yes/no questions: "Do you trust the people who live in your local area?" and, "Do you think that it is important to be helpful to other people in your local area?" Community attachment was measured with the yes/no question, "Do you have an attachment to your local area?" Social support was measured with the following three yes/no questions: "Do you have someone who listens to your

concerns and complaints?" (categorized as 'receive emotional support'); "Do you listen to someone else's concerns and complaints?" (provide emotional support); and "Do you have someone who looks after you when you become sick?" (receive instrumental support).

Community-level social capital

We presumed that respondents who lived in the same districts were exposed to the same degree of community-level social capital.[20] Community-level social capital variables were obtained from factor analysis. At first, rates of each individual-level social capital response in each small district were calculated. Then, using 525 small districts as the analysis unit, factor analysis was conducted and three factors were obtained: civic participation (participation in volunteer groups, sports groups, and hobby activities), social cohesion (community trust and attachment), and reciprocity (received / provided emotional support; received instrumental support). Factor scores for each small district were used as community-level social capital variables.

Covariates

As in the studies mentioned previously, the following questions regarding sociodemographic characteristics, baseline health status, and risk factors for oral health were included in the analyses as covariates: age, sex, educational attainment, annual household income, comorbidity, smoking,

density of dental offices, population density, and number of teeth at baseline. Age was grouped into quartiles: 65-69 years, 70-74 years, 75-79 years, 80-84 years, and 85 years or older. Educational attainment was categorized as follows: <6 years, 6–9 years, 10–12 years, and ≥13 years. Annual household income was categorized as follows: <$20,000 (<¥2,000,000), $20,000–$29,999 (¥2,000,000–¥2,999,999), $30,000–$39,999 (¥3,000,000–¥3,999,999), and ≥$40,000 (≥¥4,000,000) (US$1 = ¥100). Comorbidity was measured by using the yes/no question, "Do you receive treatment now?" Smoking was categorized as follows: non-smoking, non-smoking now and quit more than 5 years ago, non-smoking now and quit within 4 years ago, and smoking now. We included density of dental offices as a continuous variable in the models. Population density was categorized as follows: urban area (≥ 1500 people/km^2), suburban area (1,000-1,500 people/km^2), and rural area (< 1,000 people/km^2).

Data analysis

The data were analysed by multilevel logistic regression analyses. We calculated odds ratio (OR) and 95% confidence interval (CI) for respondents who had a reduction in the number of remaining teeth during the study period. Because 51,280 respondents lived in 525 small districts, a two-level model (community-level and individual-level) was used. We put emphasis on the theoretical importance of the covariates and included all covariates in the multivariate model. If data were missing for explanatory

variables, the corresponding observations were assigned to "missing" categories. The significance level was set at $p < 0.05$. We used SPSS version 19.0 (IBM Corp., Armonk, NY, USA) for factor analysis and Stata version 13.1 (StataCorp, College Station, TX, USA) for multilevel analysis.

Ethical issues

JAGES respondents were informed that participation in the study was voluntary, and that completing and returning the self-administered questionnaire by mail indicated their consent for participation in the study. Ethical approval was obtained from the Ethics Committee at Nihon Fukushi University (10-05 and 13-14).

RESULTS

Of 51,280 respondents, 23,924 men and 27,356 women were included in the analysis. The average age of the 51,280 respondents was 72.5 years (SD=5.4). Among the respondents, 8.2% (n=4,180) reported a reduction in the number of their remaining teeth. Table 1 shows the descriptive statistics for each variable. Participants who were older, with less education, lower incomes, living in rural areas, with no emotional social support, having between 10-19 teeth, or who were smokers tended to have a higher incidence of tooth loss.

Table 2 shows the results of the multilevel logistic analysis. In the sex- and age-adjusted model, a significant association between

community-level social capital and incidence of tooth loss was observed at 2 variables, "civic participation" and "social cohesion" (OR: 0.84; 95% CI: 0.80–0.89 and OR: 1.14; 95% CI: 1.08–1.20, respectively). Among the individual-level social capital variables, "hobby activity participation" and "sports group participation" were significant for reducing the risk of tooth loss (OR: 0.81; 95% CI: 0.76–0.88 and OR: 0.82 95% CI: 0.76–0.90, respectively). When all variables were included in one model, living in a rich community-level social capital district at baseline and the incidence of tooth loss were observed at the variable "civic participation" (OR: 0.93; 95% CI: 0.88–0.99). Individual-level social capital variables, "hobby activity participation" and "sports group participation" still had significant associations (OR: 0.87; 95% CI: 0.80–0.95 and OR: 0.90 95% CI: 0.81–0.99, respectively).

DISCUSSION

To the best of our knowledge, this is the first study to examine the association between both community- and individual-level social capital and oral health using longitudinal data. The results suggest living in a community with a higher density of civic participation (a measurement of community-level social capital) at baseline was associated with future low risk of tooth loss. This association was still significant even after adjusting for individual-level social participation variables that were also beneficial to oral health.

The results of the present longitudinal analysis were similar to previous cross-sectional studies. In Japan, a previous study demonstrated a significant positive association between social participation and dental health status among older people.[21] Another cross-sectional study suggested that community-level horizontal social capital and vertical social capital have different effects on health; only the former had a contextual effect on dental status.[22] A review of the papers on social capital and oral health also reported the beneficial association between social capital and oral health.[16] This review, however, pointed out the need for a longitudinal analysis. The present study adds evidence supportive of an association between social capital and oral health by cohort study. In addition, those people who had a small number of teeth at baseline tended to lose their teeth (Table 2). This was consistent with the results of a previous study in Japan that used data from a nationwide dental survey.[23] Therefore, it is important to prevent tooth loss through public health interventions, individual efforts, and clinical care.

There are numerous possible pathways between social capital and oral health. Rouxel *et al.* summarized the hypothesized pathways linking social capital and oral health: behavioural and psychosocial, via access to oral health services and via policy development.[16] Regarding the behavioural pathway, social capital is considered to affect health behaviours through social contagion and informal social control.[12] As an example, one study observed the contagion of smoking-cessation following a social

network.[24] Regarding the psychosocial pathway, social capital is considered associated with reducing psychosocial stress, a possible risk factor for oral diseases.[25] Through collective efficacy, a community with rich social capital can establish health-promoting policies.[12] In this context, we supposed that although population density of dental clinics was sparse during the 1960s-1970s in Japan, the establishment of a dental clinic might be promoted in a community with rich social capital. Improving access to dental care could contribute to oral health in a community because access to dental care has been reported to promote oral health.[26]

From the present results, social capital may contribute to improvements in oral health. Previous intervention studies attempted to promote health through the enhancement of social capital.[27-29] The participation in the community salon (a resident-centred community intervention programme) contributed to the prevention of incident functional disability.[27, 29] Hikichi *et al.* found that participation in the community salon contributed to the prevention of incident functional disability.[29] Although previous intervention studies related to social capital did not examine the effects on oral health, public health interventions enhancing social capital, described above, [27-29] might improve oral health.

The strengths of our study are its prospective cohort design and its use of panel data. This design was suitable for the inference of causality compared to previous cross-sectional studies. This is the first multilevel study of social capital and oral health using longitudinal data, including not

only individual-level social capital but also community-level social capital. In addition, this study enabled us to consider a wider range of community contextual characteristics by surveying 525 communities in Japan with more than 50,000 older-age participants.

This study has some notable limitations. First, while this survey was large, oral health (in terms of number of remaining teeth) was self-reported, and even though the validity of this measure has been well-established with respect to objective measures,[30-32] the longitudinal change of self-reported dental health was imprecise relative to clinical dental check-ups. Second, the follow-up periods differed between municipalities. Because some municipalities had shorter follow-up periods than others did, it was difficult to conclude causality in this study. Third, our study included no information about changes in social capital. Therefore, there is the possibility that time-varying, confounding factors such as economic changes or natural disasters may have biased our results. However, this study aimed to examine whether baseline social capital was associated with follow-up tooth loss in a cohort study; therefore, we applied the present cohort study design. Even if we could have used change of social capital, it is very difficult to determine causality with only two time-point observations.

CONCLUSION

This large-scale cohort study covered a broad area of this country and has provided evidence that high community-level and individual-level social

capital at baseline is associated with lower incidence of tooth loss at follow-up among older Japanese people.

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from the Japan Foundation for Aging and Health.

TABLES

Table 1. Baseline characteristics of respondents and reduction of remaining teeth at follow-up (n=51280)

		Reduction of remaining teeth (N, %)				
		No		Yes		Total
Sex	Man	21652	91%	2272	9%	23924
	Woman	25448	93%	1908	7%	27356
Age	65-69	16367	93%	1187	7%	17554
	70-74	14899	92%	1281	8%	16180
	75-79	10748	91%	1089	9%	11837
	80-84	2798	89%	346	11%	3144
	85+	1111	88%	152	12%	1263
Education	< 6 years	541	88%	77	12%	618
	6-9 years	19210	91%	1923	9%	21133
	10-12 years	16832	93%	1299	7%	18131
	≥13 years	8957	93%	702	7%	9659
Annual household income	< $10,000	4727	90%	504	10%	5231
	$10,000-$19,999	13758	92%	1208	8%	14966
	$20,000-$29,999	10198	92%	832	8%	11030
	$30,000-$39,999	6472	93%	502	7%	6974
	≥$40,000	4768	93%	364	7%	5132
Living area	Urban area	12844	93%	897	7%	13741
	Suburban area	22231	92%	1987	8%	24218
	Rural area	12025	90%	1296	10%	13321
Hobby activity	Less than once per week	23139	91%	2207	9%	25346
	Once or more per week	16695	93%	1232	7%	17927
Sports group	Less than once per week	28213	92%	2596	8%	30809
	Once or more per week	10384	93%	756	7%	11140
Volunteer group	Less than once per week	32222	92%	2797	8%	35019
	Once or more per week	4688	92%	388	8%	5076

Community trust	No	12544	92%	1098	8%	13642
	Yes	32310	92%	2879	8%	35189
Community reciprocity	No	19386	92%	1657	8%	21043
	Yes	25252	92%	2294	8%	27546
Community attachment	No	7947	92%	709	8%	8656
	Yes	37904	92%	3356	8%	41260
Receive emotional support	No	2305	90%	268	10%	2573
	Yes	42452	92%	3677	8%	46129
Provide emotional support	No	2516	90%	295	10%	2811
	Yes	42015	92%	3622	8%	45637
Receive instrumental support	No	2127	92%	176	8%	2303
	Yes	42834	92%	3788	8%	46622
Number of teeth in 2010	≥20 teeth	19902	92%	1825	8%	21727
	10-19 teeth	13775	90%	1508	10%	15283
	1-9 teeth	13423	94%	847	6%	14270
Smoking	Non smoking	26527	93%	2045	7%	28572
	Non-smoking now, quit before 5 years	10309	92%	941	8%	11250
	Non-smoking now, quit within 4 years	2096	90%	240	10%	2336
	Smoking	4304	89%	551	11%	4855
Do you have hospital treatment?	Yes	32255	92%	2771	8%	35026
	No	11154	91%	1052	9%	12206

Table 2. Data are presented as odds ratios (95% confidence intervals), p value of reduction of remaining teeth of the respondents (n=51280)

		Sex and Age Analysis OR (95% CI), p value		Multivariate Analysis OR (95% CI), p value	
Sex (Ref: Woman)	Man			0.77 (0.71-0.83)	<0.001
Age (Ref: 65-69)	70-74			1.26 (1.16-1.37)	<0.001
	75-79			1.54 (1.41-1.69)	<0.001
	80-84			1.99 (1.74-2.27)	<0.001
	85+			2.26 (1.88-2.73)	<0.001
Education (Ref: ≥13 years)	< 6 years	1.67 (1.29-2.16)	<0.001	1.44 (1.11-1.86)	0.007
	6-9 years	1.31 (1.19-1.44)	<0.001	1.17 (1.06-1.29)	0.002
	10-12 years	1.04 (0.95-1.15)	0.412	1.01 (0.91-1.11)	0.911
Annual household income (Ref: ≥ $40,000)	< $10,000	1.42 (1.23-1.64)	<0.001	1.30 (1.13-1.51)	<0.001
	$10,000-$19,999	1.14 (1.01-1.29)	0.039	1.10 (0.97-1.24)	0.14
	$20,000-$29,999	1.05 (0.93-1.20)	0.426	1.04 (0.92-1.19)	0.53
	$30,000-$39,999	1.01 (0.87-1.16)	0.936	1.01 (0.88-1.16)	0.915
Living area (Ref: Rural area)	Urban area	0.63 (0.57-0.70)	<0.001	0.68 (0.57-0.82)	<0.001
	Suburban area	0.82 (0.76-0.90)	<0.001	0.87 (0.79-0.94)	0.001

Community-level social capital	Civic participation	0.84 (0.80-0.89)	<0.001	0.93 (0.88-0.99)	0.022
	Social cohesion	1.14 (1.08-1.20)	<0.001	1.06 (0.99-1.13)	0.111
	Reciprocity or Support	1.04 (0.97-1.11)	0.28	0.97 (0.90-1.05)	0.414
Density of dental office	Density of dental office per 10,000 people	0.87 (0.84-0.91)	<0.001	1.01 (0.94-1.08)	0.878
Individual-level social capital	Hobby activity	0.81 (0.76-0.88)	<0.001	0.87 (0.80-0.95)	0.002
	Sports group	0.82 (0.76-0.90)	<0.001	0.90 (0.81-0.99)	0.024
	Volunteer group	0.98 (0.88-1.10)	0.722	1.08 (0.96-1.21)	0.216
	Community trust	0.98 (0.91-1.05)	0.58	1.00 (0.93-1.08)	0.992
	Community reciprocity	1.00 (1.00-1.00)	0.914	1.00 (1.00-1.00)	0.477
	Community attachment	1.00 (1.00-1.00)	0.851	1.00 (1.00-1.00)	0.8
	Receive emotional support	1.00 (1.00-1.00)	0.426	1.00 (1.00-1.00)	0.73
	Provide emotional support	1.00 (1.00-1.00)	0.202	1.00 (1.00-1.00)	0.942

	Receive instrumental support	1.00 (1.00-1.00)	0.197	1.00 (1.00-1.00)	0.183
Number of teeth in 2010 (Ref: ≥20 teeth)	10-19 teeth	1.14 (1.06-1.23)	<0.001	1.06 (0.98-1.14)	0.127
	1-9 teeth	0.61 (0.56-0.66)	<0.001	0.53 (0.48-0.57)	<0.001
Smoking (Ref: Non-smoking)	Non-smoking now, quit before 5 years	0.98 (0.89-1.08)	0.665	1.04 (0.95-1.15)	0.387
	Non-smoking now, quit within 4 years	1.30 (1.12-1.51)	0.001	1.39 (1.19-1.61)	<0.001
	Smoking	1.48 (1.32-1.66)	<0.001	1.58 (1.41-1.77)	<0.001
Do you have hospital treatment? (Ref: No)	Yes	1.17 (1.08-1.26)	<0.001	1.16 (1.07-1.25)	<0.001
Random-effects Parameters					
	Community-level variance Ωμ (standard error)			0.0037 (0.0062)	

Contributorship statement

Koyama and Aida participated in the data acquisition and study design, performed statistical analysis, and drafted the manuscript. Saito participated in the data acquisition and was an advisor on study concept, statistical analysis and interpretation, and helped to draft the manuscript. N. Kondo, Sato, Matsuyama, Tani, and Sasaki participated in data acquisition, helped in the analysis and interpretation, and helped to draft the manuscript. K. Kondo, the principal investigator of the JAGES project, helped to develop the idea of the study, participated in the data acquisition, served as an advisor on statistical analysis and interpretation, and revised the manuscript. Ojima, Yamamoto, Tsuboya, and Osaka participated in the data collection, advised on statistical analysis and interpretation, and revised the manuscript. All authors read and approved the final manuscript.

Competing interests

All authors report no conflicts of interest related to our manuscript.

Data sharing statement

No additional data available.

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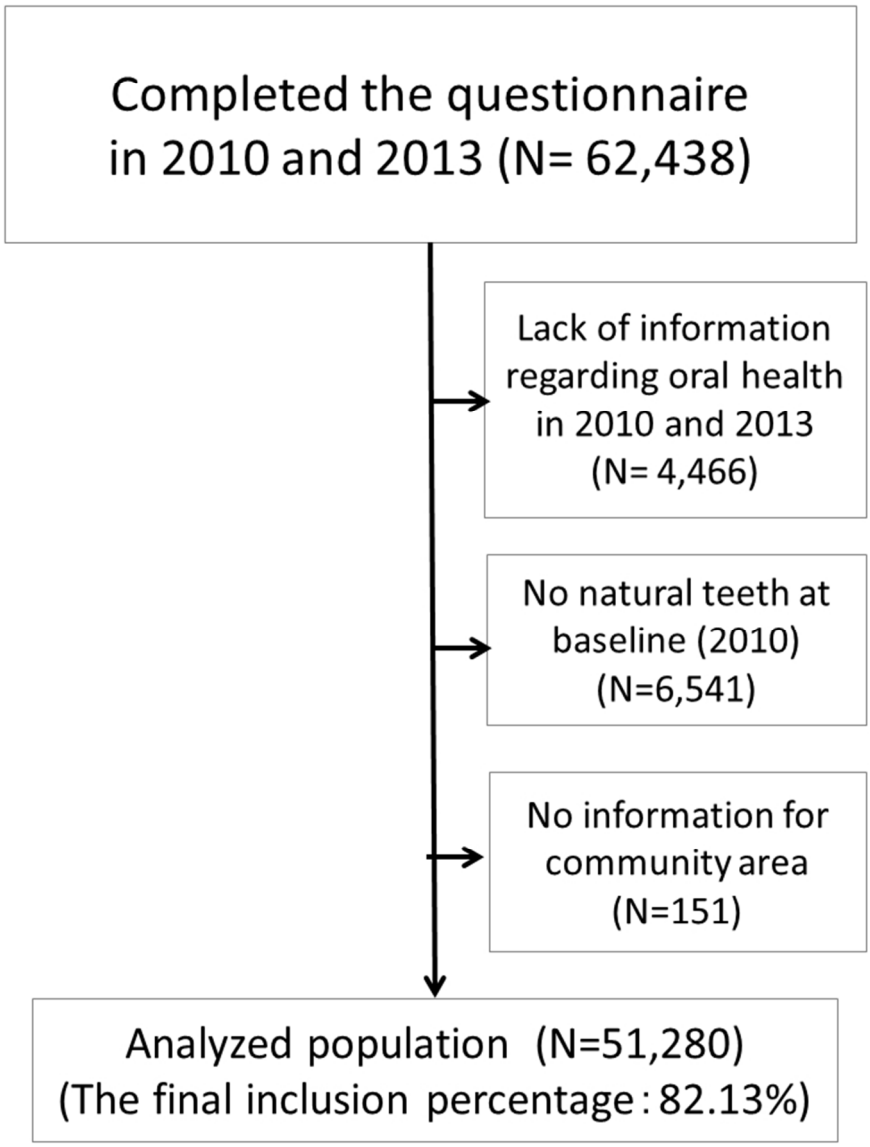
Health Sci Health Care 2012;12:4-12.

FIGURE LEGENDS

Figure 1. Data from 51,280 respondents were included in the analysis.



Data from 51,280 respondents were included in the analysis.
190x254mm (96 x 96 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	#1 #3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	#3 #4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	#5#6
Objectives	3	State specific objectives, including any prespecified hypotheses	#6
Methods			
Study design	4	Present key elements of study design early in the paper	#6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	#6 #7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	#6 #7 Fig1
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	#7-#10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	#7-#10
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	#6 #7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	#7-#10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	#10 #11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	#7 #8 Fig1
		(*d*) If applicable, explain how loss to follow-up was addressed	#6 #7
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	#7 Fig 1
		(b) Give reasons for non-participation at each stage	#7 Fig 1
		(c) Consider use of a flow diagram	Fig 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	#6 #7
		(b) Indicate number of participants with missing data for each variable of interest	#6 #7
		(c) Summarise follow-up time (eg, average and total amount)	#6 #7
Outcome data	15*	Report numbers of outcome events or summary measures over time	#11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	#12
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	#11 #12
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	#15
Generalisability	21	Discuss the generalisability (external validity) of the study results	#15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Community social capital and tooth loss in Japanese older people: a longitudinal cohort study

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Complete List of Authors:	Koyama, Shihoko; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Aida, Jun; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Saito, Masashige; Nihon Fukushi University, Department of Social Welfare kondo, naoki; University of Tokyo School of Public Health, Department of Health Economics and Epidemiology Research Sato, Yukihiro; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Matsuyama, Yusuke; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health Tani, Yukako; University of Tokyo School of Public Health, Department of Health Education and Health Sociology Sasaki, Yuri; Chiba University, Center for Preventive Medical Sciences Kondo, Katsunori; Chiba University, Center for Preventive Medical Sciences Ojima, Toshiyuki; Hamamatsu University School of Medicine, Department of Community Health and Preventive Medicine Yamamoto, Tatsuo; Graduate School of Dentistry, Kanagawa Dental University, Department of Oral Science Tsuboya, Toru; Tohoku university, School of Dentistry Osaka, Ken; Tohoku University Graduate School of Dentistry, Department of International and Community Oral Health
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Secondary Subject Heading:	Epidemiology, Dentistry and oral medicine
Keywords:	Social capital, Multilevel analysis, Tooth loss, Cohort study, Panel data

Title

Community social capital and tooth loss in Japanese older people: a longitudinal cohort study

Corresponding author: Jun Aida

Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry

4-1, Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8575, Japan Tel: +81-22-717-7639; Fax: +81-22-717-7644

E-mail: j-aida@umin.ac.jp

Shihoko Koyama[1], Jun Aida[1], Masashige Saito[2], Naoki Kondo[3], Yukihiro Sato[1], Yusuke Matsuyama[1], Yukako Tani[3], Yuri Sasaki[4], Katsunori Kondo[4], Toshiyuki Ojima[5], Tatsuo Yamamoto[6], Toru Tsuboya[1], Ken Osaka[1]

[1] Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry, Miyagi, Japan

[2] Department of Social Welfare, Nihon Fukushi University, Aichi, Japan

[3] Department of Health Education and Health Sociology, School of Public Health, The University of Tokyo

[4] Center for Preventive Medical Sciences, Chiba University

[5] Department of Community Health and Preventive Medicine, Hamamatsu University School of Medicine, Shizuoka, Japan

[6] Division of Dental Sociology, Department of Oral Science, Graduate

School of Dentistry, Kanagawa Dental University, Yokosuka City, Kanagawa, Japan

Key words: Social capital; Multilevel analysis; Tooth loss; Cohort study; Panel data

Word count: 2511

ABSTRACT (244words)

Objective: To date, no study has prospectively examined the association between social capital (SC) in the community and oral health. The aim of this longitudinal cohort study was to examine the association between both community- and individual-level social capital and poor oral health in older Japanese people.

Design: Prospective cohort study

Setting: We utilized data from the Japan Gerontological Evaluation Study (JAGES) performed in 2010 and 2013 and conducted in 525 districts.

Participants: The target population was restricted to non-institutionalized people aged 65 years or older. Participants included 51,280 people who responded to two surveys and who had teeth at baseline.

Primary outcome measure: The primary outcome measure was loss of remaining teeth, measured by the downward change of any category of remaining teeth, between baseline and follow-up.

Results: The mean age of the participants was 72.5 years (SD=5.4). During the study period, 8.2% (n=4,180) lost one or more of their remaining teeth. Among 3 community-level social capital variables obtained from factor analysis, an indicator of civic participation significantly reduced the risk of tooth loss (OR: 0.93; 95% CI: 0.88–0.99). The individual-level social capital variables "hobby activity participation" and "sports group participation" were also associated with a reduced risk of tooth loss (OR: 0.87; 95% CI: 0.80–0.95 and OR: 0.90; 95% CI: 0.81–0.99, respectively).

Conclusions: Living in a community with rich social capital and individuals with good social capital is associated with lower incidence of tooth loss among older Japanese people.

Strengths and limitations of this study

- This is the first prospective cohort study to examine the association between both community- and individual-level social capital and tooth loss.
- This study surveyed people from 525 communities around Japan in order to gain a wider range of community contextual characteristics.
- More than 50,000 people aged 65 and up participated in both baseline and follow-up surveys.
- Despite this large sample size, the measurements rely entirely on self-reported data.

INTRODUCTION

A higher prevalence of oral diseases causes not only individual burden, but also comes at a social cost. Untreated caries in permanent teeth represent the most prevalent condition, while severe periodontitis and untreated caries in deciduous teeth were the 6th and 10th most prevalent conditions of 291 diseases and injuries.[1] Tooth loss often occurs as a result of these diseases; in fact, severe tooth loss was the 36th most prevalent condition.[1] In 2010, the direct and indirect global economic burden caused by oral diseases amounted to US $442 billion.[2] In addition, oral health affects general health and can exacerbate conditions such as cardiovascular disease,[3, 4] dementia,[5] incidence of falls,[6, 7] and functional disability.[8]

Widespread inequalities in oral health are observed across the globe, including Japan,[9] and are associated with individual and social burdens. Social determinants of health are the most important cause of health inequalities.[10, 11] Social capital, defined by Kawachi and Berkman[12] as "resources that are accessed by individuals as a result of their membership of a network or a group", is increasingly recognized as a determinant of population health as well as that of health inequality.[13, 14] Recently, an increasing number of cross-sectional studies have demonstrated the association between social capital and resources obtained from social capital on oral health.[15-18] In spite of a large volume of cross-sectional studies focused on social capital and oral health outcomes, few studies have used longitudinal observation with community-level social capital, rather than

individual-level measurements. Due to the possibility that a community's contextual social capital could affect the health of all its residents, it is important to study population health. Although one prospective study from the United Kingdom suggests that the change in an individual's social capital corresponds to plausible changes in an older person's life course, this study did not use community-level social capital measurements.[19]

Questions regarding the association between community-level social capital and oral health based on longitudinal studies remain unanswered. The aim of this longitudinal cohort study was to examine the association between community-level and individual-level social capital and poor oral health (a reduction in remaining teeth) in elderly Japanese people. We hypothesized that living in high community-level social capital at baseline predicts good oral health at follow-up even when adjusting for individual-level social capital.

METHODS

Study setting

We utilized data from the Japan Gerontological Evaluation Study (JAGES). The JAGES Project investigated social, behavioural, and health factors in people aged 65 years or older. The JAGES sample was restricted to people who did not already have physical or cognitive disabilities, which were defined as receiving long-term public care insurance benefits. This longitudinal study used the panel data from 2 surveys. The baseline survey

was conducted between August 2010 and January 2012 among 141,452 older people. Self-administered questionnaires were mailed to the entire population of 10 municipalities, and in 14 municipalities, questionnaires were mailed to randomly selected members of the population, based on the official residential registers obtained from the respective municipal governments. A total of 92,272 people responded to the questionnaire (response rate = 65.2%). The follow-up survey was conducted between October 2013 and December 2013. Self-administered questionnaires used for the follow-up survey were subsequently mailed to the same municipalities and respondents. Collectively, 62,438 individuals completed both the 2010 and 2013 questionnaires.

Of these respondents, 4,466 were excluded because of a lack of information regarding oral health in 2010 and 2013. We excluded another 6,541 individuals who had no natural teeth at baseline (2010), and 151 individuals who gave no information for their residential area. Finally, 51,280 respondents from 525 districts were included in our analyses. (Figure 1)

Outcome variables

The outcome variable used was dichotomous and defined as a "reduction of remaining teeth or not" between baseline and follow-up. In both surveys, we asked for the number of remaining teeth by the following categories: "≥ 20 teeth"; "10-19 teeth"; "1-9 teeth"; "no natural teeth". At the

follow-up survey, if respondents chose a category with a smaller number of teeth compared to that of baseline, they were defined as people who had experienced a reduction in the number of their remaining teeth during the interim period. Data on respondents who had no natural teeth at baseline were excluded from multilevel analysis.

Predictor variables

Individual-level social capital

Individual-level social capital used was participation in each community activity (volunteer groups, sports groups/clubs, hobby activity group), community trust, community attachment, and social support (receive emotional support, provide emotional support, receive instrumental support) in 2010.

The response categories used for community activity participation variables were "once or more per week" and "less than once per week". Community trust was measured by asking two yes/no questions: "Do you trust the people who live in your local area?" and, "Do you think that it is important to be helpful to other people in your local area?" Community attachment was measured with the yes/no question, "Do you have an attachment to your local area?" Social support was measured with the following three yes/no questions: "Do you have someone who listens to your

concerns and complaints?" (categorized as 'receive emotional support'); "Do you listen to someone else's concerns and complaints?" (provide emotional support); and "Do you have someone who looks after you when you become sick?" (receive instrumental support).

Community-level social capital

We presumed that respondents who lived in the same districts were exposed to the same degree of community-level social capital.[20] Community-level social capital variables were obtained from factor analysis. At first, rates of each individual-level social capital response in each small district were calculated. Then, using 525 small districts as the analysis unit, factor analysis was conducted and three factors were obtained: civic participation (participation in volunteer groups, sports groups, and hobby activities), social cohesion (community trust and attachment), and reciprocity (received / provided emotional support; received instrumental support). Factor scores for each small district were used as community-level social capital variables.

Covariates

As in the studies mentioned previously, the following questions regarding sociodemographic characteristics, baseline health status, and risk factors for oral health were included in the analyses as covariates: age, sex, educational attainment, annual household income, comorbidity, smoking,

density of dental offices, population density, and number of teeth at baseline. Age was grouped into quartiles: 65-69 years, 70-74 years, 75-79 years, 80-84 years, and 85 years or older. Educational attainment was categorized as follows: <6 years, 6–9 years, 10–12 years, and ≥13 years. Annual household income was categorized as follows: <$20,000 (<¥2,000,000), $20,000–$29,999 (¥2,000,000–¥2,999,999), $30,000–$39,999 (¥3,000,000–¥3,999,999), and ≥$40,000 (≥¥4,000,000) (US$1 = ¥100). Comorbidity was measured by using the yes/no question, "Do you receive treatment now?" Smoking was categorized as follows: non-smoking, non-smoking now and quit more than 5 years ago, non-smoking now and quit within 4 years ago, and smoking now. We included density of dental offices as a continuous variable in the models. Population density was categorized as follows: urban area (≥ 1500 people/km^2), suburban area (1,000-1,500 people/km^2), and rural area (< 1,000 people/km^2).

Data analysis

The data were analysed by multilevel logistic regression analyses. We calculated odds ratio (OR) and 95% confidence interval (CI) for respondents who had a reduction in the number of remaining teeth during the study period. Because 51,280 respondents lived in 525 small districts, a two-level model (community-level and individual-level) was used. We put emphasis on the theoretical importance of the covariates and included all covariates in the multivariate model. If data were missing for explanatory

variables, the corresponding observations were assigned to "missing" categories. The significance level was set at $p < 0.05$. We used SPSS version 19.0 (IBM Corp., Armonk, NY, USA) for factor analysis and Stata version 13.1 (StataCorp, College Station, TX, USA) for multilevel analysis.

Ethical issues

JAGES respondents were informed that participation in the study was voluntary, and that completing and returning the self-administered questionnaire by mail indicated their consent for participation in the study. Ethical approval was obtained from the Ethics Committee at Nihon Fukushi University (10-05 and 13-14).

RESULTS

Of 51,280 respondents, 23,924 men and 27,356 women were included in the analysis. The average age of the 51,280 respondents was 72.5 years (SD=5.4). Among the respondents, 8.2% (n=4,180) reported a reduction in the number of their remaining teeth. Table 1 shows the descriptive statistics for each variable. Participants who were older, with less education, lower incomes, living in rural areas, with no emotional social support, having between 10-19 teeth, or who were smokers tended to have a higher incidence of tooth loss.

Table 2 shows the results of the multilevel logistic analysis. In the sex- and age-adjusted model, a significant association between

community-level social capital and incidence of tooth loss was observed at 2 variables, "civic participation" and "social cohesion" (OR: 0.84; 95% CI: 0.80–0.89 and OR: 1.14; 95% CI: 1.08–1.20, respectively). Among the individual-level social capital variables, "hobby activity participation" and "sports group participation" were significant for reducing the risk of tooth loss (OR: 0.81; 95% CI: 0.76–0.88 and OR: 0.82 95% CI: 0.76–0.90, respectively). When all variables were included in one model, living in a rich community-level social capital district at baseline and the incidence of tooth loss were observed at the variable "civic participation" (OR: 0.93; 95% CI: 0.88–0.99). Individual-level social capital variables, "hobby activity participation" and "sports group participation" still had significant associations (OR: 0.87; 95% CI: 0.80–0.95 and OR: 0.90 95% CI: 0.81–0.99, respectively).

DISCUSSION

To the best of our knowledge, this is the first study to examine the association between both community- and individual-level social capital and oral health using longitudinal data. The results suggest living in a community with a higher density of civic participation (a measurement of community-level social capital) at baseline was associated with future low risk of tooth loss. This association was still significant even after adjusting for individual-level social participation variables that were also beneficial to oral health.

The results of the present longitudinal analysis were similar to previous cross-sectional studies. In Japan, a previous study demonstrated a significant positive association between social participation and dental health status among older people.[21] Another cross-sectional study suggested that community-level horizontal social capital and vertical social capital have different effects on health; only the former had a contextual effect on dental status.[22] A review of the papers on social capital and oral health also reported the beneficial association between social capital and oral health.[16] This review, however, pointed out the need for a longitudinal analysis. The present study adds evidence supportive of an association between social capital and oral health by cohort study. In addition, those people who had a small number of teeth at baseline tended to lose their teeth (Table 2). This was consistent with the results of a previous study in Japan that used data from a nationwide dental survey.[23] Therefore, it is important to prevent tooth loss through public health interventions, individual efforts, and clinical care.

There are numerous possible pathways between social capital and oral health. Rouxel *et al.* summarized the hypothesized pathways linking social capital and oral health: behavioural and psychosocial, via access to oral health services and via policy development.[16] Regarding the behavioural pathway, social capital is considered to affect health behaviours through social contagion and informal social control.[12] As an example, one study observed the contagion of smoking-cessation following a social

network.[24] Regarding the psychosocial pathway, social capital is considered associated with reducing psychosocial stress, a possible risk factor for oral diseases.[25] Through collective efficacy, a community with rich social capital can establish health-promoting policies.[12] In this context, we supposed that although population density of dental clinics was sparse during the 1960s-1970s in Japan, the establishment of a dental clinic might be promoted in a community with rich social capital. Improving access to dental care could contribute to oral health in a community because access to dental care has been reported to promote oral health.[26]

From the present results, social capital may contribute to improvements in oral health. Previous intervention studies attempted to promote health through the enhancement of social capital.[27-29] The participation in the community salon (a resident-centred community intervention programme) contributed to the prevention of incident functional disability.[27, 29] Hikichi *et al.* found that participation in the community salon contributed to the prevention of incident functional disability.[29] Although previous intervention studies related to social capital did not examine the effects on oral health, public health interventions enhancing social capital, described above, [27-29] might improve oral health.

The strengths of our study are its prospective cohort design and its use of panel data. This design was suitable for the inference of causality compared to previous cross-sectional studies. This is the first multilevel study of social capital and oral health using longitudinal data, including not

only individual-level social capital but also community-level social capital. In addition, this study enabled us to consider a wider range of community contextual characteristics by surveying 525 communities in Japan with more than 50,000 older-age participants.

This study has some notable limitations. First, while this survey was large, oral health (in terms of number of remaining teeth) was self-reported, and even though the validity of this measure has been well-established with respect to objective measures,[30-32] the longitudinal change of self-reported dental health was imprecise relative to clinical dental check-ups. Second, the follow-up periods differed between municipalities. Because some municipalities had shorter follow-up periods than others did, it was difficult to conclude causality in this study. Third, our study included no information about changes in social capital. Therefore, there is the possibility that time-varying, confounding factors such as economic changes or natural disasters may have biased our results. However, this study aimed to examine whether baseline social capital was associated with follow-up tooth loss in a cohort study; therefore, we applied the present cohort study design. Even if we could have used change of social capital, it is very difficult to determine causality with only two time-point observations.

CONCLUSION

This large-scale cohort study covered a broad area of this country and has provided evidence that high community-level and individual-level social

capital at baseline is associated with lower incidence of tooth loss at follow-up among older Japanese people.

ACKNOWLEDGMENTS

This study used data from the Japan Gerontological Evaluation Study (JAGES), conducted by the Center for Well-being and Society, Nihon Fukushi University, as one of their research projects.

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from the Japan Foundation for Aging and Health.

TABLES

Table 1. Baseline characteristics of respondents and reduction of remaining teeth at follow-up (n=51280)

		Reduction of remaining teeth (N, %)				
		No		Yes		Total
Sex	Man	21652	91%	2272	9%	23924
	Woman	25448	93%	1908	7%	27356
Age	65-69	16367	93%	1187	7%	17554
	70-74	14899	92%	1281	8%	16180
	75-79	10748	91%	1089	9%	11837
	80-84	2798	89%	346	11%	3144
	85+	1111	88%	152	12%	1263
Education	< 6 years	541	88%	77	12%	618
	6-9 years	19210	91%	1923	9%	21133
	10-12 years	16832	93%	1299	7%	18131
	≥13 years	8957	93%	702	7%	9659
Annual household income	< $10,000	4727	90%	504	10%	5231
	$10,000-$19,999	13758	92%	1208	8%	14966
	$20,000-$29,999	10198	92%	832	8%	11030
	$30,000-$39,999	6472	93%	502	7%	6974
	≥$40,000	4768	93%	364	7%	5132
Living area	Urban area	12844	93%	897	7%	13741
	Suburban area	22231	92%	1987	8%	24218
	Rural area	12025	90%	1296	10%	13321
Hobby activity	Less than once per week	23139	91%	2207	9%	25346
	Once or more per week	16695	93%	1232	7%	17927
Sports group	Less than once per week	28213	92%	2596	8%	30809
	Once or more per week	10384	93%	756	7%	11140
Volunteer group	Less than once per week	32222	92%	2797	8%	35019
	Once or more per week	4688	92%	388	8%	5076

Community trust	No	12544	92%	1098	8%	13642
	Yes	32310	92%	2879	8%	35189
Community reciprocity	No	19386	92%	1657	8%	21043
	Yes	25252	92%	2294	8%	27546
Community attachment	No	7947	92%	709	8%	8656
	Yes	37904	92%	3356	8%	41260
Receive emotional support	No	2305	90%	268	10%	2573
	Yes	42452	92%	3677	8%	46129
Provide emotional support	No	2516	90%	295	10%	2811
	Yes	42015	92%	3622	8%	45637
Receive instrumental support	No	2127	92%	176	8%	2303
	Yes	42834	92%	3788	8%	46622
Number of teeth in 2010	≥20 teeth	19902	92%	1825	8%	21727
	10-19 teeth	13775	90%	1508	10%	15283
	1-9 teeth	13423	94%	847	6%	14270
Smoking	Non smoking	26527	93%	2045	7%	28572
	Non-smoking now, quit before 5 years	10309	92%	941	8%	11250
	Non-smoking now, quit within 4 years	2096	90%	240	10%	2336
	Smoking	4304	89%	551	11%	4855
Do you have hospital treatment?	Yes	32255	92%	2771	8%	35026
	No	11154	91%	1052	9%	12206

Table 2. Data are presented as odds ratios (95% confidence intervals), p value of reduction of remaining teeth of the respondents (n=51280)

		Sex and Age Analysis OR (95% CI), p value		Multivariate Analysis OR (95% CI), p value	
Sex (Ref: Woman)	Man			0.77 (0.71-0.83)	<0.001
Age (Ref: 65-69)	70-74			1.26 (1.16-1.37)	<0.001
	75-79			1.54 (1.41-1.69)	<0.001
	80-84			1.99 (1.74-2.27)	<0.001
	85+			2.26 (1.88-2.73)	<0.001
Education (Ref: ≥13 years)	< 6 years	1.67 (1.29-2.16)	<0.001	1.44 (1.11-1.86)	0.007
	6-9 years	1.31 (1.19-1.44)	<0.001	1.17 (1.06-1.29)	0.002
	10-12 years	1.04 (0.95-1.15)	0.412	1.01 (0.91-1.11)	0.911
Annual household income (Ref: ≥ $40,000)	< $10,000	1.42 (1.23-1.64)	<0.001	1.30 (1.13-1.51)	<0.001
	$10,000-$19,999	1.14 (1.01-1.29)	0.039	1.10 (0.97-1.24)	0.14
	$20,000-$29,999	1.05 (0.93-1.20)	0.426	1.04 (0.92-1.19)	0.53
	$30,000-$39,999	1.01 (0.87-1.16)	0.936	1.01 (0.88-1.16)	0.915
Living area (Ref: Rural area)	Urban area	0.63 (0.57-0.70)	<0.001	0.68 (0.57-0.82)	<0.001
	Suburban area	0.82 (0.76-0.90)	<0.001	0.87 (0.79-0.94)	0.001

Community-level social capital	Civic participation	0.84 (0.80-0.89)	<0.001	0.93 (0.88-0.99)	0.022
	Social cohesion	1.14 (1.08-1.20)	<0.001	1.06 (0.99-1.13)	0.111
	Reciprocity or Support	1.04 (0.97-1.11)	0.28	0.97 (0.90-1.05)	0.414
Density of dental office	Density of dental office per 10,000 people	0.87 (0.84-0.91)	<0.001	1.01 (0.94-1.08)	0.878
Individual-level social capital	Hobby activity	0.81 (0.76-0.88)	<0.001	0.87 (0.80-0.95)	0.002
	Sports group	0.82 (0.76-0.90)	<0.001	0.90 (0.81-0.99)	0.024
	Volunteer group	0.98 (0.88-1.10)	0.722	1.08 (0.96-1.21)	0.216
	Community trust	0.98 (0.91-1.05)	0.58	1.00 (0.93-1.08)	0.992
	Community reciprocity	1.00 (1.00-1.00)	0.914	1.00 (1.00-1.00)	0.477
	Community attachment	1.00 (1.00-1.00)	0.851	1.00 (1.00-1.00)	0.8
	Receive emotional support	1.00 (1.00-1.00)	0.426	1.00 (1.00-1.00)	0.73
	Provide emotional support	1.00 (1.00-1.00)	0.202	1.00 (1.00-1.00)	0.942

	Receive instrumental support	1.00 (1.00-1.00)	0.197	1.00 (1.00-1.00)	0.183
Number of teeth in 2010 (Ref: ≥20 teeth)	10-19 teeth	1.14 (1.06-1.23)	<0.001	1.06 (0.98-1.14)	0.127
	1-9 teeth	0.61 (0.56-0.66)	<0.001	0.53 (0.48-0.57)	<0.001
Smoking (Ref: Non-smoking)	Non-smoking now, quit before 5 years	0.98 (0.89-1.08)	0.665	1.04 (0.95-1.15)	0.387
	Non-smoking now, quit within 4 years	1.30 (1.12-1.51)	0.001	1.39 (1.19-1.61)	<0.001
	Smoking	1.48 (1.32-1.66)	<0.001	1.58 (1.41-1.77)	<0.001
Do you have hospital treatment? (Ref: No)	Yes	1.17 (1.08-1.26)	<0.001	1.16 (1.07-1.25)	<0.001
Random-effects Parameters					
	Community-level variance Ωμ (standard error)			0.0037 (0.0062)	

Contributorship statement

Koyama and Aida participated in the data acquisition and study design, performed statistical analysis, and drafted the manuscript. Saito participated in the data acquisition and was an advisor on study concept, statistical analysis and interpretation, and helped to draft the manuscript. N. Kondo, Sato, Matsuyama, Tani, and Sasaki participated in data acquisition, helped in the analysis and interpretation, and helped to draft the manuscript. K. Kondo, the principal investigator of the JAGES project, helped to develop the idea of the study, participated in the data acquisition, served as an advisor on statistical analysis and interpretation, and revised the manuscript. Ojima, Yamamoto, Tsuboya, and Osaka participated in the data collection, advised on statistical analysis and interpretation, and revised the manuscript. All authors read and approved the final manuscript.

Competing interests

All authors report no conflicts of interest related to our manuscript.

Data sharing statement

No additional data available.

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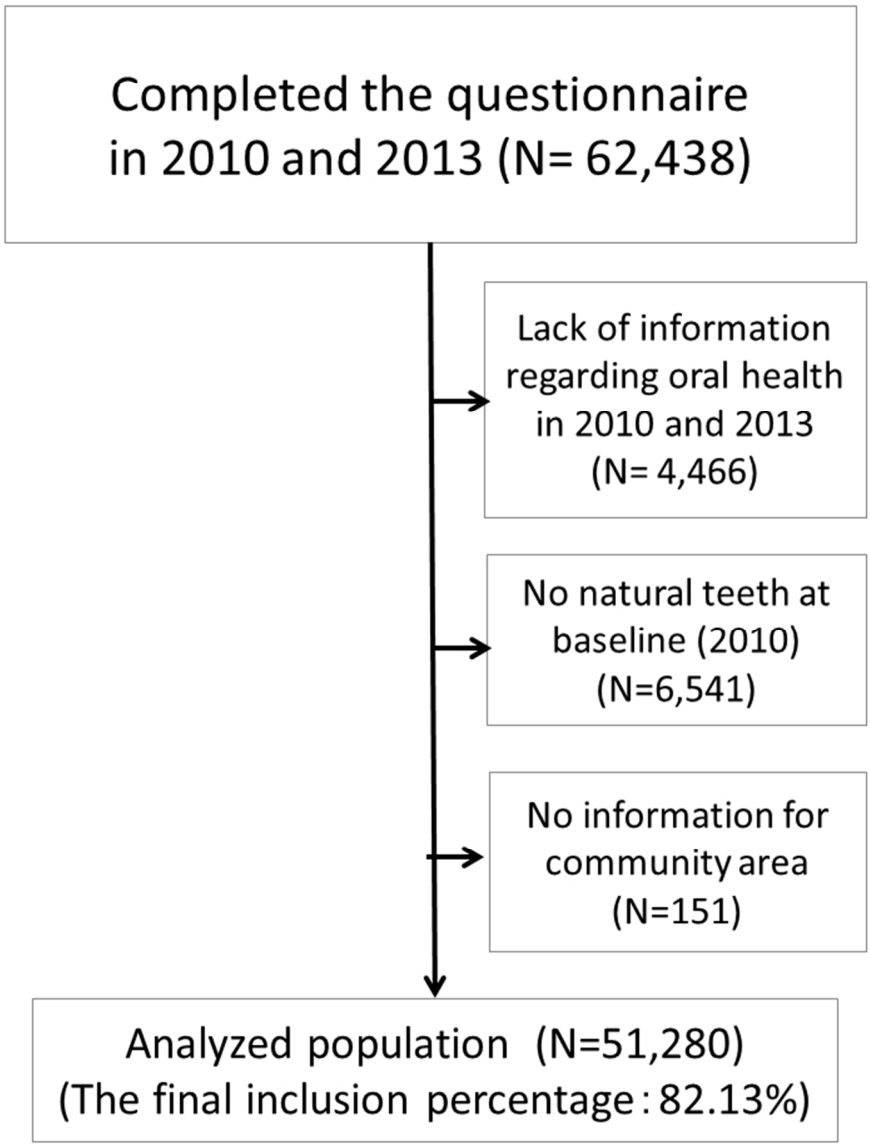
Health Sci Health Care 2012;12:4-12.

FIGURE LEGENDS

Figure 1. Data from 51,280 respondents were included in the analysis.



Data from 51,280 respondents were included in the analysis.
190x254mm (96 x 96 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	#1 #3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	#3 #4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	#5#6
Objectives	3	State specific objectives, including any prespecified hypotheses	#6
Methods			
Study design	4	Present key elements of study design early in the paper	#6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	#6 #7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	#6 #7 Fig1
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	#7-#10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	#7-#10
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	#6 #7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	#7-#10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	#10 #11
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	#7 #8 Fig1
		(*d*) If applicable, explain how loss to follow-up was addressed	#6 #7
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	#7 Fig 1
		(b) Give reasons for non-participation at each stage	#7 Fig 1
		(c) Consider use of a flow diagram	Fig 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	#6 #7
		(b) Indicate number of participants with missing data for each variable of interest	#6 #7
		(c) Summarise follow-up time (eg, average and total amount)	#6 #7
Outcome data	15*	Report numbers of outcome events or summary measures over time	#11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	#12
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	#11 #12
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	#15
Generalisability	21	Discuss the generalisability (external validity) of the study results	#15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.