DIGITAL ACCESS TO SCHOLARSHIP AT HARVARD
DASH.HARVARD.EDU

HARVARD LIBRARY

Social interaction and cognitive decline: Results of a 7-year community intervention

Citation

Hikichi, Hiroyuki, Katsunori Kondo, Tokunori Takeda, and Ichiro Kawachi. 2016. “Social interaction and cognitive decline: Results of a 7-year community intervention.” Alzheimer's & Dementia : Translational Research & Clinical Interventions 3 (1): 23-32. doi:10.1016/j.trci.2016.11.003. http://dx.doi.org/10.1016/j.trci.2016.11.003.

Published version

https://doi.org/10.1016/j.trci.2016.11.003

Link

http://nrs.harvard.edu/urn-3:HUL.InstRepos:34492479

Terms of use

This article was downloaded from Harvard University’s DASH repository, and is made available under the terms and conditions applicable to Other Posted Material (LAA), as set forth at https://harvardwiki.atlassian.net/wiki/external/NGY5NDE4ZjgzNTc5NDQzMGIzZWZhMGFlOWI2M2EwYTg

Accessibility

https://accessibility.huit.harvard.edu/digital-accessibility-policy

Share Your Story

The Harvard community has made this article openly available.
Please share how this access benefits you. Submit a story

Alzheimer's & Dementia: Translational Research & Clinical Interventions 3 (2017) 23-32

Featured Article

Social interaction and cognitive decline: Results of a 7-year community intervention

Hiroyuki Hikichi[a,*], Katsunori Kondo[b,c], Tokunori Takeda[d], Ichiro Kawachi[a]

[a]*Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, MA, USA*
[b]*Center for Preventive Medical Sciences, Chiba University, Chiba-shi, Chiba, Japan*
[c]*Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Obu, Aichi, Japan*
[d]*Department of Rehabilitation and Care, Seijoh University, Tokai-shi, Aichi, Japan*

Abstract

Introduction: There are few intervention studies that demonstrated linking social participation to lower risk of cognitive decline. We examined prospectively the protective effect of a community intervention program promoting social participation on the incidence of cognitive disability.

Methods: The baseline was established in a survey of community-dwelling older people aged 65 years old or more in July 2006 (2793 respondents, response rate 48.5%). The setting was Taketoyo town in Japan, where municipal authorities launched an intervention that was based on the establishment of community-based centers called "salons," where the town's senior residents could congregate and participate in social activities, ranging from arts and crafts, games, and interactive activities with preschool children. Three salons were established in May 2010, and a total of 10 salons were in operation by 2013. We recorded the frequency of salon participation among survey respondents till 2013 and conducted two follow-up surveys (in 2010 and 2013) to collect information about health status and behaviors. The onset of cognitive disability was followed from May 2007 to January 2014. We used the marginal structural models to evaluate the effect of program.

Results: The range of prevalence of cognitive disability was from 0.2% to 2.5% during the observation period. The proportion of respondents who participates to salons increased over time to about 11.7%. The frequency of salon participation was protectively associated with cognitive decline, even after adjusting for time-dependent covariates and attrition (odds ratio = 0.73, 95% confidence interval: 0.54–0.99).

Discussion: Our study suggests that operating community salons that encourage social interactions, light physical activity, and cognitive activities among older participants may be effective for preventing cognitive decline. In future studies, we need to understand what sorts of activities (e.g., those involving light physical activity vs. purely intellectual activities) are most effective in maintaining cognitive function.

© 2016 The Authors. Published by Elsevier Inc. on behalf of the Alzheimer's Association. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Keywords: Prevention; Community intervention; Social participation; Japan; Marginal structural models

1. Introduction

Dementia is a major cause of disability and dependency among older people. Worldwide, an estimated 47.5 million people suffer from dementia while 7.7 million new cases are added each year [1]. The number of people living with dementia is projected to triple by 2050 [2].

*Corresponding author. Tel.: +1-617-998-1086; Fax: +1-617-495-8543.
E-mail address: hikichi@hsph.harvard.edu

http://dx.doi.org/10.1016/j.trci.2016.11.003
2352-8737/ © 2016 The Authors. Published by Elsevier Inc. on behalf of the Alzheimer's Association. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Japanese society is confronted with the fastest pace of population aging in the world, with a population prevalence of dementia that is nearly double the world average (Japan: 15.0% in 2012 [3] vs. world average: 5.2% in 2015 [4]). The population with dementia is forecast to reach 7 million by 2025 [5]. The prevention of dementia is therefore a top priority for Japanese public health policy [6]. One approach advocated by Japanese government to prevent cognitive decline in older adults has been to encourage more social participation [7]. Observational studies suggested that social participation is associated with lower risk of cognitive decline [8]. However, these studies are prone to confounding bias due to their observational nature; specifically, the selective participation of cognitively healthier individuals in community-based programs encouraging social participation.

Since 2007, the municipality of Taketoyo (population 41,000) in Aichi Prefecture, Japan, has been engaged in a community intervention program designed to facilitate social participation among older residents, with the aim of preventing cognitive and physical functional decline. The intervention program is based on opening 10 community-based centers (referred to as "salons"), where seniors can congregate to engage in a variety of social programs and activities [9,10].

In the present study, we report on the 7-year evaluation of this intervention program. Our design is quasi-experimental in the sense that the community salons were newly established by the Taketoyo municipality (where none previously existed), and we have information (from an ongoing cohort study) about the health status of individuals before and after the salons were opened. Because of the repeated assessments of salon participation and covariates over time, there is a possibility of time-varying confounding. For example, social participation could improve health status (covariates), which also may influence the probability of social participation in subsequent time periods. Therefore, we attempted to address time-varying confounding through marginal structural modeling with inverse probability weighting.

2. Methods

2.1. Study population

The study population consisted of participants in the Aichi Gerontological Evaluation Study (AGES), which was established in 1999 in Aichi prefecture. One of the field sties of the AGES cohort was in the town of Taketoyo (population 41,531 in 2006) [11]. We conducted a mail-in questionnaire survey of all community-dwelling older people who were physically and cognitively independent and aged 65 years or older ($n = 5759$) in July 2006.

The questionnaire survey inquired about personal characteristics, health status, and health habits of the respondents. As shown in Fig. 1, the response rate to the baseline survey was 48.5% ($n = 2793$). An additional 200 subjects were removed from the baseline of the present study because of missing/invalid information, relocation out of the area, or death/incident disability.

Of the 2593 eligible participants from the baseline survey, we lost 326 subjects due to death/functional decline and relocation during the 3-year and 3-month follow-up period. In the second survey in August 2010, we recontacted 1769 individuals (participation rate: 78.0%). During an additional 3-year and 2-month follow-up term, 268 respondents dropped out of our cohort. We obtained 1352 responses from 1501 eligible subjects in the third survey conducted in October 2013 (participation rate: 90.1%). The cumulative follow-up rate during the total period was therefore 73.9%. We also collected information on their frequency of participating in salons until the end of March 2014. In addition, the onset of functional and cognitive disability was followed from May 1, 2007 to January 7, 2014. (The observation period was 2443 days.) Our study protocol was approved by the Ethics Committee at Nihon Fukushi University and Seijoh University.

2.2. The intervention

Taketoyo town is located approximately 35 km south of Nagoya in Aichi Prefecture, Japan. The community salon project was launched in May 2007 when the municipal authorities began to open community-based centers where the town's senior residents could congregate and participate in social activities. Initially, three salons were established, and by 2013, a total of 10 salons were in operation, staffed by community volunteers (Fig. 1).

In September 2013, we conducted a survey of a sample of 152 volunteers in the Taketoyo program. Of the 91 volunteers who responded to the survey (26 male and 65 female), the average age was 71 years, and the average duration of volunteering was 4.3 years. Almost all of them were recruited to volunteer by their friends who were participating in the salon activities. They were all required to take a training course conducted by two occupational therapists.

Although the salon programs were not standardized across locations, popular activities included dance classes, chatting with other participants, arts and crafts (calligraphy, origami, and poetry recitation), singing, playing musical instruments, quizzes and games (e.g., bingo, cards, Japanese chess), as well as interactive activities with preschool children. In each salon, 90–120 minutes of programming were scheduled between 1 to 3 times per month.

Any resident aged 65 years or older was eligible to participate for a nominal fee of 100 Japanese Yen (roughly 1 US dollar) per visit.

2.3. Outcome variable

Our primary outcome is the onset of cognitive disability assessed by a standardized in-home assessment. The Japanese government established a national long-term care insurance scheme in 2000 [12]. Under this system, a certification

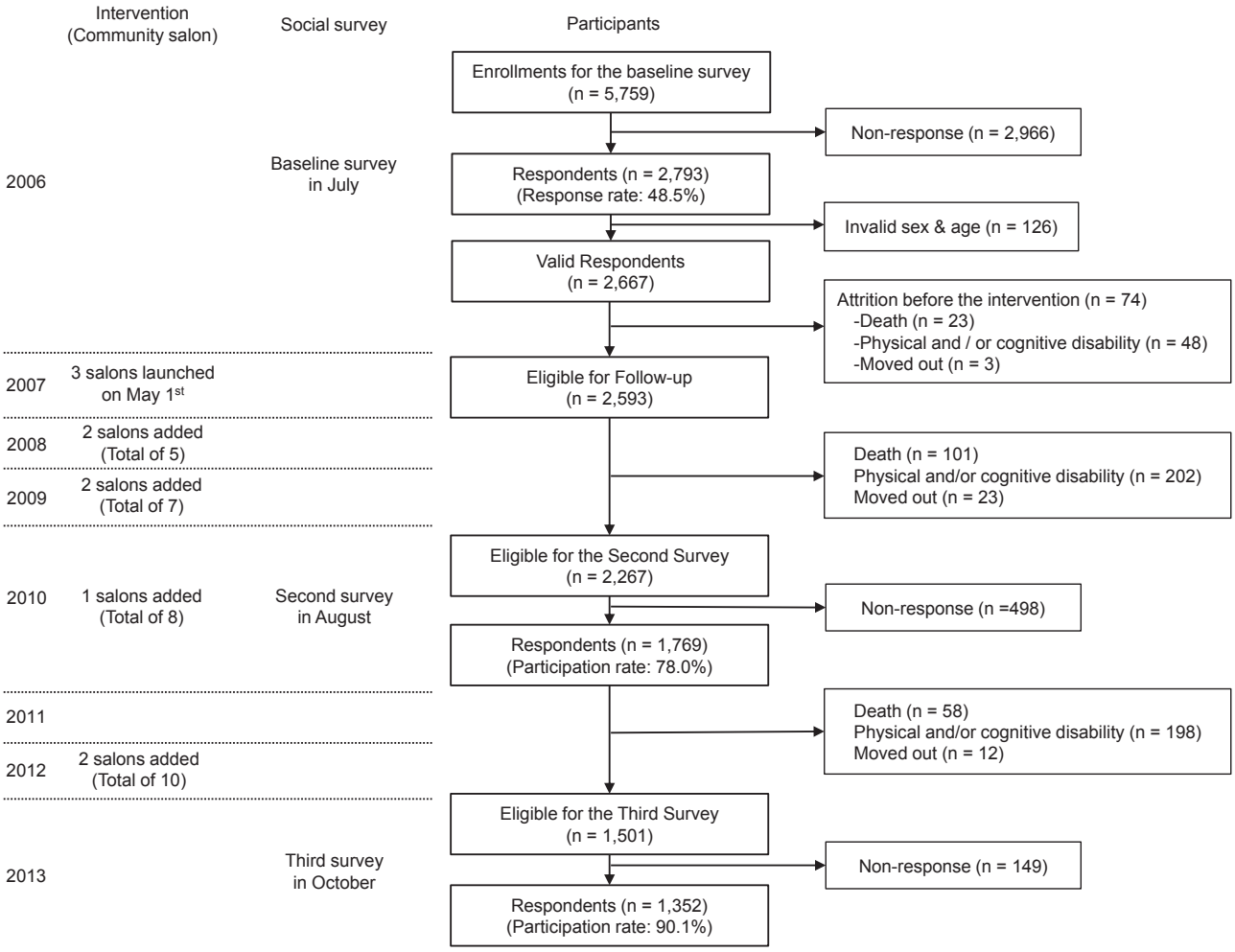

Fig. 1. Participants flow during the follow-up period.

committee in each municipality dispatches trained investigators to applicants' homes to evaluate their eligibility for nursing care (e.g., home helper).

During the home visit, each individual is assessed with regard to their activities of daily living and instrumental activities of daily living status, cognitive function (e.g., short-term memory, orientation, and communication), as well as mental and behavioral disorders (e.g., delusions of persecution, confabulation, and soliloquy) using a standardized protocol. Following the assessment, the applicants are classified into one of eight levels according to the severity of their cognitive disability (Supplementary Table 1).

The level of cognitive decline is strongly correlated with the Mini–Mental State Examination (Spearman rank correlation $\rho = -0.73$, $P < .001$), according to a previous validation study among 116 institutionalized older residents and 66 older individuals requiring outpatient day long-term care (The age range was between 60 to 101 years) [13]. Another previous study demonstrated that level I of the home assessment scale corresponds to a 0.5-point rating on the clinical dementia rating (suspected dementia) for 590 older individuals aged 75 years and more (specificity and sensitivity, both 0.88) [14]. On the basis of these validation studies, a cognitive decline rating of level I or higher was defined as incident cognitive disability in this study.

We matched data from the AGES participants to the long-term care insurance registry for the follow-up period from May 1, 2007 to January 7, 2014. Respondents who died, or who developed incident functional disability without cognitive decline, or moved out of the area, or did not respond to the survey during the follow-up period, were censored.

2.4. Explanatory variable

Our primary treatment variable was frequency of participation in community salons in each year. Taketoyo town keeps a participant register that recorded the participant's name and frequency of salon participation. Among participants during the 7-year follow-up, 10%–50% of them participated only once to 3 times in any given year. Our definition of "participant" was restricted to those who participated more than 3 times a year (numbers of the participants: 99, 159, 152,

162, 162, 175, and 158, for each year) (Supplementary Table 2) because we hypothesized that participation on fewer occasions could not be plausibly expected to prevent functional disability. Therefore, anyone who participated on fewer than four occasions was classified as nonparticipants. Because the distribution was right-skewed in each year, we log-transformed the values (arbitrarily inserting "1" instead of "0" for those who did not participate at all).

2.5. Covariates

We selected as potential confounding variables sex, age, educational attainment, and equalized household income [15], depressive symptoms measured by the Geriatric Depression Scale-15 (GDS-15) [16], low cognitive function [17], comorbidities including stroke, heart disease, and hypertension [18], drinking and smoking [19], walking time [20], and frequency of participating in sports clubs [21].

We did not perform a detailed assessment of mild cognitive impairment; instead we asked three items on the survey: "Have people around you noticed that you are forgetful, for example, by telling you that you often ask the same thing?" "Can you look up phone numbers and make phone calls by yourself" and "Do you sometimes forget what date it is today?" [17].

Age was grouped into the following categories: 65–74 years and 75 years or over. Educational attainment was categorized as 9 years or under and 10 years or over. Household income was equalized by the square root of the number of household members and categorized into "Under 2.0 million JPY" and "2.0 million JPY and over." Depressive symptoms were categorized into lower risk (4 points and under) versus higher risk (5 points and over) [22]. Low cognitive function was categorized as negative condition (1–3 points) versus neutral condition (0 point) [17]. As shown in Supplementary Fig. 1, our covariates were updated by the surveys conducted in 2010 and 2013.

2.6. Statistical analysis

Initially, we conducted a discrete time logistic regression analysis adjusting for all covariates to examine the association between frequency of salon participation and onset of cognitive disability.

In longitudinal data, exposures and covariates can have complex bidirectional associations. For example, salon participation (our treatment of interest) could affect the onset of diseases. Incident chronic conditions can therefore simultaneously act as a confounder of the relation between salon participation and cognitive function as well as a potential mediating variable between future salon participation and cognitive function. This scenario of time-varying confounding cannot be addressed by conventional methods such as restriction, stratification, or covariance adjustment [23]. In addition, our data had a high attrition rate in which 1241 respondents dropped out before the third wave survey, which may induce selection bias [24].

To address these potential biases, we used Marginal Structural Models (MSMs) that estimated the stabilized inverse probability of receiving the treatment (i.e., salon participation) $SW(t)$ and the probability of remaining uncensored up to time t $SW(c)$ to create a pseudo-population to balance the distribution of potential confounders across exposure levels and uncensored cases [25]. $SW(t)$ and $SW(c)$ are defined as

$$SW(t)=\prod_{k=0}^{t}\frac{f\{A(k)|\overline{A}(k-1),\ V,\ \overline{C}(k)=0\}}{f\{A(k)|\overline{A}(k-1),\overline{L}(k),\ \overline{C}(k)=0\ \}}$$

and

$$SW(c)=\prod_{k=0}^{t}\frac{\Pr\{C(k)=0|\overline{C}(k-1)=0,\ \overline{A}(k-1),\ V\}}{\Pr\{C(k)=0|\overline{C}(k-1)=0,\overline{A}(k-1),\ \overline{L}(k-1)\ \}}$$

where $A(k)$ denotes the exposure at year k, $\overline{A}(k-1)$ represents the exposure history prior year k, V is baseline covariates, $\overline{L}(k-1)$ represents the covariates history including V, $C(k)$ is the incident censoring at year k, $\overline{C}(k-1)$ is uncensored history until year $k-1$.

Because our treatment—that is, frequency of salon participation—is a continuous measure, we estimated each person's probability density of receiving treatment in each year [26]. We used Poisson regression to create $SW(t)$ because the exposure is a zero-inflated variable [27]. The $SW(c)$ was estimated using logistic regression. And, we obtained an overall weight $SW=SW(t)\times SW(c)$ [28].

To estimate the odds ratios of cognitive decline as a result of salon participation, we used all baseline covariates V as well as time-varying covariate history $\overline{L}$ in the weighted MSMs model to control for potential confounding in the pseudo-population [29].

In addition, the data obtained from the questionnaires included missing answers in each wave, which may cause loss of power and biased estimations [30]. To address potential bias due to missing data, we used multiple imputation by Markov Chain Monte Carlo method for covariates in each year [31]. We created 20 imputed data sets and combined each result of analysis using the Stata command "mi estimate."

All analyses were performed using STATA version 14.0 (STATA Corp LP., College Station, Texas, USA).

3. Results

Descriptive statistics are shown in Table 1. The incidence of cognitive disability tended to increase over time. The range of prevalence of cognitive disability was from 0.2% to 2.5% during the observation period. The proportion of respondents who participates to salons increased over time to about 11.7%. The incidence rate ratio for salon participation versus nonsalon participation was 0.61 (95% confidence interval [CI]: 0.30–1.10). The averaged frequency of

Table 1
Characteristics of analytic samples during follow-up period

	2007		2008		2009		2010		2011		2012		2013	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Cognitive disability														
Nonincidence	2556	98.6	2524	98.8	2494	98.8	1753	99.1	1715	97.8	1673	97.5	1349	99.8
Incidence	37	1.4	32	1.2	30	1.2	16	0.9	38	2.2	42	2.5	3	0.2
Total	2593	100	2556	100	2524	100	1769	100	1753	100	1715	100	1352	100
Participation*														
Nonparticipants	2494	96.2	2397	93.8	2372	94.0	1607	90.8	1591	90.8	1540	89.8	1194	88.3
Participants	99	3.8	159	6.2	152	6.0	162	9.2	162	9.2	175	10.2	158	11.7
Total	2593	100	2556	100	2524	100	1769	100	1753	100	1715	100	1352	100
Sex														
Male	1306	50.4	-	-	-	-	874	49.4	-	-	-	-	665	49.2
Female	1287	49.6	-	-	-	-	895	50.6	-	-	-	-	687	50.8
Total	2593	100	-	-	-	-	1769	100	-	-	-	-	1352	100
Age														
65–74 years	1770	68.3	-	-	-	-	910	51.4	-	-	-	-	387	28.6
75 years and over	823	31.7	-	-	-	-	859	48.6	-	-	-	-	965	71.4
Total	2593	100	-	-	-	-	1769	100	-	-	-	-	1352	100
Educational attainment														
9 years and under	1405	54.8	-	-	-	-	925	52.7	-	-	-	-	701	52.2
10 years and over	1158	45.2	-	-	-	-	831	47.3	-	-	-	-	643	47.8
Total	2563	100	-	-	-	-	1756	100	-	-	-	-	1344	100
Equalized income														
<2.0 million JPY	921	47.1	-	-	-	-	682	48.3	-	-	-	-	574	53.5
≥2.0 million JPY	1034	52.9	-	-	-	-	730	51.7	-	-	-	-	498	46.5
Total	1955	100	-	-	-	-	1412	100	-	-	-	-	1072	100
Number of comorbidities														
0	756	41.6	-	-	-	-	530	36.8	-	-	-	-	368	32.5
1	899	49.4	-	-	-	-	790	54.9	-	-	-	-	647	57.2
2	150	8.3	-	-	-	-	117	8.1	-	-	-	-	109	9.6
3	14	0.7	-	-	-	-	2	0.2	-	-	-	-	7	0.7
Total	1819	100	-	-	-	-	1439	100	-	-	-	-	1131	100
Depressive symptoms (GDS-15)														
4 points and under	1617	72.3	-	-	-	-	1104	72.9	-	-	-	-	838	74.7
5 points and over	620	27.7	-	-	-	-	411	27.1	-	-	-	-	284	25.3
Total	2237	100	-	-	-	-	1515	100	-	-	-	-	1122	100
Low cognitive function														
0 point	1486	59.7	-	-	-	-	1027	61.5	-	-	-	-	846	64.2
1 point and over	1002	40.3	-	-	-	-	644	38.5	-	-	-	-	471	35.8
Total	2488	100	-	-	-	-	1671	100	-	-	-	-	1317	100
Current drinking														
No	1535	60.3	-	-	-	-	1102	65.6	-	-	-	-	900	68.1
Yes	1010	39.7	-	-	-	-	579	34.4	-	-	-	-	422	31.9
Total	2545	100	-	-	-	-	1681	100	-	-	-	-	1322	100
Current smoking														
No	1946	86.0	-	-	-	-	1459	91.0	-	-	-	-	1254	94.9
Yes	318	14.0	-	-	-	-	144	9.0	-	-	-	-	67	5.1
Total	2264	100	-	-	-	-	1603	100	-	-	-	-	1321	100
Walking time (continuous)														
Less than 30 minutes	759	30.7	-	-	-	-	600	35.7	-	-	-	-	351	26.6
30–60 minutes	909	36.7	-	-	-	-	571	34.0	-	-	-	-	518	39.2
60–90 minutes	405	16.4	-	-	-	-	259	15.4	-	-	-	-	226	17.1
90 minutes and more	402	16.2	-	-	-	-	250	14.9	-	-	-	-	226	17.1
Total	2475	100	-	-	-	-	1680	100	-	-	-	-	1321	100
Frequency participating to sports club														
Never	1763	77.0	-	-	-	-	1034	71.2	-	-	-	-	756	67.6
A few times a year	59	2.6	-	-	-	-	57	3.9	-	-	-	-	39	3.5
1 to 3 times a month	52	2.3	-	-	-	-	52	3.6	-	-	-	-	51	4.6
Once a week	179	7.8	-	-	-	-	109	7.5	-	-	-	-	89	8.0
2 or 3 times a week	190	8.3	-	-	-	-	151	10.4	-	-	-	-	105	9.3
Almost everyday	47	2.0	-	-	-	-	49	3.4	-	-	-	-	79	7.0
Total	2290	100	-	-	-	-	1452	100	-	-	-	-	1119	100

Abbreviation: JPY, Japanese Yen.
*We defined more than 3-time visitors as "participants."

participation also increased from 9.02 to 18.67 times per year (Supplementary Table 2). Equalized income gradually decreased during the follow-up period. More than half of the sample reported household income under 2 million Japanese Yen (about 20,000 US dollars) by 2013.

Systematic differences were observed in who participated in the salons (Supplementary Table 3). Women were more likely to participate than men, as well as those who also participated in sports clubs. By contrast, individuals from higher SES background (higher educational attainment and equalized income), higher depression scores, sedentary individuals, as well as smokers and regular drinkers were less likely to participate. That is, healthier and more sociable persons at baseline were more likely to participate in salons.

As shown in Table 2, the results of the multivariate model showed that salon participation frequency (continuous variable) was not significantly associated with lower risk of cognitive disability (odds ratio [OR] = 0.96, 95% CI: 0.91–1.01). The log-transformed frequency of salon participation was also associated with lower risk of incident cognitive disability (OR = 0.72, 95% CI: 0.54–0.98). In addition, the MSMs results indicated that frequency of salon participation was protectively associated with cognitive disability, even after adjusting for time-dependent covariates and attrition (OR = 0.73, 95% CI: 0.54–0.99) (Table 3). This model also showed that older age (75 years or older) is an important risk factor for incident cognitive decline (OR = 3.25, 95% CI: 1.86–5.69), while increasing walking time was protective (OR = 0.69, 95% CI: 0.55–0.87).

4. Discussion

To our knowledge, this is the first study to demonstrate that a community-based intervention encouraging social participations is effective for the prevention of incident cognitive disability. The association remained after controlling for time-dependent confounding and attrition during the follow-up period, using MSMs. The association between frequency of salon participation and incident cognitive disability appears to be statistically and clinically important. For example, salon participation was associated with the prevention of cognitive disability (OR = 0.73, 95% CI: 0.54–0.99, in model 2 of MSMs) as well as the daily walking (OR = 0.69, 95% CI: 0.55–0.87).

As shown in Supplementary Table 3, people who participated in the salons were more likely to be female, from lower socioeconomic background (lower educational attainment and equalized income), less likely to report depressive symptoms, less physically active, and less likely to smoke or drink. Therefore, an important challenge in

Table 2
Odds ratio and 95% CI for the risk of cognitive decline in the results of multivariate model

	Multivariate model			
	Model 1		Model 2	
	Odds (95% CI)	*P*	Odds (95% CI)	*P*
Frequency of participation				
ln (X + 1)	0.96 (0.91–1.01)	.12	0.72 (0.54–0.98)	.04
Sex (Ref.: male)				
Female	0.93 (0.67–1.29)	.68	0.95 (0.68–1.31)	.73
Educational attainment (Ref.: 9 years)				
10 years and over	0.81 (0.60–1.10)	.17	0.81 (0.59–1.09)	.16
Age (Ref: 65–74 years)				
75 years and over	6.21 (4.14–9.32)	<.01	6.23 (4.15–9.34)	<.01
Equivalent income (Ref.: <2 million JPY)				
2 million JPY and more	0.97 (0.68–1.40)	.88	0.97 (0.68–1.40)	.88
Number of comorbidities				
0–3	0.93 (0.73–1.17)	.52	0.92 (0.73–1.17)	.51
Depressive symptoms (Ref.: ≤4 points)				
≥5 points	1.52 (1.09–2.13)	.01	1.51 (1.08–2.12)	.02
Low cognition score (Ref.: 0 point)				
≥1 point	2.36 (1.72–3.24)	<.01	2.36 (1.71–3.24)	<.01
Current drinking				
Yes (Ref.: no)	0.75 (0.51–1.09)	.13	0.75 (0.51–1.09)	.13
Current smoking				
Yes (Ref.: no)	1.52 (0.98–2.33)	.06	1.51 (0.98–2.33)	.06
Walking time				
1: <30 minutes to 4: ≥90 minutes	0.75 (0.63–0.89)	<.01	0.75 (0.63–0.89)	<.01
Frequency participating in sports club				
1: a few times to 6: almost everyday	0.98 (0.93–1.05)	.63	0.98 (0.93–1.05)	.63
Cons.	0.01 (0.01–0.02)	<.01	0.01 (0.01–0.02)	<.01

Abbreviations: CI, confidence interval; Odds, odds ratio; Ref., reference; JPY = Japanese Yen.

Table 3
Odds ratio and 95% CI for the risk of cognitive decline in the results of marginal structural model

	Marginal structural models			
	Model 1		Model 2	
	Odds (95% CI)	*P*	Odds (95% CI)	*P*
Frequency of participation				
ln (X + 1)	0.72 (0.53–0.98)	.04	0.73 (0.54–0.99)	.04
Time-invariant covariates				
Sex (Ref.: male)				
Female	1.08 (0.78–1.51)	.64	1.04 (0.74–1.46)	.82
Educational attainment (Ref.: 9 years)				
10 years and over	0.82 (0.59–1.13)	.22	0.86 (0.62–1.18)	.36
Time-variant covariates at baseline				
Age (Ref: 65–74 years)				
75 years and over	4.89 (3.5–6.82)	<.01	2.30 (1.54–3.45)	<.01
Equivalent income (Ref.: <2 million JPY)				
2 million JPY and more	0.90 (0.63–1.3)	.58	0.92 (0.58–1.45)	.71
Number of comorbidities				
0–3	1.01 (0.77–1.31)	.97	1.06 (0.74–1.52)	.74
Depressive symptoms (Ref.: ≤4 points)				
≥5 points	1.23 (0.83–1.80)	.30	0.84 (0.49–1.45)	.53
Low cognition score (Ref.: 0 point)				
≥1 points	1.67 (1.22–2.29)	<.01	1.04 (0.68–1.59)	.85
Current drinking				
Yes (Ref.: no)	0.90 (0.63–1.30)	.58	1.42 (0.78–2.60)	.25
Current smoking				
Yes (Ref.: no)	1.26 (0.82–1.93)	.29	0.86 (0.31–2.41)	.78
Walking time (continuous)				
1: <30 minutes to 4: ≥90 minutes	0.87 (0.73–1.02)	.09	1.16 (0.93–1.44)	.19
Frequency participating in sports club				
1: a few times to 6: almost everyday	1.09 (0.95–1.25)	.21	1.10 (0.96–1.26)	.19
Time-variant covariates during follow-up term				
Age (Ref: 65–74 years)				
75 years and over			3.25 (1.86–5.69)	<.01
Equivalent income (Ref.: <2 million JPY)				
2 million JPY and more			1.01 (0.64–1.61)	.96
Number of comorbidities				
0–3			0.91 (0.67–1.25)	.58
Depressive symptoms (Ref.: ≤4 points)				
≥5 points			1.68 (1.03–2.74)	.04
Low cognition score (Ref.: 0 point)				
≥1 point			2.26 (1.44–3.53)	<.01
Current drinking				
Yes (Ref.: no)			0.61 (0.31–1.18)	.14
Current smoking				
Yes (Ref.: no)			1.68 (0.59–4.81)	.33
Walking time				
1: <30 minutes to 4: ≥90 minutes			0.69 (0.55–0.87)	<.01
Frequency participating in sports club				
1: a few times to 6: almost everyday			0.94 (0.88–1.01)	.11
Cons.	0.01 (0.01–0.02)	<.01	0.01 (0.01–0.02)	<.01

Abbreviations: CI, confidence interval; Odds, odds ratio; Ref., reference; JPY, Japanese Yen.

scaling up the salon intervention to the general population is to understand how to design the programs in such a way as to appeal to broader segments of the population. One possibility is to adopt a social marketing approach consisting of outreach, education, and networking efforts within a targeted area [32].

There are plausible mechanisms by which salon participation might assist in the prevention of cognitive disability. In the interim appraisal that was conducted 2 years after the start of this intervention program, the salon participants reported that they had joined other local organizations such as sports or hobby clubs. They also reported increased social support (both receipt and provision) after joining the community salons [33]. That is, participants appear to have expanded their social network through salon participation, which in turn helped to preserve cognitive function [34]. In addition, some salon activities included light physical activity (e.g., stretching exercises) and other activities such as

handicrafts that might have helped in the maintenance of cognitive functions [35,36]. Salon participation may also have helped to reduce the risk of depression (itself a risk factor for cognitive decline) by boosting people's sense of purpose in life [37].

In an interim appraisal of 100 salon participants conducted 3 years after the start of the salon project, the participants were more likely to perform well on cognitive tests such as the three-words delayed recall test and word fluency test [38]. However, this study did not compare the cognitive function of nonparticipants or control for confounding factors. In a previous analysis from the same intervention study—based on 5 years of follow-up—we reported that salon participation was associated with lower risk of functional disability [9]. However, we were able to control for baseline covariates only and did not take account of time-varying risk factors during follow-up.

In the United States, the Experience Corps was an intervention program that recruited retired seniors in Baltimore to serve as a volunteer teacher's aides in local schools. The program was designed to support the academic success of children and to promote the health of older volunteers by enhancing their physical, social, and cognitive functioning [39]. Their intervention found that brain cortical and hippocampal volumes were increased among male participants in the treatment group during 2-year follow-up [40]. In another intervention study conducted in Oregon, an online conversation program was provided to 83 seniors living in retirement communities or senior centers [41]. The intervention sought to increase social interaction among seniors through online conversations with trained interviewers for 6 weeks. The intervention group showed improved semantic and phonemic fluency compared with the control group. Multimodal interventions incorporating social engagement are therefore likely to be effective for the prevention of cognitive decline; however, evidences remain extremely scarce [42]. Our study suggests that operating community salons that encourage cognitive activities, social interactions, and light physical activity among older participants may be effective for preventing cognitive decline.

An important strength of this study was to reduce estimation bias caused by time-dependent variables. Although about 50% subjects dropped out from our cohort during 7-year observation terms, the proportion of salon participants increased year by year (Table 1). It causes a selection bias: Healthy subjects (time $t - 1$) are more likely to participate in the community salons (time $t - 1$ and t), thereby maintaining their health conditions as well as the lower risk of cognitive decline (time $t + 1$). The MSMs created a pseudo-population in which the exposure is independent of measured confounders [29]. An additional strength is our objective measures of the frequency of salon participation as well as cognitive disability based on in-home assessment.

A limitation of our study is the response rate at baseline survey that was 48.5%. This may limit the generalizability of our findings, although our response rate is comparable to other surveys of community-based residents [43]. The demographic profile of our analytic sample is also similar to the independent census data for Taketoyo residents aged 65 years or older (Supplementary Table 4). In addition, the follow-up rates for the two follow-up surveys were quiet high (78.0% and 90.1%, for respectively). On the other hand, because we did not perform a detailed assessment of early presymptoms of cognitive decline, we cannot rule out the possibility of reverse causation, for example, that individuals with early symptoms of cognitive decline were less likely to participate in salon activities. In addition, there is a possibility that differential misclassification occurred in our assessment of outcomes because older persons who have mild cognitive impairment may tend to avoid medical diagnosis. We also lacked information about incident diabetes mellitus which may have affected both salon participation and cognitive decline. Our outcome variable (an 8-point scale of cognitive decline obtained from in-home assessment) does not amount to a clinically based diagnosis of dementia, although it has been demonstrated to be highly correlated with MMSE scores and CDR scores in previous validation studies [13,14].

In conclusion, opening and operating community-based salons may be an effective intervention for the prevention of cognitive decline in the older Japanese population. In future studies, the assessment of cognitive decline under the long-term care insurance scheme should be validated against *The Fourth Edition of Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*) criteria. We need to also understand what sorts of activities and programs (e.g., those involving light physical activity vs. purely intellectual activities) are most effective in maintaining cognitive function.

Acknowledgments

The authors appreciate the support and cooperation of the Iwanuma Mayor's office, and the staff of the Department of Health and Welfare of Iwanuma city government.
This work was supported by grants-in-Aid for Scientific Research from the Japan Society for the Promotion of Science (24653150, 23243070, 22119506, and 15H01972); a Health Labour Sciences Research Grant from the Japanese Ministry of Health, Labour and Welfare (H22-Choju-Shitei-008, H25-Choju-Ippan-003, H27- Ninchisho-Ippan-001, and H28-Choju-Ippan-002); and a grant from the Strategic Research Foundation Grant-Aided Project for Private Universities from the Japanese Ministry of Education, Culture, Sports, Science and Technology (S0991035).
The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the article; and decision to submit the article for publication.
There are no conflicts of interest to declare.

This study has not been submitted elsewhere nor is it being considered elsewhere for publication.

Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.trci.2016.11.003.

RESEARCH IN CONTEXT

1. Systematic review: The authors reviewed the published literature using PubMed. Although many observational studies have shown that social participation in older people is protectively associated with incident cognitive decline, no previous studies have demonstrated that social participation is effective for prevention of incident cognitive disability in the context of a community intervention study.
2. Interpretation: Our findings suggest that operating a "community salon" program can contribute to the prevention of the onset of cognitive decline through increasing the social participation of the participants.
3. Future directions: Further studies are needed to understand what sorts of activities and programs (e.g., those involving light physical activity vs. purely intellectual activities) are most effective in maintaining cognitive function.

References

[1] WHO. Dementia. Available at: http://www.who.int/mediacentre/factsheets/fs362/en/; 2015. Accessed February 7, 2016.

[2] WHO. 10 facts on dementia. Available at: http://www.who.int/features/factfiles/dementia/en/; 2015. Accessed February 7, 2016.

[3] Ninomiya T, Ozawa M. Japanese perspectives on dietary patterns and risk of dementia. In: Preedy VR, ed. Diet and Nutrition in Dementia and Cognitive Decline. San Diego: Academic Press; 2015. p. 285–94.

[4] Prince M, Wimo A, Guerchet ML, Ali G-C, Wu Y-T, Prina M, et al. The Global Impact of dementia: an analysis of prevalence, incidence, cost and trends—World Alzheimer Report 2015. London, UK: Alzheimer's Disease International; 2015.

[5] Ishii S, Umeda-Kameyama Y, Akishita M. Brain health: a Japanese viewpoint. J Am Med Directors Assoc 2016;17:455.

[6] The American Chamber of Commerce in Japan, The European Business Council in Japan. Prevention and early diagnosis of dementia; 2015. p. 109–11. Tokyo, Japan.

[7] Fukutomi E, Kimura Y, Wada T, Okumiya K, Matsubayashi K. Long-term care prevention project in Japan. Lancet 2013;381:116.

[8] Glei DA, Landau DA, Goldman N, Chuang YL, Rodríguez G, Weinstein M. Participating in social activities helps preserve cognitive function: an analysis of a longitudinal, population-based study of the elderly. Int J Epidemiol 2005;34:864–71.

[9] Hikichi H, Kondo N, Kondo K, Aida J, Takeda T, Kawachi I. Effect of a community intervention programme promoting social interactions on functional disability prevention for older adults: propensity score matching and instrumental variable analyses, JAGES Taketoyo study. J Epidemiol Community Health 2015;69:905–10.

[10] Ichida Y, Hirai H, Kondo K, Kawachi I, Takeda T, Endo H. Does social participation improve self-rated health in the older population? A quasi-experimental intervention study. Soc Sci Med 2013;94:83–90.

[11] Taketoyo TownNenrei betsu Jinkō [in Japanese] [Population by age group] Available at:, http://www.town.taketoyo.lg.jp/cmsfiles/contents/0000000/547/4d10031fda7e5.pdf; 2006. Accessed Febraury, 9, 2016.

[12] Tamiya N, Noguchi H, Nishi A, Reich MR, Ikegami N, Hashimoto H, et al. Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. Lancet 2011;378:1183–92.

[13] Hisano S. Kaitei Hasegawa shiki Kan'i Chinou Hyouka Scale (HDS-R), Mini-Mental State Examination (MMSE) to Syōgai Rōjin no Nichijyō Seikatsu Jiritsu do no Kanren ni tsuite. [The relationship between Revised Hasegawa Dementia Scale (HDS-R), Mini-Mental State Examination (MMSE) and Bed-fast Scale, Dementia Scale] [in Japanese]. Jpn J Geriatr Psychiatry 2009;20:883–91.

[14] Meguro K, Tanaka N, Kasai M, Nakamura K, Ishikawa H, Nakatsuka M, et al. Prevalence of dementia and dementing diseases in the old-old population in Japan: the Kurihara Project. Implications for long-term care insurance data. Psychogeriatrics 2012;12:226–34.

[15] Wilson RS, Krueger KR, Arnold SE, Schneider JA, Kelly JF, Barnes LL, et al. Loneliness and risk of alzheimer disease. Arch Gen Psychiatry 2007;64:234–40.

[16] Mourao RJ, Mansur G, Malloy-Diniz LF, Castro Costa E, Diniz BS. Depressive symptoms increase the risk of progression to dementia in subjects with mild cognitive impairment: systematic review and meta-analysis. Int J Geriatr Psychiatry 2016;31:905–11.

[17] Fukutomi E, Okumiya K, Wada T, Sakamoto R, Ishimoto Y, Kimura Y, et al. Importance of cognitive assessment as part of the "Kihon Checklist" developed by the Japanese Ministry of Health, Labor and Welfare for prediction of frailty at a 2-year follow up. Geriatr Gerontol Int 2013;13:654–62.

[18] Tang EYH, Harrison SL, Errington L, Gordon MF, Visser PJ, Novak G, et al. Current developments in dementia risk prediction modelling: an updated systematic review. PLoS One 2015;10:e0136181.

[19] Gureje O, Ogunniyi A, Kola L, Abiona T. Incidence of and risk factors for dementia in the Ibadan study of aging. J Am Geriatr Soc 2011;59:869–74.

[20] Murai T, Yamaguchi T, Maki Y, Isahai M, Kaiho Sato A, Yamagami T, et al. Prevention of cognitive and physical decline by enjoyable walking-habituation program based on brain-activating rehabilitation. Geriatr Gerontol Int 2016;16:701–8.

[21] Karp A, Paillard-Borg S, Hui-Xin W, Silverstein M, Winblad B, Fratiglioni L. Mental, physical and social components in leisure activities equally contribute to decrease dementia risk [in English]. Demen Geriatr Cogn Disord 2006;21:65–73.

[22] Weintraub D, Oehlberg KA, Katz IR, Stern MB. Test characteristics of the 15-item geriatric depression scale and Hamilton depression rating scale in Parkinson disease. Am J Geriatr Psychiatry 2006;14:169–75.

[23] Robins JM, Hern MA, Brumback B. Marginal structural models and causal inference in epidemiology. Epidemiology 2000;11:550–60.

[24] Gray L. The importance of post hoc approaches for overcoming non-response and attrition bias in population-sampled studies. Social Psychiatry Psychiatr Epidemiol 2015;51:155–7.

[25] Godin O, Elbejjani M, Kaufman JS. Body mass index, blood pressure, and risk of depression in the elderly: a marginal structural model. Am J Epidemiol 2012;176:204–13.

[26] Do DP, Wang L, Elliott MR. Investigating the relationship between neighborhood poverty and mortality risk: a marginal structural modeling approach. Social Sci Med 2013;91:58–66.

[27] Hazelbag MC, Zaal JI, Devlin WJ, Gatto MN, Hoes WA, Slooter CAJ, et al. An Application of inverse probability weighting estimation of marginal structural models of a continuous exposure: benzodiazepines and delirium. Epidemiology 2015;26:e52–3.
[28] Fewell Z, Hernan MA, Wolfe F, Tilling K, Choi H, Sterne JAC. Controlling for time-dependent confounding using marginal structural models. Stata J 2004;4:402–20.
[29] Cole SR, Hernán MA. Constructing inverse probability weights for marginal structural models. Am J Epidemiol 2008;168:656–64.
[30] Little RJ, D'Agostino R, Cohen ML, Dickersin K, Emerson SS, Farrar JT, et al. The prevention and treatment of missing data in clinical trials. N Engl J Med 2012;367:1355–60.
[31] Young R, Johnson DR. Handling missing values in longitudinal panel data with multiple imputation. J marriage Fam 2015;77:277–94.
[32] Fujihira H, Kubacki K, Ronto R, Pang B, Rundle-Thiele S. Social marketing physical activity interventions among adults 60 years and older: a systematic review. Social Marketing Q 2015;21:214–29.
[33] Murayama H, Kondo K, Fujiwara Y. Social capital interventions to promote healthy aging. In: Kawachi I, Takao S, Subramanian SV, eds. Global Perspectives on Social Capital and Health. New York, NY: Springer New York; 2013. p. 205–38.
[34] Andrew MK, Rockwood K. Social vulnerability predicts cognitive decline in a prospective cohort of older Canadians. Alzheimer's Demen 2010;6:319–325.e1.
[35] Sugano K, Yokogawa M, Yuki S, Dohmoto C, Yoshita M, Hamaguchi T, et al. Effect of cognitive and aerobic training intervention on older adults with mild or no cognitive impairment: a derivative study of the nakajima project. Demen Geriatr Cogn Disord extra 2012;2:69–80.
[36] Llamas-Velasco S, Contador I, Villarejo-Galende A, Lora-Pablos D, Bermejo-Pareja F. Physical activity as protective factor against dementia: a prospective population-based study (NEDICES). J Int Neuropsychological Soc 2015;21:861–7.
[37] Murayama Y, Ohba H, Yasunaga M, Nonaka K, Takeuchi R, Nishi M, et al. The effect of intergenerational programs on the mental health of elderly adults. Aging Ment Health 2015;19:306–14.
[38] Kimura D, Takeda T, Ohura T, Imai A. Evaluation of facilitative factors for preventing cognitive decline: a 3-year cohort study of community intervention. Psychogeriatrics 2016; http://dx.doi.org/10.1111/psyg.12182.
[39] Martinez IL, Frick K, Glass TA, Carlson M, Tanner E, Ricks M, et al. Engaging older adults in high impact volunteering that enhances health: recruitment and retention in The Experience Corps Baltimore. J Urban Health 2006;83:941–53.
[40] Carlson MC, Kuo JH, Chuang Y-F, Varma VR, Harris G, Albert MS, et al. Impact of the Baltimore Experience Corps Trial on cortical and hippocampal volumes. Alzheimer's Demen 2015;11:1340–8.
[41] Dodge HH, Zhu J, Mattek NC, Bowman M, Ybarra O, Wild KV, et al. Web-enabled conversational interactions as a method to improve cognitive functions: results of a 6-week randomized controlled trial. Alzheimer's Dement (N Y) 2015;1:1–12.
[42] Olanrewaju O, Clare L, Barnes L, Brayne C. A multimodal approach to dementia prevention: a report from the Cambridge Institute of Public Health. Alzheimer's Dement (N Y) 2015;1:151–6.
[43] Santos-Eggimann B, Cuénoud P, Spagnoli J, Junod J. Prevalence of frailty in middle-aged and older community-dwelling Europeans living in 10 countries. J Gerontol A Biol Sci Med Sci 2009;64:675–81.