



# Three-year effects of neighborhood social network intervention on mental and physical health of older adults

Harada, Kazuhiro ; Masumoto, Kouhei ; Katagiri, Keiko ; Fukuzawa, Ai ;  
Touyama, Michiko ; Sonoda, Daichi ; Chogahara, Makoto ; Kondo, Narihik...

---

(Citation)

Aging & Mental Health, 25(12):2235-2245

(Issue Date)

2021-12-02

(Resource Type)

journal article

(Version)

Accepted Manuscript

(Rights)

This is an Accepted Manuscript of an article published by Taylor & Francis in [Aging & Mental Health on 2021] available online:

<http://www.tandfonline.com/10.1080/13607863.2020.1839858>

(URL)

<https://hdl.handle.net/20.500.14094/90008811>



# Three-year Effects of Neighborhood Social Network Intervention on Mental and Physical Health of Older Adults

Kazuhiro Harada<sup>a\*</sup>, Kouhei Masumoto<sup>a</sup>, Keiko Katagiri<sup>a</sup>, Ai Fukuzawa<sup>a</sup>, Michiko Touyama<sup>a</sup>, Daichi Sonoda<sup>a</sup>, Makoto Chogahara<sup>a</sup>, Narihiko Kondo<sup>a</sup>, and Shuichi Okada<sup>a</sup>

<sup>a</sup> *Active Aging Research Hub, Graduate School of Human Development and Environment, Kobe University, Kobe, Japan*

\*Correspondence concerning this article should be addressed to Kazuhiro Harada, Active Aging Research Hub, Graduate School of Human Development and Environment, Kobe University, 3-11, Tsurukabuto, Nada, Kobe City, Hyogo 657-8501, Japan. Tel and Fax: +81-78-803-7886. E-mail address: [harada@harbor.kobe-u.ac.jp](mailto:harada@harbor.kobe-u.ac.jp)

## Funding Details

This work was supported by Grant-in-Aid for Scientific Research A (24240093), Japan Society for the Promotion of Science; Grant-in-Aid for Scientific Research B (15KT0006), Japan Society for the Promotion of Science; Grant-in-Aid for Challenging Research (18H05298), Japan Society for the Promotion of Science; a Grant from a Community Development Partnership between Kobe University and Nada ward, Kobe City; and Graduate School of Human Development and Environment Grant-in-Aid for Young Scientists, Kobe University.

## Disclosure of Interests

The authors report no conflict of interest.

## Data Availability Statement

The data that support the findings of this study are available from the corresponding author, K. Harada, upon reasonable request.

## **Acknowledgements**

We would like to thank Editage ([www.editage.com](http://www.editage.com)) for English language editing.

# Three-year Effects of Neighborhood Social Network Intervention on Mental and Physical Health of Older Adults

**Objectives:** Although neighborhood is considered to be a crucial source of social network to promote health among older adults, current findings are mostly derived from observational study designs. This study examined whether participations in event-based community programs could increase neighborhood social network and whether such increase could lead to desirable changes in mental and physical health among older adults. **Method:** This study employed quasi-experimental design. A baseline questionnaire survey was sent to residents of Tsurukabuto community aged 60 years or more ( $n = 1769$ ); 1,068 responded. Community events were implemented approximately once a month for three years. Then, a three-year follow-up survey questionnaire was sent to the respondents of the baseline survey. The total number of respondents in the latter survey was 662; of the total, 173 participated in the intervention. Strong and weak ties with neighbors, mental well-being (Ikigai-9), health-related quality of life (HRQOL), and instrumental activity of daily living (IADL) were measured in the surveys. **Results:** The path analysis revealed that intervention participation was significantly associated with changes in strong ties (standardized path coefficient = 0.12) and changes in strong ties were associated with those in Ikigai-9 scores (standardized path coefficient = 0.15). The total and indirect effects of intervention participation on Ikigai-9 scores were significant. Significant intervention effects were not observed for HRQOL and IADL scores. **Conclusion:** This study found that participation in our event-based intervention could indirectly and positively influence older adults' mental well-being through their strong ties with their neighbors.

**Keywords:** Social Support; Quality of Life/ Wellbeing; Psychosocial Interventions; Physical Health Status

## Introduction

Better social relationships among older adults contribute to improvement in their mental and physical health status. Social relationships consist of functional and structural aspects. Social support reflects a functional aspect of social relationships, whereas social network, which represents the structural aspect, refers to connections and ties between individuals (Holt-Lunstad & Uchino, 2015). The presence of a social network does not

necessarily equate to it being functional. Nonetheless, meta-analyses have shown that both functional and structural aspects of social relationships are associated with mental well-being (Pinquart & Soensen, 2000), cognitive function (Kuiper et al., 2016), the risk of getting coronary heart disease and stroke (Valtorta et al., 2016), and mortality risk (Holt-Lunstad et al., 2010). The desirable effects of a social network on mental and physical health differ depending on its various sources. Previous studies have indicated that neighborhood is a crucial source of social network in promoting mental and physical health among older adults. The impacts of social networks with friends/neighbors on depression (Litwin, 2011), instrumental activity of daily living (Li & Zhang, 2015), and mortality risks (Santini et al., 2015) are more remarkable than those of social networks with families. While the present study focused on the neighborhood social network, referring to social capital studies would be meaningful because social capital studies have also illustrated the importance of neighborhood social network. Social capital is a key concept in public health and social epidemiology, and conceptually has various dimensions such as bonding, bridging, and linking social capital (Islam et al., 2006; Moore & Kawachi, 2017). Neighborhood social network can be regarded as one measure of bonding social capital, which refers to social relationships within homogeneous groups such as family members, neighbors, close friends, etc. (Islam et al., 2006; Moore & Kawachi, 2017). Social capital studies have showed that after adjusting for social network at the individual level, social network at the community level is associated with mental health status at the individual level, such as dementia symptoms (Muayama et al., 2018) and life satisfaction (Inaba et al., 2015).

However, the current findings on the desirable influences of neighborhood social network on health promotion are mostly derived from observational study designs. Only few intervention studies have confirmed such influences. To establish a link between neighborhood social network and health among older adults, evidence from both

57 observational and interventional studies are essential; the latter can ascertain the causalities of  
58 the link by investigating whether an increase in neighborhood social network results in the  
59 promotion of health status among older adults. Previous intervention studies targeting social  
60 relationships among older adults have not necessarily reported positive changes in health  
61 variables. While social capital studies have indicated that promoting social capital at  
62 neighborhood levels would be feasible (Chiu et al., 2007; Grant, 2001; Kleinbans et al.,  
63 21007), they have not examined the interventional effects of promoting the social capital on  
64 health variables. For the social relationships at individual levels, review articles (Dickens et  
65 al. 2011; Poscia et al., 2018) have showed that certain interventions have succeeded in  
66 increasing social relationship variables among older adults. As the review articles (Dicken et  
67 al., 2011; Poscia et al., 2018) have not limited the specific types of interventions, various  
68 types of interventions were included in their reviews. The examples of the interventions were  
69 a reminiscence program led by a psychologist (Gaggioli et al., 2014), an online program  
70 (Jones et al., 2015), a social and recreational activity program (Low et al., 2015), the use of a  
71 companion robot (Robinson et al., 2013), and a group-based activity program (Saito et al.,  
72 2012). However, according to the review articles, it is still inconclusive whether desirable  
73 changes in social relationship variables induced by the intervention can translate into the  
74 promotion of health status because previous studies have reported both significant and non-  
75 significant results for such translating effects. Dicken et al. (2011) found that 5 of the 12  
76 interventions that showed a significant increase in any social relationship variable but failed  
77 to lead desirable changes in mental and/or physical health status among older adults.  
78 Similarly, Poscia et al. (2018) showed that two of the six interventions they reviewed reported  
79 non-significant changes in health variables, despite significant desirable changes in social  
80 relationships variables. Moreover, few previous studies have examined indirect effects of the  
81 interventions on health variables mediated by the changes in social relationships. For

example, although all six interventions reviewed by Poscia et al. (2018) examined the total effects of the interventions, they did not investigate the process of translating the effects of intervention on health status mediated by social relationships (Gaggioli et al., 2014; Jones et al., 2015; Low et al., 2015; Robinson et al., 2013; Saito et al., 2012). The process of intervention effects can be conceptualized as one in which interventions do not have direct influences on health status but, rather, manipulate social relationships, which, in turn, influence social relationships that cause changes in health status. By investigating this process, the causal link between social relationships and health status can be strengthened. We consider that the lack of the investigation on this process is an important challenge for the research area of social relationships and health.

Given these findings, we developed and implemented an event-based community program using a university resource. The logic of the event-based community program was to create many opportunities to meet and talk with neighbors, which contribute to improving neighborhood social network. Participation in community events can be regarded as one type of social participation (Levasseur et al., 2010). Thus, the framework for the pathway from social participation to health would be helpful in ascertaining the theoretical basis of the process of our intervention effects. Social participation is associated with various health outcomes of older adults, such as loneliness (Niedzwiedz et al., 2016), depression (Wang et al., 2020), instrumental activities of daily living (Tomioka et al., 2017), and functional disability (Otsuka et al., 2018). Regarding the mechanisms of these associations, previous studies have proposed that social participation influences health through several pathways such as enhancing health literacy (Amoah, 2018), accumulating physical activity (Kikuchi et al., 2017), promoting self-management behavior (Ang, 2019), and gaining better social relationships (Li et al., 2018; Lin et al., 1999). As for the pathway of social relationships, conceptual models (Li et al., 2018; Lin et al., 1999) consider that social participation can

induce better social relationships, and that better social relationships can promote health. Supporting these models, Mackenzie & Abdulrazaq (in press) reported that social network mediates the relationship between social participation variables and mental health status among older adults. The conceptual models of the pathways of social relationships (Li et al., 2018; Lin et al., 1999) and reports from Mackenzie & Abdulrazaq (in press) correspond with the process of our intervention effects. Because getting older is associated with higher risks of geriatric syndrome (Makizako et al., 2017), decline in social relationships with friends (Shaw et al., 2007), and lower levels of social participation (Bukov et al., 2002), promoting participation in community events would be beneficial. In Harada et al. (2018), we analyzed one year of follow-up data and reported that the program can enhance neighborhood social networks of older adults. Although previous studies have employed various types of interventions to increase social relationships among older adults, none of the previous intervention studies have utilized event-based community programs. Thus, our study proposes a new option of intervention type for increasing social relationships among older adults, however, we did not examine any health impacts of the intervention. Therefore, the present study examined whether the intervention participation could augment neighborhood social network at the third year of the follow-up study and whether the increases in neighborhood social network could lead to desirable changes in mental and physical health among older adults. The link between neighborhood social network and health is still unestablished because few social network interventions have examined the pathway from intervention participation to the health status of older adults. The present study contributes to the establishment of such a link by showing the pathway.



## Methods

### *Participants and Procedures*

The present study reported the effects of the “Tsurukabuto Active Aging Project” over a three-year period. The overview of the project is also available in Harada et al. (2018). The project employed a non-blinded quasi-experimental design. The field of the project was Tsurukabuto community, Nada ward, Kobe City, Japan. There are about 5,000 people in Tsurukabuto community (with an area of 0.6 km<sup>2</sup>), 130,000 in Nada ward (area: 32.7 km<sup>2</sup>), and 1.5 million in Kobe City (area: 552.3 km<sup>2</sup>). Tsurukabuto community was developed by cutting a mountain from the 1960s to the 1970s. Compared to the population ageing rate of Nada ward and Kobe city in 2015 at 24.6% and 26.8%, respectively, the Tsurukabuto community saw an ageing rate of 37.1%, which was remarkably high. This is because those who have lived in this community since the 1960s and 70s have reached the age of 65 years or above now. Regarding the other characteristics of this community, as 27.7% participants from Kobe City, 32.9% from Nada Ward, and 32.5% from the Tsurukabuto community completed their college education (4-years or more) (Statistics Bureau of Japan, 2011), the residents of the community generally had an intermediate socio-economic status. Of the participants, 77.7% from Kobe City, 71.7% from Nada Ward, and 79.6% from the Tsurukabuto Community had lived the same residence for at least five years (Statistics Bureau of Japan, 2016), and residential mobility in the Tsurukabuto Community was slightly lower than that of Nada Ward and Kobe City. Furthermore, 54.4% of participants from Kobe City, 65.3% from Nada Ward, and 84.5% from the Tsurukabuto Community lived in apartment houses (Statistics Bureau of Japan, 2016). Thus, the majority of residents in the Tsurukabuto Community live in apartment houses. It can be assumed that many of the residents in this community would not have a sufficient neighborhood social network because this community

is not the hometown for all of the older residents. Based on these facts, this community was the target for this project.

Figure 1 represents the flow diagram for examining the three-year effect of the project. We sampled all residents of the Tsurukabuto community aged  $\geq 60$  years ( $N = 1,769$ ) from the electoral register in Nada ward. A baseline questionnaire survey was sent to them via postal mail in November 2013; 1,068 of them (61.8%) responded. After the baseline survey, the project implemented the intervention program. In January 2017, 1,021 respondents of the baseline survey, which excluded 47 who had died, were asked to answer a three-year follow-up questionnaire survey via postal mail. Of the 1,021 baseline respondents, 686 (67.2%) responded to the three-year follow-up survey. The latter survey included a question on whether they had participated in the intervention program answered by a “yes” or a “no”; 662 individuals answered this item. Among these 662 individuals, the present study treated the 173 who answered “yes” as participants of the intervention and the 489 who answered “no” as non-participants.

As all eligible residents of Tsurukabuto community were targeted in the project, no prior sample size calculation was conducted.

Informed consent was obtained from all respondents of the survey. The Tsurukabuto Active Aging Project received prior approval from the ethical committee of the Graduate School of Human Development and Environment, Kobe University. All procedures were carried out in accordance with the Helsinki Declaration.

The Tsurukabuto Active Aging Project was not preregistered anywhere.

### ***Intervention Program***

The project provided event-based intervention programs to residents of Tsurukabuto community. For the mechanisms of the interventions, the present study assumed that the participation in intervention programs would indirectly influence neighborhood social

network mediated by several steps (Harada et al., 2018). First, participation in the programs might provide opportunities for participants to communicate with their neighbors during the programs. Second, such opportunities during the programs would facilitate social interactions in their daily lives outside the programs. Lastly, facilitated social interactions might result in reinforcement of the neighborhood social network. Harada et al. (2018) described the detailed process of developing the programs. The project developed the intervention programs through discussions in three community meetings. Since November 2013, the project had implemented community events approximately once a month: 3 events in 2013, 15 in 2014, 9 in 2015, and 10 in 2016. Most of the events were offered on weekends. Examples of the events are musical entertainment, lecture about sleep and health promotion, moon viewing academic festival, gardening class, and group walking. Kobe University staff members organized all the events. The facilities of Kobe University were used as venues. When recruiting participants for each event, flyers were posted on all houses in Tsurukabuto community. Each event was advertised through the residents' association and university's homepage. Residents of Tsurukabuto community could participate in any event for free. While most programs accepted all residents, the project organized the programs by regarding older adults as the main audience. For some programs such as group walking, the project accepted those above 60 years. The present study did not measure attrition rate of the intervention programs because the intervention programs were event-based and the project recruited different participants for each event.

The event-based programs were intended to increase opportunities for interaction among older adults, which was expected to result in reinforced neighborhood social network. Therefore, each event was organized to facilitate social interactions in various ways. For example, at the beginning of each event, project facilitators explained that the event was aimed to increase social networks in Tsurukabuto community and asked them to get to know

one another. Typically, project facilitators asked participants to wear nametags. As much as possible, the events included interactive activities, such as group work, games, and discussions. Our previous study confirmed that participation in our events could facilitate social interaction among participants (Masumoto et al., 2017).

## **Measures**

### *Neighborhood Social Network*

Similar to our secondary analysis of the data obtained from the project (Fukuzawa et al., 2019), the present study measured two subtypes of neighborhood social network: strong ties (close people) and weak ties (acquaintances). The respondents were asked the question “How many people do you have relationships with in the Tsurukabuto community?”, and the respondents indicated the specific number of the residents in the community (a) with whom they joined to engage in neighborhood activities together, (b) who they helped together in any problems, (c) who they visited at home, (d) who they greeted, and (e) with whom they talked and chatted (Fukuzawa et al., 2019). Items (a), (b), and (c) reflect strong ties, while items (d) and (e) reflect weak ties (Fukuzawa et al., 2019). The mean number for the three strong-tie items and two weak-tie items were treated as scores of strong ties and weak ties, respectively. As reported in Fukuzawa et al. (2019), the project developed these items with reference to Harper (2002) and Takagi et al. (2010). Among various dimensions of social network such as frequency of contact, density, duration (Berkman et al., 2000), these items measured the size of the neighborhood social network. Cronbach’s alphas for the items of strong ties were 0.79 in baseline and 0.81 in the three-year follow-up survey (Fukuzawa et al., 2019). Pearson’s correlation coefficient for the items of weak ties were 0.94 in baseline and 0.75 in the three-year follow-up survey (Fukuzawa et al., 2019).

226 *Mental and Physical Health*

227 The present study analyzed mental well-being and the mental component of health-related  
228 quality of life (HRQOL) as indices of mental health. The physical component of HRQOL and  
229 instrumental activity of daily living (IADL) were treated as indices for physical health.

230 Mental well-being was measured using the Ikigai-9 scale (Imai et al., 2012). This scale  
231 consisted of nine items, such as “I often feel that I am happy” and “My daily lives are  
232 meaningful.” The individuals responded to each item on a 5-point Likert scale, ranging from 1  
233 (very much) to 5 (not at all). Following Imai et al. (2012), the score was calculated by  
234 summing the answers of each item. The scale’s concurrent validity (Pearson’s correlations  
235 with mental health scale,  $r = 0.33$ ,  $p < 0.01$ ), factorial validity (Goodness of Fit Index [GFI]=  
236 0.95, Comparative Fit Index [CFI]= 0.95, Root Mean Square Error of Approximation  
237 [RMSEA]= 0.09), and internal consistency (Cronbach’s alpha = 0.87) were reported in Imai et  
238 al. (2012).

239 The project employed the Japanese version of the Medical Outcomes Study Short  
240 Form 8-Item Health Survey (SF-8: Fukuhara & Suzukamo, 2004) to assess the HRQOL. The  
241 answers of each item in SF-8 were transformed into standardized scores by using the  
242 normative values of the general Japanese population (Fukuhara & Suzukamo, 2004). Then,  
243 the summary scores (range, 0 to 100; mean [standard deviation] in national sample, 50 [10])  
244 were calculated for the physical and mental components of health using a standardized  
245 calculation formula (Fukuhara & Suzukamo, 2004). The formula was developed based on the  
246 results of the factor analyses in the previous study (Fukuhara & Suzukamo, 2004). The  
247 alternate form reliability of SF-8 ( $r = 0.70$  to  $0.88$ ) and correlation with SF-36 ( $r = 0.56$  to  
248  $0.87$ ) were reported in Fukuhara and Suzukamo (2004).

249 IADL was measured using the subscale of the Tokyo Metropolitan Institute of  
250 Gerontology Index of Competence. Koyano et al. (1991) confirmed the reliability and validity  
251 of this index: the Cronbach’s alpha was 0.91; one-year test-retest reliability was 0.86, the

model's indices for confirmatory factor analysis were adequate (GFI = 0.95; Root Mean Square Residual [RMSE]= 0.04); the odds ratio for predicting one-year mortality was 1.22 for every 1 point decrease. Among these indices, the IADL subscale consisted of five items; in each item, "yes" and "no" answers corresponded to 1 and 0 point, respectively. The score was calculated by summing the points of each item (Koyano et al., 1991).

#### *Total Number of Intervention Participation*

In the three-year follow-up survey, participants of the intervention program were asked to indicate the total number of times they participated in the events.

#### *Demographic Factors*

The present study analyzed the baseline data for age, gender (men, women), educational background (middle to high school, higher than high school), living arrangement (alone, with spouse, in a multigenerational household), and current working status (no, yes) as demographic factors, because previous studies have reported that age (Fujiwara et al., 2008), gender (Pinquart & Sörensen, 2001), educational background (Huang et al., 2010), living arrangement (Sarwari et al., 1998), and current working status (Minami et al., 2015) are associated with the health status of older adults.

#### *Analyses*

##### *Main Analyses*

Participation in the intervention program (0 = non-participants, 1 = participants) was treated as the independent variable. Using this variable, the present study conducted linear mixed models and a path analysis as the main analyses. The liner mixed model examined the total effects of the intervention participation on neighborhood social network and mental and physical health. As the present study assumed that intervention participation would indirectly

influence mental and physical health status through neighborhood social network, direct and indirect relationships among these variables were examined using path analysis. Similar to previous studies (Cavallo et al., 2014; Gunnell et al., 2014), the path analysis examined residualized change scores as changes in the neighborhood social network and mental and physical health variables in the three-year follow-up survey. The predicted value of the three-year follow-up survey was obtained by first regressing the baseline value and then calculating the residualized change score by subtracting the predicted value from the actual value. While the linear mixed models can examine the time fixed effects, it would be inconvenient to show the direct and indirect effects clearly. The path analyses using the residualized change scores are useful to examine direct and indirect effects of the intervention participation though our path analyses did not include time fixed effects. Thus, conducting both the analyses could supplement each other. The missing values were treated by pair-wise deletion. Statistical significance was set at  $< 0.05$ .

In the linear mixed models, the dependent variables were strong ties, weak ties, mental well-being, HRQOL, and IADL. Group (0 = non-participants, 1 = participants), survey time (0 = baseline survey, 1 = three-year follow-up survey), and the interaction of group and survey time were treated as the independent variables. The interaction term represented the total intervention effects on the dependent variable. Examining these interaction terms is known as the difference-in-difference approach. This approach considers baseline differences between the two groups and natural time trends, and is widely accepted to show causal inference in quasi-experimental studies (Dimick & Ryan, 2014; Wing et al., 2018). This approach compares the difference over time (follow-up minus baseline) of the intervention group with the difference over time (follow-up minus baseline) of the control group. If the difference over time of the intervention group is significantly different from the difference in the control group, it indicates that the intervention has an effect. In the statistical model, the

interaction term of group with time represents such difference-in-difference (Dimick & Ryan, 2014; Wing et al., 2018). Age, gender (men = 0, women = 1), educational background (middle to high school = 0, higher than high school = 1), dummy variables of living arrangement, and current working status (no = 0, yes = 1) were included as covariates. Dummy variables of living arrangement were treated as living alone (no = 0, yes = 1) and living with spouse (no = 0, yes = 1). Maximum likelihood estimation was used to fit the model. The mixed command of Stata version 14 (StataCorp LLC, College Station, Texas, the United States) were used.

For the path analyses, the present study calculated GFI, adjusted goodness of fit index (AGFI), CFI, and RMSEA as indices of model fit. The present study examined the main paths in the model as follows: 1) paths from the intervention participation to the strong and weak ties; 2) paths from the intervention participation to mental well-being, two components of HRQOL, and IADL; and 3) paths from the strong and weak ties to mental well-being, two components of HRQOL, and IADL. This study included the three types of main paths in the model regardless of their statistical significance. To adjust for potential confounding effects of demographic factors, the model also included statistically significant paths from age, gender, educational background, dummy variables of living arrangement, and current working status to the intervention participation, the strong and weak ties, mental well-being, two components of HRQOL, and IADL. Statistically non-significant paths from these demographic factors were removed from the model. Correlations within demographic factors, between strong and weak ties, and within mental well-being, two components of HRQOL, and IADL were also included in the model if correlations were statistically significant. This study removed statistically non-significant correlations from the model. The bias-corrected bootstrap method (1,000 bootstrap samples) was used to estimate standardized direct, indirect, and total effects, and 95% confidence intervals of the intervention participation on the



neighborhood social network and mental and physical health in the pass model. The AMOS version 21.0 (IBM Japan, Ltd., Tokyo, Japan) was used.

### *Additional Sensitivity Analyses*

To confirm the robustness of the main analyses, this study conducted further linear mixed models and path analysis by setting the total number of intervention participation as the independent variable. Therefore, while the main analyses treated the independent variable as a dichotomous variable, additional sensitivity analyses treated it as a continuous variable. Data from non-participants in the intervention was coded as 0 for the total number of intervention participation. The procedures of both linear mixed models and path analysis were the same as those of main analyses.

## **Results**

### *Participants' Baseline Characteristics*

Table 1 presents participants' baseline characteristics. Participants' mean age at baseline was 72 years old. About 56.3% were women; 45.6% had an educational degree higher than high school; 20.5% lived alone and 53.0% lived with their spouse; and 26.3% were engaged in work. Compared with non-participants, the t-tests and chi-squared tests showed that intervention participants were more likely to be younger, have obtained an educational degree higher than high school, and have higher scores for strong and weak ties, HRQOL physical component, and IADL.

### *Total Effects of Intervention Participation on Neighborhood Social Network and Mental and Physical Health in Mixed Model*

Table 2 presents the overall effects of intervention participation on neighborhood social network and mental and physical health. Although the effect on weak ties was not supported, the liner mixed model showed statistically significant intervention effect on strong ties ( $p =$

0.031). Among four variables for mental and physical health status, intervention effect was observed in mental well-being, with a threshold level of 0.050 for statistical significance.

### ***Direct and Indirect Effects of Intervention Participation on Neighborhood Social Network and Mental and Physical Health in Path Analysis***

The path analysis (Figure 2) showed that participation in the intervention was statistically significantly associated with increased changes in strong and weak ties, and that increased changes in strong ties were associated with those in mental well-being. Dummy variables of living arrangement were removed from the model because all paths from it to strong ties, weak ties, mental well-being, HRQOL, and IADL were not statistically significant. The correlation coefficients for all variables in the path model are shown in Supplemental Table 1. The direct path from intervention participation to changes in mental well-being was not statistically significant. Changes in both strong and weak ties were not statistically significantly associated with changes in HRQOL and IADL.

Table 3 shows the direct, indirect, and total effects of intervention participation on neighborhood social network and mental and physical health in the path analysis. The intervention participation had statistically significant indirect and total effects on mental well-being through neighborhood social network. The intervention participation also had direct effects on strong and weak ties. Any direct, indirect, and total effects of the intervention participation on HRQOL mental component, HRQOL physical component, and IADL did not show statistically significant levels.

### ***Effect of Number of Intervention Participation on Neighborhood Social Network and Mental and Physical Health***

The average number of intervention participation was 0.78 times (SD = 2.00) among all respondents and was 3.09 times (SD = 2.97) among those who participated in the intervention at least once. The results of the linear mixed models are presented in Supplemental Table 2.

The linear mixed models showed that the interactive effect of the total number of intervention participation and survey time on strong ties was statistically significant. Supplemental Figure 1 illustrates the results of post hoc analysis for strong ties by categorizing the total number of intervention participation into five groups (0 time, 1 time, 2 to 3 times, 4 to 5 times, and 6 or more times). For other variables, including weak ties, statistically significant intervention effects were not observed. Thus, the present study did not conduct post hoc analyses for other variables.

Similar to the main analyses, the path analyses in the sensitivity analyses (Supplemental Figure 2) also revealed that a higher number of intervention participation was statistically significantly associated with increased changes in strong and weak ties and that increased changes in strong ties were associated with those in mental well-being. The correlation coefficients in the path model are shown in Supplemental Table 3. As indicated in Supplemental Table 4, the indirect effect of the number of intervention participation on mental well-being through neighborhood social network was statistically significant, although the total effect of the number of intervention participation on mental well-being was not. Indirect, direct, and total effects on HRQOL and IADL were not statistically significant.

## **Discussion**

The present study found that participation in our event-based intervention program was indirectly associated with mental well-being mediated by the increase in strong ties among older adults. The indirect effects of the intervention participation on mental well-being were supported in both main and additional sensitivity analyses. The results indicated that the increase in neighborhood social network induced by the intervention prevents decline in mental well-being among older adults. Based on an interventional study design, the present study supports and strengthens the findings of previous observational studies (Litwin, 2011; Li & Zhang, 2015; Santini et al., 2015) on the relations between neighborhood social network

and mental health among older adults. For the potential mechanisms of the link between social relationships and health, three potential pathways are generally proposed (Holt-Lunstad & Uchino, 2015; Thoits, 2011; Kawachi et al., 2001): main effect, stress-buffering, and stress-prevention process. The main effect process proposes that sufficient social relationships can provide positive feelings, such as self-esteem and self-control, which can promote health. In stress-buffering process, social relationships weaken the negative influences of stressful events. In stress-prevention process, individuals with sufficient social network have less opportunities to encounter negative life events. In this study, the increase in strong ties with neighbors, along with the potential pathways, may influence one's mental well-being.

Additionally, intervention participation would influence mental well-being indirectly and marginally, rather than directly and saliently. In the main analyses, although the path analysis revealed a statistically significant total effect of the intervention participation on mental well-being, the mixed model showed that the statistical significance of the total effect was at threshold level ( $p = 0.050$ ). In the additional sensitivity analyses, both path analysis and mixed model did not support the statistically significant total effect of the number of intervention participation on mental well-being. Similar to the present study, previous review articles (Dickens et al. 2011; Poscia et al., 2018) have shown that the health impacts of interventions targeting social relationships are equivocal. One potential explanation for the unclear total effects of the interventions in both the present and previous studies is that the link between the interventions and mental well-being might not be proximal. Manipulation of social relationships by interventions may not be easy tasks as some previous interventions have failed to improve social relationships (Dickens et al. 2011; Poscia et al., 2018). Moreover, there could be several pathways between social relationships and health status.

Regarding the two variables for neighborhood social network, changes in strong ties were favorably associated with those in mental well-being in both main and additional

analyses, whereas changes in weak ties were not statistically significantly associated with those in mental well-being in both analyses. While previous studies for general populations including younger adults have indicated the importance of weak ties for mental health status (Kim, 2019; Sandstrom & Dunn, 2014), it has also been reported that there are age differences in emotional reactions to the social interactions (Birditt, 2014; Charles et al., 2009). The socioemotional selectivity theory (Carstensen, 1999) proposes that as people get older, they prioritize closer social relationships and terminate unimportant relationships, and Lockenhoff and Carstensen (2004) supported this theory. Based on previous studies and findings from the present study, there would be age differences regarding the relative importance of strong and weak ties on mental well-being; strong ties would be more important in the daily lives and mental well-being of older adults. However, further studies would be necessary to confirm the age differences.

In contrary to mental well-being, statistically significant intervention effects on the mental component of HRQOL and statistically significant associations between the mental component of HRQOL and changes in neighborhood social network were not observed. Although mental well-being as measured in the present study reflected the positive aspects of mental health, majority of the items on the mental component of HRQOL measure the negative aspects of mental health. Positive and negative states of mental health are not necessarily on the same dimension (Keyes, 2005). The results implied that neighborhood social network may induce positive feelings rather than reduce negative feelings, thereby corresponding to the main effect process of the potential mechanisms of the link between social relationships and health.

In the present study, the intervention effects on both physical health variables, instrumental activity of daily living, and the physical component of SF-8 were not revealed. Our neighborhood social network intervention would have limited impact on these variables

among older adults. Although the relations between social network and physical health have been mostly confirmed by observational studies, the findings from intervention studies have been ambiguous according to review articles (Dickens et al., 2011; Poscia et al., 2018). Although Dickens et al. (2011) showed that some intervention studies reported statistically significant intervention effects on physical health, Poscia et al. (2018) indicated that recent studies did not report such effects. One potential reason for the inconsistencies is that the link between social relationships and physical health might be more distal than that with mental health. The primary focus of the intervention was improvements of the neighborhood social network and the present study assumes that our program will lead to the improvement of the neighborhood social network mediated by several steps. The present study considers the effects on physical health as just ancillary. Moreover, as Table 1 shows, participants had better physical health status than non-participants, thus, there is not much scope for further improvement of physical health through intervention participation. A low dosage of the intervention would be insufficient to improve physical health and more intensive interventions, such as more frequent and longer-term programs, would be required to impact physical health outcomes.

The strengths of the present study included following three-year-period intervention effects and targeting all older people living in one community. However, the present study had limitations. First, it did not employ the randomized assignments for the intervention or control groups. This would cause self-selection bias. Second, a retrospective self-reported method was used to measure participation in the intervention program. It would cause the recall bias. Moreover, the present study did not measure detailed data for the dosage of the program participation, such as frequencies and intervals of the participation. Such data would be desirable to investigate the effects of the intervention participation more accurately. Third, although the response rate of the baseline survey (61.6%) was comparable to other

questionnaire surveys targeting Japanese older population (e.g., 66% in Harada et al., 2017), it might have included selection bias. Fourth, the present study did not consider intervention participation at the neighborhood-level (aggregate level of individual participation) though the social capital studies have indicated the importance of considering it at the neighborhood levels (e.g., Kawachi et al., 1999). Fifth, the path analyses did not examine the time fixed effects. Sixth, the present study did not consider social participation variables at both individual and neighborhood levels, which may serve as important confounders in the analyses. Seventh, there are possibilities of reverse causalities for the link between intervention participation and health status. Therefore, further intervention studies should employ more methodologically sophisticated study designs, such as random assignments, objective measures of participation in the intervention programs, door-to-door surveys, examinations after controlling for neighborhood-level variables and time fixed effects, and careful consideration of reverse causalities. Nonetheless, the present study contributes to better understanding of the associations of neighborhood social network with mental and physical health among older adults.

In conclusion, the present study revealed that although desirable influences on the indices of physical health were observed, participation in our event-based intervention indirectly and positively influenced older adults' mental well-being through their strong ties with their neighbors. The findings of the present study strengthen and support previous findings of observational studies on the link between social relationships and mental health. As for the practical implications, our project considered various types of events as intervention programs if the events were attractive to older adults and if the events contained elements facilitating social interaction. If adequate financial support is provided, it would be feasible for many universities to organize event-based community intervention programs. In Japan, a national policy developed by Ministry of Health, Labour and Welfare (2012) called

499 Healthy Japan 21 set the increase in the number of older adults engaging in social  
500 participations as one of its goals of health promotion. Disseminating our intervention program  
501 to other universities might contribute to achieving this goal. Further, long-term interventions  
502 studies with rigorous study designs and adequate dosages of the program participation would  
503 be warranted to confirm the effects of neighborhood social network intervention on health  
504 status.

505

## 506 **References**

- 507 Amoah, P. A. (2018). Social participation, health literacy, and health and well-being: A cross-  
508 sectional study in Ghana. *SSM - Population Health*, 4, 263–270.  
509 <https://doi.org/10.1016/j.ssmph.2018.02.005>
- 510 Ang, S. (2019). How Social Participation Benefits the Chronically Ill: Self-Management as a  
511 Mediating Pathway. *Journal of Aging and Health*, 31(7), 1134–1154.  
512 <https://doi.org/10.1177/0898264318761909>
- 513 Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to  
514 health: Durkheim in the new millennium. *Social Science and Medicine*, 51(6), 843–857.  
515 [https://doi.org/10.1016/S0277-9536\(00\)00065-4](https://doi.org/10.1016/S0277-9536(00)00065-4)
- 516 Birditt, K. S. (2014). Age differences in emotional reactions to daily negative social encounters.  
517 *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*, 69(4),  
518 557–566. <https://doi.org/10.1093/geronb/gbt045>
- 519 Bukov, A., Maas, I., & Lampert, T. (2002). Social participation in very old age: Cross-sectional  
520 and longitudinal findings from BASE. *Journals of Gerontology - Series B Psychological*  
521 *Sciences and Social Sciences*, 57(6), 510–517. <https://doi.org/10.1093/geronb/57.6.P510>



522 Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously. A theory of  
 523 socioemotional selectivity. *The American Psychologist*, 54(3), 165–181.  
 524 <https://doi.org/10.1037/0003-066X.54.3.165>

525 Cavallo, D. N., Brown, J. D., Tate, D. F., DeVellis, R. F., Zimmer, C., & Ammerman, A. S.  
 526 (2014). The role of companionship, esteem, and informational support in explaining  
 527 physical activity among young women in an online social network intervention. *Journal*  
 528 *of Behavioral Medicine*, 37(5), 955–966. <https://doi.org/10.1007/s10865-013-9534-5>

529 Charles, S. T., Piazza, J. R., Luong, G., & Almeida, D. M. (2009). Now you see it, now you  
 530 don't: age differences in affective reactivity to social tensions. *Psychology and Aging*,  
 531 24(3), 645–653. <https://doi.org/10.1037/a0016673>

532 Chiu, L. F., & West, R. M. (2007). Health intervention in social context: Understanding social  
 533 networks and neighbourhood. *Social Science and Medicine*, 65(9), 1915–1927.  
 534 <https://doi.org/10.1016/j.socscimed.2007.05.035>

535 Dickens, A. P., Richards, S. H., Greaves, C. J., & Campbell, J. L. (2011). Interventions targeting  
 536 social isolation in older people: a systematic review. *BMC Public Health*, 11(1), 647.  
 537 <https://doi.org/10.1186/1471-2458-11-647>

538 Dimick, J. B., & Ryan, A. M. (2014). Methods for evaluating changes in health care policy: the  
 539 difference-in-differences approach. *JAMA*, 312(22), 2401–2402.  
 540 <https://doi.org/10.1001/jama.2014.16153>

541 Fujiwara, Y., Yoshida, H., Amano, H., Fukaya, T., Liang, J., Uchida, H., & Shinkai, S. (2008).  
 542 Predictors of improvement or decline in instrumental activities of daily living among  
 543 community-dwelling older Japanese. *Gerontology*, 54(6), 373–380.  
 544 <https://doi.org/10.1159/000151221>

545 Fukuzawa, A., Katagiri, K., Harada, K., Masumoto, K., Chogahara, M., Kondo, N., & Okada, S.  
 546 (2019). A longitudinal study of the moderating effects of social capital on the

relationships between changes in human capital and ikigai among Japanese older adults.

*Asian Journal of Social Psychology*, 22(2), 172–182. <https://doi.org/10.1111/ajsp.12353>

Fukuhara, S., & Suzukamo, Y. (2004). Manual of the SF-8 Japanese Edition. Kyoto: Institute for Health Outcomes & Process Evaluation Research. (In Japanese.)

Gaggioli, A., Morganti, L., Bonfiglio, S., Scaratti, C., Cipresso, P., Serino, S., & Riva, G. (2014). Intergenerational group reminiscence: A potentially effective intervention to enhance elderly psychosocial wellbeing and to improve children's perception of aging. *Educational Gerontology*, 40(7), 486–498. <https://doi.org/10.1080/03601277.2013.844042>

Grant, E. (2001). Social capital and community strategies: Neighbourhood development in Guatemala City. *Development and Change*, 32(5), 975–997. <https://doi.org/10.1111/1467-7660.00234>

Gunnell, K. E., Crocker, P. R. E., Mack, D. E., Wilson, P. M., & Zumbo, B. D. (2014). Goal contents, motivation, psychological need satisfaction, well-being and physical activity: A test of self-determination theory over 6 months. *Psychology of Sport and Exercise*, 15(1), 19–29. <https://doi.org/10.1016/j.psychsport.2013.08.005>

Harada, K., Lee, S., Shimada, H., Lee, S., Bae, S., Anan, Y., Harada, K., & Suzuki, T. (2017). Psychological predictors of participation in screening for cognitive impairment among community-dwelling older adults. *Geriatrics & Gerontology International*, 17(8), 1197–1204. <https://doi.org/10.1111/ggi.12841>

Harada, K., Masumoto, K., Katagiri, K., Fukuzawa, A., Chogahara, M., Kondo, N., & Okada, S. (2018). Community intervention to increase neighborhood social network among Japanese older adults. *Geriatrics & Gerontology International*, 18(3), 462–469. <https://doi.org/10.1111/ggi.13208>

571 Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality risk: A  
572 meta-analytic review. *PLoS Medicine*, 7(7), e1000316.  
573 <https://doi.org/10.1371/journal.pmed.1000316>

574 Holt-Lunstad, J., & Uchino, B. N. (2015). Social support and health. In K. Glanz, B. K. Rimer,  
575 & K. Viswanath (Eds.), *Health behavior: Theory, research, and practice* (pp. 183–204).  
576 San Francisco, CA, US: Jossey-Bass.

577 Huang, C. Q., Wang, Z. R., Li, Y. H., Xie, Y. Z., & Liu, Q. X. (2010). Education and risk for  
578 late life depression: A meta-analysis of published literature. *International Journal of*  
579 *Psychiatry in Medicine*, 40(1), 109–124. <https://doi.org/10.2190/PM.40.1.i>

580 Imai, T., Osada, H., & Nishimura, Y. (2012). Ikigai ishiki syakudo no shinraisei to datosei no  
581 kento [The reliability and validity of a new scale for measuring the concept of Ikigai  
582 (Ikigai-9)]. *Nihon Koshu Eisei Zasshi [Japanese Journal of Public Health]*, 59(7), 433–  
583 439. [https://doi.org/10.11236/jph.59.7\\_433](https://doi.org/10.11236/jph.59.7_433) (in Japanese)

584 Inaba, Y., Wada, Y., Ichida, Y., & Nishikawa, M. (2015). Which part of community social  
585 capital is related to life satisfaction and self-rated health? A multilevel analysis based on  
586 a nationwide mail survey in Japan. *Social Science and Medicine*, 142, 169–182.  
587 <https://doi.org/10.1016/j.socscimed.2015.08.007>

588 Islam, M. K., Merlo, J., Kawachi, I., Lindström, M., & Gerdtham, U. G. (2006). Social capital  
589 and health: Does egalitarianism matter? A literature review. *International Journal for*  
590 *Equity in Health*, 5(1), 3. <https://doi.org/10.1186/1475-9276-5-3>

591 Japan Ministry of Education, Culture, Sports, Science and Technology. (2008).  
592 *Internationalization of universities and their local contribution, FY 2008 white paper on*  
593 *education, culture, sports, science and technology*.  
594 [http://warp.ndl.go.jp/info:ndljp/pid/11373293/www.mext.go.jp/b\\_menu/hakusho/html/hp](http://warp.ndl.go.jp/info:ndljp/pid/11373293/www.mext.go.jp/b_menu/hakusho/html/hp)  
595 [aa200901/detail/1283334.htm](http://warp.ndl.go.jp/info:ndljp/pid/11373293/www.mext.go.jp/b_menu/hakusho/html/hp_aa200901/detail/1283334.htm) (6-January-2020 accessed)

596 Jones, R. B., Ashurst, E. J., Atkey, J., & Duffy, B. (2015). Older people going online: Its value  
 597 and before-after evaluation of volunteer support. *Journal of Medical Internet Research*,  
 598 17(5), e122. <https://doi.org/10.2196/jmir.3943>

599 Kawachi, I., Kennedy, B. P., & Glass, R. (1999). Social capital and self-rated health: A  
 600 contextual analysis. *American Journal of Public Health*, 89(8), 1187–1193.  
 601 <https://doi.org/10.2105/AJPH.89.8.1187>

602 Kawachi, I., & Berkman, L. F. (2001). Social ties and mental health. *Journal of Urban Health*,  
 603 78(3), 458–467. <https://doi.org/10.1093/jurban/78.3.458>

604 Keyes, C. L. M. (2005). Mental illness and/or mental health? Investigating axioms of the  
 605 complete state model of health. *Journal of Consulting and Clinical Psychology*, 73(3),  
 606 539–548. <https://doi.org/10.1037/0022-006X.73.3.539>

607 Kikuchi, H., Inoue, S., Fukushima, N., Takamiya, T., Odagiri, Y., Ohya, Y., Amagasa, S., Oka,  
 608 K., & Owen, N. (2017). Social participation among older adults not engaged in full- or  
 609 part-time work is associated with more physical activity and less sedentary time.  
 610 *Geriatrics and Gerontology International*, 17(11), 1921–1927.  
 611 <https://doi.org/10.1111/ggi.12995>

612 Kim, H. (2017). “Strength of Weak Ties,” neighborhood ethnic heterogeneity, and depressive  
 613 symptoms among adults: A multilevel analysis of Korean General Social Survey (KGSS)  
 614 2012. *Social Sciences*, 6(2), 65. <https://doi.org/10.3390/socsci6020065>

615 Kleinhans, R., Priemus, H., & Engbersen, G. (2007). Understanding social capital in recently  
 616 restructured urban neighbourhoods: Two case studies in Rotterdam. *Urban Studies*,  
 617 44(5–6), 1069–1091. <https://doi.org/10.1080/00420980701256047>

618 Koyano, W., Shibata, H., Nakazato, K., Haga, H., & Suyama, Y. (1991). Measurement of  
 619 competence: Reliability and validity of the TMIG Index of Competence. *Archives of*

620 *Gerontology and Geriatrics*, 13(2), 103–116. <https://doi.org/10.1016/0167->

621 4943(91)90053-s

622 Kuiper, J. S., Zuidersma, M., Zuidema, S. U., Burgerhof, J. G., Stolk, R. P., Oude Voshaar, R.

623 C., & Smidt, N. (2016). Social relationships and cognitive decline: A systematic review

624 and meta-analysis of longitudinal cohort studies. *International Journal of Epidemiology*,

625 45(4), 1169–1206. <https://doi.org/10.1093/ije/dyw089>

626 Levasseur, M., Richard, L., Gauvin, L., & Raymond, É. (2010). Inventory and analysis of

627 definitions of social participation found in the aging literature: Proposed taxonomy of

628 social activities. *Social Science & Medicine*, 71(12), 2141–2149.

629 <https://doi.org/10.1016/j.socscimed.2010.09.041>

630 Li, C., Jiang, S., Li, N., & Zhang, Q. (2018). Influence of social participation on life satisfaction

631 and depression among Chinese elderly: Social support as a mediator. *Journal of*

632 *Community Psychology*, 46(3), 345–355. <https://doi.org/10.1002/jcop.21944>

633 Li, T., & Zhang, Y. (2015). Social network types and the health of older adults: Exploring

634 reciprocal associations. *Social Science & Medicine*, 130, 59–68.

635 <https://doi.org/10.1016/j.socscimed.2015.02.007>

636 Lin, N., Ye, X., & Ensel, W. M. (1999). Social support and depressed mood: a structural

637 analysis. *Journal of Health and Social Behavior*, 40(4), 344–359.

638 <https://doi.org/10.2307/2676330>

639 Litwin, H. (2011). The association between social network relationships and depressive

640 symptoms among older Americans: What matters most? *International Psychogeriatrics*,

641 23(6), 930–940. <https://doi.org/10.1017/S1041610211000251>

642 Löckenhoff, C. E., & Carstensen, L. L. (2004). Socioemotional selectivity theory, aging, and

643 health: the increasingly delicate balance between regulating emotions and making tough

644 choices. *Journal of Personality*, 72(6), 1395–1424. <https://doi.org/10.1111/j.1467->  
 645 6494.2004.00301.x

646 Low, L. F., Baker, J. R., Harrison, F., Jeon, Y. H., Haertsch, M., Camp, C., & Skropeta, M.  
 647 (2015). The lifestyle engagement activity program (LEAP): Implementing social and  
 648 recreational activity into case-managed home care. *Journal of the American Medical*  
 649 *Directors Association*, 16(12), 1069–1076. <https://doi.org/10.1016/j.jamda.2015.07.002>

650 Mackenzie, C. S., & Abdulrazaq, S. (in press). Social engagement mediates the relationship  
 651 between participation in social activities and psychological distress among older adults.  
 652 *Aging & Mental Health*, in press. <https://doi.org/10.1080/13607863.2019.1697200>

653 Makizako, H., Shimada, H., Doi, T., Tsutsumimoto, K., Lee, S., Lee, S. C., Harada, K., Hotta,  
 654 R., Nakakubo, S., Bae, S., Harada, K., Yoshida, D., Uemura, K., Anan, Y., Park, H., &  
 655 Suzuki, T. (2017). Age-dependent changes in physical performance and body  
 656 composition in community-dwelling Japanese older adults. *Journal of Cachexia,*  
 657 *Sarcopenia and Muscle*, 8(4), 607–614. <https://doi.org/10.1002/jcsm.12197>

658 Masumoto, K., Yaguchi, T., Matsuda, H., Tani, H., Tozuka, K., Kondo, N., & Okada, S. (2017).  
 659 Measurement and visualization of face-to-face interaction among community-dwelling  
 660 older adults using wearable sensors. *Geriatrics & Gerontology International*, 17(10),  
 661 1752–1758. <https://doi.org/10.1111/ggi.12933>

662 Minami, U., Nishi, M., Fukaya, T., Hasebe, M., Nonaka, K., Koike, T., Suzuki, H., Murayama,  
 663 Y., Uchida, H., & Fujiwara, Y. (2015). Effects of the Change in Working Status on the  
 664 Health of Older People in Japan. *PloS One*, 10(12), e0144069.  
 665 <https://doi.org/10.1371/journal.pone.0144069>

666 Ministry of Health, Labour, and Welfare. (2012). *Ministerial Notification No. 430 of the*  
 667 *Ministry of Health, Labour and Welfare*. [https://www.mhlw.go.jp/file/06-Seisakujouhou-](https://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000047330.pdf)  
 668 [10900000-Kenkoukyoku/0000047330.pdf](https://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000047330.pdf) (3-September-2020 accessed)

669 Moore, S., & Kawachi, I. (2017). Twenty years of social capital and health research: A glossary.  
670 *Journal of Epidemiology and Community Health*, 71(5), 513–517.  
671 <https://doi.org/10.1136/jech-2016-208313>

672 Murayama, H., Sugiyama, M., Inagaki, H., Okamura, T., Miyamae, F., Ura, C., Edahiro, A.,  
673 Motokawa, K., & Awata, S. (2018). Is community social capital associated with  
674 subjective symptoms of dementia among older people? A cross-sectional study in Japan.  
675 *Geriatrics & Gerontology International*, 18(11), 1537–1542.  
676 <https://doi.org/10.1111/ggi.13519>

677 Niedzwiedz, C. L., Richardson, E. A., Tunstall, H., Shortt, N. K., Mitchell, R. J., & Pearce, J. R.  
678 (2016). The relationship between wealth and loneliness among older people across  
679 Europe: Is social participation protective? *Preventive Medicine*, 91, 24–31.  
680 <https://doi.org/10.1016/j.ypmed.2016.07.016>

681 Otsuka, T., Tomata, Y., Zhang, S., Sugiyama, K., Tanji, F., Sugawara, Y., & Tsuji, I. (2018).  
682 Association between social participation and incident risk of functional disability in  
683 elderly Japanese: The Ohsaki Cohort 2006. *Journal of Psychosomatic Research*,  
684 111(October 2017), 36–41. <https://doi.org/10.1016/j.jpsychores.2018.05.004>

685 Poscia, A., Stojanovic, J., La Milia, D. I., Duplaga, M., Grysztar, M., Moscato, U., Onder, G.,  
686 Collamati, A., Ricciardi, W., & Magnavita, N. (2018). Interventions targeting loneliness  
687 and social isolation among the older people: An update systematic review. *Experimental*  
688 *Gerontology*, 102(October 2017), 133–144. <https://doi.org/10.1016/j.exger.2017.11.017>

689 Pinquart, M., & Sörensen, S. (2000). Influences of socioeconomic status, social network, and  
690 competence on subjective well-being in later life: A meta-analysis. *Psychology and*  
691 *Aging*, 15(2), 187–224. <https://doi.org/10.1037/0882-7974.15.2.187>

692 Pinquart, M., & Sörensen, S. (2001). Gender differences in self-concept and psychological well-  
 693 being in old age: a meta-analysis. *The Journals of Gerontology. Series B, Psychological*  
 694 *Sciences and Social Sciences*, 56(4), P195-213. <https://doi.org/10.1093/geronb/56.4.p195>  
 695 Robinson, H., Macdonald, B., Kerse, N., & Broadbent, E. (2013). The psychosocial effects of a  
 696 companion robot: A randomized controlled trial. *Journal of the American Medical*  
 697 *Directors Association*, 14(9), 661–667. <https://doi.org/10.1016/j.jamda.2013.02.007>  
 698 Saito, T., Kai, I., & Takizawa, A. (2012). Effects of a program to prevent social isolation on  
 699 loneliness, depression, and subjective well-being of older adults: A randomized trial  
 700 among older migrants in Japan. *Archives of Gerontology and Geriatrics*, 55(3), 539–547.  
 701 <https://doi.org/10.1016/j.archger.2012.04.002>  
 702 Sandstrom, G. M., & Dunn, E. W. (2014). Social interactions and well-being: The surprising  
 703 power of weak ties. *Personality and Social Psychology Bulletin*, 40(7), 910–922.  
 704 <https://doi.org/10.1177/0146167214529799>  
 705 Santini, Z. I., Koyanagi, A., Tyrovolas, S., Haro, J. M., Fiori, K. L., Uwakwa, R., Thiyagarajan,  
 706 J. A., Webber, M., Prince, M., & Prina, A. M. (2015). Social network typologies and  
 707 mortality risk among older people in China, India, and Latin America: A 10/66 Dementia  
 708 Research Group population-based cohort study. *Social Science & Medicine*, 147, 134–  
 709 143. <https://doi.org/10.1016/j.socscimed.2015.10.061>  
 710 Sarwari, A. R., Fredman, L., Langenberg, P., & Magaziner, J. (1998). Prospective study on the  
 711 relation between living arrangement and change in functional health status of elderly  
 712 women. *American Journal of Epidemiology*, 147(4), 370–378.  
 713 <https://doi.org/10.1093/oxfordjournals.aje.a009459>  
 714 Shaw, B. A., Krause, N., Liang, J., & Bennett, J. (2007). Tracking changes in social relations  
 715 throughout late life. *The Journals of Gerontology. Series B, Psychological Sciences and*  
 716 *Social Sciences*, 62(2), S90-9. <http://www.ncbi.nlm.nih.gov/pubmed/17379686>



717 Statistics Bureau of Japan. (2011). *2010 Population Census*.  
718 <https://www.stat.go.jp/data/kokusei/2010/> (3-September-2020 accessed) (in Japanese)  
719 Statistics Bureau of Japan. (2016). *2015 Population Census*.  
720 <https://www.stat.go.jp/data/kokusei/2015/index.html> (3-September-2020 accessed) (in  
721 Japanese)  
722 Takagi, D., Tsuji, R., & Ikeda, K. (2010). Chiiki komyuniti ni yoru hanzai yokusei [Crime  
723 control by local communities]. *Syakai Shinri Gaku Kenkyu [Japanese Journal of Social*  
724 *Psychology]*, 26(1), 36–45. <https://doi.org/10.14966/jssp.KJ00006714762> (in Japanese)  
725 Thoits, P. A. (2011). Mechanisms linking social ties and support to physical and mental health.  
726 *Journal of Health and Social Behavior*, 52(2), 145–161.  
727 <https://doi.org/10.1177/0022146510395592>  
728 Tomioka, K., Kurumatani, N., & Hosoi, H. (2017). Association between social participation and  
729 3-year change in instrumental activities of daily living in community-dwelling elderly  
730 adults. *Journal of the American Geriatrics Society*, 65(1), 107–113.  
731 <https://doi.org/10.1111/jgs.14447>  
732 Wang, R., Feng, Z., Liu, Y., & Lu, Y. (2020). Relationship between neighbourhood social  
733 participation and depression among older adults: A longitudinal study in China. *Health*  
734 *and Social Care in the Community*, 28(1), 247–259. <https://doi.org/10.1111/hsc.12859>  
735 Wing, C., Simon, K., & Bello-Gomez, R. A. (2018). Designing Difference in Difference  
736 Studies: Best Practices for Public Health Policy Research. *Annual Review of Public*  
737 *Health*, 39, 453–469. <https://doi.org/10.1146/annurev-publhealth-040617-013507>  
738 Valtorta, N. K., Kanaan, M., Gilbody, S., Ronzi, S., & Hanratty, B. (2016). Loneliness and  
739 social isolation as risk factors for coronary heart disease and stroke: Systematic review  
740 and meta-analysis of longitudinal observational studies. *Heart*, 102(13), 1009–1016.  
741 <https://doi.org/10.1136/heartjnl-2015-308790>

## **Supplemental Materials**

Supplemental Table 1. Correlation coefficients in a path model for associations of intervention participation with neighborhood social network, mental health, and physical health.

Supplemental Table 2. Additional sensitivity analysis for total effects of the number of intervention participation on neighborhood social network, mental health, and physical health: A linear mixed model.

Supplemental Figure 1. Number of intervention participation and changes in social ties. Scores of social ties were adjusted by age, gender, educational background, dummy variables of living arrangements, and working status.

Supplemental Figure 2. Additional sensitivity analysis for path model for associations of the number of intervention participation with neighborhood social network, mental health, and physical health. Bold and dash lines represent statistically significant and non-significant paths, respectively. All path coefficients are standardized. For visual clarity, correlations within demographic factors, between strong and weak ties, and within mental well-being, two components of HRQOL, and IADL are indicated in Supplemental Table 3 and are not displayed in this figure. Dummy variables of living arrangements were removed from the model because all paths from it to number of intervention participation, strong ties, weak ties, mental well-being, HRQOL, and IADL were not statistically significant. Each change score represents residualized change score. GFI = 0.991, AGFI = 0.974, CFI > 0.999, RMSEA < 0.001. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ . HRQOL: health related quality of life; IADL: instrumental activity of daily living.

Supplemental Table 3. Correlation coefficients in a path model for associations of the number of intervention participation with neighborhood social network, mental health, and physical health.

Supplemental Table 4. Additional sensitivity analysis for direct, indirect, and total effects of the number of intervention participation on neighborhood social network, mental health, and physical health: Path analysis.

Table 1. Participants' Baseline Characteristics. Table 1.

	Total		Non-participant		Participants		
	(N = 662)		(n = 489)		(n = 173)		
	M or %	SD	M or %	SD	M or %	SD	p-value <sup>a</sup>
Demographic factors							
Age (years), M	72.0	7.2	71.6	7.5	72.9	6.2	0.048
Gender (women), %	56.3%	—	54.4%	—	61.6%	—	0.100
Educational background (> high school), %	45.6%	—	42.7%	—	53.8%	—	0.012
Living arrangement, %							0.268
Alone	20.5%	—	19.5%	—	23.3%	—	
With spouse	53.0%	—	52.5%	—	54.7%	—	
In a multigenerational household	26.4%	—	28.0%	—	22.1%	—	
Current working status (yes), %	26.3%	—	28.2%	—	21.1%	—	0.068
Neighborhood social network							
Strong ties (score), M	2.1	2.9	1.9	2.8	2.9	2.8	<0.001
Weak ties (score), M	11.4	9.5	10.3	8.3	14.3	11.7	<0.001
Mental and physical health							
Mental well-being (score), M	30.0	6.9	29.7	7.2	30.8	6.0	0.081
HRQOL mental component (score), M	50.0	6.4	49.8	6.7	50.7	5.5	0.105
HRQOL physical component (score), M	47.9	6.9	47.6	7.3	49.0	5.8	0.024
IADL (score), M	4.8	0.6	4.8	0.7	4.9	0.3	0.009

*Note.* M: mean; SD: standard deviation; HRQOL: health related quality of life; IADL:

instrumental activity of daily living. <sup>a</sup> t-tests for age, strong and weak ties, mental well-being,

HRQOL, and IADL, and chi-squared test for gender, educational background, living arrangement, and current working status.

Table 2. Total Effects of Intervention Participation on Neighborhood Social Network, Mental Health, and Physical Health: A Linear Mixed Model

	Total <i>M (SE)</i>		Non-participants <i>M (SE)</i>		Participants <i>M (SE)</i>		Intervention effects, <i>p</i> -values <sup>a</sup>		
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Group	Time	Group × Time
Neighborhood social network									
Strong ties	2.1 (0.1)	2.5 (0.1)	1.8 (0.2)	2.0 (0.2)	2.9 (0.3)	3.7 (0.3)	0.001	0.104	0.031
Weak ties	11.3 (0.4)	11.6 (0.4)	10.2 (0.4)	10.2 (0.4)	14.4 (0.7)	15.4 (0.7)	<0.001	0.993	0.159
Mental and physical health									
Mental well-being	29.9 (0.3)	29.0 (0.3)	29.6 (0.3)	28.4 (0.3)	30.8 (0.5)	30.7 (0.5)	0.039	<0.001	0.050
HRQOL mental component	50.0 (0.3)	50.2 (0.3)	49.7 (0.3)	49.9 (0.3)	50.7 (0.5)	51.0 (0.5)	0.115	0.562	0.903
HRQOL physical component	47.9 (0.3)	47.2 (0.3)	47.5 (0.3)	46.9 (0.3)	49.2 (0.5)	48.1 (0.5)	0.005	0.044	0.393
IADL	4.8 (0.0)	4.7 (0.0)	4.8 (0.0)	4.6 (0.0)	5.0 (0.1)	4.9 (0.1)	0.015	<0.001	0.443

*Note.* <sup>a</sup> The *p*-values show the statistical significances of the independent variables in the linear mixed models. In total, six models were examined by setting two neighborhood social network variables and four mental and physical health variables as dependent variables; group (non-participants, participants), time (baseline, follow-up), and the interaction term of group with time as independent variables; and age, gender, educational background, dummy variables of living arrangement, and current working status as covariates. Each model included all data of the

participants without any missing data. *M*: adjusted mean; *SE*: standard error; HRQOL: health related quality of life; IADL: instrumental activity of daily living.

Table 3. Direct, Indirect, and Total Effects of Intervention Participation on Neighborhood Social Network, Mental Health, and Physical Health:

Path analysis

	Standardized direct effect		Standardized indirect effect		Standardized total effect	
	Estimated (95%CI)	<i>p</i> -value	Estimated (95%CI)	<i>p</i> -value	Estimated (95%CI)	<i>p</i> -value
Changes in neighborhood social network						
Changes in strong ties	0.12 (0.00, 0.21)	0.045	—		0.12 (0.00, 0.21)	0.045
Changes in weak ties	0.21 (0.10, 0.30)	0.002	—		0.21 (0.10, 0.30)	0.002
Changes in mental and health status						
Changes in mental well-being	0.05 (-0.03, 0.16)	0.137	0.03 (0.01, 0.06)	0.016	0.11 (0.01, 0.20)	0.028
Changes in HRQOL mental component	0.05 (-0.05, 0.15)	0.336	0.01 (-0.01, 0.03)	0.433	0.06 (-0.04, 0.16)	0.236
Changes in HRQOL physical component	-0.03 (-0.12, 0.07)	0.612	0.02 (-0.00, 0.05)	0.102	-0.01 (-0.11, 0.09)	0.853
Changes in IADL	0.04 (-0.04, 0.12)	0.225	0.02 (-0.00, 0.04)	0.099	0.08 (-0.01, 0.14)	0.094

*Note.* The bias-corrected method (1,000 bootstrap samples) was used. 95%CI: 95% confidence interval; HRQOL: health related quality of life;

IADL: instrumental activity of daily living. Each change score represents residualized change score. As shown in Figure 2, age, gender,

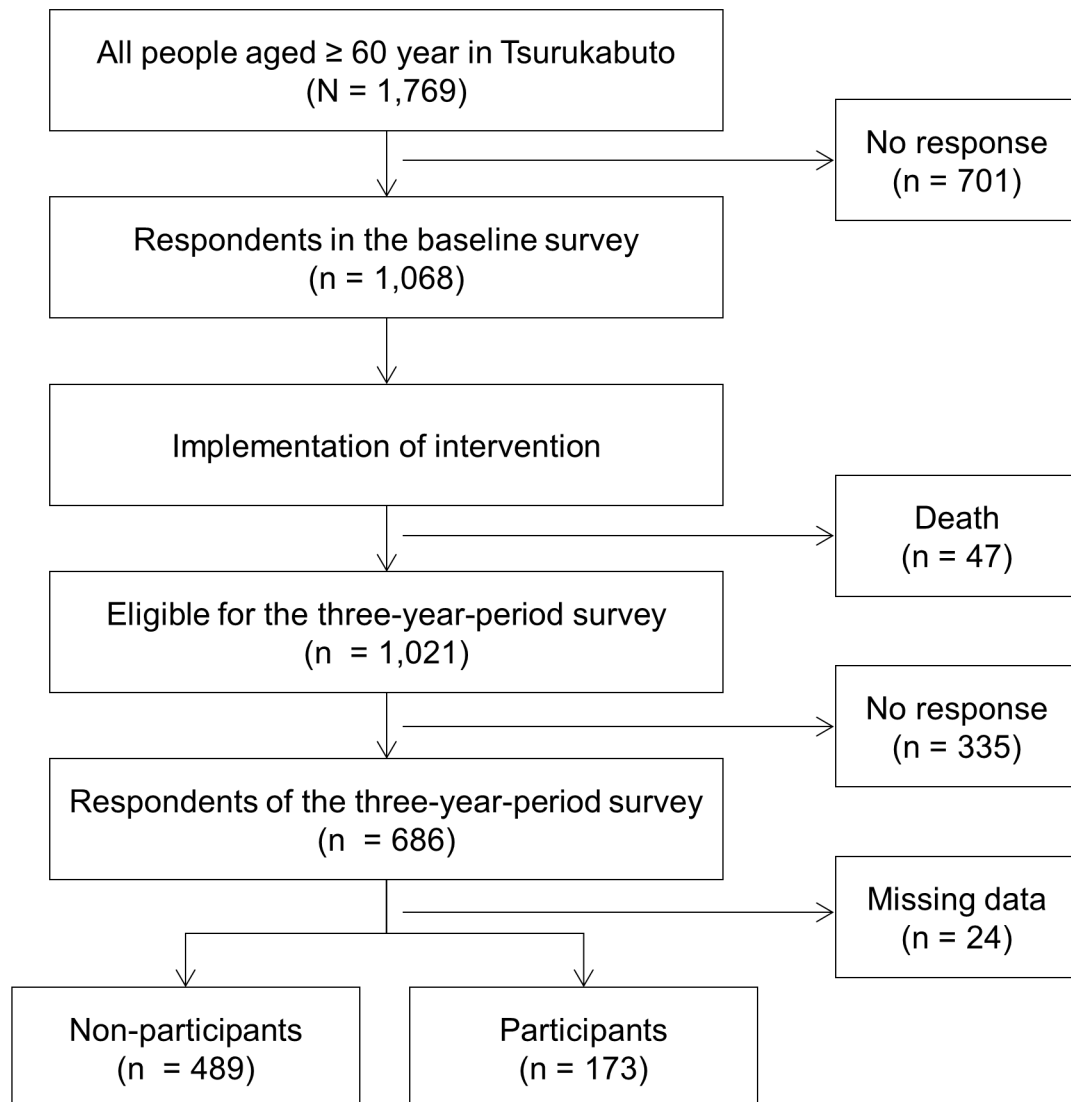
educational background, and current working status were included in the path model.

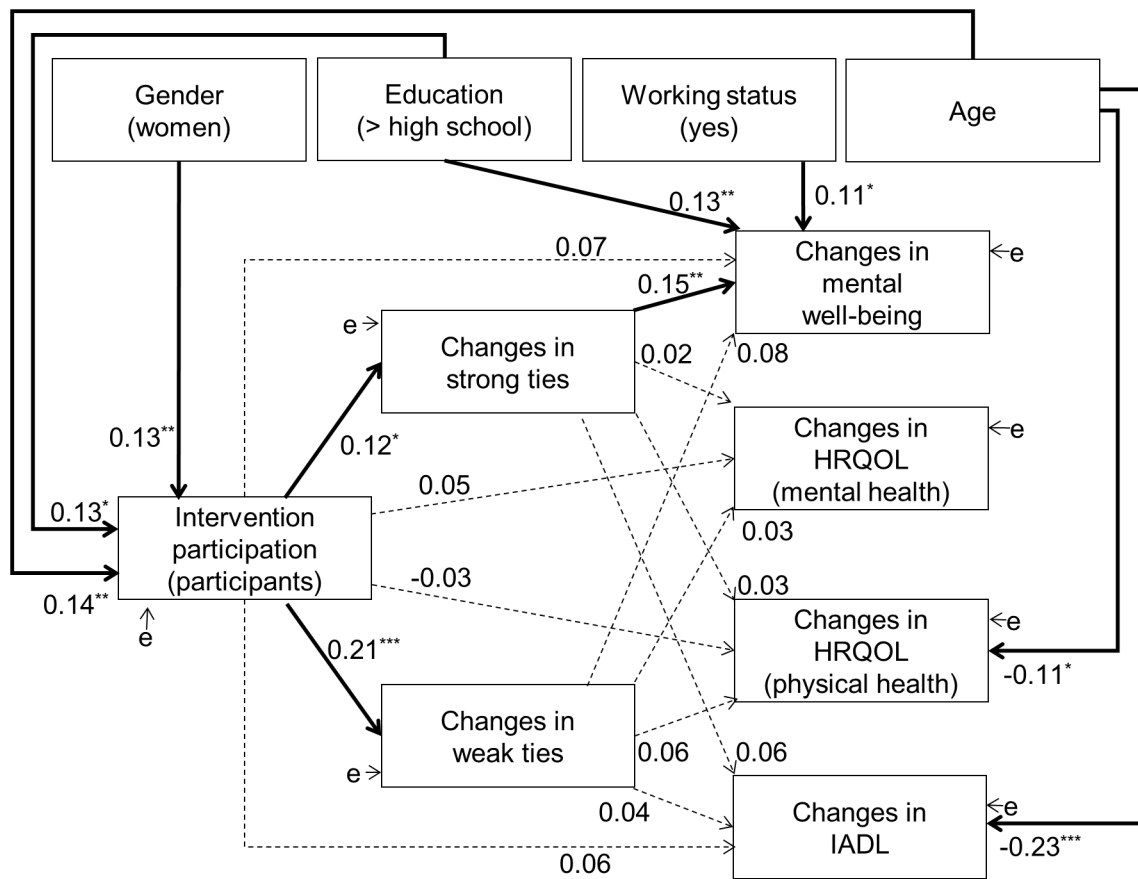


## Figure Captions

Figure 1. Flow diagram for examining the three-year-period effects of Tsurukabuto Active Aging Project. This project targeted all older adults living in Tsurulabuto community.

Figure 2. A path model for associations of intervention participation with neighborhood social network, mental health, and physical health. Bold and dash lines represent statistically significant and non-significant paths, respectively. All path coefficients are standardized. For visual clarity, correlations within demographic factors, between strong and weak ties, and within mental well-being, two components of HRQOL, and IADL are indicated in Supplemental Table 1 and not displayed in this figure. Dummy variables of living arrangements were removed from the model because all paths from it to intervention participation, strong ties, weak ties, mental well-being, HRQOL, and IADL were not statistically significant. Each change score represents residualized change score. GFI = 0.990, AGFI = 0.975, CFI > 0.999, RMSEA < 0.001. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ . HRQOL: health related quality of life; IADL: instrumental activity of daily living.





Supplementary Table 1. Correlation coefficients in a path model for associations of intervention participation with neighborhood social network, mental health, and physical health.

	Correlation coefficient	p-value
Gender and education	-0.19	<0.001
Gender and working status	-0.21	<0.001
Age and education	-0.11	0.020
Age and working status	-0.42	<0.001
Changes in strong ties and changes in weak ties	0.48	<0.001
Changes in mental well-being and changes in HRQOL (mental health)	0.34	<0.001
Changes in mental well-being and changes in HRQOL (physical health)	0.20	<0.001
Changes in mental well-being and changes in IADL	0.25	<0.001
Changes in HRQOL (mental health) and changes in IADL	0.12	0.015
Changes in HRQOL (physical health) and changes in IADL	0.13	0.011

A path model is shown in Figure 2. HRQOL: health related quality of life; IADL: instrumental activity of daily living.

Supplemental Table 2. Additional sensitivity analysis for total effects of the number of intervention participation on neighborhood social network, mental health, and physical health: A linear mixed model.

	Effects of number of intervention participation <sup>a</sup>		Effects of time <sup>a</sup>		Interaction effects <sup>a</sup>	
	B (95%CI)	<i>p</i> -values	B (95%CI)	<i>p</i> -values	B (95%CI)	<i>p</i> -values
Neighborhood social network						
Strong ties	0.21 (0.07, 0.34)	0.003	0.21 (-0.06, 0.48)	0.131	0.27 (0.15, 0.39)	<0.001
Weak ties	0.86 (0.50, 1.21)	<0.001	0.11 (-0.57, 0.78)	0.759	0.21 (-0.09, 0.51)	0.160
Mental and physical health						
Mental well-being	0.35 (0.08, 0.61)	0.010	-0.88 (-1.36, -0.41)	<0.001	0.01 (-0.21, 0.22)	0.951
HRQOL mental component	0.19 (-0.06, 0.45)	0.142	0.37 (-0.29, 1.02)	0.273	-0.13 (-0.43, 0.17)	0.386
HRQOL physical component	0.32 (0.06, 0.58)	0.015	-0.68 (-1.23, -0.13)	0.016	-0.04 (-0.30, 0.21)	0.749
IADL	0.03 (-0.00, 0.06)	0.056	-0.13 (-0.19, -0.07)	<0.001	0.00 (-0.03, 0.03)	0.883

*Note.* <sup>a</sup> Linear mixed models with age, gender, educational background, dummy variables of living arrangement, and current working status as covariates. 95% CI: 95% confidence interval; HRQOL: health related quality of life; IADL: instrumental activity of daily living.

Supplemental Table 3. Additional sensitivity analysis for direct, indirect, and total effects of the number of intervention participation on neighborhood social network, mental health, and physical health: Path analysis

	Standardized direct effect		Standardized indirect effect		Standardized total effect	
	Estimated (95%CI)	<i>p</i> -value	Estimated (95%CI)	<i>p</i> -value	Estimated (95%CI)	<i>p</i> -value
Changes in neighborhood social network						
Changes in strong ties	0.29 (0.10, 0.45)	0.002	—		0.29 (0.10, 0.45)	0.002
Changes in weak ties	0.20 (0.05, 0.35)	0.007	—		0.20 (0.05, 0.35)	0.007
Changes in mental and health status						
Changes in mental well-being	0.01 (-0.06, 0.07)	0.827	0.06 (0.01, 0.12)	0.003	0.07 (-0.02, 0.15)	0.093
Changes in HRQOL MCS	-0.03 (-0.12, 0.06)	0.539	0.02 (-0.01, 0.05)	0.166	-0.01 (-0.11, 0.07)	0.758
Changes in HRQOL PCS	0.01 (-0.07, 0.08)	0.814	0.01 (-0.02, 0.04)	0.387	0.02 (-0.04, 0.09)	0.430
Changes in IADL	0.04 (-0.05, 0.09)	0.384	0.02 (0.00, 0.04)	0.106	0.05 (-0.02, 0.10)	0.136

*Note.* The bias-corrected method (1,000 bootstrap samples) was used. 95%CI: 95% confidence interval; HRQOL: health related quality of life; IADL: instrumental activity of daily living. Each change score represents residualized change score. As shown in Supplemental Figure 2, age, gender, educational background, and current working status were included in the path model.

Supplementary Table 4. Correlation coefficients in a path model for associations of the number of intervention participation with neighborhood social network, mental health, and physical health.

	Correlation coefficient	p-value
Gender and education	-0.19	<0.001
Gender and working status	-0.20	<0.001
Age and education	-0.10	0.025
Age and working status	-0.42	<0.001
Changes in strong ties and changes in weak ties	0.46	<0.001
Changes in mental well-being and changes in HRQOL (mental health)	0.34	<0.001
Changes in mental well-being and changes in HRQOL (physical health)	0.16	<0.001
Changes in mental well-being and changes in IADL	0.21	<0.001
Changes in HRQOL (mental health) and changes in IADL	0.12	0.020

A path model is shown in Supplemental Figure 2. HRQOL: health related quality of life; IADL: instrumental activity of daily living.

