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1 **Title: Changes in social activities and the occurrence and persistence of**
2 **depressive symptoms: do type and combination of social activities make a**
3 **difference?**

4

5 **ABSTRACT**

6 **Objective:** We aimed to explore the association between changes in social activities
7 and the occurrence/persistence of depressive symptoms and investigate the difference
8 in effect sizes among the types and combinations of social activities.

9 **Methods:** The study adopted a valid 15-item Geriatric Depression Scale to assess
10 depressive symptoms in 2480 community-dwelling adults aged 64/65 years. Changes
11 in social-related, learning, and personal activities were classified into four categories:
12 continued low frequency (CLF), increased frequency (IF), decreased frequency (DF),
13 and continued regular frequency (CRF)¹. Relative ratios (RRs) and 95% confidence
14 intervals (95% CI) were calculated using a modified Poisson regression model.

15 **Results:** Those without depressive symptoms at baseline and who engaged in
16 social-related (RR_{IF} = 0.56 (0.39, 0.81), RR_{CRF} = 0.55 (0.41, 0.74)), learning (RR_{IF} =
17 0.63 (0.44, 0.89), RR_{CRF} = 0.62 (0.46, 0.85)), and personal activities (RR_{IF} = 0.37
18 (0.24, 0.57), RR_{CRF} = 0.41 (0.30, 0.56)) at IF or CRF were less likely to develop
19 depressive symptoms. Those with depressive symptoms at baseline, engaging in
20 personal activities at IF (RR=0.67 (0.51, 0.87)) and CRF (RR= 0.80 (0.65-1.00)) were
21 less likely to have persistent depressive symptoms. Participation in all three activities
22 consistently at a regular frequency was inversely associated with the
23 occurrence/persistence of depressive symptoms.

24 **Conclusions:** The effect of personal activities was more manifest in preventing
25 depressive symptoms than the other two kinds, regardless of depressive symptoms at
26 baseline. Regularly engaging in a combination of all three activities at baseline and
27 follow-up was associated with the occurrence and persistence of depressive
28 symptoms.

29 **KEYWORDS**

30 social-related activity, learning activity, personal activity, occurrence of depressive
31 symptoms, persistence of depressive symptoms

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¹ CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency

1 **1. Introduction**

2 Depressive disorders in older adults are associated with an increased risk of
3 comorbidity and mortality (Blazer, 2003). In Japan, the prevalence of depressive
4 disorders among adults aged 65 years and over increases with age (GHDx). Among all
5 people with mood disorders (e.g., manic depression and depression), the percentage of
6 the average length of hospitalization for older adults aged 65 years and over has
7 increased from 55% in 2017 to 60% in 2021 (Ministry of Health). This trend is raising
8 concern for causing a huge burden not only for the depressed patients but also for
9 their families and the medical and social resources. With the rapid aging of its
10 population, Japan needs to take measures for potential interventions for depressive
11 disorder among community-dwelling older adults to reduce the social burden.

12 The main predictors of depressive disorders in older adults include somatic diseases,
13 functional or mental impairment, a history of depressive disorders, and lack of social
14 participation (Djernes, 2006). Social participation, from which people could get social
15 support, establish social networks and connections, has been demonstrated to have
16 protective effects against depressive symptoms among older adults (Nakagomi et al.,
17 2020; Shiba et al., 2021; Watanabe et al., 2019), but the effect size is related to
18 intensity and type of social participation. For example, informal social activities (date
19 a friend, talking face-to-face with friends or children) have greater effects on reducing
20 the risks of developing depressive symptoms compared with formal activities
21 (religious or volunteer activities) (Seung Hee & Kim, 2014; Steger & Kashdan, 2009).

22 Nevertheless, the same type of social activity may produce inconsistent results in
23 terms of effects on depressive symptoms in different participants. An European study
24 on adults aged 50 years and over found that participation in religious and
25 political/community activities is associated with decreased and increased depressive
26 symptoms after four years, respectively (Croezen et al., 2015). An Asian study on
27 adults aged 60 years and over reported the opposite results: attending religious
28 activities is associated with increased depressive symptoms, but participating in social
29 gatherings is associated with a decrease in depressive symptoms after four years (Min
30 et al., 2016). This suggested that the association between social activities and
31 depressive symptoms may differ not only across different types of social activities,
32 but also across different social cultures (Min et al., 2016). Thus, in examining the
33 effects of social activities on depressive symptoms, although the specific types of
34 social activities are easier to explore in terms of their effect on depressive symptoms,
35 research on the comparison between different studies and the generalization across
36 different races has been limited. Therefore, combining multiple social activities into a
37 scale or measurement would be significant in exploring the protection or intervention
38 of depressive symptoms. First, participation in multiple social activities allows older
39 adults to occupy various roles increasing their self-esteem and then benefit their
40 mental health (Choi et al., 2021). Moreover, different types of social activities may act
41 differently on depressive symptoms, and there may be a cumulative or compensatory
42 effect among multiple types of social activities. For example, engaging in more
43 diverse activities with positive effects implies greater benefits on depressive

1 symptoms; and increased participation in socializing with others may counteract the
2 harmful effects of negative activities (Chao, 2016).

3 Although previous studies have explored the association between changes in social
4 activity and depressive symptoms, (Chao, 2016; Choi et al., 2015) these studies have
5 only either the linear relation between changes in social activities without considering
6 the occurrence of or improvement in depressive symptoms, or considered changes in
7 individual social activity, and not the changes in the combination of different types of
8 social activities.

9 The current study assessed social activities for community-dwelling older adults using
10 a set of questions and divided them into three types based on the internal consistency
11 of these activity types: social-related, learning, and personal activities. We explored
12 the association between frequency changes in social activities and both the occurrence
13 and persistence of depressive symptoms. We further explored the types and
14 combinations of multiple types of social activities that have a greater influence on
15 depressive symptoms.

16 **2. Methods**

17 *2.1 Study design and participants*

18 This study was carried out as part of the New Integrated Suburban Seniority
19 Investigation (NISSIN) project, an ongoing prospective cohort study. The participants
20 were age-specific (64/65 years old) community-dwelling residents living in Nisshin
21 City, Aichi Prefecture. From 1996 to 2005, participants were invited to attend a
22 comprehensive health check and complete a self-administered questionnaire; a total of
23 3,073 participants who provided informed consent were included. From 2002 to 2011,
24 these participants were invited to participate in a second comprehensive health check
25 and complete the self-administered questionnaire. Details of the project design are
26 provided elsewhere.(Kitamura et al., 2009) Of all the eligible participants (n = 3, 073),
27 we excluded 161 participants with missing values for the covariates and 50
28 participants who had invalid response (n = 1) and missing values (n = 49) to the
29 Geriatric Depression Scale (GDS) at baseline. We also excluded participants who
30 relocated (n = 123) or died (n = 97) before follow-up. In addition, participants who
31 did not attend the check-ups (n = 145), who had missing values of GDS
32 questionnaires (n = 17) at follow-up were also excluded. Thus, in this study, we
33 included a total of 2, 480 participants, of whom 1, 958 had no depressive symptoms
34 and 522 had depressive symptoms at baseline (Fig.1).

35 *2.2 Assessment of depressive symptoms*

36 We used a valid 15-item GDS to assess the depressive symptoms at baseline and
37 follow-up (Yatomi, 1994). The total score was calculated as the sum of scores for each
38 of the 15 questions, ranging from 0 to 15. A higher score indicated the severity of
39 depressive symptoms, and a score ≥ 6 was regarded as having depressive symptoms
40 (Schreiner et al., 2003).

41 *2.3 Assessment of social activities*

1 Social activities involved social-related, learning, and personal activities, which were
2 equally assessed at both baseline and follow-up. Social-related activities included six
3 questions, learning activities four questions, and personal activities ten questions (see
4 Supplementary Table S1) (Aoki et al., 1996). For each question, scores of 3, 2, and 1
5 corresponded to “regularly doing,” “occasionally doing,” and “not doing” these
6 activities, respectively. For each participant, we calculated the total score for each part
7 as the sum of scores for the number of questions, ranging from 6 to 18 for
8 social-related, 4 to 12 for the learning, and 10 to 30 for personal activities. We then
9 assigned all participants to different frequency groups based on the first quartile of
10 participants without depressive symptoms at baseline. Participants with scores lower
11 than the first quartile (social-related activities: 7, learning activities: 4, personal
12 activities: 17) were assigned to the “low frequency” group. In contrast, the others
13 were assigned to the “regular frequency” group. At follow-up, participants were
14 similarly categorized using the same cut-off points. Overall, these questions exhibited
15 an acceptable level of internal consistency, with the Cronbach’s α for all the three
16 parts being larger than 0.61 at both baseline and follow-up.

17 We classified the combination of multiple social activities into four groups based on
18 the frequency of each activity. Group A included participants with a low frequency of
19 engagement in all three activities. Group B included participants with a low frequency
20 of engagement in two activities but a regular frequency of attention on one activity.
21 Group C included participants with a low frequency of engagement in one activity but
22 a regular frequency in two activities. Finally, Group D included participants with a
23 regular frequency of engagement in all three activities.

24 *2.4 Changes in depressive symptoms and changes in social activities*

25 We examined four patterns of changes in depressive symptoms over time: two for
26 participants who did not have depressive symptoms at baseline, namely “continued
27 absence of depressive symptoms” and “occurrence of depressive symptoms;” and two
28 for participants who had depressive symptoms at baseline, namely “improvement of
29 depressive symptoms” and “persistence of depressive symptoms.”

30 We then classified the changes in social activities between baseline and follow-up into
31 four categories: continued low frequency (CLF), increased frequency (IF), decreased
32 frequency (DF), and continued regular frequency (CRF). Regarding the changes in
33 combination of multiple social activities between baseline and follow-up, we
34 identified 16 variations, shown in Supplementary Table S2.

35 *2.5 Covariates*

36 Data on covariates were collected using self-administered questionnaires and a
37 comprehensive health check-up performed at baseline. Sociodemographic variables
38 included sex, year of participation (1996–2005), marital status (married, other),
39 educational background (junior high school or lower, high school, college or higher),
40 and residential status (living alone, other). Health-related variables included smoking
41 (never, former, current), drinking (never, current), body mass index (BMI, calculated
42 as the self-reported body weight divided by the square of the self-reported body

1 height) (<18.5; 18.5–25.0; >25.0), history of chronic diseases, and competence of
2 daily living (low, high). History of chronic disease was collected by asking
3 participants if they had a history of any cancer, hypertension, diabetes, arthritis, or
4 cardiovascular disease. Competence of daily living was evaluated by the Tokyo
5 Metropolitan Institute of Gerontology Index of Competence questionnaire, which
6 contains 13 close-ended questions and has been validated in the Japanese population
7 (Koyano et al., 1991). The total score was calculated as the sum of scores for
8 responses to each of the 13 questions; a higher total score indicates a higher
9 competence in daily living. The value of 11 and over indicate higher competence of
10 the elderly (Okabayashi et al., 2019).

11 *2.6 Statistical analysis*

12 We compared the baseline demographic characteristics among participants who
13 showed a transition of depressive symptoms using a chi-squared test for categorical
14 data. Due to the higher prevalence rate of our outcome (the occurrence (12.6%) and
15 persistence (49.8%) of depressive symptoms), a modified Poisson regression model
16 for binary outcome data, with a log link function and robust error variance, was
17 constructed to estimate the risk ratios (RRs) and 95% confidence intervals (95% CIs).
18 We used the RRs and CIs to determine the association between changes in social
19 activities, changes in combination of multiple social activities, and
20 occurrence/persistence of depressive symptoms while adjusting for potential
21 confounders. Statistical analyses were performed using SAS software package version
22 9.4 for Microsoft Windows (SAS Institute Inc., Cary, NC, USA). Statistical
23 significance was set as $P < 0.05$.

24 **3. Results**

25 *3.1 Baseline characteristics*

26 Among participants who had changes in social-related activities, participants with
27 CRF in engagement were more likely to be never smoker, have higher education
28 backgrounds and competence of daily living, and be free of depressive symptoms.
29 Most participants engaged in learning activities at CRF were women; they were less
30 likely to be current smokers and drinkers. They had higher education backgrounds
31 and competence of daily living and a lower proportion of having depressive
32 symptoms. Among participants who demonstrated changes in personal activities, a
33 higher proportion of those in the CRF classification were female and never smoker or
34 never drinkers. They also had higher educational backgrounds and competence of
35 daily living and were less likely to have depressive symptoms (Table1).

36 *3.2 Association between changes in social activities and the occurrence of depressive 37 symptoms among participants with no depressive symptoms at baseline*

38 A total of 246 (12.6%) developed depressive symptoms after six-year follow-up
39 period. Compared with participants who partook in activities at CLF, those who
40 participated in social-related, learning activities, and personal activities at IF or CRF
41 were less likely to develop depressive symptoms. Those who had DF of social-related
42 activities also showed significant association with the occurrence of depressive

1 symptoms (Table 2).

2 On the association between changes in combination of multiple social activities and
3 the occurrence of depressive symptoms, compared with participants who remained in
4 Group A, those who remained in Group B, Group C, and Group D were less likely to
5 develop depressive symptoms. Similarly, those who increased the number of regular
6 frequency activities to two (Group A and Group B to Group C) or three (Group A,
7 Group B and Group C to Group D) after the six-year follow-up period were less likely
8 to experience depressive symptoms. Meanwhile, participants who had a decrease in
9 the number of regular frequency activities (from Group D to Group A) were more
10 likely to report the occurrence of depressive symptoms. However, this was not the
11 case for participants from Group D to Group C (Table 3).

12 *3.3 Association between changes in social activities and the persistence of depressive* 13 *symptoms among those with depressive symptoms at baseline*

14 A total 260 (49.8%) participants reported persistent depressive symptoms after the
15 six-year follow-up period. Compared with participants who engaged in activities at
16 CLF, those who reported IF or CRF for personal activities were less likely to have
17 persistent depressive symptoms after controlling for all the confounding factors. The
18 DF group for learning activities had a higher likelihood for having persistent
19 depressive symptoms (Table 4).

20 On the association between changes in combination of multiple social activities and
21 the persistence of depressive symptoms, compared with participants who remained in
22 Group A, those who remained in Group D, those who increased the number of regular
23 frequency activities from Group A to Group C, from Group C to Group D, and those
24 who decreased the number of regular frequency activities from Group D to Group A
25 showed significant association with the persistence of depressive symptoms (Table 3).

26 **4. Discussions**

27 We explored the association between changes in social activities and the occurrence
28 and persistence of depressive symptoms. Regarding the changes in each social activity,
29 we found that older adults without depressive symptoms, who participated in these
30 social activities at CRF or IF had a significant association with the occurrence of
31 depressive symptoms. However, for older adults with depressive symptoms at
32 baseline, only the CRF and IF of personal activities and DF of learning activities
33 showed an association with the persistence of depressive symptoms. Regarding the
34 changes in the combination of multiple social activities, we found that participants
35 were less likely to develop depressive symptoms if they maintained the same level of
36 participation or increased the number of regular frequency social activities to two or
37 three. However, for those who had depressive symptoms, they had either maintain all
38 three kinds of activities at a regular frequency or increase the number of social
39 activities at regular frequency to have an association with the persistence of
40 depressive symptoms.

41 A prospective study on Koreans aged 45 years or older found that continued or new
42 participation in social activities is negatively associated with the occurrence of

1 depressive symptoms (Choi et al., 2015). They found that the strength of the negative
2 association varies across types of social activities, with stronger negative effects of
3 leisure, culture or sports club, and family or school reunion activities compared with
4 volunteer or political activities (Choi et al., 2015). Our results also confirmed that the
5 effect size of the negative relation between CRF or IF of social activities and
6 depressive symptoms varied across different types of social activities. Personal
7 activities had the strongest effect, followed by socially relevant activities and then by
8 learning activities. Cross-sectional and prospective studies have demonstrated that a
9 higher level of perceived emotional support could protect people from depressive
10 symptoms, whereas a lower level is associated with the presence or development of
11 depressive symptoms (Santini et al., 2015). Another longitudinal study on adults aged
12 60 years and over also found that decreased participation in social activities is
13 associated with higher score on the Center for Epidemiological Studies-Depression
14 scale (higher scores indicate severe depressive symptoms) (Chao, 2016). Our results
15 similarly demonstrated that decreased social-related activities was associated with the
16 occurrence of depressive symptoms and decreased learning activities was associated
17 with the persistence of depressive symptoms. This longitudinal study also found the
18 cumulative and compensatory effects of different types of leisure activities on
19 depressive symptoms, which means a gain in certain activities may compensate for
20 losses in other activities (Chao, 2016). Our results on changes in the accumulation of
21 social activities and the occurrence of depressive symptoms also suggested that even
22 with a low frequency of one or two activities, maintaining the same combination
23 status during follow-up showed significant association with the development
24 depressive symptoms, which may suggest a compensatory effect among different
25 frequency groups of social activities.

26 Early research has revealed that the strength and direction of the association of social
27 activities with persistent depressive symptoms also related to the type of activity
28 (Croezen et al., 2015; Min et al., 2016; Ryu et al., 2021). Increased participation in
29 sports, social clubs, and other club activities is associated with a contemporary decline
30 in depressive symptoms but does not predict changes in depressive symptoms after
31 multi-year follow-up period. A possible explanation is that the short-term benefits of
32 social engagement on depressive symptoms diminish over time; another is that
33 depressive symptoms affect engagement in social activities (Croezen et al., 2015). In
34 our study, we found an association of CFR and IF of personal activities with the
35 persistence of depressive symptoms after controlling for all the confounding factors.
36 The measurement of changes in social activities and persistence of depressive
37 symptoms in our study were at the same wave; the association also seemed
38 contemporaneous. More longitudinal studies are needed to explain the association
39 between changes in social activities and the improvement of depressive symptoms.

40 The age-specific participants allowed us to eliminate the confounding factor of age. In
41 addition, we used a set of questions rather than a single question to assess social
42 activities from multiple perspectives, which makes our results more generalizable.
43 Several limitations also should be considered. First, the self-reported questions on
44 social activity assessment may lead to recalled biases. Second, social activities and

1 depressive symptoms may interact with each other over time, the exposure and
2 outcome in our study were measured at the same time; as much, we could not
3 consider causality. Future studies should carefully consider the statistical methods or
4 use prospective or intervention studies to explore this interaction between social
5 activity and depressive symptoms over time, especially for participants with
6 depressive symptoms at baseline. Third, cognitive function was not included as a
7 confounding factor because relatively few participants completed the assessments.

8 **5. Conclusions**

9 We found that Japanese community-dwelling older adults participating in personal
10 activities had a greater impact on depressive symptoms than social-related and
11 learning activities. A combination of more types of social activities at regular
12 frequency and an increase in the number of social activities at regular frequency was
13 significantly associated with the occurrence of depressive symptoms in older people.
14 For participants who had depressive symptoms, only a greater number of regular
15 frequency activities both at baseline and follow-up was associated with the
16 persistence of depressive symptoms.

17

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24

25 **CRedit authorship contribution statement**

26 Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando,
27 and Akiko Tamakoshi: project administration, data collection. Yifan Shan, Wenjing
28 Zhao, and Akiko Tamakoshi: study design. Yifan Shan, Wenjing Zhao, Wen Hao and
29 Takashi Kimura: data analysis and manuscript preparation. Yifan Shan, Wenjing Zhao,
30 Wen Hao, Takashi Kimura, Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura,
31 Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: review and editing.

32 Yifan Shan, Wenjing Zhao, and Akiko Tamakoshi: Conceptualization; Shigekazu
33 Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko
34 Tamakoshi: Data curation; Yifan Shan, Wen Hao Takashi Kimura: Formal analysis;
35 Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando,
36 and Akiko Tamakoshi: Funding acquisition; Shigekazu Ukawa, Hideki Ohira, Takashi
37 Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: Investigation; Yifan
38 Shan, Wenjing Zhao, Akiko Tamakoshi: Methodology; Shigekazu Ukawa, Hideki
39 Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi:
40 Project administration; Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji
41 Wakai, Masahiko Ando, and Akiko Tamakoshi: Resources; Yifan Shan, Wenjing Zhao,

1 Wen Hao, Takashi Kimura: Software; Akiko Tamakoshi: Supervision; Takashi Kimura:
 2 Validation; Yifan Shan, Akiko Tamakoshi: Visualization; Yifan Shan: Writing -
 3 original draft; Yifan Shan, Wenjing Zhao, Wen Hao, Takashi Kimura, Shigekazu
 4 Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko
 5 Tamakoshi: Writing - review & editing.

6 **Declaration of Competing Interest**

7 There are no conflicts of interest to declare.

8

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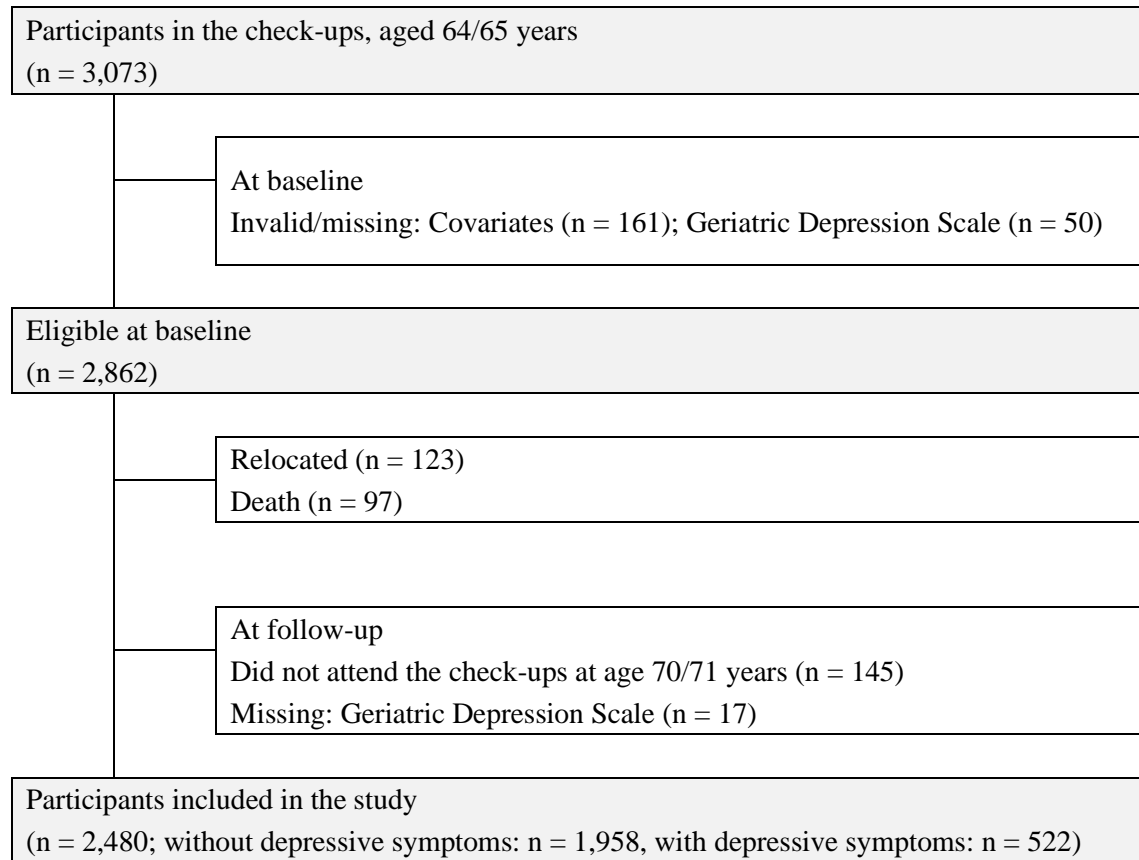


Fig. 1. Flowchart of participant recruitment

Table 1 Baseline characteristic of participants who had changes in social activities

| Items | Total | Changes in social-related activity | | | | <i>P</i> | Changes in learning activity | | | | <i>P</i> |
|-------------------------------|-------------|------------------------------------|------------|------------|------------|--------------|------------------------------|------------|------------|------------|------------------|
| | | CLF | IF | DF | CRF | | CLF | IF | DF | CRF | |
| Number of participants | 2480 | 449 | 569 | 169 | 1293 | | 915 | 510 | 240 | 815 | |
| Sex (female) | 1239 (50.0) | 205 (45.7) | 272 (47.8) | 88 (52.1) | 674 (52.1) | 0.068 | 405 (44.3) | 225 (44.1) | 134 (55.8) | 475 (58.3) | <.0001 |
| Participation year | | | | | | | | | | | |
| 1996 | 169 (6.8) | 33 (7.3) | 43 (7.6) | 10 (5.9) | 83 (6.4) | | 67 (7.3) | 42 (8.2) | 12 (5.0) | 48 (5.9) | |
| 1997 | 201 (8.1) | 46 (10.2) | 48 (8.4) | 11 (6.5) | 96 (7.4) | | 69 (7.5) | 50 (9.8) | 15 (6.3) | 67 (8.2) | |
| 1998 | 224 (9.0) | 29 (6.5) | 61 (10.7) | 16 (9.5) | 118 (9.1) | | 73 (8.0) | 46 (9.0) | 25 (10.4) | 80 (9.8) | |
| 1999 | 270 (10.9) | 52 (11.6) | 53 (9.3) | 26 (15.4) | 139 (10.8) | | 97 (10.6) | 56 (11.0) | 27 (11.3) | 90 (11.0) | |
| 2000 | 263 (10.6) | 61 (13.6) | 60 (10.5) | 19 (11.2) | 123 (9.5) | 0.109 | 103 (11.3) | 56 (11.0) | 28 (11.7) | 76 (9.3) | 0.268 |
| 2001 | 296 (11.9) | 60 (13.4) | 65 (11.4) | 24 (14.2) | 147 (11.4) | | 122 (13.3) | 61 (12.0) | 24 (10.0) | 89 (10.9) | |
| 2002 | 284 (11.5) | 55 (12.2) | 66 (11.6) | 17 (10.1) | 146 (11.3) | | 96 (10.5) | 54 (10.6) | 35 (14.6) | 99 (12.1) | |
| 2003 | 283 (11.4) | 39 (8.7) | 63 (11.1) | 16 (9.5) | 165 (12.8) | | 94 (10.3) | 55 (10.8) | 35 (14.6) | 99 (12.1) | |
| 2004 | 240 (9.7) | 43 (9.6) | 48 (8.4) | 16 (9.5) | 133 (10.3) | | 101 (11.0) | 34 (6.7) | 18 (7.5) | 87 (10.7) | |
| 2005 | 250 (10.1) | 31 (6.9) | 62 (10.9) | 14 (8.3) | 143 (11.1) | | 93 (10.2) | 56 (11.0) | 21 (8.8) | 80 (9.8) | |
| BMI | | | | | | | | | | | |
| <18.5 | 116 (4.7) | 32 (7.1) | 25 (4.4) | 8 (4.7) | 51 (3.9) | | 46 (5.0) | 19 (3.7) | 11 (4.6) | 40 (4.9) | |
| 18.5-25.0 | 1819 (73.3) | 327 (72.8) | 417 (73.3) | 125 (74.0) | 950 (73.5) | 0.209 | 661 (72.2) | 374 (73.3) | 173 (72.1) | 611 (75.0) | 0.710 |
| >25.0 | 545 (22.0) | 90 (20.0) | 127 (22.3) | 36 (21.3) | 292 (22.6) | | 208 (22.7) | 117 (22.9) | 56 (23.3) | 164 (20.1) | |
| Smoking | | | | | | | | | | | |
| Never | 1384 (55.8) | 219 (48.8) | 308 (54.1) | 94 (55.6) | 763 (59.0) | | 462 (50.5) | 266 (52.2) | 138 (57.5) | 518 (63.6) | |
| Former | 678 (27.3) | 134 (29.8) | 166 (29.2) | 40 (23.7) | 338 (26.1) | 0.003 | 244 (26.7) | 151 (29.6) | 63 (26.3) | 220 (27.0) | <.0001 |
| Current | 418 (16.9) | 96 (21.4) | 95 (16.7) | 35 (20.7) | 192 (14.8) | | 209 (22.8) | 93 (18.2) | 39 (16.3) | 77 (9.4) | |

| | | | | | | | | | | | |
|---|-------------|-------------|-------------|-------------|--------------|------------------|-------------|-------------|-------------|-------------|------------------|
| Drinking (current drinker) | 1116 (45.0) | 189 (42.1) | 264 (46.4) | 63 (37.3) | 600 (46.4) | 0.069 | 406 (44.4) | 267 (52.4) | 102 (42.5) | 341 (41.8) | 0.002 |
| Marital status (married) | 2228 (89.8) | 390 (86.9) | 512 (90.0) | 150 (88.8) | 1176 (91.0) | 0.096 | 817 (89.3) | 460 (90.2) | 217 (90.4) | 734 (90.1) | 0.918 |
| Education background | | | | | | | | | | | |
| Junior high school or lower | 765 (30.8) | 170 (37.9) | 178 (31.3) | 59 (34.9) | 358 (27.7) | | 387 (42.3) | 150 (29.4) | 72 (30.0) | 156 (19.1) | |
| High school | 1106 (44.6) | 181 (40.3) | 262 (46.0) | 80 (47.3) | 583 (45.1) | 0.001 | 367 (40.1) | 232 (45.5) | 105 (43.8) | 402 (49.3) | <.0001 |
| College or higher | 609 (24.6) | 98 (21.8) | 129 (22.7) | 30 (17.8) | 352 (27.2) | | 161 (17.6) | 128 (25.1) | 63 (26.3) | 257 (31.5) | |
| Living alone | 94 (3.8) | 23 (5.1) | 22 (3.9) | 7 (4.1) | 42 (3.2) | 0.349 | 31 (3.4) | 17 (3.3) | 8 (3.3) | 38 (4.7) | 0.469 |
| History of chronic disease | 718 (29.0) | 121 (26.9) | 178 (31.3) | 47 (27.8) | 372 (28.8) | 0.474 | 264 (28.9) | 145 (28.4) | 62 (25.8) | 247 (30.3) | 0.586 |
| Competence of daily living | | | | | | | | | | | |
| low | 258 (10.4) | 102 (22.72) | 69 (12.13) | 16 (9.47) | 71 (5.49) | | 145 (15.85) | 58 (11.37) | 16 (6.67) | 39 (4.79) | |
| high | 2222 (89.6) | 347 (77.28) | 500 (87.87) | 153 (90.53) | 1222 (94.51) | <.0001 | 770 (84.15) | 452 (88.63) | 224 (93.33) | 776 (95.21) | <.0001 |
| Depressive symptoms | | | | | | | | | | | |
| not have | 1958 (79.0) | 288 (64.1) | 434 (76.3) | 132 (78.1) | 1104 (85.4) | | 656 (71.7) | 401 (78.6) | 189 (78.8) | 712 (87.4) | |
| have | 522 (21.0) | 161 (35.9) | 135 (23.7) | 37 (21.9) | 189 (14.6) | <.0001 | 259 (28.3) | 109 (21.4) | 51 (21.3) | 103 (12.6) | <.0001 |

Difference among different changes in social activities tested by chi-square test. CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency

continued Table 1 Baseline characteristic of participants who had changes in social activities

| Items | Changes in personal activity | | | | <i>P</i> |
|-----------------------------------|------------------------------|------------|------------|-------------|------------------|
| | CLF | IF | DF | CRF | |
| Number of participants | 335 | 403 | 208 | 1534 | |
| Sex (female) | 128 (38.2) | 158 (39.2) | 110 (52.9) | 843 (55.0) | <.0001 |
| Participation year | | | | | |
| 1996 | 26 (7.8) | 30 (7.4) | 23 (11.1) | 90 (5.9) | |
| 1997 | 35 (10.4) | 36 (8.9) | 9 (4.3) | 121 (7.9) | |
| 1998 | 32 (9.6) | 43 (10.7) | 17 (8.2) | 132 (8.6) | |
| 1999 | 42 (12.5) | 34 (8.4) | 31 (14.9) | 163 (10.6) | |
| 2000 | 40 (11.9) | 33 (8.2) | 25 (12.0) | 165 (10.8) | |
| 2001 | 40 (11.9) | 48 (11.9) | 31 (14.9) | 177 (11.5) | 0.025 |
| 2002 | 27 (8.1) | 46 (11.4) | 19 (9.1) | 192 (12.5) | |
| 2003 | 37 (11.0) | 46 (11.4) | 17 (8.2) | 183 (11.9) | |
| 2004 | 27 (8.1) | 40 (9.9) | 24 (11.5) | 149 (9.7) | |
| 2005 | 29 (8.7) | 47 (11.7) | 12 (5.8) | 162 (10.6) | |
| BMI | | | | | |
| <18.5 | 22 (6.6) | 25 (6.2) | 10 (4.8) | 59 (3.8) | |
| 18.5-25.0 | 249 (74.3) | 281 (69.7) | 151 (72.6) | 1138 (74.2) | 0.131 |
| >25.0 | 64 (19.1) | 97 (24.1) | 47 (22.6) | 337 (22.0) | |
| Smoking | | | | | |
| Never | 156 (46.6) | 179 (44.4) | 116 (55.8) | 933 (60.8) | |
| Former | 85 (25.4) | 145 (36.0) | 47 (22.6) | 401 (26.1) | <.0001 |
| Current | 94 (28.1) | 79 (19.6) | 45 (21.6) | 200 (13.0) | |
| Drinking (current drinker) | 158 (47.2) | 203 (50.4) | 78 (37.5) | 677 (44.1) | 0.020 |
| Marital status (married) | 298 (89.0) | 357 (88.6) | 186 (89.4) | 1387 (90.4) | 0.664 |

| | | | | | |
|-----------------------------------|-------------|-------------|------------|--------------|--------|
| Education background | | | | | |
| Junior high school or lower | 126 (37.6) | 121 (30.0) | 88 (42.3) | 430 (28.0) | |
| High school | 126 (37.6) | 176 (43.7) | 76 (36.5) | 728 (47.5) | <.0001 |
| College or higher | 83 (24.8) | 106 (26.3) | 44 (21.2) | 376 (24.5) | |
| Living alone (Yes) | 15 (4.5) | 11 (2.7) | 9 (4.3) | 59 (3.8) | 0.603 |
| Chronic disease (have) | 102 (30.4) | 111 (27.5) | 66 (31.7) | 439 (28.6) | 0.656 |
| Competence of daily living | | | | | |
| low | 112 (33.43) | 69 (17.12) | 21 (10.1) | 56 (3.65) | |
| high | 223 (66.57) | 334 (82.88) | 187 (89.9) | 1478 (96.35) | <.0001 |
| Depressive symptoms | | | | | |
| not have | 207 (61.8) | 290 (72.0) | 159 (76.4) | 1302 (84.9) | |
| have | 128 (38.2) | 113 (28.0) | 49 (23.6) | 232 (15.1) | <.0001 |

Difference among different changes in social activities tested by chi-square test. CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency

Table 2 Association between changes in social activities and the occurrence of depressive symptoms among participants who did not have depressive symptoms at baseline

| Changes in social activities | Participants without depressive symptoms at baseline (n =1958) | Occurrence of depressive symptoms (n = 246) | Model 1 | Model 2 | Model 3 |
|--------------------------------|--|---|-----------------------|-----------------------|-----------------------|
| | | | RR (95% CI) | RR (95% CI) | RR (95% CI) |
| Social-related activity | | | | | |
| CLF | 232 | 56 (19.4) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| IF | 388 | 46 (10.6) | 0.54 (0.37, 0.77) ** | 0.55 (0.39, 0.80) ** | 0.56 (0.39, 0.80) ** |
| DF | 94 | 38 (28.8) | 1.45 (1.02, 2.07) * | 1.45 (1.02, 2.08) * | 1.56 (1.09, 2.23) * |
| CRF | 998 | 106 (9.6) | 0.48 (0.36, 0.65) *** | 0.51 (0.37, 0.69) *** | 0.55 (0.41, 0.74) *** |
| Learning activity | | | | | |
| CLF | 548 | 108 (16.5) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| IF | 363 | 38 (9.5) | 0.58 (0.41, 0.82) ** | 0.60 (0.43, 0.85) ** | 0.63 (0.45, 0.89) ** |
| DF | 153 | 36 (19.1) | 1.14 (0.81, 1.60) | 1.19 (0.85, 1.68) | 1.24 (0.88, 1.75) |
| CRF | 648 | 64 (9) | 0.53 (0.40, 0.71) *** | 0.58 (0.42, 0.78) ** | 0.62 (0.46, 0.84) ** |
| Personal activity | | | | | |
| CLF | 153 | 54 (26.1) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| IF | 265 | 25 (8.6) | 0.33 (0.21, 0.51) *** | 0.34 (0.22, 0.53) *** | 0.37 (0.24, 0.58) *** |
| DF | 109 | 50 (31.5) | 1.17 (0.84, 1.62) | 1.20 (0.86, 1.66) | 1.32 (0.94, 1.86) |
| CRF | 1185 | 117 (9) | 0.33 (0.25, 0.44) *** | 0.35 (0.26, 0.47) *** | 0.41 (0.30, 0.57) *** |

CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency; RR = relative ratio, CI = confidence interval; Model 1 adjusted for sex and year of participation; Model 2 adjusted for sex, year of participation, smoking, drinking, marital status, education background and living alone; Model 3 adjusted for sex, year of participation, smoking, drinking, marital status, education background, living alone, BMI, history of chronic disease and competence of daily living; *P<0.05, **P<0.01, ***P<0.001

Table 3 Association between changes in combination of multiple social activities and the occurrence/persistence of depressive symptoms

| Changes in combination of multiple social activities | Participants without depressive symptoms at baseline (n =1958) | Occurrence of depressive symptoms (n = 246) | adjusted model | Participants with depressive symptoms at baseline (n = 522) | Persistence of depressive symptoms (n=260) | adjusted model |
|--|--|---|-----------------------|---|--|----------------------|
| | | | RR (95% CI) | | | RR (95% CI) |
| remained in Group A | 66 | 23 (34.8) | 1.00 (ref) | 56 | 38 (67.9) | 1.00 (ref) |
| Group B → Group A | 117 | 17 (14.5) | 1.10 (0.66, 1.83) | 54 | 30 (55.6) | 0.91 (0.61, 1.34) |
| Group C → Group A | 220 | 20 (9.1) | 1.48 (0.82, 2.68) | 42 | 26 (61.9) | 0.61 (0.27, 1.40) |
| Group D → Group A | 494 | 39 (7.9) | 3.02 (1.70, 5.38) ** | 51 | 16 (31.4) | 1.71 (1.21, 2.42) ** |
| Group A → Group B | 75 | 16 (21.3) | 0.74 (0.42, 1.30) | 44 | 21 (47.7) | 0.72 (0.49, 1.05) |
| remained in Group B | 72 | 4 (5.6) | 0.49 (0.28, 0.85) * | 34 | 12 (35.3) | 0.94 (0.68, 1.28) |
| Group C → Group B | 39 | 2 (5.1) | 0.63 (0.35, 1.13) | 11 | 4 (36.4) | 0.93 (0.62, 1.40) |
| Group D → Group B | 174 | 15 (8.6) | 0.80 (0.35, 1.81) | 52 | 26 (50.0) | 1.16 (0.71, 1.9) |
| Group A → Group C | 116 | 10 (8.6) | 0.18 (0.06, 0.48) ** | 43 | 25 (58.1) | 0.60 (0.37, 0.98) * |
| Group B → Group C | 282 | 28 (9.9) | 0.29 (0.16, 0.54) *** | 47 | 14 (29.8) | 0.85 (0.60, 1.19) |
| remained in Group C | 52 | 18 (34.6) | 0.32 (0.19, 0.56) *** | 26 | 15 (57.7) | 1.01 (0.73, 1.39) |
| Group D → Group C | 22 | 10 (45.5) | 0.46 (0.25, 0.83) * | 8 | 3 (37.5) | 0.78 (0.44, 1.40) |
| Group A → Group D | 78 | 14 (17.9) | 0.17 (0.04, 0.69) * | 23 | 13 (56.5) | 0.65 (0.32, 1.34) |
| Group B → Group D | 14 | 10 (71.4) | 0.31 (0.16, 0.62) ** | 3 | 3 (100.0) | 0.97 (0.69, 1.37) |
| Group C → Group D | 26 | 6 (23.1) | 0.38 (0.23, 0.63) ** | 8 | 6 (75.0) | 0.51 (0.31, 0.82) ** |
| remained in Group D | 111 | 14 (12.6) | 0.30 (0.18, 0.49) *** | 20 | 8 (40.0) | 0.60 (0.37, 0.96) * |

RR = relative ratio, CI = confidence interval; Adjusted for sex, year of participation, smoking, drinking, marital status, education background, living alone, BMI, history of chronic disease and competence of daily living; *P<0.05, **P<0.01, ***P<0.001

Table 4 Association between changes in social activities and the persistence of depressive symptoms among participants who have depressive symptoms at baseline

| Changes in social activities | Participants with depressive symptoms at baseline (n = 522) | Persistence of depressive symptoms (n=260) | Model 1 | Model 2 | Model 3 |
|--------------------------------|--|---|----------------------|----------------------|----------------------|
| | | | RR (95% CI) | RR (95% CI) | RR (95% CI) |
| Social-related activity | | | | | |
| CLF | 161 | 89 (55.3) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| IF | 135 | 72 (53.3) | 0.98 (0.80, 1.21) | 0.99 (0.80, 1.23) | 1.05 (0.84, 1.30) |
| DF | 37 | 20 (54.1) | 1.00 (0.72, 1.38) | 0.99 (0.72, 1.38) | 1.05 (0.76, 1.45) |
| CRF | 189 | 79 (41.8) | 0.78 (0.62, 0.97) * | 0.78 (0.63, 0.97) * | 0.84 (0.67, 1.05) |
| Learning activity | | | | | |
| CLF | 259 | 140 (54.1) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| IF | 109 | 45 (41.3) | 0.78 (0.61, 1.00) * | 0.82 (0.64, 1.05) | 0.83 (0.65, 1.07) |
| DF | 51 | 31 (60.8) | 1.20 (0.93, 1.53) | 1.27 (0.99, 1.62) | 1.33 (1.04, 1.70) * |
| CRF | 103 | 44 (42.7) | 0.81 (0.63, 1.03) | 0.88 (0.68, 1.13) | 0.91 (0.71, 1.17) |
| Personal activity | | | | | |
| CLF | 128 | 81 (63.3) | 1.00 (ref) | 1.00 (ref) | 1.00 (ref) |
| IF | 113 | 46 (40.7) | 0.61 (0.47, 0.80) ** | 0.64 (0.49, 0.83) ** | 0.66 (0.50, 0.86) ** |
| DF | 49 | 28 (57.1) | 0.85 (0.65, 1.12) | 0.83 (0.63, 1.09) | 0.88 (0.67, 1.16) |
| CRF | 232 | 105 (45.3) | 0.72 (0.59, 0.87) ** | 0.73 (0.60, 0.89) ** | 0.80 (0.64, 0.99) * |

CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency; RR = relative ratio, CI = confidence interval; Model 1 adjusted for sex and year of participation; Model 2 adjusted for sex, year of participation, smoking, drinking, marital status, education background and living alone; Model 3 adjusted for sex, year of participation, smoking, drinking, marital status, education background, living alone, BMI, history of chronic disease and competence of daily living; *P<0.05, **P<0.01, ***P<0.001