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The Effects of Social Activity Participation and Trust in the Community on the Transition of Frailty Classification in Late-Stage Older Adults: A Four-Year Prospective Cohort Study

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1 The Effects of Social Activity Participation and Trust in the Community on the
2 Transition of Frailty Classification in Late-Stage Older Adults: A Four-Year
3 Prospective Cohort Study

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Abstract

Objectives: In Japan, frailty is a major risk factor for requiring long-term care, especially among older adults aged 75 years or older (i.e., late-stage older adults). Therefore, extending healthy life expectancy and reducing the duration of time spent in nursing care are urgent issues in Japan. Both physical and social factors (e.g., social activities, social support, and trust in the community) are protective factors against frailty. However, few longitudinal studies have examined reversible change or stage improvement in frailty. This study investigated social activity participation and trust in the community that may affect the transition of late-stage older adults' frailty status.

Design: A mail-based survey was used to analyse the improvement or deterioration of frailty status (categorised as frailty, pre-frailty, and robust) over a four-year period. Binomial and multinomial logistic regression analyses were conducted; the transition in frailty classification was the dependent variable, while a change in social activity participation and the degree of trust in the community were the independent variables.

Setting: Ikoma City, Nara Prefecture, Japan.

Participants: 4,249 community-dwelling older adults, aged ≥ 75 years, not requiring long-term care who completed a follow-up questionnaire, from April to May 2016.

Results: Adjusting for confounding factors, no significant social factors were detected regarding improvement in frailty. However, an increase in exercise-based social participation was an improvement factor in the pre-frailty group. Conversely, a decrease in community-based social activity was a risk factor in the deterioration from pre-frailty to frailty. In the robust group, increased community-based social activity was a protective factor against frailty, whereas decreased trust in the community was a risk factor.

Conclusions: These findings suggest that late-stage older adults' participation in social activities hinders the development of frailty. Promoting participation in exercise-based activities is important, especially in the pre-frailty stage.

Trial registration: UMIN, UMIN000025621. Registered 11 Jan 2017.

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Strengths and limitations of this study

- This study considered the effects of changes in late-stage older adults’ participation in social activities and trust in the community on their frailty status.
- Social factors affecting stage transitions in frailty classification over a four-year period are investigated in terms of improvement and deterioration.
- Unlike diseases, frailty does not have a specific date of onset; hence, the exact time a frailty transition occurs is unclear.
- This study’s disease burden adjustment variable was self-reported and not based on physicians’ diagnostic records.

52 BACKGROUND

53 According to a report published by the Japanese Cabinet Office [1], 28.8% of Japan's
54 population was aged ≥ 65 years (13.8% and 14.9% were aged 65–74 and ≥ 75 years,
55 respectively) in 2021. It is estimated that by 2065, the age of approximately 1 in 2.6 and 1 in
56 3.9 individuals in Japan will be ≥ 65 years and ≥ 75 years, respectively. The number of older
57 adults requiring nursing care is increasing because of the ageing population, with a
58 particularly substantial proportion of those aged > 75 years [1]. Additionally, frailty is the
59 leading cause of needing nursing care among older adults aged ≥ 75 years [2]. Therefore,
60 extending healthy life expectancy and shortening the period of nursing care are urgent
61 challenges in Japan, which has the longest life expectancy worldwide [3].

62 The occurrence of frailty adversely affects the future health of older adults [4,5].
63 However, the definition of frailty in Japan was not clearly defined until the Japanese
64 Geriatrics Society published a report in 2014 [6]. In this report, it was defined as 'a condition
65 in which vulnerability to stress increases due to a decline in physiological reserve in old age,
66 which can lead to functional disability, nursing care needs, death and other outcomes.' This
67 concept includes physical problems (e.g. loss of agility due to muscle weakness and the

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tendency to fall), mental and psychological problems (e.g. cognitive dysfunction and depression) and social problems (e.g. living alone and economic deprivation).

There are two main approaches for the evaluation of frailty. First, the ‘disability accumulation model’ [5] evaluates frailty by assessing the accumulation of disabilities, impairments in life functions and diseases associated with ageing. Second, the ‘phenotype model’ [4] considers syndromes that appear owing to the decline in biological functions associated with ageing. In Japan, the latter is predominantly used to evaluate small samples as it requires measuring walking speed and grip strength, and the results are limited to physical frailty. For large-scale surveys, a comprehensive evaluation is often performed using the Ministry of Health, Labour and Welfare’s Kihon checklist (KCL) [7] and includes items such as cognitive function and depression. Additionally, the term ‘frailty’ generally refers to older adults who are at increased risk of becoming eligible for public nursing care insurance services. Increased attention is paid to preventing the need for nursing care (through a seven-level evaluation) or the occurrence of frailty. Such prevention is largely attributed to the economic burden associated with the increasing costs of long-term care insurance services and medical care.

The definition of frailty includes the ability to return to a healthy state [8], and early detection and appropriate intervention are necessary to avoid frailty and maintain and improve life functions. Although numerous studies have investigated the risk and protective factors for frailty, only a few longitudinal studies have monitored the transition of frailty [9–12]. A systematic review of longitudinal studies that tracked changes in the stages of frailty demonstrated that risk factors for frailty include sex, cognitive function, and brain pathology. These findings indicate that physical and socioeconomic factors (e.g. education, poverty and social support) influence frailty [12]. Protective factors that slow the progression of frailty include physical and cultural activities. However, these studies are characterised by variability of the subjects' age and the follow-up period. Moreover, it has been stated that results concerning risk factors and prevalence of frailty depend on the population and setting [13]. In Japan, the risk of falls, fractures, and the need for long-term care is higher among late-stage (≥ 75 years) older adults than among early-stage older adults (age 65–74 years) [14]. Therefore, studies that consider all individuals aged ≥ 65 years as older adults, may underestimate the risk of frailty among late-stage older adults.

In recent years, attention has focused on social frailty as a risk factor for depression, dementia [15], and all-cause mortality [16]. Although the definition of social frailty differs

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101 between studies, there is a consistent understanding that the determination of social frailty
102 includes the lack of social relationships, interactions with others, and social support [17–19].
103 The incidence of social frailty increases significantly in those aged ≥ 75 years [20] and leads
104 to a higher risk of disability incidence, cognitive decline, and physical decline, even after
105 adjusting for physical activity, disease, and medication use [18,20]. The results of these
106 studies suggest that changes in social activities may be an independent influencing factor in
107 the stage transition of frailty; however, these relationships have not been clarified.

108 Previously, we focused on the reversibility of frailty and investigated the social and
109 psychological factors that influence the improvement of frailty in late-stage older adults
110 through a two-year longitudinal study. We found that increased exercise-based social
111 participation and improved self-rated health were independent influencing factors [21]. The
112 present study extended the follow-up period of the late-stage older adults’ cohort to four
113 years, to investigate stage transitions (both improvement and deterioration) of frailty.

114 First, we hypothesised that increased participation in social activities would improve
115 frailty, whereas a decrease would worsen it. Second, we hypothesised that trust in the
116 community, which is related to the risk of requiring long-term care and is a major component
117 of social capital [22], influences changes in frailty status.

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4 118 This study clarifies the effects of changes in the participation of social activities and
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8 119 trust in the community, on the transition of frailty in community-dwelling late-stage older
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17 122 **METHODS**

21 123 **Study population**

24 124 The study included community-dwelling older adults aged ≥ 75 years (i.e., late-stage
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27 125 older adults) in Ikoma City, Nara Prefecture, Japan. At baseline, a postal survey was
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31 126 conducted by the community-based integrated care division of Ikoma City, using the KCL of
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34 127 the Ministry of Health, Labour and Welfare. This approach was used to assess frailty among
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37 128 8,685 late-stage older adults not requiring long-term care (i.e., complete survey), from April
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41 129 to May 2016. A total of 6,517 participants completed the survey (response rate: 75.0%),
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44 130 excluding those who did not follow up and those with missing data. During the follow-up
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47 131 survey (performed from April to May 2020 [median: 48 months]), 567 individuals had been
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51 132 newly identified as requiring long-term care. Given this study's focus on the prevention of
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54 133 the need for nursing care, the individuals newly requiring long-term care services and the
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57 134 1,701 participants who did not respond to the KCL, or were missing (relocation or death)
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135 were excluded. Finally, 4,249 participants completed the KCL (follow-up rate: 70.4%) and
136 were included in the analysis.

137 The study protocol received ethical approval from the Ethics Committee of Kio
138 University (approval number: H28–57). The study was conducted in accordance with the
139 tenets of the Declaration of Helsinki and the Ethical Guidelines for Medical and Biological
140 Research Involving Human Subjects by the Ministry of Health, Labour and Welfare in Japan
141 (2021). The need for informed consent was waived by Kio University’s Institutional Review
142 Board owing to the use of anonymised information that does not identify specific individuals.
143 Data anonymisation was performed by the community-integrated care section of Ikoma City,
144 and the researchers were blinded to participants’ personal data. Data were extracted from the
145 KCL and the long-term care database, which is managed by the community-integrated care
146 section of Ikoma City.

147 **Patient and public involvement**

148 None.

149 **Measures**

150 Dependent variables: comprehensive frailty assessment

KCL is a postal self-administered questionnaire (Supplementary Figure 1), comprising 25 questions with 'yes' or 'no' answers in seven fields (i.e., daily life-related activities, motor functions, nutritional status, oral functions, homebound status, cognitive functions, and depressed mood). It is included in the frailty management guidelines for the Asia-Pacific region, and has been validated according to the Cardiovascular Health Study frailty criteria [23]. Assessment using the KCL score is useful for determining the frailty status of older adults and for predicting the need for support/care through the long-term care insurance system [7,24]. A functional decline in each field is assessed with the following: at least three of five motor function items, both nutritional status items, at least two of three oral function items, homebound status, at least one of three cognitive function items, and at least two of five depressed mood items. For daily life-related activities, a decline in instrumental activities of daily living was defined as any of the five items that corresponded to any of three instrumental activities of daily living items (i.e., using trains and buses, shopping and withdrawing/depositing money).

According to previous research, the classification of frailty is based on the number of checked items from 25 questions: 0–3 for robust, 4–7 for pre-frailty, and ≥ 8 for frailty [25]. The transition of frailty and change in the frailty status between the baseline and follow-up

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168 surveys were compared. Changes were categorised as ‘maintenance’, ‘improvement’ and
169 ‘deterioration’. As frailty classification is a categorical variable, an increase or decrease in
170 the number of functional declines during the follow-up period was considered ‘maintenance’
171 if the change remained in the same stage. Additionally, as this study focuses on dynamic
172 changes in frailty status, maintenance of each status (i.e., remaining robust or remaining frail)
173 was considered a reference category. In the robust and frailty groups, in some cases, the
174 transition category changed in two steps (e.g., from robust to frailty, or frailty to robust), but
175 no weighting was used in the analysis in the present study.

176 Independent variables: assessment of social participation activity and trust in the community

177 Social participation activities were further categorised into community-based
178 activities, exercise-based activities, hobbies, and volunteer/non-profit organisation activities,
179 respectively. Community activities included participation in senior citizen clubs, residents’
180 associations and older adult salons. Exercise-based activities referred to regular participation
181 in gymnastics classes, ground golf (Japanese style golf suitable for older adults), and
182 Japanese croquet, among others. Hobby activities included non-exercise activities (e.g.,
183 handicrafts, gardening and board games), while volunteer/non-profit organisation activities
184 included community-cleaning activities and counselling neighbouring residents.

In the questionnaire, respondents were asked to record all the above social activities in which they regularly participated (regardless of the frequency of the activity). For changes in their participation in social activities, we focused on changes in the participation status at baseline and follow-up. For example, those with no exercise-based social activity at baseline but were participating at follow-up were defined as increasing, and vice versa. Those who were inactive or remained active at both time points, were considered maintenance. The degree of interaction with neighbours was rated using a 4-point scale [26], where the following sentences were utilised: 4) 'I talk and cooperate in terms of life with other people', 3) 'I have a daily standing conversation with at least one other person', 2) 'I only socialise by greeting others', and 1) 'I have no interaction with neighbours'. A higher score indicated a closer interaction. The level of trust in the community (i.e., 'people in your neighbourhood can be trusted') was assessed using a 5-point scale [27]. Answer options were: 5 = 'agree', 4 = 'partially agree', 3 = 'neither agree nor disagree', 2 = 'partially disagree', or 1 = 'disagree'. A higher score indicated deeper trust.

Covariates

Sociodemographic characteristics (e.g., age, sex, living alone, etc.), the number of chronic diseases (e.g., hypertension, sequelae of stroke, heart disease, diabetes mellitus,

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depression, respiratory disease, arthropathy with pain and dental disease, etc.) and self-rated health were assessed as covariates. The number of chronic diseases of each participant was defined as the disease burden. Self-rated health was assessed using a 5-point scale, as previously described [28].

Statistical analysis

At baseline, between-group comparisons of participant characteristics were performed based on frailty classification. One-way analysis of variance was used for comparing continuous variables, and Fisher’s least significant difference was utilised for multiple comparison tests. To compare nominal variables, the χ^2 test and residual analysis were used. Adjusted residual values >1.96 and <-1.96 denoted significantly more and fewer participants than expected, respectively.

Next, we analysed the change in frailty classification from baseline to follow-up, defining those without change as ‘maintenance’, those with improvement as ‘improvement’ and those with progressive frailty as ‘deterioration’. Changes from baseline social activity participation and trust in the community were classified accordingly: maintenance (or no change), improvement and deterioration, respectively.

Subsequently, according to the frailty classification at baseline, the data set was divided into three data subsets: robust group (n = 2,121), pre-frailty group (n = 1,228) and frailty group (n = 900). We identified the social activity participation or trust in the community that influenced the change in frailty status during the study period. Accordingly, we conducted a binomial logistic regression analysis. For individuals classified into the robust group at baseline, the change to pre-frailty or frailty (i.e., deterioration) was the dependent variable. For individuals classified into the frailty group at baseline, an improvement from frailty was the objective variable. For individuals classified into the pre-frailty group at baseline, multinomial logistic regression analysis, with the maintenance of pre-frailty as the reference category, was conducted to identify factors that influenced both the improvement and deterioration in frailty status.

In all regression analyses, age, sex, disease burden, self-rated health and living alone were used as adjustment variables, and the forced imputation method was utilised to select the independent variables. SPSS software (version 26.0; IBM Corp., Armonk, NY, USA) was used to perform statistical analysis.

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234 RESULTS

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Figure 1 shows the transition in frailty classification over a four-year period. At follow-up, 583 (13.7%) and 154 (3.6%) participants exhibited a progression of frailty by one and two levels from robust at baseline, respectively. Of those classified into the pre-frailty group at baseline, 263 participants (6.1%) exhibited a progression of frailty by one level, and 263 participants (6.2%) improved to robust. Among those classified into the frailty group at baseline, 117 (2.8%) and 34 (0.8%) participants showed one and two levels of improvement, respectively. In summary, a total of 414 participants (9.7%) improved during the four-year observation period, whereas 1,072 participants (25.2%) showed a progression of frailty (more than two-fold higher rate).

Table 1 shows the characteristics of participants at baseline and the results of the participants according to the degree of frailty. A comparison of basic characteristics between the groups showed that participants included in the frailty group were older, had a higher proportion of females, and had more comorbidities. Additionally, the frailty group showed poorer results than the other groups, regarding all psychological and social assessment items, except for the number of individuals living alone (See Table 1).

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Table 1. Participant characteristics and frailty classification at baseline survey

Items	All (n = 4,249)	Robust (n = 2,121)	Pre-frailty (n = 1,228)	Frailty (n = 900)	P	Between-group difference
Age, y (SD)	78.5 (2.8)	78.2 (2.7)	78.9 (2.9)	79.3 (2.9)	<0.001	Frail>Pre-frail>Robust
Sex: female, n (%)	2,074 (48.8)	1,157 (45.2)	599 (53.2)	318 (56.6)	<0.001	Frail>Pre-frail>Robust
Disease burden (SD)	1.5 (0.7)	1.4 (0.7)	1.6 (0.8)	1.8 (0.9)	<0.001	Frail>Pre-frail>Robust
Living alone, n (%)	632 (14.9)	374 (14.6)	166 (14.7)	92 (16.4)	0.561	n.s.
IADL decline, n (%) †	138 (3.2)	104 (4.1)	149 (13.4)	141 (28.1)	<0.001	Frail>Pre-frail>Robust
Motor dysfunction, n (%) †	585 (13.8)	44 (1.7)	234 (20.8)	307 (54.6)	<0.001	Frail>Pre-frail>Robust
Malnutrition, n (%) †	77 (1.8)	15 (0.6)	28 (2.5)	34 (6.0)	<0.001	Frail>Pre-frail>Robust
Oral dysfunction, n (%) †	705 (16.6)	106 (4.1)	297 (26.4)	302 (53.7)	<0.001	Frail>Pre-frail>Robust
Homebound, n (%) †	194 (4.6)	32 (1.2)	49 (4.4)	113 (20.1)	<0.001	Frail>Robust
Cognitive decline, n (%) †	1,222 (28.8)	374 (14.6)	465 (41.3)	383 (61.8)	<0.001	Frail>Pre-frail>Robust
Depressive mood, n (%) †	882 (20.8)	73 (2.9)	360 (32.0)	449 (79.9)	<0.001	Frail>Pre-frail>Robust
History of falls, n (%) †	669 (15.7)	201 (7.9)	261 (23.3)	207 (37.0)	<0.001	Frail>Pre-frail>Robust
Fear of falling, n (%) †	1677 (39.5)	565 (22.4)	663 (59.5)	449 (80.9)	<0.001	Frail>Pre-frail>Robust
Self-rated health (SD)	3.6 (1.0)	3.8 (0.9)	3.3 (0.8)	2.8 (0.8)	<0.001	Robust>Pre-frail>Frail
Number of social activity (SD)	0.9 (1.0)	1.0 (1.0)	0.8 (0.9)	0.5 (0.7)	<0.001	Robust>Pre-frail>Frail
Interaction with neighbours (SD)	1.9 (0.8)	2.0 (0.7)	1.8 (0.8)	1.6 (0.8)	<0.001	Robust>Pre-frail>Frail

Trust in the community (SD)	3.1 (0.7)	3.2 (0.6)	3.0 (0.7)	2.9 (0.7)	<0.001	Robust>Pre-frail>Frail
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†Based on Kihon Checklist (KCL) sub-score of each area. ‡Frailty identification: Out of KCL 25 items, 0–3 for robust, 4–7 for pre-frailty, and >8 for frailty. Categorical variables were analysed by χ^2 -test (with residual test), and continuous variables were analysed by one-way ANOVA (with post-hoc LSD test). SD: standard deviation; n.s.: not significant.

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252 In the frailty group at baseline, binomial logistic regression analysis after adjustment
253 for age, gender, disease burden, self-rated health and living alone showed a trend toward
254 increased exercise-based social participation contributing to an improvement in frailty, but
255 there were no statistically significant factors contributing to this result (See Table 2). The
256 results of the multinomial logistic regression analysis for the pre-frailty group at baseline
257 showed that increased exercise-based social participation [odds ratio (OR) = 2.43), 95%
258 confidence interval (CI) = 1.08–5.45] influenced stage improvement. In contrast, decreased
259 community-based social participation (OR = 0.46, 95% CI = 0.22–0.93) was identified as a
260 risk factor (See Table 3). For stage deterioration, no significant factors were determined in
261 the pre-frailty group. For those classified into the robust group at baseline, trust in the
262 community was recognised as a significant factor for both the increase and decrease in
263 categories. Notably, the decrease in trust was more influential (increase in trust, OR = 1.38,
264 95% CI: 1.00–1.90; decrease in trust, OR = 1.87, 95% CI: 1.38–2.52; Table 4).

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Table 2. Transition factors for participants categorised frailty at baseline (n=900)

Items	Unadjusted		Multivariate*	
	OR (95% CI)	P	OR (95% CI)	P
Exercise-based social activity (no change)	Ref		Ref	
Increased	1.67 (0.73-3.81)	0.224	2.26 (0.66-7.79)	0.196
Decreased	0.78 (0.25-2.45)	0.675	0.68 (0.16-2.86)	0.601
Hobby-based social activity (no change)	Ref		Ref	
Increased	1.26 (0.54-2.93)	0.588	1.25 (0.35-4.44)	0.734
Decreased	0.48 (0.19-1.20)	0.117	0.70 (0.19-2.48)	0.578
Community-based social activity (no change)	Ref		Ref	0.439
Increased	1.08 (0.49-2.37)	0.851	0.62 (0.23-1.69)	0.350
Decreased	0.70 (0.32-1.53)	0.376	0.58 (0.18-1.92)	0.375
Interaction with neighbours (no change)	Ref		Ref	
Increased	0.93 (0.55-1.58)	0.934	0.96 (0.44-2.07)	0.916
Decreased	0.73 (0.41-1.28)	0.269	0.62 (0.26-1.45)	0.252
Trust in the community (no change)	Ref		Ref	
Increased	1.21 (0.72-2.02)	0.475	0.78 (0.36-1.69)	0.532
Decreased	1.45 (0.84-2.50)	0.177	1.73 (0.72-4.17)	0.218

Note: Binomial logistic regression analysis (dependent variable = improvement from frailty). Reference category indicates no change (or maintained). *Adjusted for sex, age, disease burden, self-rated health and living alone. Ref: reference; NPO: non-profit organisation; OR: odds ratio; 95% CI: 95% confidence interval. Nagelkerke R²=0.201

Table 3. Transition factors for participants categorised pre-frailty at baseline (n = 1,228)

Items	Model 1: Improvement				Model 2: Deterioration			
	Unadjusted		Multivariate*		Unadjusted		Multivariate*	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Exercise-based social activity (no change)	Ref		Ref		Ref		Ref	
Increased	1.38 (0.73-2.59)	0.311	2.43 (1.08-5.45)	0.030	0.99 (0.50-1.98)	0.990	1.06 (0.40-2.83)	0.905
Decreased	0.88 (0.48-1.62)	0.695	1.05 (0.47-2.35)	0.895	1.02 (0.58-1.76)	0.948	1.61 (0.79-3.28)	0.195
Hobby-based social activity (no change)	Ref		Ref		Ref		Ref	
Increased	1.80 (0.97-3.32)	0.061	1.38 (0.63-3.03)	0.410	0.86 (0.43-1.72)	0.678	0.53 (0.19-1.45)	0.213
Decreased	0.83 (0.49-1.39)	0.478	0.85 (0.43-1.69)	0.661	0.71 (0.44-1.17)	0.185	0.80 (0.40-1.60)	0.521
Community-based social activity (no change)	Ref		Ref		Ref		Ref	
Increased	1.40 (0.80-2.43)	0.234	1.19 (0.59-2.40)	0.623	0.61 (0.31-1.18)	0.143	0.66 (0.28-1.55)	0.338
Decreased	0.99 (0.60-1.65)	0.998	0.46 (0.22-0.93)	0.032	1.02 (0.63-1.52)	0.94	0.75 (0.39-1.44)	0.385
Volunteer/NPO activity (no change)	Ref		Ref		Ref		Ref	
Increased	2.30 (0.96-5.48)	0.060	1.93 (0.64-5.84)	0.240	1.57 (0.62-3.97)	0.337	0.95 (0.23-3.93)	0.948
Decreased	1.47 (0.70-1.12)	0.305	1.44 (0.55-3.77)	0.454	1.73 (0.83-3.59)	0.143	1.63 (0.63-4.23)	0.314
Interaction with neighbours (no change)	Ref		Ref		Ref		Ref	
Increased	0.96 (0.65-1.43)	0.856	0.68 (0.40-1.16)	0.161	0.83 (0.56-1.25)	0.385	0.64 (0.37-1.13)	0.126

Decreased	0.67 (0.42-1.05)	0.081	0.57 (0.32-1.01)	0.054	1.53 (1.06-2.19)	0.022	0.97 (0.59-1.62)	0.916
Trust in the community (no change)	Ref		Ref		Ref		Ref	
Increased	1.1 (0.70-1.65)	0.709	1.34 (0.76-2.36)	0.305	1.43 (0.97-2.11)	0.066	1.37 (0.79-2.40)	0.266
Decreased	1.1 (0.73-1.63)	0.659	1.03 (0.60-1.78)	0.892	0.92 (0.63-1.36)	0.700	0.94 (0.55-1.62)	0.835

Note: Multinomial logistic regression analysis (dependent variable = transition from pre-frailty). Reference category indicates no change (or maintain). *Adjusted for sex, age, disease burden, self-rated health and living alone. Ref: reference; OR: odds ratio; 95% CI: 95% confidence interval. Nagelkerke R² = 0.148

Table 4. Transition factors for participants categorised robust at baseline (n = 2,121)

Items	Unadjusted		Multivariate*	
	OR (95% CI)	P	OR (95% CI)	P
Exercise-based social activity (no change)	Ref		Ref	0.672
Increased	0.92 (0.64-1.33)	0.680	1.20 (0.77-1.84)	0.410
Decreased	1.11 (0.79-1.54)	0.531	0.94 (0.59-1.48)	0.778
Hobby-based social activity (no change)	Ref		Ref	0.881
Increased	0.81 (0.56-1.15)	0.246	1.10 (0.75-1.59)	0.616
Decreased	0.98 (0.74-1.31)	0.926	1.00 (0.65-1.53)	0.989
Community-based social activity (no change)	Ref		Ref	0.020
Increased	0.55 (0.37-0.81)	0.003	0.49 (0.28-0.81)	0.006
Decreased	0.97 (0.73-1.28)	0.926	1.07 (0.75-1.51)	0.714
Volunteer/NPO activity (no change)	Ref		Ref	0.132
Increased	0.48 (0.28-0.84)	0.011	0.87 (0.52-1.43)	0.574
Decreased	0.91 (0.61-1.35)	0.664	0.49 (0.24-1.00)	0.050
Interaction with neighbours (no change)	Ref		Ref	0.760
Increased	1.05 (0.81-1.35)	0.697	1.10 (0.81-1.47)	0.553
Decreased	1.39 (1.11-1.74)	0.004	1.10 (0.78-1.53)	0.582
Trust in the community (no change)	Ref		Ref	0.000
Increased	1.44 (1.12-1.83)	0.003	1.38 (1.00-1.90)	0.049
Decreased	1.61 (1.27-2.02)	0.000	1.87 (1.38-5.52)	0.000

Note: Binomial logistic regression analysis (dependent variable = deterioration from robust). Reference category indicates no change (or maintained). *Adjusted for sex, age, disease burden, self-rated health and living alone. Ref: reference; NPO: non-profit organisation; OR: odds ratio; 95% CI: 95% confidence interval. Nagelkerke $R^2=0.10$

DISCUSSION

In this study, we investigated transitions in frailty classification and factors affecting the improvement or deterioration at each stage, in a four-year cohort study of late-stage older adults not requiring nursing care. The largest proportion of stage changes in frailty classification was recorded among those who were healthy at baseline and maintained a healthy status for four years. The second most common transition was a one-stage deterioration from robust to pre-frailty status, which was greater than the number of individuals who maintained the pre-frailty status at follow-up. This may reflect changes in physical functions caused by natural ageing over the four-year study period. Nevertheless, very few of those classified into the frailty group at baseline improved to the pre-frailty or robust status at follow-up (2.8% and 0.8%, respectively). Gill et al. [29] studied 754 community-dwelling older adults aged ≥ 70 years, over a period of three years. They reported that the progression of frailty was more common ($\leq 43.3\%$) than the transition to milder frailty ($\leq 23.0\%$), and the rate of transition from a frail status to a non-frail status was very low (0–0.9%). Although our study included a

larger scale and longer follow-up period than the previous study, the results of the two investigations are consistent.

In another study of 551 community-dwelling older adults in Japan [30], changes in frailty status were investigated over a five-year period. According to the data, 21.4% of participants reported that their frailty status deteriorated, whereas 10.3% reported an improvement. In this study, the transition rate was 25.2% for the progression of frailty and 9.7% for the improvement by at least one stage. These rates were slightly lower than those reported in the aforementioned study. This difference may be because the previous study included early-stage older adults (i.e., aged ≥ 65 years). Other studies that focused on the transition of frailty also differed in terms of age group, follow-up period, and the method for diagnosing frailty. This variability in research methodology complicates the direct comparison of the present transition rates with those reported in the literature [10,31–36].

In this study, we hypothesised that changes in social activity participation and trust in the community significantly influence frailty classification. Consequently, stage improvement over the four-year study period was rare among those classified into the

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6 frailty group at baseline. Moreover, no significant social factors contributing to the
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10 improvement of frailty were detected in the frailty group at baseline. An increase in
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13 exercise-based social activity participation was an expected factor for improvement.
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16 Nevertheless, this study did not identify any social activities as significant independent
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19 factors. Except for interventional studies [37], few studies have investigated factors that
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22 improve frailty. Abe et al. [31] reported that agriculture, intellectual activity, and social
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25 participation were factors associated with an improvement in frailty status; however,
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28 only frailty and non-frailty categories were used in their study, and the ages of
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31 participants differed. The fact that no significant improvement factors were detected in
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34 our study may be owing to the small number of participants who improved from frailty.
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40 For those classified into the pre-frailty group at baseline, there was a transition
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43 to an improvement or deterioration, with increased exercise-based social participation
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46 identified as a factor causing the improvement. This supports the findings of numerous
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49 studies demonstrating that physical activity is a protective/improvement factor against
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52 frailty [11,30,36,38]. In contrast, a decrease in community-based social activity was
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identified as a risk factor. Changes in participation in social activities may, therefore, play an important role in stage improvement for individuals with a pre-frailty status.

For those classified into the robust group at baseline, a decreased trust in the community was identified as an independent factor for deterioration to the pre-frail or frail status. An increase in trust in neighbours was also adopted as an influencing factor, and this indicator may be associated with both positive and negative effects. A decreased trust in neighbours may result from relocation or bereavement of friends, among others, and is linked to a risk of social isolation. Conversely, the fact that an increase in trust was also recognised as a negative factor in this study may be related to increased dependence on neighbours in daily activities. However, it is difficult to draw conclusions based on the data of this study.

Limitations

This study has a few limitations. First, it focused on changes in endpoints and frailty during the observation period; therefore, we did not examine factors related to the maintenance of physical function. For late-stage older adults, maintaining a healthy state for four years or preventing deterioration in a frail state cannot be underestimated,

and future analyses should include an analysis of maintenance at each state. Second, unlike diseases, frailty does not have a specific date of onset; hence, the exact time when the actual transition occurs is unclear. Therefore, the transition may have recurred multiple times during the four-year period. Third, the disease burden adjustment variable in this study was self-reported; thus, the type and number of comorbidities were not based on the physicians' diagnostic records. Finally, the results of the mail survey used in this study, in which many relatively health-conscious individuals responded, may have been influenced by selection bias.

As the sample size decreases with the extension of the follow-up period, we plan to continue the study as a long-term longitudinal study, supplementing the number of participants through a dynamic cohort approach involving multiple periods of observation.

CONCLUSION

This study followed late-stage older adults for four years, to identify social activity influencing the transition in frailty classification. Consequently, no increase or

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6 decrease in any social activity was adopted as a significant influencing factor in those
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10 who were determined to be in the frail category at baseline. For those classified in the
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13 pre-frailty group, increasing exercise-based social participation may improve their
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16 condition. In the robust group, increasing social community-based social activity and
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19 trust in the community were identified as protective factors against frailty. These
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22 findings suggest that social participation activities among late-stage older adults are
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25 protective against the development of frailty and that it is especially important to
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28 encourage exercise-related social participation during the pre-frailty stage.
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36 **Data availability statement**

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39 The datasets used and/or analysed during the current study are available from the
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43 corresponding author on reasonable request.
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53 public, commercial, or not-for-profit sectors.
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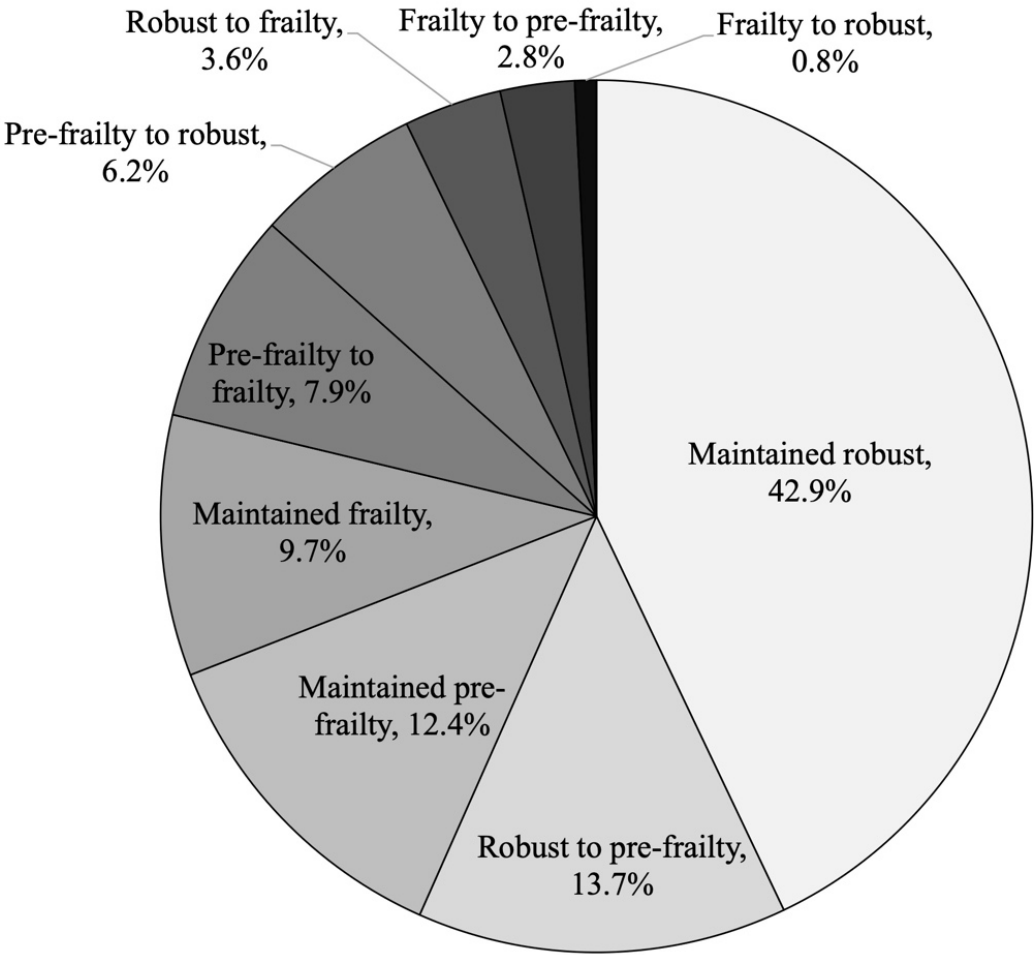


Figure 1

Figure legends

Four-year transition of frailty classification (n=4,249).

No.	Questions	Answer	
1	Do you go out by bus or train by yourself?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
2	Do you go shopping to buy daily necessities by yourself?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
3	Do you manage your own deposits and savings at the bank?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
4	Do you sometimes visit your friends?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
5	Do you turn to your family or friends for advice?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
6	Do you normally climb stairs without using handrail or wall for support?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
7	Do you normally stand up from a chair without any aids?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
8	Do you normally walk continuously for 15 minutes?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
9	Have you experienced a fall in the past year?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
10	Do you have a fear of falling while walking?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
11	Have you lost 2 kg or more in the past 6 months?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
12	Height: cm, weight: kg, BMI: kg/m ² . If BMI is less than 18.5, this item is scored.	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
13	Do you have any difficulties eating tough foods compared to 6 months ago?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
14	Have you choked on your tea or soup recently?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
15	Do you often experience having a dry mouth?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
16	Do you go out at least once a week?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
17	Do you go out less frequently compared to last year?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
18	Do your family or your friends point out your memory loss? e.g. "You ask the same question over and over again."	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
19	Do you make a call by looking up phone numbers?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
20	Do you find yourself not knowing today's date?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
21	In the last 2 weeks have you felt a lack of fulfilment in your daily life?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
22	In the last 2 weeks have you felt a lack of joy when doing the things you used to enjoy?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
23	In the last 2 weeks have you felt difficulty in doing what you could do easily before?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
24	In the last 2 weeks have you felt helpless?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
25	In the last 2 weeks have you felt tired without a reason?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO

Working Group on Frailty in Japanese Geriatrics Society. BMI, body mass index.

Arai H, Satake S. English translation of the Kihon Checklist. *Geriatr Gerontol Int*. 2015 Apr;15(4):518-519.

Supplemental Figure 1. English version of the Kihon Checklist

1058x793mm (72 x 72 DPI)

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	9
		(b) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-14
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9-10
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-14
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	14
		(b) Describe any methods used to examine subgroups and interactions	14-15
		(c) Explain how missing data were addressed	9
		(d) If applicable, explain how loss to follow-up was addressed	10
		(e) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9-10
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	16
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) Summarise follow-up time (eg, average and total amount)	9
Outcome data	15*	Report numbers of outcome events or summary measures over time	10-14

1	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16-17
2			(b) Report category boundaries when continuous variables were categorized	11
3			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	17
4	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	16
5	Discussion			
6	Key results	18	Summarise key results with reference to study objectives	19
7	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19-20
8	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20-21
9	Generalisability	21	Discuss the generalisability (external validity) of the study results	21
10	Other information			
11	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a

*Give information separately for exposed and unexposed groups.

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

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The Effects of Social Activity Participation and Trust in the Community on the Transition of Frailty Classification in Late-Stage Older Adults: A Four-Year Prospective Cohort Study

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1 The Effects of Social Activity Participation and Trust in the Community on the
2 Transition of Frailty Classification in Late-Stage Older Adults: A Four-Year
3 Prospective Cohort Study

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Abstract

Objectives: In Japan, frailty is a major risk factor for requiring long-term care, especially among older adults aged 75 years or older (i.e., late-stage older adults). Both physical and social factors (e.g., social activities, social support, and community trust) are protective factors against frailty. However, few longitudinal studies have examined reversible change or stage improvement in frailty. This study investigated social activity participation and trust in the community that may affect the transition of late-stage older adults' frailty status.

Design: A mail-based survey was used to analyse the improvement or deterioration of frailty status (categorised as frailty, pre-frailty, and robust) over a four-year period. Binomial and multinomial logistic regression analyses were conducted; the transition in frailty classification was the dependent variable, while a change in social activity participation and the degree of trust in the community were the independent variables.

Setting: Ikoma City, Nara Prefecture, Japan

Participants: 4,249 community-dwelling older adults, aged ≥ 75 years, not requiring long-term care who completed a follow-up questionnaire from April to May 2016

Results: Adjusting for confounding factors, no significant social factors were detected regarding improvement in frailty. However, an increase in exercise-based social participation

32 was an improvement factor in the pre-frailty group (OR (95% CI) 2.43 (1.08 to 5.45)).

33 Conversely, a decrease in community-based social activity was a risk factor in the

34 deterioration from pre-frailty to frailty (OR (95% CI) 0.46 (0.22 to 0.93)). In the robust

35 group, increased community-based social activity (OR (95% CI) 1.38(1.00 to 1.90)) was a

36 protective factor against frailty, whereas decreased community trust was a risk factor (OR

37 (95% CI) 1.87 (1.38 to 2.52)).

38 **Conclusions:** No social factors had a significant influence on the improvement of frailty in

39 late-stage older adults. However, promotion of exercise-based social participation was found

40 to be important for improvement in the pre-frailty state.

41 **Trial registration:** UMIN, UMIN000025621. Registered 11 Jan 2017.

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Strengths and limitations of this study

- This is a four-year longitudinal study that followed changes in frailty status among late-stage older adults living in the community.
- This study focuses on changes in social participation activities at baseline as well as at follow-up.
- Social factors affecting stage transitions in frailty classification over a four-year period are investigated in terms of improvement and deterioration.
- Unlike diseases, frailty does not have a specific date of onset; hence, the exact time a frailty transition occurs is unclear.
- This study’s disease burden adjustment variable was self-reported and not based on physicians’ diagnostic records.

60 BACKGROUND

61 According to a report published by the Japanese Cabinet Office [1], 28.8% of Japan's
62 population was aged ≥ 65 years (13.8% and 14.9% were aged 65–74 and ≥ 75 years,
63 respectively) in 2021. It is estimated that by 2065, the age of approximately 1 in 2.6 and 1 in
64 3.9 individuals in Japan will be ≥ 65 years and ≥ 75 years, respectively. The number of older
65 adults requiring nursing care is increasing because of the ageing population, with a
66 particularly substantial proportion of those aged > 75 years [1]. Additionally, frailty is the
67 leading cause of needing nursing care among older adults aged ≥ 75 years [2]. Therefore,
68 extending healthy life expectancy and shortening the period of nursing care are urgent
69 challenges in Japan, which has the longest life expectancy worldwide [3].

70 The occurrence of frailty adversely affects the future health of older adults [4,5].
71 However, the definition of frailty in Japan was not clearly defined until the Japanese
72 Geriatrics Society published a report in 2014 [6]. In this report, it was defined as 'a condition
73 in which vulnerability to stress increases due to a decline in physiological reserve in old age,
74 which can lead to functional disability, nursing care needs, death and other outcomes.' This
75 concept includes physical problems (e.g. loss of agility due to muscle weakness and the

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tendency to fall), mental and psychological problems (e.g. cognitive dysfunction and depression) and social problems (e.g. living alone and economic deprivation).

There are two main approaches for the evaluation of frailty. First, the ‘disability accumulation model’ [5] evaluates frailty by assessing the accumulation of disabilities, impairments in life functions and diseases associated with ageing. Second, the ‘phenotype model’ [4] considers syndromes that appear owing to the decline in biological functions associated with ageing. In Japan, the latter is predominantly used to evaluate small samples as it requires measuring walking speed and grip strength, and the results are limited to physical frailty. For large-scale surveys, a comprehensive evaluation is often performed using the Ministry of Health, Labour and Welfare’s Kihon checklist (KCL) [7] and includes items such as cognitive function and depression. Additionally, the term ‘frailty’ generally refers to older adults who are at increased risk of becoming eligible for public nursing care insurance services. Increased attention is paid to preventing the need for nursing care (through a seven-level evaluation) or the occurrence of frailty. Such prevention is largely attributed to the economic burden associated with the increasing costs of long-term care insurance services and medical care.

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4 92 The definition of frailty includes the ability to return to a healthy state [8], and early
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11 94 improve life functions. Although numerous studies have investigated the risk and protective
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14 95 factors for frailty, only a few longitudinal studies have monitored the transition of frailty [9–
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17 96 12]. A systematic review of longitudinal studies that tracked changes in the stages of frailty
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21 97 demonstrated that risk factors for frailty include sex, cognitive function, and brain pathology.
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24 98 These findings indicate that physical and socioeconomic factors (e.g. education, poverty and
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27 99 social support) influence frailty [12]. Protective factors that slow the progression of frailty
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31 100 include physical and cultural activities. However, these studies are characterised by
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34 101 variability of the subjects' age and the follow-up period. Moreover, it has been stated that
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38 102 results concerning risk factors and prevalence of frailty depend on the population and setting
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41 103 [13]. In Japan, the risk of falls, fractures, and the need for long-term care is higher among
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44 104 late-stage (≥ 75 years) older adults than among early-stage older adults (age 65–74 years)
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48 105 [14]. Therefore, studies that consider all individuals aged ≥ 65 years as older adults, may
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51 106 underestimate the risk of frailty among late-stage older adults.

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54 107 In recent years, attention has focused on social frailty as a risk factor for depression,
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58 108 dementia [15], and all-cause mortality [16]. Although the definition of social frailty differs
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109 between studies, there is a consistent understanding that the determination of social frailty
110 includes the lack of social relationships, interactions with others, and social support [17–19].
111 The incidence of social frailty increases significantly in those aged ≥ 75 years [20] and leads
112 to a higher risk of disability incidence, cognitive decline, and physical decline, even after
113 adjusting for physical activity, disease, and medication use [18,20]. The results of these
114 studies suggest that changes in social participation activities may be an independent
115 influencing factor in the stage transition of frailty; however, these relationships have not been
116 clarified. Social participation can be defined as a person's involvement in activities providing
117 interactions with others in community life and in important shared spaces, evolving according
118 to available time and resources [21]. Examples of social activity, also known as social
119 participation or engagement, may include meeting friends, attending events or functions, and
120 volunteering or participating in occupational duties or group recreational activities [22].

121 Previously, we focused on the reversibility of frailty and investigated the social and
122 psychological factors that influence the improvement of frailty in late-stage older adults
123 through a two-year longitudinal study. We found that increased exercise-based social
124 participation and improved self-rated health were independent influencing factors [23]. The

present study extended the follow-up period of the late-stage older adults' cohort to four years, to investigate stage transitions (both improvement and deterioration) of frailty.

First, we hypothesised that increased participation in social activities would improve frailty, whereas a decrease would worsen it. Second, we hypothesised that trust in the community, which is related to the risk of requiring long-term care and is a major component of social capital [24], influences changes in frailty status. This is because trust in the community has been reported to be related to various diseases and health behaviours [25]. A cohort study in Japan also reported that a decrease in trust in the community increases the risk of requiring long-term care [26].

This study clarifies the effects of changes in the participation of social activities and trust in the community, on the transition of frailty in community-dwelling late-stage older adults.

METHODS

Study design and population

The study included community-dwelling older adults aged ≥ 75 years (i.e., late-stage older adults) in Ikoma City, Nara Prefecture, Japan. At baseline, a postal survey was

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conducted by the community-based integrated care division of Ikoma City, using the KCL of the Ministry of Health, Labour and Welfare. This approach was used to assess frailty among 8,685 late-stage older adults not requiring long-term care (i.e., complete survey), from April to May 2016. A total of 6,517 participants completed the survey (response rate: 75.0%), excluding those who did not follow up and those with missing data. During the follow-up survey (performed from April to May 2020 [median: 48 months]), 567 individuals had been newly identified as requiring long-term care. Given this study’s focus on the prevention of the need for nursing care, the individuals newly requiring long-term care services and the 1,701 participants who did not respond to the KCL, or were missing (relocation or death) were excluded. Finally, 4,249 participants completed the KCL (follow-up rate: 70.4%) and were included in the analysis.

The study protocol received ethical approval from the Ethics Committee of Kio University (approval number: H28–57). The study was conducted in accordance with the tenets of the Declaration of Helsinki and the Ethical Guidelines for Medical and Biological Research Involving Human Subjects by the Ministry of Health, Labour and Welfare in Japan (2021). The need for informed consent was waived by Kio University’s Institutional Review Board owing to the use of anonymised information that does not identify specific individuals.

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4 159 Data anonymisation was performed by the community-integrated care section of Ikoma City,
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8 160 and the researchers were blinded to participants' personal data. Data were extracted from the
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11 161 KCL and the long-term care database, which is managed by the community-integrated care
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17 163 **Patient and public involvement**

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22 23 24 165 **Measures**

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27 166 Dependent variables: comprehensive frailty assessment

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31 167 KCL is a postal self-administered questionnaire (Supplementary Figure 1), comprising
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34 168 25 questions with 'yes' or 'no' answers in seven fields (i.e., daily life-related activities, motor
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37 169 functions, nutritional status, oral functions, homebound status, cognitive functions, and
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41 170 depressed mood). It is included in the frailty management guidelines for the Asia-Pacific
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44 171 region [27] and has been validated according to the Cardiovascular Health Study frailty
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47 172 criteria [7]. Assessment using the KCL score is useful for determining the frailty status of
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51 173 older adults and for predicting the need for support/care through the long-term care insurance
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54 174 system [7,28]. A functional decline in each field is assessed with the following: at least three
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58 175 of five motor function items (Supplemental Figure 1: Nos. 6-10), both nutritional status items
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(Supplemental Figure 1: Nos. 11-12), at least two of three oral function items (Supplemental Figure 1: Nos. 13-15), homebound status (Supplemental Figure 1: Nos. 16-17), at least one of three cognitive function items (Supplemental Figure 1: Nos. 18-20), and at least two of five depressed mood items (Supplemental Figure 1: Nos. 21-25). For daily life-related activities, a decline in instrumental activities of daily living was defined as any of the five items (Supplemental Figure 1: Nos. 1-5) that corresponded to any of three instrumental activities of daily living items (i.e., using trains and buses, shopping and withdrawing/depositing money).

According to previous research, the classification of frailty is based on the number of checked items from 25 questions: 0–3 for robust, 4–7 for pre-frailty, and ≥ 8 for frailty [29].

The transition of frailty and change in the frailty status between the baseline and follow-up surveys were compared. Changes were categorised as ‘maintenance’, ‘improvement’ and ‘deterioration’. As frailty classification is a categorical variable, an increase or decrease in the number of functional declines during the follow-up period was considered ‘maintenance’ if the change remained in the same stage. Additionally, as this study focuses on dynamic changes in frailty status, maintenance of each status (i.e., remaining robust or remaining frail) was considered a reference category. In the robust and frailty groups, in some cases, the

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4 192 transition category changed in two steps (e.g., from robust to frailty, or frailty to robust), but
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8 193 no weighting was used in the analysis in the present study.
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11 194 Independent variables: assessment of social participation activity and trust in the community
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14 195 Social participation activities were categorised into community-based activities,
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17 196 exercise-based activities, hobbies, and volunteer/non-profit organisation activities,
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20 197 respectively. Community activities included participation in senior citizen clubs, residents'
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26 199 in gymnastics classes, ground golf (Japanese style golf suitable for older adults), and
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29 200 Japanese croquet, among others. Hobby activities included non-exercise activities (e.g.,
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32 201 handicrafts, gardening and board games), while volunteer/non-profit organisation activities
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35 202 included community-cleaning activities and counselling neighbouring residents.
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41 203 In the questionnaire, respondents were asked to record all the above social activities
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44 204 in which they were currently participating regularly (regardless of the frequency of the
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47 205 activity) (Supplemental Figure 2). For changes in their participation in social activities, we
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50 206 focused on changes in the participation status at baseline and follow-up. For example, those
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53 207 with no exercise-based social activity at baseline but were participating at follow-up were
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56 208 defined as increasing, and vice versa. Those who were inactive or remained active at both
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time points, were considered maintenance. The degree of interaction with neighbours was rated using a 4-point scale [30], where the following sentences were utilised: 4) ‘I talk and cooperate in terms of life with other people’, 3) ‘I have a daily standing conversation with at least one other person’, 2) ‘I only socialise by greeting others’, and 1) ‘I have no interaction with neighbours’. A higher score indicated a closer interaction. The level of trust in the community (i.e., ‘people in your neighbourhood can be trusted’) was assessed using a 5-point scale [31]. Answer options were: 5 = ‘agree’, 4 = ‘partially agree’, 3 = ‘neither agree nor disagree’, 2 = ‘partially disagree’, or 1 = ‘disagree’. A higher score indicated deeper trust.

Covariates

Sociodemographic characteristics (e.g., age, sex, living alone, etc.), the number of chronic diseases (e.g., hypertension, sequelae of stroke, heart disease, diabetes mellitus, depression, respiratory disease, arthropathy with pain and dental disease, etc.) and self-rated health were assessed as covariates. These evaluation items were included in the mailed questionnaire. The number of chronic diseases of each participant was defined as the disease burden. Self-rated health was assessed using a 5-point scale, as previously described [32].

Statistical analysis

At baseline, between-group comparisons of participant characteristics were performed based on frailty classification. One-way analysis of variance was used for comparing continuous variables, and Fisher's least significant difference was utilised for multiple comparison tests. To compare nominal variables, the χ^2 test and residual analysis were used. Adjusted residual values >1.96 and <-1.96 denoted significantly more and fewer participants than expected, respectively.

Next, we analysed the change in frailty classification from baseline to follow-up, defining those without change as 'maintenance', those with improvement as 'improvement' and those with progressive frailty as 'deterioration'. Changes from baseline social activity participation and trust in the community were classified accordingly: maintenance (or no change), improvement and deterioration, respectively.

Subsequently, according to the frailty classification at baseline, the data set was divided into three data subsets: robust group ($n = 2,121$), pre-frailty group ($n = 1,228$) and frailty group ($n = 900$). We identified the social activity participation or trust in the community that influenced the change in frailty status during the study period. Accordingly, we conducted a binomial logistic regression analysis. For individuals classified into the robust group at baseline, the change to pre-frailty or frailty (i.e., deterioration) was the

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242 dependent variable. For individuals classified into the frailty group at baseline, an
243 improvement from frailty was the objective variable. For individuals classified into the pre-
244 frailty group at baseline, multinomial logistic regression analysis, with the maintenance of
245 pre-frailty as the reference category, was conducted to identify factors that influenced both
246 the improvement and deterioration in frailty status.

247 In all regression analyses, age, sex, disease burden, self-rated health and living alone
248 were used as adjustment variables, and the forced imputation method was utilised to select
249 the independent variables. SPSS software (version 26.0; IBM Corp., Armonk, NY, USA) was
250 used to perform statistical analysis.

251
252 **RESULTS**

253 **Frailty classification transition**

254 Figure 1 shows the transition in frailty classification over a four-year period. At
255 follow-up, 583 (13.7%) and 154 (3.6%) participants exhibited a progression of frailty by one
256 and two levels from robust at baseline, respectively. Of those classified into the pre-frailty
257 group at baseline, 335 participants (7.9%) exhibited a progression of frailty by one level, and
258 263 participants (6.2%) improved to robust. Among those classified into the frailty group at

baseline, 117 (2.8%) and 34 (0.8%) participants showed one and two levels of improvement, respectively. In summary, a total of 414 participants (9.7%) improved during the four-year observation period, whereas 1,072 participants (25.2%) showed a progression of frailty (more than two-fold higher rate).

Table 1 shows the characteristics of participants at baseline and the results of the participants according to the degree of frailty. A comparison of basic characteristics between the groups showed that participants included in the frailty group were older, had a higher proportion of females, and had more comorbidities. Additionally, the frailty group showed poorer results than the other groups, regarding all psychological and social assessment items, except for the number of individuals living alone (See Table 1).

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Table 1. Participant characteristics and frailty classification at baseline survey

Items	All (n = 4,249)	Robust (n = 2,121)	Pre-frailty (n = 1,228)	Frailty (n = 900)	P	Between-group difference
Age, y (SD)	78.5 (2.8)	78.2 (2.7)	78.9 (2.9)	79.3 (2.9)	<0.001	Frail>Pre-frail>Robust
Sex: female, n (%)	2,074 (48.8)	1,157 (45.2)	599 (53.2)	318 (56.6)	<0.001	Frail>Pre-frail>Robust
Disease burden (SD)	1.5 (0.7)	1.4 (0.7)	1.6 (0.8)	1.8 (0.9)	<0.001	Frail>Pre-frail>Robust
Living alone, n (%)	632 (14.9)	374 (14.6)	166 (14.7)	92 (16.4)	0.561	n.s.
IADL decline, n (%) †	138 (3.2)	104 (4.1)	149 (13.4)	141 (28.1)	<0.001	Frail>Pre-frail>Robust
Motor dysfunction, n (%) †	585 (13.8)	44 (1.7)	234 (20.8)	307 (54.6)	<0.001	Frail>Pre-frail>Robust
Malnutrition, n (%) †	77 (1.8)	15 (0.6)	28 (2.5)	34 (6.0)	<0.001	Frail>Pre-frail>Robust
Oral dysfunction, n (%) †	705 (16.6)	106 (4.1)	297 (26.4)	302 (53.7)	<0.001	Frail>Pre-frail>Robust
Homebound, n (%) †	194 (4.6)	32 (1.2)	49 (4.4)	113 (20.1)	<0.001	Frail>Robust
Cognitive decline, n (%) †	1,222 (28.8)	374 (14.6)	465 (41.3)	383 (61.8)	<0.001	Frail>Pre-frail>Robust
Depressive mood, n (%) †	882 (20.8)	73 (2.9)	360 (32.0)	449 (79.9)	<0.001	Frail>Pre-frail>Robust
History of falls, n (%) †	669 (15.7)	201 (7.9)	261 (23.3)	207 (37.0)	<0.001	Frail>Pre-frail>Robust
Fear of falling, n (%) †	1677 (39.5)	565 (22.4)	663 (59.5)	449 (80.9)	<0.001	Frail>Pre-frail>Robust
Self-rated health (SD)	3.6 (1.0)	3.8 (0.9)	3.3 (0.8)	2.8 (0.8)	<0.001	Robust>Pre-frail>Frail
Number of social activity (SD)	0.9 (1.0)	1.0 (1.0)	0.8 (0.9)	0.5 (0.7)	<0.001	Robust>Pre-frail>Frail
Interaction with neighbours (SD)	1.9 (0.8)	2.0 (0.7)	1.8 (0.8)	1.6 (0.8)	<0.001	Robust>Pre-frail>Frail

Trust in the community (SD)	3.1 (0.7)	3.2 (0.6)	3.0 (0.7)	2.9 (0.7)	<0.001	Robust>Pre-frail>Frail
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†Based on Kihon Checklist (KCL) sub-score of each area. ‡Frailty identification: Out of KCL 25 items, 0–3 for robust, 4–7 for pre-frailty, and >8 for frailty. Categorical variables were analysed by χ^2 -test (with residual test), and continuous variables were analysed by one-way ANOVA (with post-hoc LSD test). SD: standard deviation; n.s.: not significant.

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Influencing factors from frailty or pre-frailty status at baseline

In the frailty group at baseline, binomial logistic regression analysis after adjustment for age, gender, disease burden, self-rated health and living alone showed a trend toward increased exercise-based social participation contributing to an improvement in frailty, but there were no statistically significant factors contributing to this result (See Table 2). The results of the multinomial logistic regression analysis for the pre-frailty group at baseline showed that increased exercise-based social participation [odds ratio (OR) = 2.43), 95% confidence interval (CI) = 1.08–5.45] influenced stage improvement. In contrast, decreased community-based social participation (OR = 0.46, 95% CI = 0.22–0.93) was identified as a risk factor (See Table 3). For stage deterioration, no significant factors were determined in the pre-frailty group.

Influencing factors from robust status at baseline

For those classified into the robust group at baseline, trust in the community was recognised as a significant factor for both the increase and decrease in categories. Notably, the decrease in trust was more influential (increase in trust, OR =1.38, 95% CI: 1.00–1.90; decrease in trust, OR = 1.87, 95% CI: 1.38–2.52; Table 4).

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Table 2. Transition factors for participants categorised frailty at baseline (n=900)

Items	Unadjusted		Multivariate*	
	OR (95% CI)	P	OR (95% CI)	P
Exercise-based social activity (no change)	Ref		Ref	
Increased	1.67 (0.73-3.81)	0.224	2.26 (0.66-7.79)	0.196
Decreased	0.78 (0.25-2.45)	0.675	0.68 (0.16-2.86)	0.601
Hobby-based social activity (no change)	Ref		Ref	
Increased	1.26 (0.54-2.93)	0.588	1.25 (0.35-4.44)	0.734
Decreased	0.48 (0.19-1.20)	0.117	0.70 (0.19-2.48)	0.578
Community-based social activity (no change)	Ref		Ref	0.439
Increased	1.08 (0.49-2.37)	0.851	0.62 (0.23-1.69)	0.350
Decreased	0.70 (0.32-1.53)	0.376	0.58 (0.18-1.92)	0.375
Interaction with neighbours (no change)	Ref		Ref	
Increased	0.93 (0.55-1.58)	0.934	0.96 (0.44-2.07)	0.916
Decreased	0.73 (0.41-1.28)	0.269	0.62 (0.26-1.45)	0.252
Trust in the community (no change)	Ref		Ref	
Increased	1.21 (0.72-2.02)	0.475	0.78 (0.36-1.69)	0.532
Decreased	1.45 (0.84-2.50)	0.177	1.73 (0.72-4.17)	0.218

Note: Binomial logistic regression analysis (dependent variable = improvement from frailty). Reference category indicates no change (or maintained). *Adjusted for sex, age, disease burden, self-rated health and living alone. Ref: reference; NPO: non-profit organisation; OR: odds ratio; 95% CI: 95% confidence interval. Nagelkerke $R^2=0.201$

Table 3. Transition factors for participants categorised pre-frailty at baseline (n = 1,228)

	Model 1: Improvement				Model 2: Deterioration			
	Unadjusted		Multivariate*		Unadjusted		Multivariate*	
Items	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Exercise-based social activity (no change)	Ref		Ref		Ref		Ref	
Increased	1.38 (0.73-2.59)	0.311	2.43 (1.08-5.45)	0.030	0.99 (0.50-1.98)	0.990	1.06 (0.40-2.83)	0.905
Decreased	0.88 (0.48-1.62)	0.695	1.05 (0.47-2.35)	0.895	1.02 (0.58-1.76)	0.948	1.61 (0.79-3.28)	0.195
Hobby-based social activity (no change)	Ref		Ref		Ref		Ref	
Increased	1.80 (0.97-3.32)	0.061	1.38 (0.63-3.03)	0.410	0.86 (0.43-1.72)	0.678	0.53 (0.19-1.45)	0.213
Decreased	0.83 (0.49-1.39)	0.478	0.85 (0.43-1.69)	0.661	0.71 (0.44-1.17)	0.185	0.80 (0.40-1.60)	0.521
Community-based social activity (no change)	Ref		Ref		Ref		Ref	
Increased	1.40 (0.80-2.43)	0.234	1.19 (0.59-2.40)	0.623	0.61 (0.31-1.18)	0.143	0.66 (0.28-1.55)	0.338
Decreased	0.99 (0.60-1.65)	0.998	0.46 (0.22-0.93)	0.032	1.02 (0.63-1.52)	0.94	0.75 (0.39-1.44)	0.385
Volunteer/NPO activity (no change)	Ref		Ref		Ref		Ref	
Increased	2.30 (0.96-5.48)	0.060	1.93 (0.64-5.84)	0.240	1.57 (0.62-3.97)	0.337	0.95 (0.23-3.93)	0.948
Decreased	1.47 (0.70-1.12)	0.305	1.44 (0.55-3.77)	0.454	1.73 (0.83-3.59)	0.143	1.63 (0.63-4.23)	0.314
Interaction with neighbours (no change)	Ref		Ref		Ref		Ref	

Increased	0.96 (0.65-1.43)	0.856	0.68 (0.40-1.16)	0.161	0.83 (0.56-1.25)	0.385	0.64 (0.37-1.13)	0.126
Decreased	0.67 (0.42-1.05)	0.081	0.57 (0.32-1.01)	0.054	1.53 (1.06-2.19)	0.022	0.97 (0.59-1.62)	0.916
Trust in the community (no change)	Ref		Ref		Ref		Ref	
Increased	1.1 (0.70-1.65)	0.709	1.34 (0.76-2.36)	0.305	1.43 (0.97-2.11)	0.066	1.37 (0.79-2.40)	0.266
Decreased	1.1 (0.73-1.63)	0.659	1.03 (0.60-1.78)	0.892	0.92 (0.63-1.36)	0.700	0.94 (0.55-1.62)	0.835
Note: Multinomial logistic regression analysis (dependent variable = transition from pre-frailty). Reference category indicates no change (or maintain). *Adjusted for sex, age, disease burden, self-rated health and living alone. Ref: reference; OR: odds ratio; 95% CI: 95% confidence interval. Nagelkerke R ² = 0.148								

Table 4. Transition factors for participants categorised robust at baseline (n = 2,121)				
	Unadjusted		Multivariate*	
Items	OR (95% CI)	P	OR (95% CI)	P
Exercise-based social activity (no change)	Ref		Ref	0.672
Increased	0.92 (0.64-1.33)	0.680	1.20 (0.77-1.84)	0.410
Decreased	1.11 (0.79-1.54)	0.531	0.94 (0.59-1.48)	0.778
Hobby-based social activity (no change)	Ref		Ref	0.881
Increased	0.81 (0.56-1.15)	0.246	1.10 (0.75-1.59)	0.616
Decreased	0.98 (0.74-1.31)	0.926	1.00 (0.65-1.53)	0.989
Community-based social activity (no change)	Ref		Ref	0.020
Increased	0.55 (0.37-0.81)	0.003	0.49 (0.28-0.81)	0.006
Decreased	0.97 (0.73-1.28)	0.926	1.07 (0.75-1.51)	0.714
Volunteer/NPO activity (no change)	Ref		Ref	0.132
Increased	0.48 (0.28-0.84)	0.011	0.87 (0.52-1.43)	0.574
Decreased	0.91 (0.61-1.35)	0.664	0.49 (0.24-1.00)	0.050
Interaction with neighbours (no change)	Ref		Ref	0.760
Increased	1.05 (0.81-1.35)	0.697	1.10 (0.81-1.47)	0.553
Decreased	1.39 (1.11-1.74)	0.004	1.10 (0.78-1.53)	0.582
Trust in the community (no change)	Ref		Ref	0.000
Increased	1.44 (1.12-1.83)	0.003	1.38 (1.00-1.90)	0.049
Decreased	1.61 (1.27-2.02)	0.000	1.87 (1.38-5.52)	0.000
Note: Binomial logistic regression analysis (dependent variable = deterioration from robust). Reference category indicates no change (or maintained). *Adjusted for sex, age, disease burden, self-rated health and living alone. Ref: reference; NPO: non-profit organisation; OR: odds ratio; 95% CI: 95% confidence interval. Nagelkerke R ² =0.10				

DISCUSSION

Frailty transition

In this study, we investigated transitions in frailty classification and factors affecting the improvement or deterioration at each stage, in a four-year cohort study of late-stage older adults not requiring nursing care. The largest proportion of stage changes in frailty classification was recorded among those who were healthy at baseline and maintained a healthy status for four years. The second most common transition was a one-stage deterioration from robust to pre-frailty status, which was greater than the number of individuals who maintained the pre-frailty status at follow-up. This may reflect changes in physical functions caused by natural ageing over the four-year study period. Nevertheless, very few of those classified into the frailty group at baseline improved to the pre-frailty or robust status at follow-up (2.8% and 0.8%, respectively). Gill et al. [33] studied 754 community-dwelling older adults aged ≥ 70 years, over a period of three years. They reported that the progression of frailty was more common ($\leq 43.3\%$) than the transition to milder frailty ($\leq 23.0\%$), and the rate of transition from a frail status to a non-frail status was very low (0–0.9%). Although our study included a

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307 larger scale and longer follow-up period than the previous study, the results of the two
308 investigations are consistent.

309 In another study of 551 community-dwelling older adults in Japan [34], changes
310 in frailty status were investigated over a five-year period. According to the data, 21.4%
311 of participants reported that their frailty status deteriorated, whereas 10.3% reported an
312 improvement. In this study, the transition rate was 25.2% for the progression of frailty
313 and 9.7% for the improvement by at least one stage. These rates were slightly lower
314 than those reported in the aforementioned study. This difference may be because the
315 previous study included early-stage older adults (i.e., aged ≥ 65 years). Other studies that
316 focused on the transition of frailty also differed in terms of age group, follow-up period,
317 and the method for diagnosing frailty. This variability in research methodology
318 complicates the direct comparison of the present transition rates with those reported in
319 the literature [10,35–40].

320 **Factors for frailty transition**

321 In this study, we hypothesised that changes in social activity participation and
322 trust in the community significantly influence frailty classification. Consequently, stage

improvement over the four-year study period was rare among those classified into the frailty group at baseline. Moreover, no significant social factors contributing to the improvement of frailty were detected in the frailty group at baseline. An increase in exercise-based social activity participation was an expected factor for improvement. Nevertheless, this study did not identify any social activities as significant independent factors. Except for interventional studies [41], few studies have investigated factors that improve frailty. Abe et al. [35] reported that agriculture, intellectual activity, and social participation were factors associated with an improvement in frailty status; however, only frailty and non-frailty categories were used in their study, and the ages of participants differed. The fact that no significant improvement factors were detected in our study may be owing to the small number of participants who improved from frailty.

For those classified into the pre-frailty group at baseline, there was a transition to an improvement or deterioration, with increased exercise-based social participation identified as a factor causing the improvement. This supports the findings of numerous studies demonstrating that physical activity is a protective/improvement factor against frailty [11,34,40,42]. In addition, the Asia-Pacific Clinical Practice Guidelines for the

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339 Management of Frailty strongly recommend physical activity, including elements of
340 resistance training, for the prevention of sarcopenia-related muscle wastage and
341 mobility loss in the oldest old and older adults with frailty [27]. Moreover, many of the
342 exercise-based activity classes in the target areas of this study were followed by a
343 social time such as a tea party, suggesting that it is important for exercise-related social
344 participation to include elements of social interaction. In contrast, a decrease in
345 community-based social activity was identified as a risk factor. Changes in participation
346 in social activities may, therefore, play an important role in stage improvement for
347 individuals with a pre-frailty status.

348 For those classified into the robust group at baseline, a decreased trust in the
349 community was identified as an independent factor for deterioration to the pre-frail or
350 frail status. An increase in trust in neighbours was also adopted as an influencing factor,
351 and this indicator may be associated with both positive and negative effects. A
352 decreased trust in neighbours may result from relocation or bereavement of friends,
353 among others, and is linked to a risk of social isolation. Conversely, the fact that an
354 increase in trust was also recognised as a negative factor in this study may be related to

355 increased dependence on neighbours in daily activities. However, it is difficult to draw
356 conclusions based on the data of this study.

357 **Limitations**

358 This study has a few limitations. First, it focused on changes in endpoints and
359 frailty during the observation period; therefore, we did not examine factors related to
360 the maintenance of physical function. For late-stage older adults, maintaining a healthy
361 state for four years or preventing deterioration in a frail state cannot be underestimated,
362 and future analyses should include an analysis of maintenance at each state. Second, the
363 assessment of all social participation activities used in this study has not been tested for
364 reliability and validity since the questions were originally designed. Third, unlike
365 diseases, frailty does not have a specific date of onset; hence, the exact time when the
366 actual transition occurs is unclear. Therefore, the transition may have recurred multiple
367 times during the four-year period. Fourth, the disease burden adjustment variable in this
368 study was self-reported; thus, the type and number of comorbidities were not based on
369 the physicians' diagnostic records. Finally, the results of the mail survey used in this

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study, in which many relatively health-conscious individuals responded, may have been influenced by selection bias.

As the sample size decreases with the extension of the follow-up period, we plan to continue the study as a long-term longitudinal study, supplementing the number of participants through a dynamic cohort approach involving multiple periods of observation.

CONCLUSION

This study followed late-stage older adults for four years, to identify social activity influencing the transition in frailty classification. Consequently, no increase or decrease in any social activity was adopted as a significant influencing factor in those who were determined to be in the frail category at baseline. For those classified in the pre-frailty group, increasing exercise-based social participation may improve their condition. In the robust group, increasing social community-based social activity and trust in the community were identified as protective factors against frailty. These findings suggest that social participation activities among late-stage older adults are

386 protective against the development of frailty and that it is especially important to

387 encourage exercise-related social participation during the pre-frailty stage.

388 Although social participation activities are particularly important to prevent
389 social isolation among the elderly, the results of this study suggest that social exchange
390 and hobby-related social participation alone may not be sufficient for preventing frailty.
391 In addition, since the issue of transportation support for the elderly is also important for
392 social participation activities, local governments need to support the creation of ‘places
393 for social interaction that include an element of exercise’ that are accessible to the
394 elderly on foot.

395

396 **Data availability statement**

397 The datasets used and/or analysed during the current study are available from the
398 corresponding author on reasonable request.

399 **Competing interests:** The authors declare that they have no competing interests.

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402 Contributors: KT contributed to the conceptualisation, methodology, software, formal
403 analysis, and writing of the original draft. DM contributed to the methodology and data
404 curation. All authors approved the final manuscript.

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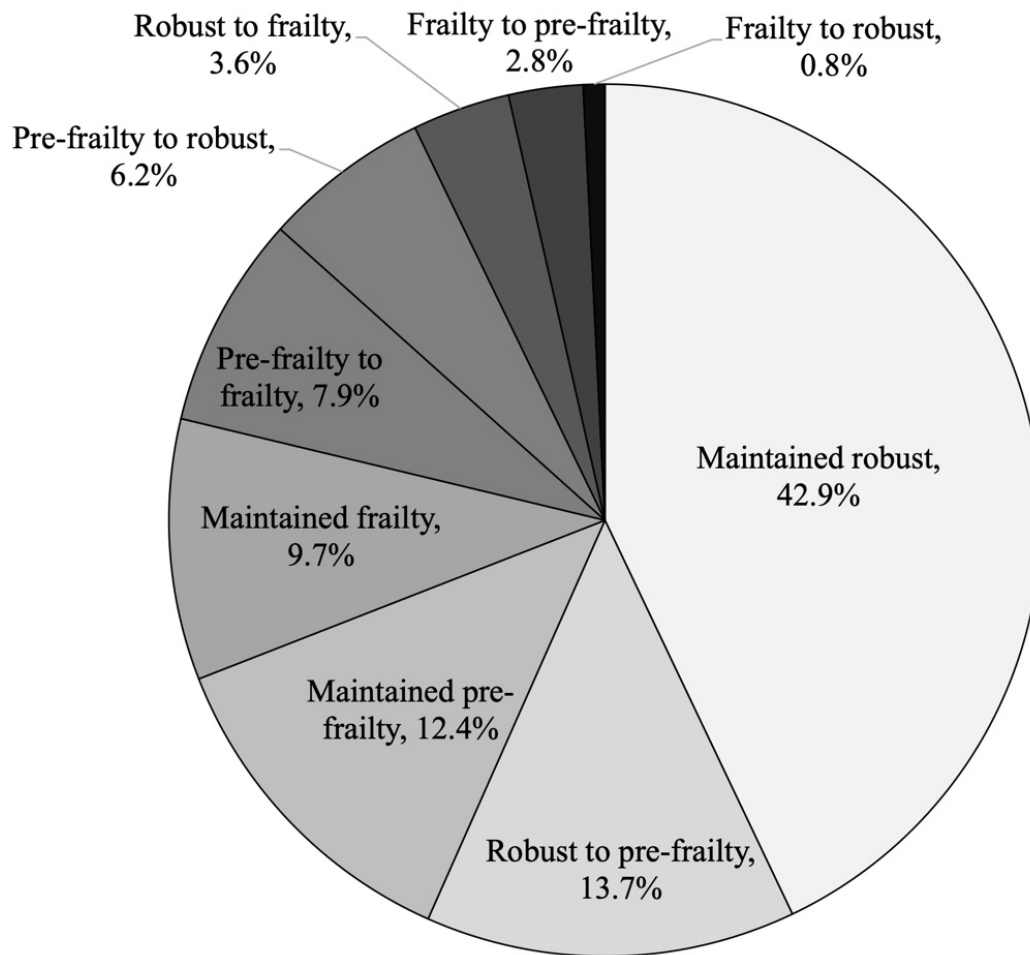


Figure 1

Figure legends

Four-year transition of frailty classification (n=4,249).

Domain	No.	Questions	Answer	
Daily life	1	Do you go out by bus or train by yourself?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	2	Do you go shopping to buy daily necessities by yourself?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	3	Do you manage your own deposits and savings at the bank?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	4	Do you sometimes visit your friends?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	5	Do you turn to your family or friends for advice?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
Physical function	6	Do you normally climb stairs without using handrail or wall for support?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	7	Do you normally stand up from a chair without any aids?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	8	Do you normally walk continuously for 15 minutes?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	9	Have you experienced a fall in the past year?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	10	Do you have a fear of falling while walking?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
Nutrition	11	Have you lost 2kg or more in the past 6 months?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	12	Height: cm, Weight: kg, BMI: kg/m ² If BMI is less than 18.5, this item is	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
Oral function	13	Do you have any difficulties eating tough foods compared to 6 months ago?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	14	Have you choked on your tea or soup recently?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	15	Do you often experience having a dry mouth?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
Homebound	16	Do you go out at least once a week?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	17	Do you go out less frequently compared to last year?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
Cognitive function	18	Do your family or your friends point out your memory loss? e.g."You ask the same question over and over again."	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	19	Do you make a call by looking up phone numbers?	<input type="checkbox"/> 0. YES	<input type="checkbox"/> 1. NO
	20	Do you find yourself not knowing today's date?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
Depression	21	In the last 2 weeks have you felt a lack of fulfillment in your daily life?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	22	In the last 2 weeks have you felt a lack of joy when doing the things you used to enjoy?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	23	In the last 2 weeks have you felt difficulty in doing what you could do easily before?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	24	In the last 2 weeks have you felt helpless?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO
	25	In the last 2 weeks have you felt tired without a reason?	<input type="checkbox"/> 1. YES	<input type="checkbox"/> 0. NO

Working group on Frailty in Japanese Geriatric Society
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Questionnaire on Social Participation Activities

1. Social Participation Activities

Q1: Do you currently participate in any of the following activities in your community?

- ① Community-based social activity (neighbourhood association, club for the elderly, exchange salon, etc.)
- ② Exercise-based social activity (gymnastics classes, ground golf, etc.)
- ③ Hobby activities (handicrafts, gardening, board games, etc.)
- ④ Volunteer/non-profit organisation activities (community-cleaning activities and counselling neighbouring residents, etc.)
- ⑤ Not participating.

2. Interaction with Neighbours¹

Q2: How do you socialize with your neighbors?

- ① I talk and cooperate in terms of life with other people.
- ② I have a daily standing conversation with at least one other person.
- ③ I only socialize by greeting others.
- ④ I have no interaction with neighbours.

3. Trust in the Community

Q3. Do you think trusting relationships with neighbors are important in your daily life?

- ① Agree.
- ② Partially agree.
- ③ Neither agree nor disagree.
- ④ Disagree.

-
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Supplemental Figure 2. Questionnaire on Social Participation Activities.

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	9
		(b) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-14
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9-10
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10-14
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	14
		(b) Describe any methods used to examine subgroups and interactions	14-15
		(c) Explain how missing data were addressed	9
		(d) If applicable, explain how loss to follow-up was addressed	10
		(e) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	9-10
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	16
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) Summarise follow-up time (eg, average and total amount)	9
Outcome data	15*	Report numbers of outcome events or summary measures over time	10-14

Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	16-17 11 17
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	16
Discussion			
Key results	18	Summarise key results with reference to study objectives	19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	19-20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20-21
Generalisability	21	Discuss the generalisability (external validity) of the study results	21
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a

*Give information separately for exposed and unexposed groups.

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