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Community social capital and the onset of functional disability among older adults in Japan: A multilevel longitudinal study using Japan Gerontological Evaluation Study (JAGES) data

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Manuscripts

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7 1 **Community social capital and the onset of functional disability among older adults in**
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9 2 **Japan: A multilevel longitudinal study using Japan Gerontological Evaluation Study**
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12 3 **(JAGES) data**
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18 5 Taiji Noguchi¹, Katsunori Kondo^{2,3}, Masashige Saito⁴, Hiroko Nakagawa-Senda¹, Sadao
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24 25 **Abstract (256 words)**

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27 26 **Objective:**

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30 27 The present study examined the association between community social capital and the
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33 28 onset of functional disability among older Japanese people by using validated indicators
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36 29 of social capital and a prospective multilevel analysis design.

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39 30 **Design:**

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42 31 Prospective cohort study

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45 32 **Setting:**

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48 33 We utilized data from the Japan Gerontological Evaluation Study (JAGES), established
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51 34 from August 2010 to January 2012 in 323 districts.

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54 35 **Participants:**

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57 36 The target population was restricted to non-institutionalized people aged 65 years or
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6 37 older who were independent in activities of daily living. Participants included 73,021
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9 38 people (34,051 men and 38,970 women) who were followed up over a 3-year period.

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12 39 **Primary outcome measure:**

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15 40 The primary outcome measure was the onset of functional disability, defined as a new
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18 41 registration in public long-term care insurance (LTCI) system records with a care-needs
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21 42 level of two or above, analysed with multilevel Cox proportional hazards regression
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24 43 models by community social capital (civic participation, social cohesion, and reciprocity).

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27 44 **Results:**

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30 45 The mean age of participants was 73.3 years (SD = 6.0) for men and 73.8 years (SD =
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33 46 6.2) for women. During the study period, the onset of functional disability occurred in
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36 47 1465 (4.3%) men and 1519 (3.9%) women. Of three community social capital variables,
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39 48 social cohesion significantly reduced the risk of onset of functional disability (hazard
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42 49 ratio = 0.910; 95% CI: 0.830–0.998) among men, after adjusting for individual social and
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45 50 behavioral variables. There was no significant effect among women.

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48 51 **Conclusions:**

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51 52 Living in a community with rich social cohesion is associated with a lower incidence of
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54 53 onset of functional disability among older Japanese men.

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55 **Strengths and limitations of this study**

- 56 · This is the first prospective cohort study to examine the association between
57 community social capital and the onset of functional disability among older people,
58 by a large, nationwide population-based Japanese sample.
- 59 · To measure community social capital, an indicator consisting of validated
60 multidimensional items was used, and we assessed these components of community
61 social capital (civic participation, social cohesion, and reciprocity).
- 62 · Multilevel survival analysis was used to examine community contextual
63 characteristics for the onset of functional disability.
- 64 · More than 73,000 people aged 65 years or older participated and were followed up for
65 3 years period.
- 66 · While this study was a large sample size, the measurements were self-reported data.

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68 **Word count: 3,023 words**

70 **INTRODUCTION**

71 In almost every country, the proportion of older people is growing at an increasing
72 rate,[1] and Japan has displayed the fastest growth. In 2012, 32% of the Japanese

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6 73 population was aged over 60 years, and this is expected to rise to 42% by 2050.[2] Age-
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9 74 related functional disability, defined as difficulty performing activities of daily living, is
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12 75 a very important public health issue worldwide.[3, 4] Because functional disability
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15 76 affects health status and the costs of long-term care,[4] the prevention of functional
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18 77 disability among older people is increasingly important.

21 78 Recently, there have been great efforts to research the effect of social capital on
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24 79 health.[5-13] Putnam defines social capital as “features of social organization, such trust,
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27 80 norms and networks that can improve the efficiency of society by facilitating coordinated
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30 81 actions.”[5] There is considerable evidence of associations between social capital and
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33 82 various health indicators.[6-12] Although both ecologic and individual-level studies of
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36 83 social capital have yielded important insight, an appropriate examination of social
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39 84 capital as a collective (and contextual) influence on health requires multilevel
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42 85 analysis.[13] Moreover, to establish a causal relationship between social capital and
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45 86 health, observational studies must include prospective longitudinal analyses.[7] Several
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48 87 multilevel prospective studies have suggested contextual effects of social capital on
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51 88 health outcomes, mortality,[14, 15] self-rated health,[16, 17] suicide,[18] depression,[19,
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54 89 20] and oral health.[21] Although two studies have reported an association between
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57 90 community social capital and the incidence of onset of functional disability among older
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7 91 people,[22, 23] evidence remains insufficient. The study areas in this previous work were
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9 92 limited to certain parts of Japan, which limits the generalization of the results.
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12 93 Additionally, these studies' measures of community social capital might not provide a
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15 94 full picture of social capital because the scales used might fail to capture the multiple
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18 95 dimensions of social capital, such as its cognitive and structural aspects.[24, 25]
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21 96 In the present study, we sought to examine the association between community
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24 97 social capital and the onset of functional disability among older people, using a
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27 98 prospective multilevel design and analyzing data from a nationwide survey in Japan. We
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30 99 measured community social capital using an indicator consisting of recently developed
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33 100 and validated multidimensional items.[26]
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39 102 **METHODS**

42 103 **Study population**

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45 104 We utilized the Japan Gerontological Evaluation Study (JAGES) 2010–2013 cohort
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48 105 data.[27] Baseline data were collected using a self-administered questionnaire survey
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51 106 conducted from August 2010 to January 2012 among 85,161 people aged ≥ 65 years. The
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54 107 sample was restricted to people who did not already have functional disabilities, where
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57 108 functional disability was defined as being certified as eligible to receive long-term public
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6 109 care insurance (LTCI) system services. A simple random sample was obtained from the
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9 110 official residence registers in 13 large municipalities, and a complete census was taken
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12 111 of older residents residing in the remaining 11 smaller municipalities (response rate =
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15 112 66.3%).

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18 113 Survey data from 81,980 respondents who provided information for
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21 114 identification by the public LTCI system were linked to the public LTCI records dataset
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24 115 over a 3-year follow-up period beginning April 1, 2010. We excluded 4,549 respondents
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27 116 from 123 community areas with < 50 respondents to avoid non-precise values from small
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30 117 sample sizes,[26] 253 respondents with unknown areas of residence, 1,599 respondents
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33 118 who did not apply for public LTCI certification despite having basic activities of daily
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36 119 living (BADL) limitations, and, to avoid the problem of reverse causation, 2,558
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39 120 respondents who did not complete the BADL items. Finally, we used data from 73,021
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42 121 respondents in 323 community areas.

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46 47 48 123 **Measurements**

49 50 51 124 Outcome

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54 125 We collected information on the onset of functional disability from municipality-
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57 126 administered public LTCI records. The public LTCI system classifies frail older adults
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6 127 into seven levels (“support need levels” 1 and 2 and “care need levels” 1–5; larger
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9 128 numbers indicate more severe need) using a nationally standardized and validated
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12 129 algorithm. This level is determined according to older adults’ physical and mental care
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15 130 needs, regardless of informal care received,[28] and it is assessed both through computer-
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18 131 based and home-visit interviews with a trained health care professional and through
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21 132 examinations conducted by a primary physician.[29] In the computer-based assessment,
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24 133 time needed for care is calculated according to nine categories of care needs, including
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27 134 five BADL domains (bathing, eating, toileting, dressing, and transferring), assistance
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29
30 135 with instrumental activities of daily living (IADL), behavioral problems, rehabilitation,
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32
33 136 and medical services.[28] In our study, the onset of functional disability was defined as
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36 137 a new registration in the public LTCI records with a care-needs level of two or above,
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39 138 which requires at least 50 minutes of care daily and generally corresponds to needing
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42 139 any type of BADL care.[29] We used this outcome measurement because it has been
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45 140 found to reflect healthy life expectancy.[30]

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51 142 Community social capital

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54 143 To measure community social capital, individual-level baseline data were aggregated for
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57 144 each of the 323 local districts. We assessed three components of community social capital
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6 145 (community civic participation, social cohesion, and reciprocity), based on the instrument
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9 146 Saito et al. developed and validated for measuring health-related community social
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12 147 capital.[27] Briefly, the community level was defined as the school district, a measure of
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15 148 community social capital was generated using factor analysis, and the factor scores for
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18 149 each small district were used as community social capital variables.[22, 27] Level of
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21 150 community civic participation was assessed by summing the percentages of participation
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24 151 in volunteer, sports, and hobby groups in each community. Level of community social
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27 152 cohesion was measured by summing the percentages answering “very” or “moderately”
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30 153 (with possible response categories of “very,” “moderately,” “neutral” “disagree a little,”
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33 154 and “disagree”) to three items: trust (“Do you think people living in your area can be
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36 155 trusted, in general?”), perception of others’ intention to help (“Do you think people living
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39 156 in your area try to help others in most situations?”), and attachment to the residential
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42 157 area (“How attached are you to the area where you live?”). Level of community reciprocity
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45 158 was measured by summing the percentages answering “yes” to three items: receives
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48 159 emotional support (“Do you have someone who listens to your concerns and complaints?”),
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51 160 provides emotional support (“Do you listen to someone’s concerns and complaints?”), and
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54 161 receives instrumental support (“Do you have someone who looks after you when you are
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57 162 sick and confined to a bed for a few days?”). Community civic participation, social
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6 163 cohesion, and reciprocity scores were standardized (subtracted from the mean and
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9 164 divided by the standard deviation). We applied school districts as the community unit
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12 165 because this was the smallest feasible area unit identifiable in the JAGES data; civic
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15 166 activities are often conducted within each school district, and older people can easily
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18 167 travel by foot or bicycle within the school district where they live.
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24 169 Individual responses on community social capital indicators

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27 170 The individual-level social components used, which are closely related to the components
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30 171 of community social capital, were group participation in the community, perception of
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33 172 community social capital, social support, and social isolation. Group participation in the
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36 173 community was measured as a count of participation in the following types of groups:
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39 174 volunteer, sports, or hobby groups. Perception of community social cohesion was
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42 175 measured as a count of a study participant's responses of "very" or "moderately" to the
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45 176 following items: trust, perception of others' intention to help, and attachment to the
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48 177 residential area. Social support was measured as a count of the number of the following
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51 178 types of social support each participant had: received emotional support, provided
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54 179 emotional support, and received instrumental support. Social isolation was measured
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57 180 using the frequency of meeting with friends: A few times per year or less was considered
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6 181 moderate isolation, and more than once per month was considered non-isolation.
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12 183 Covariates
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15 184 Sociodemographic characteristics and baseline health status were included in the
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18 185 analysis as covariates. These variables were age, equivalized income, educational
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21 186 attainment, marital status, self-rated health, self-reported body mass index (BMI), IADL,
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24 187 present illness, depression, lifestyle (smoking history, alcohol consumption, frequency of
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27 188 going outside), and individual social components. Age was categorized as 65–69, 70–74,
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30 189 75–79, 80–84, or 85 years or older. Educational attainment was categorized as < 6, 6–9,
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33 190 10–12, or ≥ 13 years. Equivalized income was categorized as low (< 1,990,000 JPY; 120
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36 191 JPY = 1 USD), middle (2,000,000–3,990,000 JPY), or high ($\geq 4,000,000$ JPY). Marital
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39 192 status was categorized married, separated/divorced, or never married. Living
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42 193 arrangement was categorized as living with others or living alone. Self-rated health was
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45 194 measured using a single question: “What is your current health status?” with response
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48 195 options of “excellent,” “good,” “fair,” and “poor.” BMI was categorized as < 18.5, 18.5–
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51 196 24.9, or ≥ 25 . IADL was assessed using a five-item subscale of the Tokyo Metropolitan
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54 197 Institute of Gerontology Higher Competence Scale.[32] We categorized those who had
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57 198 difficulty with at least one item as “with difficulty”; others were categorized as “without
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6 199 difficulty.” Present illness was measured using the following yes/no question: “Do you
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9 200 receive treatment now?” Depression was assessed using the 15-item Japanese version of
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12 201 the Geriatric Depression Scale (GDS),[32] with scores categorized as no depression (0–4
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15 202 points), depressive tendency (5–9 points), or depression (≥ 10 points). Smoking history
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18 203 was categorized as non-smoking, quit before 5 years, quit within 4 years, or currently
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21 204 smoking. Alcohol consumption was categorized as never, past drinker, or current drinker.
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24 205 Frequency of going outside was categorized as almost every day, one to three times per
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27 206 week, or once or twice per month or less. Urbanization based on population density was
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30 207 categorized as urban (≥ 1500 people/km²), suburban (1000–1500 people/ km²), or rural (<
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33 208 1000 people/ km²).

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37 38 39 210 **Statistical analysis**

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42 211 The data included 73,021 individuals (first level) nested in 323 local districts (second
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45 212 level). The median number of subjects in each local district was 90 (25th and 75th
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48 213 percentile: 63 and 317). The multilevel analysis framework assumes that individual
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51 214 health outcomes are partly dependent on the districts where individuals live. Multilevel
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54 215 models estimate the variation in outcomes across districts (random effects) and the
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57 216 effects of community-level variables on the outcome, adjusting for individual
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6 217 compositional characteristics (fixed effects). Multilevel survival analysis using Cox
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9 218 proportional hazards regression models with stratification by sex was applied to
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12 219 calculate the hazard ratio (HR) and 95% confidence interval (95% CI) for functional
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15 220 disability during the follow-up period. HRs were estimated for a 1 SD change in the
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18 221 percentages of community social capital variables. We used the following analysis models.
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21 222 First, the null model was used to assess whether the onset of functional disability varied
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24 223 across districts. Then, the effect of community social capital on the onset of functional
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27 224 disability was investigated, adjusting for age, educational attainment, equivalized
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30 225 income, marital status, living arrangements, BMI, self-rated health, present illness,
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33 226 IADL, alcohol consumption, smoking history, and urbanization (Model 1). GDS score and
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36 227 frequency of going outside were then included (Model 2). The final model also included
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39 228 social isolation, group participation in the community, social perception of community
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42 229 social capital, and social support (Model 3). Because there was frequently missing data
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45 230 on the covariates, a “missing” category was created for the analyses. The significance
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48 231 level was set at $p < 0.05$. We used R (Version 3.4.3 for Windows) for all of the statistical
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51 232 analyses. Random effects models were estimated using the “coxme” function (coxme
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54 233 package).[33]
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6 235 **Ethical issues**
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9 236 JAGES respondents were informed that participation in the study was voluntary and
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12 237 that completing and returning the self-administered questionnaire by mail indicated
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15 238 their consent to participate in the study. The ethics committee at Nihon Fukushi
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18 239 University approved the protocol and informed consent procedure for the present study
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21 240 (No. 10-05). This study conformed to the principles embodied in the Declaration of
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24 241 Helsinki.
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30 243 **Patient and public involvement**
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33 244 No patients were involved in the development of the research question, study design or
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36 245 data interpretation in this study.
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42 247 **RESULTS**
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45 248 Of the 73,021 respondents over the follow-up period (average = 2.7 years), 34,051 were
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48 249 men and 38,970 were women. The average age was 73.3 years (SD = 6.0) for men and
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51 250 73.8 years (SD = 6.2) for women. During the follow-up period, 1465 (4.3%) new cases of
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54 251 functional disability occurred among men; among women, there were 1519 (3.9%) new
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57 252 cases of functional disability.
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7 253 Table 1 shows the descriptive characteristics of the respondents at baseline.
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10 254 Respondents with onset of functional disability were more likely to be older,
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12 255 separated/divorced, presently ill, current or former drinkers, moderately socially isolated,
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15 256 and living in rural areas, and to have lower educational attainment, lower equivalized
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18 257 income, lower BMI, poor self-rated health, depression, IADL difficulties, lower frequency
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21 258 of going outside, no community group participation, and lower social support. These
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24 259 tendencies were almost identical for men and women.
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260 **Table 1. Respondent characteristics**

	Men (n=34051)			Women (n=38970)		
	n	%	Incidence rate per 1000 person-years	n	%	Incidence rate per 1000 person-years
Age (years)						
65-69	11352	34.8	4.7	12018	32.1	2.7
70-74	9751	29.9	9.9	10993	29.4	5.6
75-79	7272	22.3	21.1	8570	22.9	14.7
80-84	4045	12.4	33.8	5006	13.4	34.7
85 or older	1631	5.0	79.4	2383	6.4	79.1
Educational attainment						
<6	497	1.5	48.5	1211	3.1	59.4
6-9	14523	42.7	18.3	18903	48.5	14.0
10-12	10517	30.9	11.9	12272	31.5	10.4
≥13	6844	20.1	12.6	4332	11.1	9.7
Other or missing	1670	4.9	28.7	2252	5.8	25.6
Equivalized income						
Low	22521	69.1	14.7	22708	60.6	12.6
Middle	5653	17.3	13.0	5495	14.7	11.5
High	925	2.8	10.3	832	2.2	13.5
Missing	4952	15.2	27.1	9935	26.5	20.1
Marital status						
Married	28361	87.0	14.4	21903	58.5	8.6
Separated/divorced	3571	11.0	26.6	14132	37.7	22.0
Never married	444	1.4	9.8	815	2.2	20.9
Other or missing	1675	5.1	25.7	2120	5.7	21.8
Living arrangements						
Living with other	30211	92.7	15.3	31306	83.6	13.6
Living alone	2287	7.0	19.1	6041	16.1	17.0
Missing	1553	4.8	27.5	1623	4.3	19.7
Body mass index						
<18.5	1798	5.5	38.9	3098	8.3	26.0
18.5-24.9	22990	70.6	14.1	24947	66.6	11.7
≥25.0	7199	22.1	11.5	7896	21.1	11.7
Missing	2064	6.3	36.4	3029	8.1	32.6
Self-rated health						
Excellent	4208	12.4	6.8	4173	10.7	6.3
Good	22743	66.8	11.8	27015	69.3	11.3
Fair	5778	17.0	33.3	6351	16.3	27.7
Poor	1021	3.0	57.9	878	2.3	49.9
Missing	301	0.9	26.7	553	1.4	22.3
Present illness						
No	8391	25.8	9.7	8454	22.6	9.5
Yes	23171	71.1	17.8	26981	72.0	15.5
Missing	2489	7.6	22.4	3535	9.4	17.9
Geriatric Depression Scale						
No depression	21055	64.6	11.2	22164	59.2	10.1

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2							
3	Depressive tendency	6063	18.6	22.3	6491	17.3	19.9
4	Depression	2013	6.2	29.3	2083	5.6	29.2
5	Missing	4920	15.1	24.7	8232	22.0	18.1
6							
7	Instrumental activities of daily living						
8	Without difficulty	22452	68.9	10.8	31079	83.0	7.8
9	With difficulty	8996	27.6	27.4	5188	13.9	49.5
10	Missing	2603	8.0	23.8	2703	7.2	25.2
11							
12	Alcohol consumption						
13	Never	18187	53.4	11.6	5405	13.9	7.8
14	Past	2022	5.9	27.2	366	0.9	21.5
15	Current	11710	34.4	20.5	30709	78.8	15.1
16	Missing	2132	6.3	20.6	2490	6.4	18.4
17							
18	Smoking history						
19	Non-smoking	8191	25.1	14.4	31089	83.0	13.6
20	Non-smoking now, quit before 5						
21	years	13967	42.9	16.0	1232	3.3	16.4
22							
23	Non-smoking now, quit within 4						
24	years	2934	9.0	16.6	446	1.2	12.8
25	Smoking	6305	19.3	16.5	1130	3.0	14.9
26	Missing	2654	8.1	20.8	5073	13.5	18.7
27							
28	Frequency of going outside						
29	Once to twice a month or less	1905	5.6	48.5	2758	7.1	40.8
30	One to three times a week	10397	30.5	19.7	16099	41.3	16.2
31	Almost everyday	19632	57.7	10.6	17799	45.7	8.1
32	Missing	2117	6.2	22.8	2314	5.9	20.1
33							
34	Social isolation						
35	Non-isolation	21650	66.4	12.7	29475	78.7	11.8
36	Moderately isolation	10038	30.8	20.7	6261	16.7	21.4
37	Missing	2363	7.3	28.6	3234	8.6	25.1
38							
39	Group participation in the						
40	community						
41	Non	16011	47.0	18.3	14364	36.9	19.7
42	One	5562	16.3	9.3	6376	16.4	6.8
43	Over two	5180	15.2	7.9	6412	16.5	5.4
44	Missing	7298	21.4	22.8	11818	30.3	17.1
45							
46	Social support						
47	Non	617	1.8	17.0	305	0.8	21.3
48	One	1260	3.7	17.8	690	1.8	21.3
49	Over two	30004	88.1	15.3	35523	91.2	13.4
50	Missing	2170	6.4	26.7	2452	6.3	25.5
51							
52	Perception of community social						
53	cohesion						
54	Non	3312	9.7	18.4	4345	11.1	14.3
55	One	5001	14.7	13.7	6205	15.9	12.1
56	Over two	23560	69.2	15.1	25592	65.7	14.1
57	Missing	2178	6.4	29.5	2828	7.3	22.1
58							
59	Urbanization						
60							

1							
2							
3	Rural	10594	32.5	18.0	13169	35.2	16.2
4	Suburban	18560	57.0	15.8	20278	54.1	14.0
5	Urban	4897	15.0	11.9	5523	14.7	10.3
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6 262 Tables 2 and 3 show the results of multilevel the survival analyses for men and
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9 263 women, respectively. In the multivariable-adjusted model (Model 1), among men, a
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12 264 significant association was observed between community-level social capital and
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14
15 265 incidence of functional disability for “social cohesion” (HR = 0.904, 95% CI: 0.824–0.992,
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17
18 266 p -value < 0.05). This association was maintained after adding individual GDS score and
19
20
21 267 frequency of going outside (HR = 0.909, 95% CI: 0.829–0.996, p -value < 0.05; Model 2)
22
23
24 268 and individual responses on community social capital indicators (HR = 0.910, 95% CI:
25
26
27 269 0.830–0.998; Model 3). Although the associations of incidence of functional disability
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29
30 270 with community-level civic participation and with reciprocity were not statistically
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32
33 271 significant, the point estimates for these effects were in the same direction, with HRs <
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35
36 272 1.0 (civic participation: HR = 0.972, 95% CI: 0.893–1.058; reciprocity: HR = 0.920, 95%
37
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39 273 CI: 0.829–1.021; Model 3). Among women, no significant association was observed (civic
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42 274 participation: HR = 0.999, 95% CI: 0.918–1.087; social cohesion: HR = 0.930, 95% CI:
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45 275 0.847–1.020; reciprocity: HR = 1.002, 95% CI: 0.901–1.114; Model 3).
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276 **Table 2. Multilevel survival analysis of functional disability among male respondents (n = 34,051)**

	Model 1	Model 2	Model 3
	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)
<i>Fixed effects</i>			
<i>Community-level variables</i>			
Community-level social capital			
Civic participation	0.956 (0.878-1.041)	0.959 (0.882-1.044)	0.972 (0.893-1.058)
Social cohesion	0.904 (0.824-0.992) *	0.909 (0.829-0.996) *	0.910 (0.830-0.998) *
Reciprocity	0.930 (0.837-1.032)	0.933 (0.841-1.035)	0.920 (0.829-1.021)
Urbanization (ref: Urban)			
Suburban	1.238 (0.977-1.568)	1.230 (0.972-1.557)	1.241 (0.981-1.571)
Rural	1.278 (0.986-1.655)	1.232 (0.951-1.596)	1.251 (0.967-1.620)
<i>Individual-level variables</i>			
Age (ref: 65-69 years)			
70-74	1.963 (1.603-2.403) **	1.940 (1.584-2.376) **	1.948 (1.591-2.387) **
75-79	3.624 (2.989-4.394) **	3.550 (2.928-4.305) **	3.549 (2.924-4.307) **
80-84	5.115 (4.189-6.246) **	4.876 (3.990-5.958) **	4.800 (3.923-5.873) **
85 or older	11.241 (9.126-13.846) **	10.371 (8.407-12.795) **	10.011 (8.099-12.375) **
Educational attainment (ref: <6)			
6-9	0.717 (0.549-0.938) *	0.738 (0.564-0.965) *	0.738 (0.564-0.966) *
10-12	0.682 (0.513-0.906) **	0.720 (0.542-0.957) *	0.727 (0.547-0.967) *
≥13	0.745 (0.554-1.000)	0.781 (0.581-1.050)	0.793 (0.590-1.067)
Equivalized income (ref: Low)			
Middle	1.234 (1.043-1.459) *	1.061 (0.903-1.247)	1.067 (0.908-1.254)
High	0.961 (0.523-1.769)	1.015 (0.673-1.530)	1.007 (0.668-1.519)
Marital status (ref: Married)			
Separated/divorced	1.028 (0.875-1.208)	1.218 (1.029-1.441) *	1.241 (1.048-1.470) *
Never married	0.962 (0.638-1.449)	0.907 (0.493-1.667)	0.929 (0.504-1.713)
Living arrangements (ref: Living with other)			
Living alone	1.012 (0.799-1.282)	1.013 (0.798-1.284)	1.036 (0.815-1.317)
Body mass index (ref: 18.5-24.9)			
<18.5	1.688 (1.431-1.993) **	1.651 (1.399-1.949) **	1.633 (1.383-1.927) **
≥25.0	0.919 (0.792-1.065)	0.926 (0.798-1.074)	0.932 (0.804-1.081)
Self-rated health (ref: Excellent)			
Good	1.356 (1.068-1.722) *	1.289 (1.014-1.637) *	1.265 (0.996-1.608)
Fair	2.831 (2.205-3.636) **	2.464 (1.910-3.178) **	2.387 (1.850-3.079) **
Poor	4.396 (3.287-5.881) **	3.638 (2.699-4.903) **	3.515 (2.606-4.740) **
Present illness (ref: No)			
Yes	1.140 (0.978-1.327)	1.143 (0.981-1.331)	1.146 (0.983-1.334)
Instrumental activities of daily living (ref: Without difficulty)			
With difficulty	1.798 (1.606-2.013) **	1.654 (1.475-1.856) **	1.635 (1.457-1.835) **
Alcohol consumption (ref: Non)			
Past	1.089 (0.905-1.310)	1.074 (0.893-1.292)	1.055 (0.877-1.270)

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3	Current	0.850 (0.757-0.954) **	0.866 (0.771-0.973) *	0.873 (0.777-0.981) *
4	Smoking history (ref: Non-			
5	smoking)			
6	Non-smoking now, quit before 5	1.089 (0.948-1.250)	1.075 (0.936-1.234)	1.071 (0.932-1.230)
7	years			
8	Non-smoking now, quit within 4	1.256 (1.021-1.545) *	1.237 (1.006-1.522) *	1.221 (0.993-1.502)
9	years			
10	Smoking	1.357 (1.153-1.598) **	1.320 (1.120-1.554) **	1.304 (1.107-1.536) **
11				
12	Geriatric Depression Scale (ref: No			
13	depression)			
14	Depression tendency		1.224 (1.069-1.402) **	1.214 (1.059-1.392) **
15	Depression		1.222 (1.011-1.477) *	1.236 (1.017-1.501) *
16				
17	Frequency of going outside (ref:			
18	Almost everyday)			
19	One to three times a week		1.237 (1.096-1.397) **	1.225 (1.084-1.383) **
20	Once to twice a month or less		1.899 (1.611-2.238) **	1.801 (1.524-2.128) **
21				
22	Social isolation (ref: Non-isolation)			
23	Moderately isolation			1.060 (0.939-1.196)
24				
25	Group participation in the			
26	community (ref: Non)			
27	One			0.778 (0.645-0.937) **
28	Over two			0.725 (0.588-0.894) **
29				
30	Social support (ref: Non)			
31	One			0.993 (0.625-1.578)
32	Over two			1.287 (0.864-1.917)
33				
34	Perception of community social			
35	cohesion (ref: Non)			
36	One			0.852 (0.686-1.057)
37	Over two			1.020 (0.853-1.220)
38				
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41	Random effects			
42	Community-level variance	0.0223	0.0210	0.0199

43 277 * $p < 0.05$, ** $p < 0.01$

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45 278 Values presented are HRs (hazard ratios) and 95% CIs (confidence intervals). Community-level social capital variables (civic
46 279 participation, social cohesion, and reciprocity) are 1 SD increase estimates. Variance of the intercept in the null model = 0.0336

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280 **Table 3. Multilevel survival analysis of functional disability among female respondents (n = 38,970)**

	Model 1	Model 2	Model 3
	HR (95% CI)	HR (95% CI)	HR (95% CI)
<i>Fixed effects</i>			
<i>Community-level variables</i>			
Community-level social capital			
Civic participation	0.986 (0.907-1.072)	0.987 (0.908-1.072)	0.999 (0.918-1.087)
Social cohesion	0.936 (0.854-1.027)	0.935 (0.853-1.025)	0.930 (0.847-1.020)
Reciprocity	1.003 (0.903-1.115)	1.007 (0.906-1.119)	1.002 (0.901-1.114)
Urbanization (ref: Urban)			
Suburban	0.977 (0.772-1.236)	0.968 (0.765-1.225)	0.978 (0.772-1.238)
Rural	1.045 (0.809-1.351)	1.013 (0.784-1.309)	1.024 (0.792-1.324)
<i>Individual-level variables</i>			
Age (ref: 65-69 years)			
70-74	1.911 (1.478-2.469) **	1.899 (1.469-2.455) **	1.896 (1.466-2.451) **
75-79	4.174 (3.293-5.290) **	4.111 (3.242-5.213) **	4.066 (3.203-5.161) **
80-84	8.084 (6.371-10.257) **	7.915 (6.232-10.052) **	7.733 (6.079-9.838) **
85 or older	14.654 (11.434-18.780) **	14.137 (11.016-18.143) **	13.749 (10.694-17.677) **
Educational attainment (ref: <6)			
6-9	0.723 (0.611-0.857) **	0.729 (0.615-0.863) **	0.734 (0.620-0.870) **
10-12	0.679 (0.561-0.822) **	0.687 (0.568-0.832) **	0.701 (0.578-0.849) **
≥13	0.792 (0.617-1.015)	0.806 (0.629-1.034)	0.826 (0.643-1.059)
Equivalent income (ref: Low)			
Middle	1.037 (0.876-1.229)	1.062 (0.896-1.259)	1.063 (0.897-1.261)
High	1.440 (0.989-2.097)	1.505 (1.033-2.193) *	1.500 (1.029-2.186) *
Marital status (ref: Married)			
Separated/divorced	1.078 (0.949-1.224)	1.068 (0.940-1.213)	1.064 (0.936-1.209)
Never married	1.356 (0.983-1.870)	1.330 (0.964-1.834)	1.338 (0.969-1.848)
Living arrangements (ref: Living with other)			
Living alone	1.055 (0.912-1.221)	1.044 (0.902-1.209)	1.071 (0.924-1.241)
Body mass index (ref: 18.5-24.9)			
<18.5	1.423 (1.220-1.661) **	1.395 (1.195-1.628) **	1.363 (1.168-1.592) **
≥25.0	0.997 (0.865-1.149)	0.994 (0.862-1.146)	1.003 (0.870-1.157)
Self-rated health (ref: Excellent)			
Good	1.404 (1.098-1.795) **	1.350 (1.054-1.727) *	1.333 (1.041-1.707) *
Fair	2.354 (1.818-3.049) **	2.111 (1.622-2.746) **	2.078 (1.596-2.706) **
Poor	3.439 (2.524-4.685) **	2.934 (2.138-4.027) **	2.856 (2.077-3.926) **
Present illness (ref: No)			
Yes	0.943 (0.811-1.097)	0.946 (0.813-1.101)	0.954 (0.820-1.111)
Instrumental activities of daily living (ref: Without difficulty)			
With difficulty	2.449 (2.167-2.767) **	2.287 (2.016-2.595) **	2.171 (1.911-2.467)
Alcohol consumption (ref: Non)			
Past	1.574 (1.005-2.467) *	1.550 (0.988-2.430)	1.624 (1.035-2.548) *

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3	Current	0.915 (0.751-1.116)	0.936 (0.767-1.141)	0.949 (0.778-1.157)
4	Smoking history (ref: Non-			
5	smoking)			
6	Non-smoking now, quit before 5	1.490 (1.121-1.981) **	1.454 (1.093-1.934) *	1.455 (1.094-1.936) *
7	years			
8	Non-smoking now, quit within 4	1.289 (0.758-2.193)	1.291 (0.759-2.197)	1.250 (0.735-2.129)
9	years			
10	Smoking	1.468 (1.077-2.000) *	1.430 (1.048-1.949) *	1.400 (1.026-1.911) *
11				
12	Geriatric Depression Scale (ref: No			
13	depression)			
14	Depression tendency		1.232 (1.074-1.414) **	1.240 (1.080-1.423) **
15	Depression		1.346 (1.116-1.624) **	1.364 (1.127-1.651) **
16				
17	Frequency of going outside (ref:			
18	Almost everyday)			
19	One to three times a week		1.119 (0.985-1.272)	1.098 (0.965-1.249)
20	Once to twice a month or less		1.323 (1.120-1.563) **	1.257 (1.060-1.491) **
21				
22	Social isolation (ref: Non-isolation)			
23	Moderately isolation			1.116 (0.977-1.275)
24				
25	Group participation in the			
26	community (ref: Non)			
27	One			0.678 (0.555-0.829) **
28	Over two			0.736 (0.587-0.923) **
29				
30	Social support (ref: Non)			
31	One			0.727 (0.408-1.295)
32	Over two			1.010 (0.619-1.647)
33				
34	Perception of community social			
35	cohesion (ref: Non)			
36	One			0.912 (0.740-1.123)
37	Over two			1.145 (0.961-1.364)
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41	Random effects			
42	Community-level variance	0.0202	0.0194	0.0209

43 281 * $p < 0.05$, ** $p < 0.01$

44 282 Values presented are HRs (hazard ratios) and 95% CIs (confidence intervals). Community-level social capital variables (civic
45 283 participation, social cohesion, and reciprocity) are 1 SD increase estimates. Variance of the intercept in the null model = 0.0351

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6 284 **DISCUSSION**
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9 285 To the best of our knowledge, this was the first study with a multilevel longitudinal
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12 286 design to examine the association between community social capital and the onset of
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15 287 functional disability using social capital indicators with verified validity in a large
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18 288 sample of older community-dwelling adults. The results suggested that living in a
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21 289 community with higher community social cohesion at baseline was associated with a
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24 290 lower future risk of functional disability, even after adjusting for individual responses
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27 291 on community social capital indicators. The present study indicated the importance of
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30 292 strategies to protect the health of older people through fostering cohesive communities
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33 293 with efforts such as promoting social connections and trust.
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36 294 There are several possible pathways between community social cohesion and
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39 295 health. Social cohesion is determined by the resources available to members of tight-knit
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42 296 communities.[34] Cohesive communities might help residents to express trust toward
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45 297 their neighbors and to be psychologically healthier. Previous studies have revealed that
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48 298 neighborhood social cohesion positively affected older people's subjective well-being,[35,
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51 299 36] and that cohesive communities prevented the occurrence of depressive symptoms in
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54 300 older people who lived alone and were at high risk of functional disability.[37] Thus, we
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57 301 considered high levels of community social cohesion to be potentially protective against
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6 302 the onset of functional disability via the positive effects on psychological health, such as
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9 303 enhancing subjective well-being and inhibiting depressive symptoms.

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12 304 Two previous studies examined the association between community social
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15 305 capital and the onset of functional disability in older people using multilevel longitudinal
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18 306 designs.[23, 24] Our results suggesting that higher community social cohesion was
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21 307 associated with lower risk of functional disability among men but not women were
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24 308 inconsistent with these previous studies. There are several possible reasons for this
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27 309 difference. First, both previous studies were surveys in a smaller area, compared with
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30 310 that in our research. Because our work used survey data from municipalities nationwide,
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33 311 the possibility for generalizing our findings might be higher. Second, the measurement
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36 312 index of community social capital in the previous studies differed from ours. Both
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39 313 previous studies used only one item (“general trust”) to measure community social
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42 314 cohesion. In contrast, we used multidimensional indicators consisting of three
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45 315 measurement items with verified validity, which might be more accurate for examining
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48 316 community contextual effects. Therefore, our results might reflect more accurate
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51 317 estimates of the effects of community social cohesion on individual health.

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54 318 In the present study, community social cohesion affected the onset of functional
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57 319 disability only among men. It is likely that, among people who are currently in the older
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6 320 age groups, men sought and had stronger relationships with their colleagues before
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9 321 retirement than did women, given the nature of companies, particularly in Japan.[38]
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12 322 When this strong commitment is lost after retirement, these men may also experience a
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15 323 variety of changes in their living arrangements, leading to changes in their physical and
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18 324 mental health.[39] A cohesive community might be helpful in building new connections
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21 325 and encouraging social participation, which may keep men healthier and improve their
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24 326 psychological well-being. Honjo, et al. reported that rich social cohesion in a community
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27 327 buffered the risk of depression among older men living alone in Japan.[37] Thus,
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30 328 community cohesiveness may protect men's psychological health by helping them to
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33 329 build new connections in the community after retirement. However, further studies are
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36 330 needed to validate this hypothesis.

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39 331 The present study had several strengths. First, using a large, nationwide
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42 332 population-based sample enabled us to conduct a community-level multilevel analysis to
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45 333 clarify the contextual relationship between community-level social capital and the onset
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48 334 of functional disability. Second, we used validated indicators consisting of
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51 335 multidimensional items to measure community social capital. Therefore, we may have
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54 336 appropriately captured the whole of community social capital. However, the study also
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57 337 had several limitations. First, because the measurement was based on a self-

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6 338 administered questionnaire, the results are subject to response bias such as social
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9 339 desirability.[40] Social desirability bias may artificially inflate social capital as
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12 340 calculated from the responses to the questionnaire. Second, our study included no
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15 341 information about changes in social capital. Therefore, it is possible that unmeasured
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18 342 time-varying covariates such as economic changes or natural disasters may have biased
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21 343 our results. Third, although our study was a prospective cohort study, the follow-up
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24 344 period was moderately short. Considering the possibility of reverse causation, analyses
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27 345 with a longer follow-up period are necessary in the future.
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32 33 347 **CONCLUSION**

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36 348 In conclusion, this multilevel prospective cohort study found that higher levels of
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39 349 community social cohesion were associated with a lower incidence of onset of functional
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42 350 disability among older men, but not among older women, even after adjusting for
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45 351 individual social and behavioral variables. The findings suggest the importance of
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48 352 fostering cohesive communities to reduce the onset functional disability among older
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55 56 57 355 **ACKNOWLEDGMENTS**

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8
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21 361 **CONTRIBUTORS**

22
23
24 362 TN had the idea for the study, participated in its design, performed the statistical
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27 363 analysis, and drafted the manuscript as the principal author. KK, the principal
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30 364 investigator of the JAGES project, helped to develop the idea of the study, participated
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32
33 365 in acquiring the data and in designing the study, and critically revised the manuscript.
34
35
36 366 MS helped to develop the idea of the study, participated in acquiring the data and in
37
38
39 367 designing the study, and critically revised the manuscript. HN helped with the data
40
41
42 368 analysis and critically revised the manuscript. SS critically revised the manuscript. All
43
44
45 369 authors read and approved the final manuscript.
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9 393 The ethics committee at Nihon Fukushi University approved the protocol and informed
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12 394 consent procedure for the present study (No. 10-05).

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18 396 **DATA SHARING**

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21 397 No additional data are available.

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27 399 **DATA AVAILABILITY STATEMENT**

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30 400 The data are from the JAGES study. All enquiries are to be addressed at the data
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33 401 management committee via e-mail: dataadmin.ml@jages.net. All JAGES datasets have
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36 402 ethical or legal restrictions for public deposition because of the inclusion of sensitive
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39 403 information about the human participants.

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45 405 **COMPERING INTERESTS**

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48 406 None declared.

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54 408 **REFERENCES**

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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 (b) Provide in the abstract an informative and balanced summary of what was done and what was found	1 2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (b) For matched studies, give matching criteria and number of exposed and unexposed	6-7 non
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-11
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-11
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, explain how loss to follow-up was addressed (e) Describe any sensitivity analyses	12-13 non 13 non non
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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	14 non non
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	14-18 16-18 14
Outcome data	15*	Report numbers of outcome events or summary measures over time	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	19-23
2			(b) Report category boundaries when continuous variables were categorized	non
3			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	non
4				
5	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	non
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11	Discussion			
12	Key results	18	Summarise key results with reference to study objectives	24
13	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	26-27
14	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	24-26
15	Generalisability	21	Discuss the generalisability (external validity) of the study results	25
16				
17	Other information			
18	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	28-29
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*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>.

BMJ Open

Community social capital and the onset of functional disability among older adults in Japan: A multilevel longitudinal study using Japan Gerontological Evaluation Study (JAGES) data

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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Geriatric medicine
Keywords:	PUBLIC HEALTH, EPIDEMIOLOGY, GERIATRIC MEDICINE, SOCIAL MEDICINE

SCHOLARONE™
Manuscripts

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7 1 **Community social capital and the onset of functional disability among older adults in**
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9 2 **Japan: A multilevel longitudinal study using Japan Gerontological Evaluation Study**
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12 3 **(JAGES) data**
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18 5 Taiji Noguchi^{1,2}, Katsunori Kondo^{2,3}, Masashige Saito⁴, Hiroko Nakagawa-Senda¹, Sadao
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24 25 **Abstract (255 words)**

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27 26 **Objective:**

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30 27 The present study examined the association between community social capital and the
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33 28 onset of functional disability among older Japanese people by using validated indicators
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36 29 of social capital and a prospective multilevel design.

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39 30 **Design:**

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42 31 Prospective cohort study

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45 32 **Setting:**

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48 33 We utilized data from the Japan Gerontological Evaluation Study (JAGES), established
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51 34 from August 2010 to January 2012 in 323 districts.

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54 35 **Participants:**

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57 36 The target population was restricted to non-institutionalized people aged 65 years or
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6 37 older who were independent in activities of daily living. Participants included 73,021
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9 38 people (34,051 men and 38,970 women) who were followed up over a 3-year period.

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12 39 **Primary outcome measure:**

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15 40 The primary outcome measure was the onset of functional disability, defined as a new
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18 41 registration in public long-term care insurance (LTCI) system records with a care-needs
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21 42 level of two or above, analysed with multilevel Cox proportional hazards regression
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24 43 models by community social capital (civic participation, social cohesion, and reciprocity).

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27 44 **Results:**

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30 45 The mean age of participants was 73.3 years (SD = 6.0) for men and 73.8 years (SD =
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33 46 6.2) for women. During the study period, the onset of functional disability occurred in
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36 47 1465 (4.3%) men and 1519 (3.9%) women. Of three community social capital variables,
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39 48 social cohesion significantly reduced the risk of onset of functional disability (hazard
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42 49 ratio = 0.910; 95% CI: 0.830–0.998) among men, after adjusting for individual social and
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45 50 behavioral variables. There was no significant effect among women.

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48 51 **Conclusions:**

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51 52 Living in a community with rich social cohesion is associated with a lower incidence of
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54 53 onset of functional disability among older Japanese men.

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55 **Strengths and limitations of this study**

- 56 · This is the first prospective cohort study to examine the association between
57 community social capital and the onset of functional disability among older people,
58 by a large, nationwide population-based Japanese sample.
- 59 · To measure community social capital, an indicator consisting of validated
60 multidimensional items was used, and we assessed three components of community
61 social capital (civic participation, social cohesion, and reciprocity).
- 62 · Multilevel survival analysis was used to examine community contextual
63 characteristics for the onset of functional disability.
- 64 · More than 73,000 people aged 65 years or older participated and were followed up
65 for 3 years period.
- 66 · While this study was a large sample size, the measurements were self-reported data.

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68 **Word count: 3,465 words**

70 **INTRODUCTION**

71 In almost every country, the proportion of older people is growing at an increasing
72 rate,[1] and Japan has displayed the fastest growth. In 2012, 32% of the Japanese

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6 73 population was aged over 60 years, and this is expected to rise to 42% by 2050.[2] Age-
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9 74 related functional disability, defined as difficulty performing activities of daily living, is
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12 75 a very important public health issue worldwide.[3, 4] Because functional disability
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15 76 affects health status and the costs of long-term care,[4] the prevention of functional
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18 77 disability among older people is increasingly important.

21 78 Recently, there have been great efforts to research the effect of social capital on
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24 79 health.[5-13] Putnam defines social capital as “features of social organization, such trust,
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27 80 norms and networks that can improve the efficiency of society by facilitating coordinated
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30 81 actions.”[5] There is considerable evidence of associations between social capital and
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33 82 various health indicators.[6-12] Although both ecologic and individual-level studies of
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36 83 social capital have yielded important insight, an appropriate examination of social
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39 84 capital as a collective (and contextual) influence on health requires multilevel
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42 85 analysis.[13] Prospective study designs are useful for establishing a valid relationship
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45 86 between social capital and health.[7] Several multilevel prospective studies have
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48 87 suggested contextual effects of social capital on health outcomes, mortality,[14, 15] self-
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51 88 rated health,[16, 17] suicide,[18] depression,[19, 20] and oral health.[21] Although two
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54 89 studies have reported an association between community social capital and the incidence
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57 90 of onset of functional disability among older people,[22, 23] evidence remains insufficient.

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7 91 The study areas in this previous work were limited to certain parts of Japan, which limits
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9 92 the generalization of the results. Additionally, these studies' measures of community
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12 93 social capital might not provide a full picture of social capital because the scales used
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15 94 might fail to capture the multiple dimensions of social capital, such as its cognitive and
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18 95 structural aspects. [24, 25]
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21 96 In the present study, we sought to examine the association between community
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24 97 social capital and the onset of functional disability among older people, using a
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27 98 prospective multilevel design and analyzing data from a nationwide survey in Japan. We
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30 99 measured community social capital using an indicator consisting of recently developed
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33 100 and validated multidimensional items.[26]
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37 38 39 102 **METHODS**

40 41 42 103 **Study population**

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45 104 We utilized the Japan Gerontological Evaluation Study (JAGES) 2010–2013 cohort
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48 105 data.[27] Baseline data were collected using a self-administered questionnaire survey
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51 106 conducted from August 2010 to January 2012 among 85,161 people aged ≥ 65 years. The
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54 107 sample was restricted to people who did not already have functional disabilities, where
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57 108 functional disability was defined as being certified as eligible to receive long-term public
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6 109 care insurance (LTCI) system services. A simple random sample was obtained from the
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9 110 official residence registers in 13 large municipalities, and a complete census was taken
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12 111 of older residents residing in the remaining 11 smaller municipalities (response rate =
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15 112 66.3%).

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18 113 Survey data from 81,980 respondents who provided information for
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21 114 identification by the public LTCI system were linked to the public LTCI records dataset
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24 115 over a 3-year follow-up period beginning April 1, 2010. We excluded 4,549 respondents
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27 116 from 123 community areas with < 50 respondents to avoid non-precise values from small
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30 117 sample sizes,[26] 253 respondents with unknown areas of residence, 1,599 respondents
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33 118 who did not apply for public LTCI certification despite having basic activities of daily
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36 119 living (BADL) limitations, and, to avoid the problem of reverse causation, 2,558
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39 120 respondents who did not complete the BADL items. Finally, we used data from 73,021
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42 121 respondents in 323 community areas (figure 1).

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46 47 48 123 **Measurements**

49 50 51 124 **Outcome**

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54 125 We collected information on the onset of functional disability from municipality-
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57 126 administered public LTCI records. The public LTCI system classifies frail older adults
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6 127 into seven levels (“support need levels” 1 and 2 and “care need levels” 1–5; larger
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9 128 numbers indicate more severe need) using a nationally standardized and validated
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12 129 algorithm. This level is determined according to older adults’ physical and mental care
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15 130 needs, regardless of informal care received,[28] and it is assessed both through computer-
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18 131 based and home-visit interviews with a trained health care professional and through
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21 132 examinations conducted by a primary physician.[29] In the computer-based assessment,
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24 133 time needed for care is calculated according to nine categories of care needs, including
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27 134 five BADL domains (bathing, eating, toileting, dressing, and transferring), assistance
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30 135 with instrumental activities of daily living (IADL), behavioral problems, rehabilitation,
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33 136 and medical services.[28] In our study, the onset of functional disability was defined as
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36 137 a new registration in the public LTCI records with a care-needs level of two or above,
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39 138 which requires at least 50 minutes of care daily and generally corresponds to needing
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42 139 any type of BADL care.[29] We used this outcome measurement because it has been
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45 140 found to reflect healthy life expectancy.[30]

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51 142 Community social capital

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54 143 To measure community social capital, individual-level baseline data were aggregated for
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57 144 each of the 323 local districts. We assessed three components of community social capital
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6 145 (community civic participation, social cohesion, and reciprocity), based on the instrument
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9 146 Saito et al. developed and validated for measuring health-related community social
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12 147 capital.[26] Briefly, the community level was defined as the school district, a measure of
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15 148 community social capital was generated using factor analysis, and the factor scores for
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18 149 each small district were used as community social capital variables.[22, 26] Level of
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21 150 community civic participation was assessed by summing the percentages of participation
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24 151 in volunteer, sports, and hobby groups in each community. Level of community social
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27 152 cohesion was measured by summing the percentages answering “very” or “moderately”
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30 153 (with possible response categories of “very,” “moderately,” “neutral” “disagree a little,”
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33 154 and “disagree”) to three items: trust (“Do you think people living in your area can be
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36 155 trusted, in general?”), perception of others’ intention to help (“Do you think people living
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39 156 in your area try to help others in most situations?”), and attachment to the residential
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42 157 area (“How attached are you to the area where you live?”). Level of community reciprocity
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45 158 was measured by summing the percentages answering “yes” to three items: receives
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48 159 emotional support (“Do you have someone who listens to your concerns and complaints?”),
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51 160 provides emotional support (“Do you listen to someone’s concerns and complaints?”), and
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54 161 receives instrumental support (“Do you have someone who looks after you when you are
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57 162 sick and confined to a bed for a few days?”). Community civic participation, social
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6 163 cohesion, and reciprocity scores were standardized (subtracted from the mean and
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9 164 divided by the standard deviation). We applied school districts as the community unit
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12 165 because this was the smallest feasible area unit identifiable in the JAGES data. School
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15 166 districts are likely to represent former ‘villages,’ which existed before repeated
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18 167 municipality mergers took place in the last few decades in Japan. Civic activities are
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21 168 often conducted within each school district, and older people can easily travel on foot or
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24 169 by bicycle within the school district where they live.
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30 171 Individual responses on community social capital indicators

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33 172 The individual-level social components used, which are closely related to the components
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36 173 of community social capital, were group participation in the community, perception of
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39 174 community social capital, social support, and social isolation. Group participation in the
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42 175 community was measured as a count of participation in the following types of groups:
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45 176 volunteer, sports, or hobby groups. Perception of community social cohesion was
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48 177 measured as a count of a study participant’s responses of “very” or “moderately” to the
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51 178 following items: trust, perception of others’ intention to help, and attachment to the
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54 179 residential area. Social support was measured as a count of the number of the following
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57 180 types of social support each participant had: received emotional support, provided
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6 181 emotional support, and received instrumental support. Social isolation was measured
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9 182 using the frequency of meeting with friends: A few times per year or less was considered
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12 183 moderate isolation, and more than once per month was considered non-isolation.
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18 185 Covariates

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21 186 Sociodemographic characteristics and baseline health status were included in the
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24 187 analysis as covariates. These variables were age, equivalized income, educational
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27 188 attainment, marital status, self-rated health, self-reported body mass index (BMI), IADL,
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30 189 present illness, depression, lifestyle (smoking history, alcohol consumption, frequency of
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33 190 going outside), and individual social components. Age was categorized as 65–69, 70–74,
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36 191 75–79, 80–84, or 85 years or older. Educational attainment was categorized as < 6, 6–9,
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39 192 10–12, or ≥ 13 years. Euivalized income was calculated by dividing the income of each
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42 193 household by the square root of the household size (number of family members); these
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45 194 figures were then categorized as low (< 1,990,000 JPY; 120 JPY = 1 USD), middle
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48 195 (2,000,000–3,990,000 JPY), or high ($\geq 4,000,000$ JPY). We used this index as a measure
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51 196 of household economic status because it adjusts for household size. Marital status was
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54 197 categorized married, separated/divorced, or never married. Living arrangement was
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57 198 categorized as living with others or living alone. Self-rated health was measured using
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6 199 a single question: “What is your current health status?” with response options of
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9 200 “excellent,” “good,” “fair,” and “poor.” BMI was categorized as < 18.5 , $18.5\text{--}24.9$, or ≥ 25 .
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12 201 IADL was assessed using a five-item subscale of the Tokyo Metropolitan Institute of
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15 202 Gerontology Higher Competence Scale.[31] We categorized those who had difficulty with
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18 203 at least one item as “with difficulty”; others were categorized as “without difficulty.”
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21 204 Present illness was measured using the following yes/no question: “Do you receive
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24 205 treatment now?” Depression was assessed using the 15-item Japanese version of the
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27 206 Geriatric Depression Scale (GDS),[32] with scores categorized as no depression (0–4
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30 207 points), depressive tendency (5–9 points), or depression (≥ 10 points). Smoking history
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33 208 was categorized as non-smoking, quit before 5 years, quit within 4 years, or currently
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36 209 smoking. Alcohol consumption was categorized as never, past drinker, or current drinker.
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39 210 Frequency of going outside was categorized as almost every day, one to three times per
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42 211 week, or once or twice per month or less. Urbanization based on population density was
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45 212 categorized as urban (≥ 1500 people/km²), suburban (1000–1500 people/ km²), or rural ($<$
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48 213 1000 people/ km²).

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54 215 **Statistical analysis**

57 216 The data included 73,021 individuals (first level) nested in 323 local districts (second

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6 217 level). The median number of subjects in each local district was 90 (25th and 75th
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9 218 percentile: 63 and 317). The multilevel analysis framework assumes that individual
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12 219 health outcomes are partly dependent on the districts where individuals live. Multilevel
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15 220 models estimate the variation in outcomes across districts (random effects) and the
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18 221 effects of community-level variables on the outcome, adjusting for individual
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21 222 compositional characteristics (fixed effects). Multilevel survival analysis using Cox
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24 223 proportional hazards regression models with stratification by sex was applied to
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27 224 calculate the hazard ratio (HR) and 95% confidence interval (95% CI) for functional
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30 225 disability during the follow-up period. HRs were estimated for a 1 SD change in the
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33 226 percentages of community social capital variables. We used the following analysis models.
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36 227 First, the null model was used to assess whether the onset of functional disability varied
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39 228 across districts. Then, the effect of community social capital on the onset of functional
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42 229 disability was investigated, adjusting for age, educational attainment, equivalized
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45 230 income, marital status, living arrangements, BMI, self-rated health, present illness,
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48 231 IADL, alcohol consumption, smoking history, and urbanization (Model 1). GDS score and
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51 232 frequency of going outside were then included (Model 2). The final model also included
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54 233 social isolation, group participation in the community, social perception of community
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57 234 social capital, and social support (Model 3). Because there was frequently missing data
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6 235 on the covariates, a “missing” category was created for the analyses. The significance
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9 236 level was set at $p < 0.05$. We used R (Version 3.4.3 for Windows) for all of the statistical
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12 237 analyses. Random effects models were estimated using the “coxme” function (coxme
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15 238 package).[33]

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20 21 240 **Ethical issues**

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24 241 JAGES respondents were informed that participation in the study was voluntary and
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27 242 that completing and returning the self-administered questionnaire by mail indicated
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30 243 their consent to participate in the study. The ethics committee at Nihon Fukushi
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33 244 University approved the protocol and informed consent procedure for the present study
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36 245 (No. 10-05). This study conformed to the principles embodied in the Declaration of
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39 246 Helsinki.

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43 44 45 248 **Patient and public involvement**

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48 249 No patients were involved in the development of the research question, study design or
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51 250 data interpretation in this study.

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55 56 57 252 **RESULTS**

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6 253 Of the 73,021 respondents over the follow-up period (average = 2.7 years), 34,051 were
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9 254 men and 38,970 were women. The average age was 73.3 years (SD = 6.0) for men and
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12 255 73.8 years (SD = 6.2) for women. During the follow-up period, 1465 (4.3%) new cases of
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15 256 functional disability occurred among men; among women, there were 1519 (3.9%) new
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18 257 cases of functional disability.
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21 258 Table 1 shows the descriptive characteristics of the respondents at baseline.
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24 259 Respondents with onset of functional disability were more likely to be older,
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27 260 separated/divorced, presently ill, current or former drinkers, moderately socially isolated,
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30 261 and living in rural areas, and to have lower educational attainment, lower equivalized
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33 262 income, lower BMI, poor self-rated health, depression, IADL difficulties, lower frequency
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36 263 of going outside, no community group participation, and lower social support. These
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39 264 tendencies were almost identical for men and women.
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265 **Table 1. Respondent characteristics**

	Men (n=34051)			Women (n=38970)		
	n	%	Incidence rate per 1000 person-years	n	%	Incidence rate per 1000 person-years
Age (years)						
65-69	11352	34.8	4.7	12018	32.1	2.7
70-74	9751	29.9	9.9	10993	29.4	5.6
75-79	7272	22.3	21.1	8570	22.9	14.7
80-84	4045	12.4	33.8	5006	13.4	34.7
85 or older	1631	5.0	79.4	2383	6.4	79.1
Educational attainment						
<6	497	1.5	48.5	1211	3.1	59.4
6-9	14523	42.7	18.3	18903	48.5	14.0
10-12	10517	30.9	11.9	12272	31.5	10.4
≥13	6844	20.1	12.6	4332	11.1	9.7
Other or missing	1670	4.9	28.7	2252	5.8	25.6
Equivalized income						
Low	22521	69.1	14.7	22708	60.6	12.6
Middle	5653	17.3	13.0	5495	14.7	11.5
High	925	2.8	10.3	832	2.2	13.5
Missing	4952	15.2	27.1	9935	26.5	20.1
Marital status						
Married	28361	87.0	14.4	21903	58.5	8.6
Separated/divorced	3571	11.0	26.6	14132	37.7	22.0
Never married	444	1.4	9.8	815	2.2	20.9
Other or missing	1675	5.1	25.7	2120	5.7	21.8
Living arrangements						
Living with other	30211	92.7	15.3	31306	83.6	13.6
Living alone	2287	7.0	19.1	6041	16.1	17.0
Missing	1553	4.8	27.5	1623	4.3	19.7
Body mass index						
<18.5	1798	5.5	38.9	3098	8.3	26.0
18.5-24.9	22990	70.6	14.1	24947	66.6	11.7
≥25.0	7199	22.1	11.5	7896	21.1	11.7
Missing	2064	6.3	36.4	3029	8.1	32.6
Self-rated health						
Excellent	4208	12.4	6.8	4173	10.7	6.3
Good	22743	66.8	11.8	27015	69.3	11.3
Fair	5778	17.0	33.3	6351	16.3	27.7
Poor	1021	3.0	57.9	878	2.3	49.9
Missing	301	0.9	26.7	553	1.4	22.3
Present illness						
No	8391	25.8	9.7	8454	22.6	9.5
Yes	23171	71.1	17.8	26981	72.0	15.5
Missing	2489	7.6	22.4	3535	9.4	17.9
Geriatric Depression Scale						
No depression	21055	64.6	11.2	22164	59.2	10.1

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3	Depressive tendency	6063	18.6	22.3	6491	17.3	19.9
4	Depression	2013	6.2	29.3	2083	5.6	29.2
5	Missing	4920	15.1	24.7	8232	22.0	18.1
6							
7	Instrumental activities of daily living						
8	Without difficulty	22452	68.9	10.8	31079	83.0	7.8
9	With difficulty	8996	27.6	27.4	5188	13.9	49.5
10	Missing	2603	8.0	23.8	2703	7.2	25.2
11							
12	Alcohol consumption						
13	Never	18187	53.4	11.6	5405	13.9	7.8
14	Past	2022	5.9	27.2	366	0.9	21.5
15	Current	11710	34.4	20.5	30709	78.8	15.1
16	Missing	2132	6.3	20.6	2490	6.4	18.4
17							
18	Smoking history						
19	Non-smoking	8191	25.1	14.4	31089	83.0	13.6
20	Non-smoking now, quit before 5						
21	years	13967	42.9	16.0	1232	3.3	16.4
22							
23	Non-smoking now, quit within 4						
24	years	2934	9.0	16.6	446	1.2	12.8
25	Smoking	6305	19.3	16.5	1130	3.0	14.9
26	Missing	2654	8.1	20.8	5073	13.5	18.7
27							
28	Frequency of going outside						
29	Once to twice a month or less	1905	5.6	48.5	2758	7.1	40.8
30	One to three times a week	10397	30.5	19.7	16099	41.3	16.2
31	Almost everyday	19632	57.7	10.6	17799	45.7	8.1
32	Missing	2117	6.2	22.8	2314	5.9	20.1
33							
34	Social isolation						
35	Non-isolation	21650	66.4	12.7	29475	78.7	11.8
36	Moderately isolation	10038	30.8	20.7	6261	16.7	21.4
37	Missing	2363	7.3	28.6	3234	8.6	25.1
38							
39	Group participation in the						
40	community						
41	Non	16011	47.0	18.3	14364	36.9	19.7
42	One	5562	16.3	9.3	6376	16.4	6.8
43	Over two	5180	15.2	7.9	6412	16.5	5.4
44	Missing	7298	21.4	22.8	11818	30.3	17.1
45							
46	Social support						
47	Non	617	1.8	17.0	305	0.8	21.3
48	One	1260	3.7	17.8	690	1.8	21.3
49	Over two	30004	88.1	15.3	35523	91.2	13.4
50	Missing	2170	6.4	26.7	2452	6.3	25.5
51							
52	Perception of community social						
53	cohesion						
54	Non	3312	9.7	18.4	4345	11.1	14.3
55	One	5001	14.7	13.7	6205	15.9	12.1
56	Over two	23560	69.2	15.1	25592	65.7	14.1
57	Missing	2178	6.4	29.5	2828	7.3	22.1
58							
59	Urbanization						
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2						
3	Rural	10594	32.5	18.0	13169	35.2
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5	Suburban	18560	57.0	15.8	20278	54.1
6	Urban	4897	15.0	11.9	5523	14.7
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For peer review only

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6 267 Tables 2 and 3 show the results of multilevel the survival analyses for men and
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9 268 women, respectively. In the multivariable-adjusted model (Model 1), among men, a
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12 269 significant association was observed between community-level social capital and
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15 270 incidence of functional disability for “social cohesion” (HR = 0.904, 95% CI: 0.824–0.992,
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18 271 p -value < 0.05). This association was maintained after adding individual GDS score and
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21 272 frequency of going outside (HR = 0.909, 95% CI: 0.829–0.996, p -value < 0.05; Model 2)
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24 273 and individual responses on community social capital indicators (HR = 0.910, 95% CI:
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27 274 0.830–0.998; Model 3). Although the associations of incidence of functional disability
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30 275 with community-level civic participation and with reciprocity were not statistically
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33 276 significant, the point estimates for these effects were in the same direction, with HRs <
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36 277 1.0 (civic participation: HR = 0.972, 95% CI: 0.893–1.058; reciprocity: HR = 0.920, 95%
37
38
39 278 CI: 0.829–1.021; Model 3). Among women, no significant association was observed (civic
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42 279 participation: HR = 0.999, 95% CI: 0.918–1.087; social cohesion: HR = 0.930, 95% CI:
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45 280 0.847–1.020; reciprocity: HR = 1.002, 95% CI: 0.901–1.114; Model 3).
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281 **Table 2. Multilevel survival analysis of functional disability among male respondents (n = 34,051)**

	Model 1	Model 2	Model 3
	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)
<i>Fixed effects</i>			
<i>Community-level variables</i>			
Community-level social capital			
Civic participation	0.956 (0.878-1.041)	0.959 (0.882-1.044)	0.972 (0.893-1.058)
Social cohesion	0.904 (0.824-0.992) *	0.909 (0.829-0.996) *	0.910 (0.830-0.998) *
Reciprocity	0.930 (0.837-1.032)	0.933 (0.841-1.035)	0.920 (0.829-1.021)
Urbanization (ref: Urban)			
Suburban	1.238 (0.977-1.568)	1.230 (0.972-1.557)	1.241 (0.981-1.571)
Rural	1.278 (0.986-1.655)	1.232 (0.951-1.596)	1.251 (0.967-1.620)
<i>Individual-level variables</i>			
Age (ref: 65-69 years)			
70-74	1.963 (1.603-2.403) **	1.940 (1.584-2.376) **	1.948 (1.591-2.387) **
75-79	3.624 (2.989-4.394) **	3.550 (2.928-4.305) **	3.549 (2.924-4.307) **
80-84	5.115 (4.189-6.246) **	4.876 (3.990-5.958) **	4.800 (3.923-5.873) **
85 or older	11.241 (9.126-13.846) **	10.371 (8.407-12.795) **	10.011 (8.099-12.375) **
Educational attainment (ref: <6)			
6-9	0.717 (0.549-0.938) *	0.738 (0.564-0.965) *	0.738 (0.564-0.966) *
10-12	0.682 (0.513-0.906) **	0.720 (0.542-0.957) *	0.727 (0.547-0.967) *
≥13	0.745 (0.554-1.000)	0.781 (0.581-1.050)	0.793 (0.590-1.067)
Equivalized income (ref: Low)			
Middle	1.234 (1.043-1.459) *	1.061 (0.903-1.247)	1.067 (0.908-1.254)
High	0.961 (0.523-1.769)	1.015 (0.673-1.530)	1.007 (0.668-1.519)
Marital status (ref: Married)			
Separated/divorced	1.028 (0.875-1.208)	1.218 (1.029-1.441) *	1.241 (1.048-1.470) *
Never married	0.962 (0.638-1.449)	0.907 (0.493-1.667)	0.929 (0.504-1.713)
Living arrangements (ref: Living with other)			
Living alone	1.012 (0.799-1.282)	1.013 (0.798-1.284)	1.036 (0.815-1.317)
Body mass index (ref: 18.5-24.9)			
<18.5	1.688 (1.431-1.993) **	1.651 (1.399-1.949) **	1.633 (1.383-1.927) **
≥25.0	0.919 (0.792-1.065)	0.926 (0.798-1.074)	0.932 (0.804-1.081)
Self-rated health (ref: Excellent)			
Good	1.356 (1.068-1.722) *	1.289 (1.014-1.637) *	1.265 (0.996-1.608)
Fair	2.831 (2.205-3.636) **	2.464 (1.910-3.178) **	2.387 (1.850-3.079) **
Poor	4.396 (3.287-5.881) **	3.638 (2.699-4.903) **	3.515 (2.606-4.740) **
Present illness (ref: No)			
Yes	1.140 (0.978-1.327)	1.143 (0.981-1.331)	1.146 (0.983-1.334)
Instrumental activities of daily living (ref: Without difficulty)			
With difficulty	1.798 (1.606-2.013) **	1.654 (1.475-1.856) **	1.635 (1.457-1.835) **
Alcohol consumption (ref: Non)			
Past	1.089 (0.905-1.310)	1.074 (0.893-1.292)	1.055 (0.877-1.270)

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3	Current	0.850 (0.757-0.954) **	0.866 (0.771-0.973) *	0.873 (0.777-0.981) *
4	Smoking history (ref: Non-			
5	smoking)			
6	Non-smoking now, quit before 5	1.089 (0.948-1.250)	1.075 (0.936-1.234)	1.071 (0.932-1.230)
7	years			
8	Non-smoking now, quit within 4	1.256 (1.021-1.545) *	1.237 (1.006-1.522) *	1.221 (0.993-1.502)
9	years			
10	Smoking	1.357 (1.153-1.598) **	1.320 (1.120-1.554) **	1.304 (1.107-1.536) **
11				
12	Geriatric Depression Scale (ref: No			
13	depression)			
14	Depression tendency		1.224 (1.069-1.402) **	1.214 (1.059-1.392) **
15	Depression		1.222 (1.011-1.477) *	1.236 (1.017-1.501) *
16				
17	Frequency of going outside (ref:			
18	Almost everyday)			
19	One to three times a week		1.237 (1.096-1.397) **	1.225 (1.084-1.383) **
20	Once to twice a month or less		1.899 (1.611-2.238) **	1.801 (1.524-2.128) **
21				
22	Social isolation (ref: Non-isolation)			
23	Moderately isolation			1.060 (0.939-1.196)
24				
25	Group participation in the			
26	community (ref: Non)			
27	One			0.778 (0.645-0.937) **
28	Over two			0.725 (0.588-0.894) **
29				
30	Social support (ref: Non)			
31	One			0.993 (0.625-1.578)
32	Over two			1.287 (0.864-1.917)
33				
34	Perception of community social			
35	cohesion (ref: Non)			
36	One			0.852 (0.686-1.057)
37	Over two			1.020 (0.853-1.220)
38				
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41	Random effects			
42	Community-level variance	0.0223	0.0210	0.0199

43 282 * $p < 0.05$, ** $p < 0.01$

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45 283 Values presented are HRs (hazard ratios) and 95% CIs (confidence intervals). Community-level social capital variables (civic
46 284 participation, social cohesion, and reciprocity) are 1 SD increase estimates. Variance of the intercept in the null model = 0.0336

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285 **Table 3. Multilevel survival analysis of functional disability among female respondents (n = 38,970)**

	Model 1	Model 2	Model 3
	HR (95% CI)	HR (95% CI)	HR (95% CI)
<i>Fixed effects</i>			
<i>Community-level variables</i>			
Community-level social capital			
Civic participation	0.986 (0.907-1.072)	0.987 (0.908-1.072)	0.999 (0.918-1.087)
Social cohesion	0.936 (0.854-1.027)	0.935 (0.853-1.025)	0.930 (0.847-1.020)
Reciprocity	1.003 (0.903-1.115)	1.007 (0.906-1.119)	1.002 (0.901-1.114)
Urbanization (ref: Urban)			
Suburban	0.977 (0.772-1.236)	0.968 (0.765-1.225)	0.978 (0.772-1.238)
Rural	1.045 (0.809-1.351)	1.013 (0.784-1.309)	1.024 (0.792-1.324)
<i>Individual-level variables</i>			
Age (ref: 65-69 years)			
70-74	1.911 (1.478-2.469) **	1.899 (1.469-2.455) **	1.896 (1.466-2.451) **
75-79	4.174 (3.293-5.290) **	4.111 (3.242-5.213) **	4.066 (3.203-5.161) **
80-84	8.084 (6.371-10.257) **	7.915 (6.232-10.052) **	7.733 (6.079-9.838) **
85 or older	14.654 (11.434-18.780) **	14.137 (11.016-18.143) **	13.749 (10.694-17.677) **
Educational attainment (ref: <6)			
6-9	0.723 (0.611-0.857) **	0.729 (0.615-0.863) **	0.734 (0.620-0.870) **
10-12	0.679 (0.561-0.822) **	0.687 (0.568-0.832) **	0.701 (0.578-0.849) **
≥13	0.792 (0.617-1.015)	0.806 (0.629-1.034)	0.826 (0.643-1.059)
Equivalized income (ref: Low)			
Middle	1.037 (0.876-1.229)	1.062 (0.896-1.259)	1.063 (0.897-1.261)
High	1.440 (0.989-2.097)	1.505 (1.033-2.193) *	1.500 (1.029-2.186) *
Marital status (ref: Married)			
Separated/divorced	1.078 (0.949-1.224)	1.068 (0.940-1.213)	1.064 (0.936-1.209)
Never married	1.356 (0.983-1.870)	1.330 (0.964-1.834)	1.338 (0.969-1.848)
Living arrangements (ref: Living with other)			
Living alone	1.055 (0.912-1.221)	1.044 (0.902-1.209)	1.071 (0.924-1.241)
Body mass index (ref: 18.5-24.9)			
<18.5	1.423 (1.220-1.661) **	1.395 (1.195-1.628) **	1.363 (1.168-1.592) **
≥25.0	0.997 (0.865-1.149)	0.994 (0.862-1.146)	1.003 (0.870-1.157)
Self-rated health (ref: Excellent)			
Good	1.404 (1.098-1.795) **	1.350 (1.054-1.727) *	1.333 (1.041-1.707) *
Fair	2.354 (1.818-3.049) **	2.111 (1.622-2.746) **	2.078 (1.596-2.706) **
Poor	3.439 (2.524-4.685) **	2.934 (2.138-4.027) **	2.856 (2.077-3.926) **
Present illness (ref: No)			
Yes	0.943 (0.811-1.097)	0.946 (0.813-1.101)	0.954 (0.820-1.111)
Instrumental activities of daily living (ref: Without difficulty)			
With difficulty	2.449 (2.167-2.767) **	2.287 (2.016-2.595) **	2.171 (1.911-2.467)
Alcohol consumption (ref: Non)			
Past	1.574 (1.005-2.467) *	1.550 (0.988-2.430)	1.624 (1.035-2.548) *

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3	Current	0.915 (0.751-1.116)	0.936 (0.767-1.141)	0.949 (0.778-1.157)
4	Smoking history (ref: Non-			
5	smoking)			
6	Non-smoking now, quit before 5	1.490 (1.121-1.981) **	1.454 (1.093-1.934) *	1.455 (1.094-1.936) *
7	years			
8	Non-smoking now, quit within 4	1.289 (0.758-2.193)	1.291 (0.759-2.197)	1.250 (0.735-2.129)
9	years			
10	Smoking	1.468 (1.077-2.000) *	1.430 (1.048-1.949) *	1.400 (1.026-1.911) *
11				
12	Geriatric Depression Scale (ref: No			
13	depression)			
14	Depression tendency		1.232 (1.074-1.414) **	1.240 (1.080-1.423) **
15	Depression		1.346 (1.116-1.624) **	1.364 (1.127-1.651) **
16				
17	Frequency of going outside (ref:			
18	Almost everyday)			
19	One to three times a week		1.119 (0.985-1.272)	1.098 (0.965-1.249)
20	Once to twice a month or less		1.323 (1.120-1.563) **	1.257 (1.060-1.491) **
21				
22	Social isolation (ref: Non-isolation)			
23	Moderately isolation			1.116 (0.977-1.275)
24				
25	Group participation in the			
26	community (ref: Non)			
27	One			0.678 (0.555-0.829) **
28	Over two			0.736 (0.587-0.923) **
29				
30	Social support (ref: Non)			
31	One			0.727 (0.408-1.295)
32	Over two			1.010 (0.619-1.647)
33				
34	Perception of community social			
35	cohesion (ref: Non)			
36	One			0.912 (0.740-1.123)
37	Over two			1.145 (0.961-1.364)
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41	Random effects			
42	Community-level variance	0.0202	0.0194	0.0209

43 286 * $p < 0.05$, ** $p < 0.01$

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45 287 Values presented are HRs (hazard ratios) and 95% CIs (confidence intervals). Community-level social capital variables (civic
46 288 participation, social cohesion, and reciprocity) are 1 SD increase estimates. Variance of the intercept in the null model = 0.0351

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6 289 **DISCUSSION**
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9 290 To the best of our knowledge, this was the first study with a multilevel longitudinal
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12 291 design to examine the association between community social capital and the onset of
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15 292 functional disability using social capital indicators with verified validity in a large
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18 293 sample of older community-dwelling adults. The results suggested that living in a
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21 294 community with higher community social cohesion at baseline was associated with a
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24 295 lower future risk of functional disability, even after adjusting for individual responses
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27 296 on community social capital indicators. The present study indicated the importance of
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30 297 strategies to protect the health of older people through fostering cohesive communities
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33 298 with efforts such as promoting social connections and trust.
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36 299 There are several possible pathways between community social cohesion and
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39 300 health. Social cohesion is determined by the resources available to members of tight-knit
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42 301 communities.[34] Cohesive communities might help residents to express trust toward
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45 302 their neighbors and to be psychologically healthier. Previous studies have revealed that
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48 303 neighborhood social cohesion positively affected older people's subjective well-being,[35,
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51 304 36] and that cohesive communities prevented the occurrence of depressive symptoms in
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54 305 older people who lived alone and were at high risk of functional disability.[37] Thus, we
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57 306 considered high levels of community social cohesion to be potentially protective against
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6 307 the onset of functional disability via the positive effects on psychological health, such as
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9 308 enhancing subjective well-being and inhibiting depressive symptoms.

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12 309 Two previous studies examined the association between community social
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15 310 capital and the onset of functional disability in older people using multilevel longitudinal
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18 311 designs.[23, 24] Our results suggesting that higher community social cohesion was
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21 312 associated with lower risk of functional disability among men but not women were
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24 313 inconsistent with these previous studies. There are several possible reasons for this
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27 314 difference. First, both previous studies were surveys in a smaller area, compared with
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30 315 that in our research. Because our work used survey data from municipalities nationwide,
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33 316 the possibility for generalizing our findings might be higher. Second, the measurement
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36 317 index of community social capital in the previous studies differed from ours. Both
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39 318 previous studies used only one item (“general trust”) to measure community social
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42 319 cohesion. In contrast, we used multidimensional indicators consisting of three
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45 320 measurement items with verified validity, which might be more accurate for examining
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48 321 community contextual effects. Therefore, our results might reflect more accurate
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51 322 estimates of the effects of community social cohesion on individual health.

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54 323 In the present study, community social cohesion affected the onset of functional
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57 324 disability only among men. It is likely that, among people who are currently in the older
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6 325 age groups, men sought and had stronger relationships with their colleagues before
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9 326 retirement than did women, given the nature of companies, particularly in Japan.[38]
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12 327 When this strong commitment is lost after retirement, these men may also experience a
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15 328 variety of changes in their living arrangements, leading to changes in their physical and
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18 329 mental health.[39] A cohesive community might be helpful in building new connections
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21 330 and encouraging social participation, which may keep men healthier and improve their
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24 331 psychological well-being. Honjo, et al. reported that rich social cohesion in a community
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27 332 buffered the risk of depression among older men living alone in Japan.[37] Thus,
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30 333 community cohesiveness may protect men's psychological health by helping them to
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33 334 build new connections in the community after retirement. However, further studies are
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36 335 needed to validate this hypothesis.

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39 336 We considered urbanization (population density) a potentially confounding
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42 337 characteristic of living areas. In exploratory analyses, we confirmed that urbanization
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45 338 had a relatively strong influence as a confounding factor on the relationship between
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48 339 community social capital and the onset of functional disability. Therefore, the other
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51 340 characteristics of living area that were related to urbanization, such as public security,
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54 341 might have caused residual confounding. However, we believe that this influence was
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57 342 relatively small because we adjusted for urbanization as a representative factor of
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6 343 communities.

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9 344 The present study had several strengths. First, using a large, nationwide
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12 345 population-based sample enabled us to conduct a community-level multilevel analysis to
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15 346 clarify the contextual relationship between community-level social capital and the onset
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18 347 of functional disability. Second, we used validated indicators consisting of
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21 348 multidimensional items to measure community social capital. Therefore, we may have
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24 349 appropriately captured the whole of community social capital. However, the study also
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27 350 had several limitations. First, because the measurement was based on a self-
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30 351 administered questionnaire, the results are subject to response biases such as social
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33 352 desirability.[40] Social desirability bias may have artificially inflated social capital,
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36 353 which was calculated from the responses to the questionnaire. This, in turn, may have
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39 354 caused an overestimation of the relationship between community social capital and the
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42 355 onset of functional disability. Second, especially because the response rate to the survey
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45 356 was moderate (66.3%), selection bias might exist. Respondents in this study tended to be
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48 357 younger and healthier than the typical older adult population in the surveyed
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51 358 municipalities. In addition, people living in communities with low social capital might
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54 359 have been less likely than others to respond to the survey. These factors may have
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57 360 reduced the generalizability of our findings. However, because the respondents were
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6 361 randomly selected or completely enumerated from 24 municipalities in Japan, we believe
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9 362 that any effect of selection bias was small. Third, there were frequently missing data on
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12 363 the model variables. In the analyses, we dealt with these missing data using a “missing”
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15 364 category.” This approach had the potential to bias the results. Therefore, we conducted
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18 365 sensitivity analyses by removing the missing data (complete case analyses). These
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21 366 analyses confirmed that the tendencies of the results were almost the identical when the
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24 367 missing data were removed (data not shown). Fourth, our study included no information
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27 368 about changes in social capital. Therefore, it is possible that unmeasured time-varying
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30 369 covariates such as economic changes or natural disasters may have biased our results.
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33 370 Fifth, we used school district as the unit of analysis for communities because this was
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36 371 the smallest identifiable unit. However, the geographic scale of this unit may be slightly
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39 372 too large for the analysis of community-level social capital. Nevertheless, a school district
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42 373 represents an area of a size that older people can easily travel on foot or by bicycle, and
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45 374 community organizations, such as senior citizens’ clubs and sports clubs, conduct their
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48 375 activities within individual school districts. Therefore, school district is a meaningful
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51 376 and appropriate unit of analysis for communities. Further work should build on our
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54 377 findings by defining regional units for spatial statistical analysis, using geographic
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57 378 information systems, for example. Finally, although our study was a prospective cohort
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6 379 study, the follow-up period was moderately short. Considering the possibility of reverse
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9 380 causation, study designs with a longer follow-up period are necessary in the future.

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13 14 15 382 **CONCLUSION**

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18 383 In conclusion, this multilevel prospective cohort study found that higher levels of
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21 384 community social cohesion were associated with a lower incidence of onset of functional
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24 385 disability among older men, but not among older women, even after adjusting for
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27 386 individual social and behavioral variables. The findings suggest the importance of
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30 387 fostering cohesive communities to reduce the onset functional disability among older
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33 388 people.

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37 38 39 390 **ACKNOWLEDGMENTS**

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55 56 57 396 **CONTRIBUTORS**

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6 397 TN had the idea for the study, participated in its design, performed the statistical
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9 398 analysis, and drafted the manuscript as the principal author. KK, the principal
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12 399 investigator of the JAGES project, helped to develop the idea of the study, participated
13
14
15 400 in acquiring the data and in designing the study, and critically revised the manuscript.
16
17
18 401 MS helped to develop the idea of the study, participated in acquiring the data and in
19
20
21 402 designing the study, and critically revised the manuscript. HN helped with the data
22
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27 404 authors read and approved the final manuscript.
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427 **ETHICS APPROCAL**

428 The ethics committee at Nihon Fukushi University approved the protocol and informed
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48 429 consent procedure for the present study (No. 10-05).

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52 53 54 431 **DATA SHARING**

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57 432 No additional data are available.
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9 434 **COMPERING INTERESTS**

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12 435 None declared.
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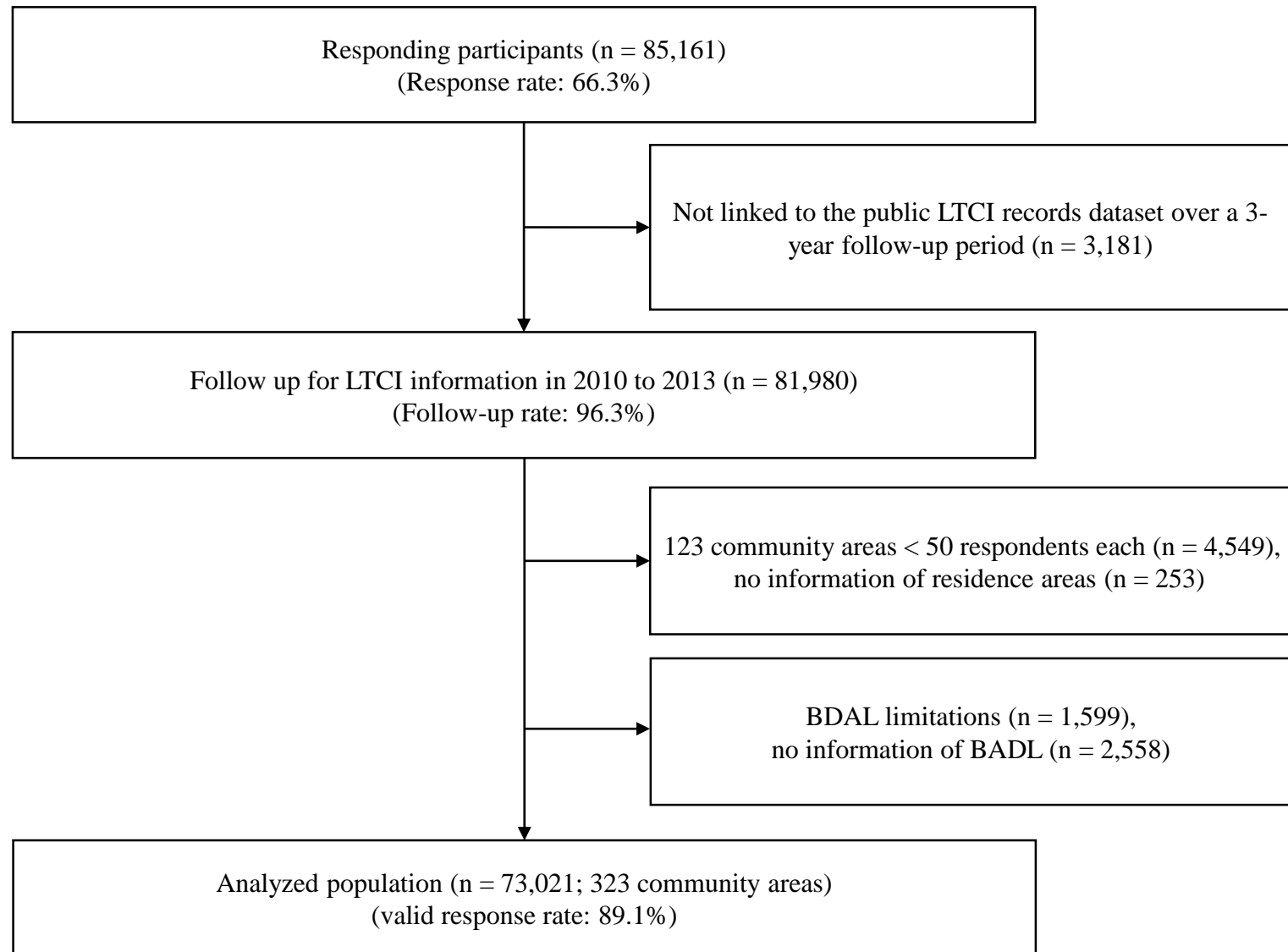
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45 536 Figure 1. Flow chart showing participation in the study cohort, 2010 to 2013. LTCI: long-
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STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	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 (b) Provide in the abstract an informative and balanced summary of what was done and what was found	1 2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (b) For matched studies, give matching criteria and number of exposed and unexposed	6-7 non
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-12
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-12
Bias	9	Describe any efforts to address potential sources of bias	13-14
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10, 11-12
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, explain how loss to follow-up was addressed (e) Describe any sensitivity analyses	12-14 non 13-14 non non
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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	15 7 7, figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	15-18 15-18 15
Outcome data	15*	Report numbers of outcome events or summary measures over time	15

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3	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
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7			non
8			non
9			
10	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
11			non
12			
13	Discussion		
14	Key results	18	Summarise key results with reference to study objectives
15			24
16	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
17			27-29
18	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
19			24-27
20	Generalisability	21	Discuss the generalisability (external validity) of the study results
21			25, 27
22			
23	Other information		
24	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
25			30-31
26			

*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>.