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Community social support and onset of dementia in older Japanese individuals: A multilevel analysis using the JAGES cohort data

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ABSTRACT

Objective: Recently, there has been an increase in the number of people with dementia. However, no study has examined the association between community-level social support and the onset of incident dementia using multilevel survival analysis.

Design: A prospective cohort study.

Participants and setting: We analyzed data pertaining to 15,313 community-dwelling adults aged 65 years or older (7,381 men, 7,932 women) who had not accessed long-term care insurance and were living in Aichi Prefecture (seven municipalities) in Japan.

Primary and secondary outcome measures: The association between community-level social support and onset of incident dementia was examined using the Japan Gerontological Evaluation Study, a prospective cohort study introduced in Japan in 2003. Incident dementia was assessed using Long-term Care Insurance records spanning 3,436 days from the baseline survey.

Results: During the 10-year follow-up, the onset of incident dementia occurred in 1,776 adults. Among older people, a 1% increase in community-level social support (in the form of receiving emotional support) was associated with an approximately 4% reduction in the risk of developing dementia, regardless of socio-demographic variables and health conditions (HR = 0.96; 95% CI = 0.94-0.99).

Conclusions: Receiving community-level social support in the form of emotional support is associated with a lower risk of developing incident dementia.

Keywords: Cognitive decline, Population health, Social epidemiology

STRENGTHS AND LIMITATIONS OF THIS STUDY

- To date, no study has examined the association between community-level social support and the onset of incident dementia using multilevel survival analysis.
- This is a long-term follow-up study that followed older adults in Japan for about 10 years.
- The sample does not fully reflect the older population in Japan because the study subjects were recruited from a single prefecture.

INTRODUCTION

Dementia constitutes a pressing health challenge, especially among the older population. The incidence of dementia worldwide is projected to rise to 66 and 131 million by 2030 and 2050, respectively.[1] In Japan alone, it is predicted that there will be 4.62 and 7 million people affected by 2012 and 2025, respectively. These rates suggest that about one in seven Japanese people aged 65 years or above may develop dementia.[2]

Currently, no effective therapeutic intervention for dementia has been determined. As such, identifying adjustable risks and preventive measures is essential for slowing down or preventing the onset of dementia.[3] Previous studies have identified genetic, vascular, and lifestyle-related factors,[4-9] such as advanced age, being female, having a low education level, being in poor health, smoking, and heavy drinking, as being associated with a higher risk of developing dementia. An additional significantly adjustable risk factor is the lack of positive social networks and influences. A previous study suggested that engagement in social activities, and having a rich network of activities within close relationships, confers some protection against dementia among older people.[4]

The definition and the attendant use of the notion of social relationships vary among researchers. The concept may encompass factors such as social participation, social networks, and social support. Social support might also be a significant protective factor for cognitive aging.[10] Social support has been categorized into four types: giving and receiving support at an emotional level, as well as giving and receiving support at an instrumental level.[11] These types of support occur at an individual level and have been associated with improved health. For example, providing emotional and instrumental social support to non-family members leads to fewer depressive symptoms.[12] Providing emotional support to relatives, friends, and neighbors, along with instrumental support to spouses, further lowers the risk of mortality.[13] Receiving emotional support is associated with improved cognitive

function.[10] However, incident dementia has been reported in instances where social support is extended between co-resident members of the family.[13]

Besides individual-level social factors, social networks, and relationships at the community level have been investigated to understand its association with moderating the risk of functional disability. Such studies investigate "social capital," that has been defined as the "resources that are accessed by individuals as a result of their membership of a network or a group."[14] A previous study found that lower social capital at the community-level is associated with an increased rate of functional disability among older women.[11] And there are reports of research on community social capital and cognitive decline.[15] However, because these studies are cross-sectional studies, they do not take into account temporal pre/posterior relationships. Nevertheless, no studies have examined how community-level social support influences the risk of dementia. Therefore, this study seeks to evaluate the relationship between social support at the community level and the onset of dementia.

METHODS

Sample

Data for this study were accessed via the Japan Gerontological Evaluation Study (JAGES). Set up in Aichi in 2003, this is a prospective cohort study of the Center for Well-being and Society of the Nihon Fukushi University.[16] The research was carried out in seven municipalities encompassing the entire southern region of the Chita peninsula and the Aichi Prefecture. In October 2003, an estimated 276,208 people resided in these locations. Of this population, 18.0% were aged 65 years or above.[14] On average, the data of 6,300 residents in the 44 school districts were analyzed in this study. Care was taken to limit the sample to people aged 65 years and above who were not recipients of long-term public health insurance benefits due to physical or mental challenges. A random selection of 33,152 people aged 65

years or older was performed. Of this sample, 15,313 individuals answered the baseline survey (response rate = 52.1%).[13] The exclusion criteria were: a) people who had difficulty in performing activities of daily living as a result of disabilities; b) people who did not provide baseline information (n=579); c) people who did not provide social support information (*n* = 1359); and d) people did not provide a school district code (*n* = 2,343). Ultimately, 11,032 subjects (5,627 women and 5,405 men) were included in this analysis.

The ethics committee of Research of Human Subjects at the Nihon Fukushi University evaluated and approved the use of the JAGES protocol (approval number 13-14). Consent to participate in the study was indicated by a written explanation at the beginning of the questionnaire and by the response received on the questionnaire.

Follow-up

The evaluation parameters of the JAGES Project included health status, functional deterioration, and mental impairment amongst older Japanese people who were not institutionalized. In Japan, there is a long-term care insurance system that covers both institutional and community-based caregiving. Individuals aged 65 years or above qualify to receive benefits on the strict basis of physical and cognitive disability. The follow-up began on November 1, 2003. Dementia-associated data from the six municipalities (specifically in terms of the onset) was assessed until March 28, 2013.

Outcome variables

Dementia was graded on a scale that includes categories from I to IV, and M based on the Activities of Daily Living Independence Assessment Criteria for Older Individuals with Dementia. The Degree of Autonomy in the Daily Lives of Older Individuals with Dementia Scale, created by the Ministry of Health, Labor, and Welfare of Japan, evaluates an

individual's ability to carry out daily tasks associated with living on a scale that includes categories from I to IV and M.

This scale was validated based on its high association with the Mini-Mental State Evaluation.[13, 17] A score of I indicates that the patient suffers from some level of cognitive decline but remains able to perform domestic and social tasks nearly independently. A score of II indicates that the patient has certain symptoms or behaviors indicative of cognitive impairment and challenges in communication that may hamper the performance of daily tasks, although some amount of external assistance is needed to facilitate routine function. A score of III indicates that the patient periodically exhibits symptoms indicating communication challenges or symptoms/behaviors, which may interfere with the performance of daily tasks, necessitating external assistance. A score of IV indicates that the patient usually shows communication or behavioral challenges, which hampers performing daily tasks, necessitating frequent care. Finally, a score of M is used when the patient shows significant cognitive impairment, displays difficult behavior, or has a serious physical illness, requiring expert medical intervention.[18, 19]

Explanatory variables

An aggregate of individual-level background data was acquired for the 44 school-based districts to evaluate community social support. An aggregate of responses for individual-level social support among the school districts was used as an indicator of community social support. Within the Japanese context, school districts (or primary schools) are primary residential units of individuals within rural zones. Generally, school districts comprise geographical settings where older individuals may readily travel via foot or bicycle.[20] Individual-level social support was assessed based on four dimensions of the Two-Way Social Support Scale.[12] The four types of support included: (a) receiving support at the

emotional level, (b) providing support at the emotional level, (c) receiving support at the instrumental level, and (d) providing support at the instrumental level.

A single item measured each support, "If you or others required additional daily assistance, who would you depend upon to assist or to be assisted by?" Receiving emotional support was conceptualized as the perception of the respondent's complaints or fears by an individual (e.g., "Do you have someone who listens to your concerns and complaints? Circle all that apply. Options included family living together, separated children and relatives, acquaintance/friends/neighbors"). Providing emotional support was conceptualized as the expression of complaints or fears by an individual to the respondents (e.g., "Do you listen to someone's concerns or complaints? Circle the numbers of all the answers that apply. Options include family living together, separated children and relatives, acquaintances/ friends/ neighbors"). Receiving instrumental support was conceived as the rendering of care to the respondent by an individual, if the respondent were ill for many days (Question: "Do you have someone who looks after you when you are sick and confined to a bed for a few days? Circle the numbers of all the answers that apply. Options include family living together, separated children and relatives, acquaintance/friends/neighbors"). Providing instrumental support was defined as nursing of an individual by the respondent if they were ill for many days (e.g., "Do you look after someone when he/she is sick and confined to a bed for a few days? Circle the numbers of all the answers that apply. Options include family living together, separated children and relatives, acquaintance/friends/neighbors").

The percentage of people who responded to each item was considered while determining the level of social support. An aggregation of the responses to the survey items, apropos the four dimensions of social support, was performed for the 44 local districts and further, considered community social support indicators.[12]

Covariates

Other explanatory variables included: gender (female, male), age (65–69, 70–74, 75–79, 80–84, and 85 years or older), living conditions (accompanied/unaccompanied), marital status (married, never married, divorced, widowed, other/missing), education (≥13 years, 10–12 years, 6–9 years, <6 years, other/missing), present illness (no, yes, missing), depressive symptoms evaluated by the GDS-15 (Geriatric Depression Scale: no depression 0–4 points, mild depression 5–9 points, depression 10–15 points, missing), smoking status (never, former, current, missing), alcohol consumption (no, do not drink every day, drink every day ≤35 g/day, drink every day >35 g/day, missing), and individual social support.

Statistical analysis

This prospective study employed multilevel survival analysis. The data of 11,032 people living in 44 local districts were used in this study. The multilevel analysis framework relied on the assumption that the health outcome of individuals is partially affected by the district in which they live. The multilevel model evaluated the change in outcome across districts (random effects) and the influences of community-level factors on the outcome, accounting for specific constituent features (fixed effects). Multilevel survival analysis was employed to compute the hazard ratio (HR) and 95% confidence interval (CI) for the onset of dementia at follow-up. The HR of the social support variable was determined as the 1% variation in the proportion of aggregated social support. For the analyses, each of the four social support indicators at the community level was concurrently adjusted. Furthermore, three sensitivity analyses were conducted, excluding (i) one year, (ii) two years, and (iii) three years after baseline. The STATA SE version 13 (Stata Corp., College Station, TX, USA) was used to conduct the analyses.

Patient and public involvement

The patients and public were not involved in the design, conduct, reporting, or dissemination plans of our research.

RESULTS

During the 9.4-year follow-up period (mean=7.9 person-years; standard deviation [SD] =2.5 person-years), dementia onset was observed in 1,776 individuals (16.1%). Supplementary Table S1 (view as supplementary data online) shows the baseline characteristics and frequency of dementia for every 1,000 people/year. The incidence rate of dementia was higher in those who were female, older, living alone, widowed or divorced, those having less than 6 years of education with an existing illness and with a higher score on GDS-15. It was also higher for those who did not consume alcohol, did not get support at the emotional level, did not offer support at the emotional level, and did not receive help at the instrumental level, compared with each counterpart category.

Table 1 shows the mean, range, median, correlation matrix, and SD of the community-level social support indicators in the 44 districts. Spearman's correlation coefficients ranged from -.11 to .44. The average proportion of people receiving community level emotional support was 89.9%, with a range of 82.7% to 93.5%. The proportion of people receiving community level emotional support was moderately correlated with the proportion of people receiving instrumental support (p = .44).

Table 1 Characteristics and Spearman's correlation coefficient matrices for community level social support indicators (N = 44 school districts)

	%	SD	Min	Max	Spearman's Rank Correlation Coefficient		
					1.	2.	3.
1. Community-level receiving emotional support	89.9	2.0	82.7	93.5	--		
2. Community-level providing emotional support	83.1	2.2	76.1	88.6	-.11*	--	
3. Community-level receiving instrumental support	94.0	1.6	91.3	97.6	.44*	.08*	--
4. Community-level providing instrumental support	91.9	2.1	85.6	97.9	-.01	.41*	.26*

SD, standard deviation; Min, minimum; Max, maximum; * p <.05

The results of the multilevel survival analyses (Model 1) for the onset of incident dementia with three sensitivity analyses models (Model 2, 3, and 4) are shown in Supplementary Table S2 (view as supplementary data online). Regarding community-level social support, in Model 1, a significant association was observed between the onset of incident dementia and the proportion of people receiving community level emotional support (HR=0.96; 95% CI=0.94-0.99). On the contrary, significant correlations or relationship between the onset of incident dementia and other community-level social support were absent. In Model 2 of a sensitivity analysis (excluding 1 year after baseline), significant correlations between the onset of incident dementia and receiving community-level emotional support (HR=0.97; 95% CI=0.94-0.99) remained. Model 3 (excluding 2 years after baseline)

and Model 4 (excluding 3 years after baseline) showed similar results to Models 1 and 2. Regarding individual-level social support, in Model 1, the incidence of dementia was significantly associated with community-level emotional support (HR=0.83; 95% CI=0.73-0.94) as well as instrumental support (HR=0.83; 95% CI=0.73-0.94).

DISCUSSION

To our knowledge, this is the first study to evaluate community-level social support using multilevel survival analysis to investigate the onset of dementia in a large sample of older community-dwelling individuals. There was a prospective association between living in a community with a higher level of social support and a lower occurrence of dementia during the 10-year study period. However, only one of the community-level social support indicators was significantly associated with dementia onset. The outcome of this research has significant implications for public health. Among older people, a 1% rise in receiving community-level emotional support correlated with an approximately 4% decrease in the incidence of dementia, irrespective of socio-demographic factors and health circumstances.

For individual-level social support, providing social support was significantly correlated with a lower risk for dementia. A previous study indicated that providing emotional and instrumental support at the individual level might be a risk factor for the onset of depression.[12] A previous study by Murata and colleagues [21] examined the association between individual-level social support and dementia development in a 10-year cohort. The results showed that receipt of support from friends and neighbors was associated with a lower risk of developing dementia for both men and women. Nonetheless, people who were providing social support might be less likely to develop dementia.

In the present study, among the four kinds of community social support, only community-level emotional support affected the onset of incident dementia, even after

adjustment for individual-level social support. Two reasons might contribute to this finding. First, a community where people receive high emotional support from each other might be a place where older people are less likely to feel lonely. Indeed, loneliness was found to predict dementia in a previous study.[22] Second, in areas rich in receiving community-level emotional support, there may be older people who maintain a good relationship with their children. A previous study indicated that positive experiences of receiving social support from children predicted the onset of dementia.[23] In the current study, social support from children was evaluated through three questions: "To what extent do they actually comprehend your feelings about things?" "How much can you depend on them if you experience a critical problem?" and "How much can you open up to them if you need to talk about your fears?" A place where many people receive emotional support may be a place where people generally have good interpersonal relationships. Therefore, a community-level indicator of receiving emotional support may only be associated with the onset of dementia.

Community social support may be an element of social capital or community-level social relationships. For this reason, several plausible pathways between receiving community level emotional support and onset of incident dementia were found in the current study. First, community-level social support may influence people's health by shaping health-associated behaviors. This may be done through faster dissemination of health-related information or by increasing the probability of people taking up healthy standards of behavior and moderating behaviors that have negative effects on health. Second, social support may shape health by enhancing the accessibility of local services and facilities. Social involvement of older people may be fostered by accessing services, including transportation, recreational spaces, and community hubs may foster, thus, restricting or arresting the development of dementia. Third, community social support has the potential to foster good cognitive health by minimizing psychological distress. Fourth, places with higher social

support at the community level generate greater egalitarian political involvement trends. This may lead to the execution of policies that ensure the safety of community members.

It is critical to mention the possible limitations associated with the present study. First, the response rate to the survey (52.1%) could affect the generalizability of the results. Second, there was no information about the type of dementia diagnoses (for instance, Alzheimer's disease, cerebrovascular dementia, or dementia with Lewy bodies). Third, the sample did not fully reflect the older population in Japan because the study subjects were recruited from a single prefecture. Therefore, the findings cannot be generalized to urban areas or places where the population has distinct characteristics. Finally, other community-level social relationships, including social capital, were not evaluated. However, we plan to assess a wider range of community-level factors in subsequent studies.

CONCLUSIONS

The results of this study showed that a higher level of social support at the community level is related to a lower incidence of dementia after adjusting for individual-level social support among older individuals. A community level social support indicator (an aggregated value of receiving emotional support) showed a significant association with dementia onset. The present prospective study suggests that receiving emotional support at the community level may result in a lower level of incident dementia among community-dwelling older individuals in Japan.

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Competing Interests

None of the authors have a conflict of interest to declare.

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Author contributions

YM conceived the research idea, participated in the study design, performed statistical analysis, and prepared the manuscript as the primary author. TT developed the research idea, participated in the study design, cooperated in the statistical analysis, and revised the

manuscript. JA and MS assisted in the data analysis and reviewed the manuscript. TT and YS acquired data, collaborated in statistical analysis, and revised the manuscript. As the lead researcher of the JAGES project, KK helped to conceptualize the study. The final manuscript was read and approved by all authors.

Data sharing statement

Data are available upon reasonable request

References

1. Prince M, Wimo A, Guerchet M, et al. *World Alzheimer Report 2015: The Global Impact of Dementia: An Analysis of Prevalence, Incidence, Cost and Trends* [online report]. London: Alzheimer's Disease International 2015. https://www.alz.co.uk/research/WorldAlzheimerReport2015.pdf
2. Ministry of Health Law, 2017. https://www.mhlw.go.jp/content/000522832.pdf
3. Middleton LE, Yaffe K. Promising strategies for the prevention of dementia. *Arch Neurol* 2009;66(10):1210–15. doi: 10.1001/archneurol.2009.201
4. Fratiglioni L, Paillard-Borg S, Winblad B. (2004). An active and socially integrated lifestyle in late life might protect against dementia. *Lancet Neurol* 2004;3(6):343–53. doi: 10.1016/s1474-4422(04)00767-7
5. Gao S, Hendrie HC, Hall KS, et al. The relationships between age, sex, and the incidence of dementia and Alzheimer disease: a meta-analysis. *Arch Gen Psychiatry* 1998;55(9):809–15. doi: 10.1001/archpsyc.55.9.809
6. Livingstone G, Sommerlad A, Orgeta V, et al. Dementia prevention, intervention, and care. *Lancet* 2017;390(10113):2673–734. https://doi.org/10.1016/S0140-6736(17)31363-6
7. Norton MC, Dew J, Smith H, et al. Lifestyle behavior pattern is associated with different levels of risk for incident dementia and Alzheimer's disease: the Cache County Study. *J Am Geriatr Soc* 2012;60(3):405–12. doi: 10.1111/j.1532-5415.2011.03860.x
8. Patterson C, Feightner JW, Garcia A, et al. Diagnosis and treatment of dementia: 1. Risk assessment and primary prevention of Alzheimer disease. *CMAJ* 2008;178(5): 548–56. doi: 10.1503/cmaj.070796

9. Santini ZI, Koyanagi A, Tyrovolas S, et al. The association between social relationships and depression: a systematic review. *J Affect Disord* 2015;175:53–65. doi: 10.1016/j.jad.2014.12.049

10. Seeman TE, Lusignolo TM, Albert M, et al. Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur Studies of Successful Aging. *Health Psychol* 2001;20(4):243–55. doi: 10.1037/0278-6133.20.4.243

11. Berkman LF, Kawachi I. Social Epidemiology. New York, NY: Oxford University Press 2015. doi: 10.1093/med/9780195377903.001.0001

12. Tsuboi H, Hirai H, Kondo K. Giving social support to outside family may be a desirable buffer against depressive symptoms in community-dwelling older adults: Japan Gerontological Evaluation Study. *BioPsychoSoc Med* 2016;10(1):18. doi: 10.1186/s13030-016-0064-6

13. Saito T, Murata C, Saito M, et al. Influence of social relationship domains and their combinations on incident dementia: a prospective cohort study. *J Epidemiol Community Health* 2017;72(1):7–12. doi: 10.1136/jech-2017-209811

14. Aida J, Kondo K, Kawachi I, et al. Does social capital affect the incidence of functional disability in older Japanese? A prospective population-based cohort study. *J Epidemiol Community Health* 2012;67(1):42–7. doi: 10.1136/jech-2011-200307

15. Murayama H, Sugiyama M, Inagaki H, et al. Is community social capital associated with subjective symptoms of dementia among older people? A cross-sectional study in Japan. *Geriatr Gerontol Int*. 2018;18(11):1537–42. doi:10.1111/ggi.13519

16. Nishi A, Kondo K, Hirai H, et al. (2011). Cohort Profile: The AGES 2003 Cohort Study in Aichi, Japan. *J Epidemiol* 2011;21(2):151–7. doi: 10.2188/jea.je20100135

17. Hisano S. (2009). The relationship between Revised Hasegawa Dementia Scale (HDS-R), Mini-Mental State Examination (MMSE) and Bed-fast Scale, Dementia Scale. *Nihon Ronen Igakkai Zasshi* 2009;20(8):883–91.

18. Hikichi H, Tsuboya T, Aida J, et al. Social capital and cognitive decline after a natural disaster—Authors reply. *Lancet Planet Health* 2017;1(6):E219. doi: 10.1016/s2542-5196(17)30098-0

19. Yamamoto T, Kondo K, Hirai H, et al. (2012). Association Between Self-Reported Dental Health Status and Onset of Dementia. *Psychosom Medi* 2012;74(3):241–8. doi: 10.1097/psy.0b013e318246dffb

20. Takagi D, Kondo K, Kawachi I. Social participation and mental health: moderating effects of gender, social role and rurality. *BMC Public Health* 2013;13(1):701. doi: 10.1186/1471-2458-13-701

21. Murata C, Saito T, Saito M, et al. (2019). The association between social support and incident dementia: a 10-year follow-up study in Japan. *Int J Environ Res Public Health* 2019;16(2):239. doi: 10.3390/ijerph16020239

22. Holwerda TJ, Deeg DJH, Beekman ATF, et al. Feelings of loneliness, but not social isolation, predict dementia onset: results from the Amsterdam Study of the Elderly (AMSTEL). *J Neurol Neurosurg Psychiatry* 2012;85(2):135–42. doi: 10.1136/jnnp-2012-302755

23. Khondoker M, Rafnsson SB, Morris S, et al. Positive and negative experiences of social support and risk of dementia in later life: an investigation using the English Longitudinal Study of Ageing. *J Alzheimers Dis* 2017;58(1):99–108. doi: 10.3233/jad-161160

Supplementary Table S1. Descriptive characteristics of study respondents (N = 11,032)

			Incidence Rate (IR) per 1000 person-years		Patients with Dementia (n = 1,776, 16.1%)	
Individual-Level variables	*n*	%	IR	95% CI	*n*	%
Sex						
Male	5,405	49.0	0.049	[0.045, 0.052]	746	13.8
Female	5,627	51.0	0.062	[0.058,0.066]	1,030	18.3
Age (years)						
65-69	4,065	36.9	0.016	[0.014,0.018]	207	5.1
70-74	3,280	29.7	0.044	[0.040,0.048]	428	13.1
75-79	2,228	20.2	0.090	[0.083,0.098]	548	24.6
80-84	1,012	9.2	0.158	[0.143,0.175]	376	37.2
85+	447	4.1	0.289	[0.253,0.330]	217	48.6
Living Alone						
No	9,959	90.3	0.054	[0.051,0.057]	1,558	15.6
Yes	1,073	9.7	0.073	[0.064,0.083]	218	20.3

Marital Status						
Married	7,905	71.7	0.044	[0.042,0.047]	1,038	13.1
Widowed or divorced	2,745	24.9	0.089	[0.082,0.096]	658	24.0
Never married	190	1.7	0.063	[0.033,0.121]	41	21.6
Other/Missing	192	1.7	0.071	[0.052,0.097]	39	20.3
Education (years)						
≥13	455	4.1	0.046	[0.039,0.053]	171	37.6
10–12	6,002	54.4	0.048	[0.044,0.052]	963	16.0
6–9	3,341	30.3	0.055	[0.052,0.059]	470	14.1
<6	1,132	10.3	0.156	[0.134,0.181]	149	13.2
Other/Missing	102	0.9	0.081	[0.054,0.121]	23	22.6
Present Illness						
No	2,906	26.3	0.040	[0.036,0.045]	354	12.2
Yes	7,679	69.6	0.062	[0.059,0.065]	1,348	17.6
Missing	447	4.1	0.058	[0.046,0.072]	74	16.6
GDS-15						

0–4	6,737	61.1	0.043	[0.040,0.045]	857	12.7
5–9	2,234	20.3	0.073	[0.067,0.080]	450	20.1
10–15	644	5.8	0.106	[0.091,0.123]	170	26.4
Missing	1,417	12.8	0.076	[0.068,0.085]	299	21.1
Smoking Status						
Never	6,501	58.9	0.059	[0.056,0.063]	1,129	17.4
Former	2,757	25.0	0.047	[0.042,0.052]	367	13.3
Current	1,396	12.7	0.055	[0.048,0.063]	213	15.3
Missing	378	3.4	0.063	[0.050,0.080]	67	17.7
Alcohol Consumption						
None	7,094	64.3	0.063	[0.059,0.066]	1,268	17.9
Not drink every day	1,513	13.7	0.042	[0.036,0.048]	188	12.4
Drink every day ≤35 g/day	1,769	16.0	0.045	[0.039,0.051]	233	13.2
Drink every day >35 g/day	495	4.5	0.033	[0.025,0.044]	49	9.9
Missing	161	1.5	0.085	[0.062,0.117]	38	23.6
Social Support						

Receiving Emotional Support						
No	1,089	9.9	0.070	[0.061,0.080]	208	19.1
Yes	9,943	90.1	0.054	[0.052,0.057]	1,568	15.8
Providing Emotional Support						
No	1,836	16.6	0.085	[0.077,0.094]	409	22.3
Yes	9,196	83.4	0.051	[0.048,0.053]	1,367	14.9
Receiving Instrumental Support						
No	868	7.9	0.063	[0.053,0.076]	112	18.1
Yes	10,164	92.1	0.055	[0.053,0.058]	1,664	16.0
Providing Instrumental Support						
No	619	5.6	0.113	[0.100,0.128]	250	28.8
Yes	10,413	94.4	0.051	[0.049,0.054]	1,526	15.0

Supplementary Table S2. Results of multilevel survival analyses for the onset of incident dementia

	Model 1	Model 2 (1 year)	Model 3 (2 year)	Model 4 (3 year)
	n = 11,032	*n* = 10,780	*n* = 10,440	*n* = 10,071
Fixed Effect	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Community-Level Variables				
Rate of receiving emotional support*	0.96 (0.94–0.99)	0.97 (0.94–0.99)	0.97 (0.94–0.99)	0.97 (0.94–0.99)
Rate of providing emotional support*	0.99 (0.96–1.01)	0.99 (0.96–1.01)	0.98 (0.95–1.01)	0.98 (0.95–1.01)
Rate of receiving instrumental support*	1.01 (0.97–1.04)	1.01 (0.97–1.04)	1.01 (0.97–1.05)	1.01 (0.97–1.06)
Rate of providing instrumental support*	1.00 (0.97–1.03)	1.00 (0.97–1.02)	1.00 (0.97–1.03)	1.00 (0.97–1.04)
Individual-Level Variables				
Social Support				
Receiving Emotional Support				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	1.04 (0.88–1.22)	1.03 (0.87–1.22)	1.03 (0.87–1.23)	0.99 (0.83–1.19)
Providing Emotional Support				

No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	0.83 (0.73–0.94)	0.88 (0.77–0.99)	0.91 (0.80–1.04)	0.91 (0.79–1.05)
Receiving Instrumental Support				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	1.22 (0.99–1.51)	1.18 (0.95–1.47)	1.13 (0.90–1.42)	1.15 (0.91–1.47)
Providing Instrumental Support				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	0.76 (0.66–0.89)	0.82 (0.70–0.96)	0.85 (0.72–1.01)	0.89 (0.74–1.07)
Sex				
Male	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Female	1.01 (0.87–1.18)	1.03 (0.88–1.20)	1.06 (0.90–1.24)	1.08 (0.91–1.28)
Age (years)				
65–69	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
70–74	2.64 (2.23–3.12)	2.67 (2.25–3.16)	2.65 (2.22–3.16)	2.71 (2.26–3.25)
75–79	5.42 (4.60–6.38)	5.59 (4.73–6.61)	5.84 (4.93–6.93)	5.97 (5.00–7.13)
80–84	9.85 (8.24–11.78)	10.08 (8.40–12.10)	10.30 (8.53–12.43)	10.31 (8.46–12.56)

85+	19.01 (15.38–23.50)	19.32 (15.52–24.06)	19.32 (15.33–24.34)	18.64 (14.52–23.92)
Living Alone				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	0.94 (0.80–1.11)	0.94 (0.79–1.12)	0.98 (0.82–1.17)	1.03 (0.86–1.24)
Marital status				
Married	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Widowed or Divorced	1.09 (0.96–1.24)	1.09 (0.96–1.24)	1.06 (0.92–1.21)	1.00 (0.86–1.15)
Never Married	1.28 (0.92–1.78)	1.22 (0.87–1.73)	1.24 (0.87–1.76)	1.25 (0.87–1.79)
Other/Missing	1.12 (0.80–1.56)	1.13 (0.80–1.58)	1.09 (0.77–1.56)	1.09 (0.76–1.57)
Education (years)				
≥13	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
10–12	0.89 (0.74–1.08)	0.89 (0.74–1.08)	0.89 (0.73–1.08)	0.92 (0.75–1.13)
6-9	0.96 (0.80–1.15)	0.95 (0.79–1.14)	0.95 (0.79–1.15)	0.96 (0.79–1.16)
<6	1.29 (1.02–1.63)	1.24 (0.97–1.57)	1.22 (0.95–1.57)	1.23 (0.95–1.61)
Other/Missing	0.89 (0.57–1.40)	0.82 (0.51–1.33)	0.80 (0.48–1.33)	0.86 (0.51–1.45)

Present Illness				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	1.15 (1.02–1.30)	1.13 (1.00–1.28)	1.13 (1.00–1.28)	1.10 (0.96–1.26)
Missing	0.96 (0.75–1.24)	0.98 (0.75–1.27)	0.99 (0.75–1.29)	1.01 (0.76–1.33)
GDS-15				
0-4	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
5-9	1.54 (1.37–1.73)	1.54 (1.37–1.74)	1.48 (1.31–1.68)	1.49 (1.30–1.69)
10-15	2.33 (1.96–2.77)	2.18 (1.82–2.62)	2.16 (1.79–2.62)	2.17 (1.78–2.66)
Missing	1.47 (1.28–1.68)	1.43 (1.25–1.64)	1.41 (1.22–1.63)	1.41 (1.22–1.64)
Smoking Status				
Never	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Former	0.99 (0.85–1.16)	1.00 (0.86–1.18)	0.99 (0.84–1.17)	1.02 (0.86–1.21)
Current	1.34 (1.12–1.60)	1.32 (1.10–1.59)	1.39 (1.15–1.68)	1.40 (1.15–1.71)
Missing	0.86 (0.65–1.15)	0.90 (0.67–1.20)	0.85 (0.63–1.15)	0.91 (0.67–1.24)
Alcohol Consumption				
None	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)

Does not drink every day	0.96 (0.82–1.13)	0.96 (0.81_1.13)	0.97 (0.82–1.15)	0.96 (0.80–1.15)
Drinks every day ≤35 g/day	0.98 (0.84–1.15)	0.99 (0.84–1.16)	1.02 (0.86–1.20)	1.03 (0.87–1.22)
Drinks every day >35 g/day	0.86 (0.64–1.17)	0.90 (0.66–1.21)	0.92 (0.68–1.26)	0.91 (0.66–1.26)
Missing	1.14 (0.78–1.66)	1.14 (0.78–1.67)	1.24 (0.84–1.83)	1.22 (0.82–1.83)
Random effects				
Community-level variance (SE)	0.06 (0.05)	0.04 (0.06)	0.04 (0.07)	0.09 (0.04)

SE, standard error; *HR for one-point increment of community social support (range: 0-100)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	6-9
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-9
		(*b*) Describe any methods used to examine subgroups and interactions	6-9
		(*c*) Explain how missing data were addressed	6-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	9

Continued on next page

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	5-6
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	6
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
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	10-12
		(*b*) Report category boundaries when continuous variables were categorized	10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
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	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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 www.strobe-statement.org.

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Community social support and onset of dementia in older Japanese individuals: A multilevel analysis using the JAGES cohort data

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ABSTRACT

Objective: Recently, there has been an increase in the number of people with dementia. However, no study has examined the association between community-level social support and the onset of incident dementia using multilevel survival analysis.

Design: A prospective cohort study.

Participants and setting: We analyzed data pertaining to 15,313 community-dwelling adults aged 65 years or older (7,381 men, 7,932 women) who had not accessed long-term care insurance and were living in Aichi Prefecture (seven municipalities) in Japan.

Primary and secondary outcome measures: The association between community-level social support and onset of incident dementia was examined using the Japan Gerontological Evaluation Study, a prospective cohort study introduced in Japan in 2003. Incident dementia was assessed using Long-term Care Insurance records spanning 3,436 days from the baseline survey.

Results: During the 10-year follow-up, the onset of incident dementia occurred in 1,776 adults. Among older people, a 1% increase in community-level social support (in the form of receiving emotional support) was associated with an approximately 4% reduction in the risk of developing dementia, regardless of socio-demographic variables and health conditions (HR = 0.96; 95% CI = 0.94-0.99).

Conclusions: Receiving community-level social support in the form of emotional support is associated with a lower risk of developing incident dementia.

Keywords: Cognitive decline, Population health, Social epidemiology

STRENGTHS AND LIMITATIONS OF THIS STUDY

- To date, no study has examined the association between community-level social support and the onset of incident dementia using multilevel survival analysis.
- This is a long-term follow-up study that followed older adults in Japan for about 10 years.
- The sample does not fully reflect the older population in Japan because the study subjects were recruited from a single prefecture.

INTRODUCTION

Dementia constitutes a pressing health challenge, especially among the older population. The incidence of dementia worldwide is projected to rise to 66 and 131 million by 2030 and 2050, respectively.[1] In Japan alone, it is predicted that there will be 4.62 and 7 million people affected by 2012 and 2025, respectively. These rates suggest that about one in seven Japanese people aged 65 years or above may develop dementia.[2]

Currently, no effective therapeutic intervention for dementia has been determined. As such, identifying adjustable risks and preventive measures is essential for slowing down or preventing the onset of dementia.[3] Previous studies have identified genetic, vascular, and lifestyle-related factors,[4-9] such as advanced age, being female, having a low education level, being in poor health, smoking, and heavy drinking, as being associated with a higher risk of developing dementia. An additional significantly adjustable risk factor is the lack of positive social networks and influences. A previous study suggested that engagement in social activities, and having a rich network of activities within close relationships, confers some protection against dementia among older people.[4]

The definition and the attendant use of the notion of social relationships vary among researchers. The concept may encompass factors such as social participation, social networks, and social support. Social support can be defined as aid and assistance exchanged through social relationships and interpersonal transactions [10], and it might be a significant protective factor for cognitive aging.[11] A previous systematic review paper indicated that people with social support had 50% lower mortality than those without it.[12] Social support has been categorized into four types—giving and receiving support at an emotional level and at an instrumental level[13]—all of which occur at an individual level and have been associated with improved health. For example, providing emotional and instrumental social support to non-family members leads to fewer depressive symptoms.[13] Providing

emotional support to the spouse, and instrumental support to relatives, friends, and neighbors, further lowers the risk of mortality.[14] Receiving emotional support is associated with improved cognitive function.[11] In addition, diverse social relationships, including social support from family members, are associated with a lower incidence of dementia.[15]

Besides individual-level social factors, social networks and relationships at the community level have been investigated to understand its association with moderating the risk of functional disability. Such studies investigate "social capital," which has been defined as the "resources that are accessed by individuals as a result of their membership of a network or a group."[16] A previous study found that lower social capital at the community-level is associated with an increased rate of functional disability among older women.[17] Moreover, there are reports of research on community social capital and cognitive decline.[18] However, because these studies are cross-sectional ones, longitudinal studies are needed. Nevertheless, no study has examined how community-level social support influences the risk of dementia. Therefore, this study seeks to evaluate the relationship between social support at the community level and the onset of dementia.

METHODS

Sample

Data for this study were accessed via the Japan Gerontological Evaluation Study (JAGES). Set up in Aichi in 2003, this was a prospective cohort study of the Center for Well-being and Society of the Nihon Fukushi University.[19] The research was carried out in seven—three larger (Handa, Tokoname, and Chita Hokubu) and four smaller (Agui, Mihama, Minamichita, and Taketoyo)— municipalities that encompass the entire southern region of the Chita peninsula and the Aichi Prefecture. In October 2003, an estimated 276,208 people resided in these locations where 18.0% were aged 65 years or above.[17] On average, the data of 6,300

residents in the 44 school districts were analyzed in this study. From the three larger municipalities, 5,000 survey candidates were randomly selected from the list of persons insured by long-term care insurance who were not certified as requiring long-term care. In the four smaller municipalities, candidates were randomly selected from those not receiving public long-term care insurance benefits due to a physical or cognitive disability. Of the 33,152 people selected, 15,313 individuals answered the baseline survey (response rate = 52.1%).[15] The exclusion criteria were: a) people who had difficulty in performing activities of daily living as a result of disabilities; b) people who did not provide baseline information (n=579); c) people who did not provide social support information (*n* = 1359); and d) people who did not provide a school district code (*n* = 2,343). Ultimately, 11,032 subjects (5,627 women and 5,405 men) were included in this analysis.

The ethics committee of Research of Human Subjects at the Nihon Fukushi University evaluated and approved the use of the JAGES protocol (approval number 13-14). Consent to participate in the study was indicated by a written explanation at the beginning of the questionnaire and by the response received on the questionnaire.

Follow-up

The evaluation parameters of the JAGES Project included health status, functional deterioration, and mental impairment amongst older Japanese people who were not institutionalized. In Japan, there is a long-term care insurance system that covers both institutional and community-based caregiving. Individuals aged 65 years or above qualify to receive benefits on the strict basis of physical and cognitive disability. The follow-up began on November 1, 2003. Dementia-associated data from the six municipalities (specifically in terms of the onset) was assessed until March 28, 2013.

Outcome variables

Dementia was graded on a scale that includes categories from I to IV, and M based on the Activities of Daily Living Independence Assessment Criteria for Older Individuals with Dementia. The Degree of Autonomy in the Daily Lives of Older Individuals with Dementia Scale, created by the Ministry of Health, Labor, and Welfare of Japan, evaluates an individual's ability to carry out daily tasks associated with living on a scale that includes categories from I to IV and M (Supplementary Table S1, view as supplementary data online).

This scale was validated based on its high association with the Mini-Mental State Evaluation.[20] It has been reported that dementia symptoms indices are strongly correlated with Mini Mental State Examination. (Spearman's rank correlation $\rho = -0.73$, $P < 0.001$). Scores I, Ⅱ, Ⅲ, and Ⅳ on the dementia scale are equivalent to 22, 16, 13, and 6 points on the Mini-Mental State Examination, respectively.[20] A score of I indicates that the patient suffers from some level of cognitive decline but remains able to perform domestic and social tasks nearly independently. A score of II indicates that the patient has certain symptoms or behaviors indicative of cognitive impairment and challenges in communication that may hamper the performance of daily tasks, although some amount of external assistance is needed to facilitate routine function. A score of III indicates that the patient periodically exhibits symptoms indicating communication challenges or symptoms/behaviors, which may interfere with the performance of daily tasks, necessitating external assistance. A score of IV indicates that the patient usually shows communication or behavioral challenges, which hampers performing daily tasks, necessitating frequent care. Finally, a score of M (M=Medical, requires specialized medical care) is used when the patient shows significant cognitive impairment, displays difficult behavior, or has a serious physical illness, requiring expert medical intervention. Symptoms and behaviors seen in the M rank include delirium,

paranoia, agitation, self-injury and harm, and other psychiatric symptoms, as well as ongoing problem behaviors caused by psychiatric symptoms.

Explanatory variables

An aggregate of individual-level background data was acquired for the 44 school-based districts to evaluate community social support. An aggregate of responses for individual-level social support among the school districts was used as an indicator of community social support. Within the Japanese context, school districts (or primary schools) are primary residential units of individuals within rural zones. Generally, school districts comprise geographical settings where older individuals may readily travel via foot or bicycle.[21] Individual-level social support was assessed based on four dimensions of the Two-Way Social Support Scale.[13] The four types of support included: (a) receiving support at the emotional level, (b) providing support at the emotional level, (c) receiving support at the instrumental level, and (d) providing support at the instrumental level (Supplementary Table S2, view as supplementary data online).

A single item measured each support, "If you or others required additional daily assistance, who would you depend upon to assist or to be assisted by?" Receiving emotional support was conceptualized as the perception of the respondent's complaints or fears by an individual (e.g., "Do you have someone who listens to your concerns and complaints? Circle all that apply. Options included family living together, separated children and relatives, acquaintance/friends/neighbors"). Providing emotional support was conceptualized as the expression of complaints or fears by an individual to the respondents (e.g., "Do you listen to someone's concerns or complaints? Circle the numbers of all the answers that apply. Options include family living together, separated children and relatives, acquaintances/friends/ neighbors"). Receiving instrumental support was conceived as the rendering of care to the

respondent by an individual, if the respondent were ill for many days (e.g., "Do you have someone who looks after you when you are sick and confined to bed for a few days? Circle the numbers of all the answers that apply. Options include family living together, separated children and relatives, acquaintance/friends/neighbors"). Providing instrumental support was defined as nursing of an individual by the respondent if they were ill for many days (e.g., "Do you look after someone when he/she is sick and confined to bed for a few days? Circle the numbers of all the answers that apply. Options include family living together, separated children and relatives, acquaintance/friends/neighbors").

The percentage of people who responded to each item was considered while determining the level of social support. An aggregation of the responses to the survey items, apropos the four dimensions of social support, was performed for the 44 local districts and further, considered community social support indicators.

Covariates

Other explanatory variables included: gender (female, male), age (65–69, 70–74, 75–79, 80–84, and 85 years or older), living conditions (accompanied/unaccompanied), marital status (married, never married, divorced, widowed, other/missing), education (≥13 years, 10–12 years, 6–9 years, <6 years, other/missing), present illness (no, yes, missing), depressive symptoms evaluated by the GDS-15 (Geriatric Depression Scale: no depression 0–4 points, mild depression 5–9 points, depression 10–15 points, missing), smoking status (never, former, current, missing), alcohol consumption (no, do not drink every day, drink every day ≤35 g/day, drink every day >35 g/day, missing), and individual social support.

Statistical analysis

This prospective study employed multilevel survival analysis. The data of 11,032 people living in 44 local districts were used in this study. The multilevel analysis framework relied on the assumption that the health outcome of individuals is partially affected by the district in which they live. The multilevel model evaluated the change in outcome across districts (random effects) and the influences of community-level factors on the outcome, accounting for specific constituent features (fixed effects). Multilevel survival analysis was employed to compute the hazard ratio (HR) and 95% confidence interval (CI) for the onset of dementia at follow-up. The HR of the social support variable was determined as the 1% variation in the proportion of aggregated social support. For the analyses, all four social support indicators at the community level and social-demographic factors were concurrently adjusted. Furthermore, three sensitivity analyses were conducted, excluding (i) one year, (ii) two years, and (iii) three years after baseline. The STATA SE version 13 (Stata Corp., College Station, TX, USA) was used for the analysis, and the "stmixed" command was used (the "mestreg" command has become a standard feature in STATA 14).

Patient and public involvement

The patients and public were not involved in the design, conduct, reporting, or dissemination plans of our research.

RESULTS

During the 9.4-year follow-up period (87,232 person-years), dementia onset was observed in 1,776 individuals (16.1%). Supplementary Table S3 (view as supplementary data online) shows the baseline characteristics and incidence rate of dementia per 1,000 person-years. The incidence rate of dementia was higher in those who were female, older, living alone, widowed or divorced, those having less than 6 years of education with an existing illness and

with a higher score on GDS-15. It was also higher for those who did not consume alcohol, did not get support at the emotional level, did not offer support at the emotional level, and did not receive help at the instrumental level, compared with each counterpart category.

Table 1 shows the mean, range, median, correlation matrix, and SD of the community-level social support indicators in the 44 districts. Spearman's correlation coefficients ranged from -.11 to .44. The average proportion of people receiving community level emotional support was 89.9%, with a range of 82.7% to 93.5%. The proportion of people receiving community level emotional support was moderately correlated with the proportion of people receiving instrumental support (ρ = .44).

Table 1 Characteristics and Spearman's correlation coefficient matrices for community level social support indicators (N = 44 school districts)

	Mean	SD	Min	Max	Spearman's Rank Correlation Coefficient		
					1	2	3
1. Community level receiving emotional support	89.9	2.0	82.7	93.5	--		
2. Community level providing emotional support	83.1	2.2	76.1	88.6	-.11*	--	
3. Community level receiving instrumental support	94.0	1.6	91.3	97.6	.44*	.08*	--
4. Community level providing instrumental support	91.9	2.1	85.6	97.9	-.01	.41*	.26*

SD, standard deviation; Min, minimum; Max, maximum; * p <.05

The results of the multilevel survival analyses (Model 1) for the onset of incident dementia with three sensitivity analyses models (Model 2, 3, and 4) are shown in Table 2 and Supplementary Table S4

Table 2 Results of multilevel survival analyses for onset of incident dementia

	Model 1	Model 2 (1 year)

	n = 11,032	n=10,780
Fixed effect	HR (95%CI)	HR (95%CI)
Community level variables		
Rate of receiving emotional support*	0.96 (0.94-0.99)	0.97 (0.94-0.99)
Rate of providing emotional support*	0.99 (0.96-1.01)	0.99 (0.96-1.01)
Rate of receiving instrumental support*	1.01 (0.97-1.04)	1.01 (0.97-1.04)
Rate of providing instrumental support*	1.00 (0.97-1.03)	1.00 (0.97-1.02)
Random effects		
Community level variance (SE)	0.06 (0.05)	0.04 (0.06)

*HR for one-point increment of community social support (range: 0-100)

HR adjusted for sex, age, living alone, marital status, education, present illness, GDS, smoking status, alcohol consumption, receiving emotional support, providing emotional support, receiving instrumental support, and providing instrumental support. (The full version, including individual-level results, is shown in Table S4).

Regarding community-level social support, in Model 1, a significant association was observed between the onset of incident dementia and the proportion of people receiving community level emotional support (HR=0.96; 95% CI=0.94-0.99). On the contrary, significant correlations or relationship between the onset of incident dementia and other community-level social support were absent. In Model 2 of a sensitivity analysis (excluding 1 year after baseline), significant correlations between the onset of incident dementia and receiving community-level emotional support (HR=0.97; 95% CI=0.94-0.99) remained. Model 3 (excluding 2 years after baseline) and Model 4 (excluding 3 years after baseline) showed similar results to Models 1 and 2 (Supplementary Table S4). Regarding individual-level social support, in Model 1, the incidence of dementia was significantly associated with receiving individual-level emotional support (HR=0.83; 95% CI=0.73-0.94) as well as providing individual-level instrumental support (HR=0.76; 95% CI=0.66-0.89).

DISCUSSION

To our knowledge, this is the first study to evaluate community-level social support using multilevel survival analysis to investigate the onset of dementia in a large sample of older

community-dwelling individuals. There was a prospective association between living in a community with a higher level of social support and a lower occurrence of dementia during the 10-year study period. However, only one of the community-level social support indicators was significantly associated with dementia onset. The outcome of this research may have significant implications for public health, i.e., by suggesting potential practical implications useful for policymakers, family members, and medical staff. Because previous intervention research indicated that promoting community through salon activity increased social support in the community [22], providing such activities may be a practical solution to prevent the onset of dementia. Among older people, a 1% rise in receiving community-level emotional support correlated with an approximately 4% decrease in the incidence of dementia, irrespective of socio-demographic factors and health circumstances.

For individual-level social support, providing social support was significantly correlated with a lower risk for dementia. A previous study indicated that providing emotional and instrumental support at the individual level might be a risk factor for the onset of depression.[13] A previous study by Murata and colleagues [23] examined the association between individual-level social support and dementia development in a 10-year cohort. The results showed that receipt of support from friends and neighbors was associated with a lower risk of developing dementia for both men and women. Nonetheless, people who were providing social support might be less likely to develop dementia.

In the present study, among the four kinds of community social support, only community-level emotional support affected the onset of incident dementia, even after adjustment for individual-level social support. Two reasons might contribute to this finding. First, a community where people receive high emotional support from each other might be a place where older people are less likely to feel lonely. Indeed, loneliness was found to predict dementia in a previous study.[24] Second, because depression was a risk factor for

developing dementia [25], abundant community-level emotional support may mitigate the risk of depression, thereby decreasing the incidence of dementia. [26] In the current study, social support from children was evaluated through three questions: “To what extent do they actually comprehend your feelings about things?” “How much can you depend on them if you experience a critical problem?” and “How much can you open up to them if you need to talk about your fears?” A place where many people receive emotional support may be a place where people generally have good interpersonal relationships. Therefore, a community-level indicator of receiving emotional support may be associated with the onset of dementia.

Community social support may be an element of social capital or community-level social relationships. For this reason, several plausible pathways between receiving community level emotional support and onset of incident dementia were found in the current study. First, community-level social support may influence people’s health by shaping health-associated behaviors. This may be done through faster dissemination of health-related information or by increasing the probability of people taking up healthy standards of behavior and moderating behaviors that have negative effects on health. Second, social support may shape health by enhancing the accessibility of local services and facilities. Social involvement of older people may be fostered by accessing services, including transportation, recreational spaces, and community hubs may foster, thus, restricting or arresting the development of dementia. Third, community social support has the potential to foster good cognitive health by minimizing psychological distress. Fourth, places with higher social support at the community level generate greater egalitarian political involvement trends. This may lead to the execution of policies that ensure the safety of community members. In addition, according to a systematic review of social capital including studies mainly conducted in western countries, most of the intervention studies in the last two decades have focused on individual-level changes, with a dearth of studies examining community-level

changes.[27] Furthermore, there are few longitudinal studies, even observational studies, that have produced dementia outcomes. Therefore, the results of this study can contribute to the social capital research agenda for developing intervention research at the community level.

It is critical to mention the possible limitations associated with the present study. First, the response rate to the survey (52.1%) could affect the generalizability of the results. However, this response rate was higher than the census conducted by the government (41.8% response rate in the postal survey 2020).[28] Second, the dementia outcome is a nationally standardized scale used by public long-term care insurance, but it is not a clinical diagnosis. Third, there was no information about the type of dementia diagnoses (for instance, Alzheimer's disease, cerebrovascular dementia, or dementia with Lewy bodies). Fourth, the sample did not fully reflect the older population in Japan because the study subjects were recruited from a single prefecture. Therefore, the findings cannot be generalized to urban areas or places where the population has distinct characteristics. Finally, other community-level social relationships, including social capital, were not evaluated. However, we plan to assess a wider range of community-level factors in subsequent studies.

CONCLUSIONS

The results of this study showed that a higher level of social support at the community level is related to a lower incidence of dementia after adjusting for individual-level social support among older individuals. A community level social support indicator (an aggregated value of receiving emotional support) showed a significant association with dementia onset. The present prospective study suggests that receiving emotional support at the community level may result in a lower level of incident dementia among community-dwelling older individuals in Japan.

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Competing Interests

None of the authors have a conflict of interest to declare.

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Author contributions

YM conceived the research idea, participated in the study design, performed statistical analysis, and prepared the manuscript as the primary author. Tabuchi T developed the research idea, participated in the study design, cooperated in the statistical analysis, and revised the manuscript. JA and MS assisted in the data analysis and reviewed the manuscript. Tsuji T and YS acquired data, collaborated in statistical analysis, and revised the manuscript. As the lead researcher of the JAGES project, KK helped to conceptualize the study. The final manuscript was read and approved by all authors.

Data sharing statement

Data are available upon reasonable request**.**

Ethics Statement

This study was approved by the Nihon Fukushi University Ethics Committee (approval number 13-14).

References

1. Prince M, Wimo A, Guerchet M, et al. *World Alzheimer Report 2015: The Global Impact of Dementia: An Analysis of Prevalence, Incidence, Cost and Trends* [online report]. London: Alzheimer's Disease International 2015. https://www.alz.co.uk/research/WorldAlzheimerReport2015.pdf
2. Ministry of Health Law, 2017. https://www.mhlw.go.jp/content/000522832.pdf
3. Middleton LE, Yaffe K. Promising strategies for the prevention of dementia. *Arch Neurol* 2009;66(10):1210–15. doi: 10.1001/archneurol.2009.201
4. Fratiglioni L, Paillard-Borg S, Winblad B. (2004). An active and socially integrated lifestyle in late life might protect against dementia. *Lancet Neurol* 2004;3(6):343–53. doi: 10.1016/s1474-4422(04)00767-7
5. Gao S, Hendrie HC, Hall KS, et al. The relationships between age, sex, and the incidence of dementia and Alzheimer disease: a meta-analysis. *Arch Gen Psychiatry* 1998;55(9):809–15. doi: 10.1001/archpsyc.55.9.809
6. Livingstone G, Sommerlad A, Orgeta V, et al. Dementia prevention, intervention, and care. *Lancet* 2017;390(10113):2673–734. https://doi.org/10.1016/S0140-6736(17)31363-6
7. Norton MC, Dew J, Smith H, et al. Lifestyle behavior pattern is associated with different levels of risk for incident dementia and Alzheimer's disease: the Cache County Study. *J Am Geriatr Soc* 2012;60(3):405–12. doi: 10.1111/j.1532-5415.2011.03860.x
8. Patterson C, Feightner JW, Garcia A, et al. Diagnosis and treatment of dementia: 1. Risk assessment and primary prevention of Alzheimer disease. *CMAJ* 2008;178(5): 548–56. doi: 10.1503/cmaj.070796

9. Santini ZI, Koyanagi A, Tyrovolas S, et al. The association between social relationships and depression: a systematic review. *J Affect Disord* 2015;175:53–65. doi: 10.1016/j.jad.2014.12.049

10. Heany CA, Israel BA. Social networks and social support. In: Glanz K, Rimer BK, Viswanath K, eds. Health Behavior and Health Education Theory, Research, and Practice. 4th ed. San Francisco, CA: Jossey-Bass; 2008:189–210.

11. Seeman TE, Lusignolo TM, Albert M, et al. Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur Studies of Successful Aging. *Health Psychol* 2001;20(4):243–55. doi: 10.1037/0278-6133.20.4.243

12. Holt-Lunstad J, Smith TB, Layton JB. Social relationships and mortality risk: a meta-analytic review. *PLoS Med* 2010;7(7):e1000316. doi:10.1371/journal.pmed.1000316

13. Tsuboi H, Hirai H, Kondo K. Giving social support to outside family may be a desirable buffer against depressive symptoms in community-dwelling older adults: Japan Gerontological Evaluation Study. *BioPsychoSoc Med* 2016;10(1):18. doi: 10.1186/s13030-016-0064-6

14. Brown SL, Nesse RM, Vinokur AD, Smith DM. Providing social support may be more beneficial than receiving it: results from a prospective study of mortality. *Psychol Sci* 2003;14(4):320–7. doi:10.1111/1467-9280.14461

15. Saito T, Murata C, Saito M, et al. Influence of social relationship domains and their combinations on incident dementia: a prospective cohort study. *J Epidemiol Community Health* 2017;72(1):7–12. doi: 10.1136/jech-2017-209811

16. Berkman LF, Kawachi I. Social Epidemiology. New York, NY: Oxford University Press 2015. doi: 10.1093/med/9780195377903.001.0001

17. Aida J, Kondo K, Kawachi I, et al. Does social capital affect the incidence of functional disability in older Japanese? A prospective population-based cohort study. *J Epidemiol Community Health* 2012;67(1):42–7. doi: 10.1136/jech-2011-200307

18. Murayama H, Sugiyama M, Inagaki H, et al. Is community social capital associated with subjective symptoms of dementia among older people? A cross-sectional study in Japan. *Geriatr Gerontol Int* 2018;18(11):1537–42. doi:10.1111/ggi.13519

19. Nishi A, Kondo K, Hirai H, et al. (2011). Cohort Profile: the AGES 2003 Cohort Study in Aichi, Japan. *J Epidemiol* 2011;21(2):151–7. doi: 10.2188/jea.je20100135

20. Hisano S. (2009). The relationship between Revised Hasegawa Dementia Scale (HDS-R), Mini-Mental State Examination (MMSE) and Bed-fast Scale, Dementia Scale. *Nihon Ronen Igakkai Zasshi* 2009;20(8):883–91.

21. Takagi D, Kondo K, Kawachi I. Social participation and mental health: moderating effects of gender, social role and rurality. *BMC Public Health* 2013;13(1):701. doi: 10.1186/1471-2458-13-701

22. Murayama H, Kondo K, Fujiwara Y. Global perspectives on social capital and health [original in Japanese]. In: Kawachi I, Takao S, Subramanian SV, eds. Social Capital To Kenkou Seisaku. 1st ed. Tokyo: Nihon Hyoronsha; 2008:189–210.

23. Murata C, Saito T, Saito M, et al. The association between social support and incident dementia: a 10-year follow-up study in Japan. *Int J Environ Res Public Health* 2019;16(2):239. doi: 10.3390/ijerph16020239

24. Holwerda TJ, Deeg DJH, Beekman ATF, et al. Feelings of loneliness, but not social isolation, predict dementia onset: results from the Amsterdam Study of the Elderly (AMSTEL). *J Neurol Neurosurg Psychiatry* 2012;85(2):135–42. doi: 10.1136/jnnp-2012-302755

25. Ownby RL, Crocco E, Acevedo A, John V, Loewenstein D. Depression and risk for Alzheimer disease: systematic review, meta-analysis, and metaregression analysis. *Arch Gen Psychiatry* 2006;63(5):530–8. doi:10.1001/archpsyc.63.5.530

26. Saito M, Kondo N, Aida J, et al. Development of an instrument for community-level health related social capital among Japanese older people: the JAGES Project [published correction appears in J Epidemiol. 2017 Oct;27(10):503]. *J Epidemiol* 2017;27(5):221–7. doi:10.1016/j.je.2016.06.005

27. Villalonga-Olives E, Wind TR, Kawachi I. Social capital interventions in public health: a systematic review. *Soc Sci Med* 2018;212:203–18. doi:10.1016/j.socscimed.2018.07.022

28. Ministry of Health, Labor and Welfare. Announcement of the end of the survey period for the 2020 National Census [original in Japanese]. https://www.stat.go.jp/data/kokusei/2020/houdou/pdf/20201021.pdf. Published October 21, 2020. Accessed February 9, 2021.

Table S1 Criteria of levels of dementia symptomatology in the Japanese LTCI system

Rank	Criteria	Examples of observable symptoms or behaviors
0	Independent	
I	Suffers from certain dementia symptoms, but daily living is almost fully independent in the domestic and social spheres.	
II	Manifests some symptoms/behaviors and communication difficulties that may hinder daily activities, but can be independent if someone takes care of them.	
II a	The above-mentioned conditions in II are observed while outside the domestic sphere.	Frequently gets lost on the street, or makes noticeable mistakes in matters that the person was previously able to handle, such as shopping, personal administrative tasks, or financial management.
II b	The abovementioned conditions in II are also observed in the domestic sphere.	Is unable to manage taking medication or stay alone at home due to an inability to answer the phone or the door.
III	Occasionally manifests communication difficulties or symptoms/behaviors that hinder daily activities, thus requiring care.	
III a	Manifests above-mentioned conditions described in III predominantly during the day.	Has difficulty or takes time to change clothes, take meals, defecate, or urinate; puts objects into the mouth, picks up and collects objects, is incontinent, makes loud and incoherent screams, carelessly handles fire, or engages in unhygienic acts or inappropriate sexual acts, etc.
III b	Manifests above-mentioned conditions described in III predominantly at night.	Same as rank IIIa.
IV	Frequently manifests difficulties communicating or symptoms/behaviors that hinder daily activities and constantly requires care.	Same as rank III.
M*	Manifests significant mental symptoms, problematic behaviors, or severe physical illnesses and requires specialized medical care.	Shows continued mental symptoms, such as delirium, delusions, and agitation, and manifests associated problematic behaviors, such as self-mutilation or harm to others.

*M=Medical

Table S2 Four categories of social support (including questionnaire items)

	Receive	**Provide**
Emotional social support	(a) receiving support at the emotional level （Question: "Do you have someone who listens to your concerns and complaints? Circle all that apply. Options included family living together, separated children and relatives, acquaintance/friends/neighbors"）	(b) providing support at the emotional level （Question: "Do you listen to someone's concerns or complaints? Circle all that apply. Options include family living together, separated children and relatives, acquaintances/friends/neighbors"）
Instrumental social support	(c) receiving support at the instrumental level （Question: "Do you have someone who looks after you when you are sick and confined to bed for a few days? Circle all that apply. Options include family living together, separated children and relatives, acquaintance/friends/neighbors"）	(d) providing support at the instrumental level （Question: "Do you look after someone when he/she is sick and confined to bed for a few days? Circle all that apply. Options include family living together, separated children and relatives, acquaintance/friends/neighbors")

Table S3 Descriptive characteristics of the respondents (n = 11,032)

			Patients with Dementia [n = 1,776 (16.1%)]		Incidence rate(IR) per 1000 person-years		
Individual level variables	n	%	n	%	Person-year	IR	95% CI
Sex							
Male	5,405	49.0	746	13.8	41,871	17.8	[16.6, 19.1]
Female	5,627	51.0	1,030	18.3	45,362	22.7	[21.4, 24.1]
Age (years)							
65-69	4,065	36.9	207	5.1	35,143	5.9	[5.1, 6.7]
70-74	3,280	29.7	428	13.1	26,842	15.9	[14.5,17.5]
75-79	2,228	20.2	548	24.6	16,689	32.8	[30.2,35.7]
80-84	1,012	9.2	376	37.2	6,502	57.8	[52.3,64.0]
85+	447	4.1	217	48.6	2,057	105.5	[92.4,120.5]
Living alone							
No	9,959	90.3	1,558	15.6	79,038	19.7	[18.8,20.7]
Yes	1,073	9.7	218	20.3	8,194	26.6	[23.3,30.4]
Marital status							
Married	7,905	71.7	1,038	13.1	63,992	16.2	[15.3,17.2]
Widowed or divorced	2,745	24.9	658	24.0	20,274	32.5	[30.1,35.0]
Never married	190	1.7	41	21.6	1,453	28.2	[20.8,38.3]
Other/Missing	192	1.7	39	20.3	1,514	25.8	[18.8,35.3]
Education (years)							
≧13	455	4.1	171	37.6	3,004	56.9	[49.0,66.1]
10-12	6,002	54.4	963	16.0	47,576	20.2	[19.0,21.6]
6-9	3,341	30.3	470	14.1	26,908	17.5	[16.0,19.1]
＜6	1,132	10.3	149	13.2	8,965	16.6	[14.2,19.5]
Other/Missing	102	0.9	23	22.6	780	29.5	[19.6,44.4]
Present illness							
No	2,906	26.3	354	12.2	24,074	14.7	[13.3,16.3]
Yes	7,679	69.6	1,348	17.6	59,636	22.6	[21.4,23.8]
Missing	447	4.1	74	16.6	3,523	21.0	[16.7,26.4]
GDS-15							

0-4	6,737	61.1	857	12.7	55,179	15.5	[14.5,16.6]
5-9	2,234	20.3	450	20.1	16,840	26.7	[24.4,29.3]
10-15	644	5.8	170	26.4	4,393	38.7	[33.3,45.0]
Missing	1,417	12.8	299	21.1	10,820	27.6	[24.7,31.0]
Smoking status							
Never	6,501	58.9	1,129	17.4	52,412	21.5	[20.3,22.8]
Former	2,757	25.0	367	13.3	21,375	17.2	[15.5,19.0]
Current	1,396	12.7	213	15.3	10,543	20.2	[17.7,23.1]
Missing	378	3.4	67	17.7	2,902	23.1	[18.2,29.3]
Alcohol consumption							
Non	7,094	64.3	1,268	17.9	55,456	22.9	[21.6,24.2]
Does not drink every_day	1,513	13.7	188	12.4	12,275	15.3	[13.3,17.7]
Drinks every_day ≦ 35 g/day	1,769	16.0	233	13.2	14,247	16.4	[14.4,18.6]
Drinks every_day > 35 g/day	495	4.5	49	9.9	4,032	12.2	[9.2,16.1]
Missing	161	1.5	38	23.6	1,222	31.1	[22.6,42.7]
Social supports							
Receiving emotional support							
No	1,089	9.9	208	19.1	8,161	25.5	[22.2,29.2]
Yes	9,943	90.1	1,568	15.8	79,071	19.8	[18.9,20.8]
Providing emotional support							
No	1,836	16.6	409	22.3	13,135	31.1	[28.3,34.3]
Yes	9,196	83.4	1,367	14.9	74,097	18.4	[17.5,19.5]
Receiving instrumental support							
No	868	7.9	112	18.1	4,849	23.1	[19.2,27.8]
Yes	10,164	92.1	1,664	16.0	82,384	20.2	[19.3,21.2]
Providing instrumental support							
No	619	5.6	250	28.8	6,044	41.4	[36.5,46.8]
Yes	10,413	94.4	1,526	15.0	81,189	18.8	[17.9,19.8]

Table S4 Results of multilevel survival analyses for onset of incident dementia（Full version of Table 3, including individual-level results）

	Model 1	Model 2 (1 year)	Model 3 (2 year)	Model 4 (3 year)
	n = 11,032	n=10,780	n = 10,440	n = 10,071
Fixed effect	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Community level variables				
Rate of receiving emotional support*	0.96 (0.94-0.99)	0.97 (0.94-0.99)	0.97 (0.94-0.99)	0.97 (0.94-0.988)
Rate of providing emotional support*	0.99 (0.96-1.01)	0.99 (0.96-1.01)	0.98 (0.95-1.01)	0.98 (0.95-1.01)
Rate of receiving instrumental support*	1.01 (0.97-1.04)	1.01 (0.97-1.04)	1.01 (0.97-1.05)	1.01 (0.97-1.06)
Rate of providing instrumental support*	1.00 (0.97-1.03)	1.00 (0.97-1.02)	1.00 (0.97-1.03)	1.00 (0.97-1.04)
Individual level variables				
Social supports				
Receiving emotional support				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	1.04 (0.88-1.22)	1.03 (0.87-1.22)	1.03 (0.87-1.23)	0.99 (0.83-1.19)
Providing emotional support				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	0.83 (0.73-0.94)	0.88 (0.77-0.997)	0.91 (0.80-1.04)	0.91 (0.79-1.05)
Receiving instrumental support				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	1.22 (0.99-1.51)	1.18 (0.95-1.47)	1.13 (0.90-1.42)	1.15 (0.91-1.47)
Providing instrumental support				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	0.76 (0.66-0.89)	0.82 (0.70-0.96)	0.85 (0.72-1.01)	0.89 (0.74-1.07)
Sex				
Male	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Female	1.01 (0.87-1.18)	1.03 (0.88-1.20)	1.06 (0.90-1.24)	1.08 (0.91-1.28)
Age (years)				
65-69	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
70-74	2.64 (2.23-3.12)	2.67 (2.25-3.16)	2.65 (2.22-3.16)	2.71 (2.26-3.25)
75-79	5.42 (4.60-6.38)	5.59 (4.73-6.61)	5.84 (4.93-6.93)	5.97 (5.00-7.13)
80-84	9.85 (8.24-11.78)	10.08 (8.40-12.10)	10.30 (8.53-12.43)	10.31 (8.46-12.56)

85+	19.01 (15.38-23.50)	19.32 (15.52-24.06)	19.32 (15.33-24.34)	18.64 (14.52-23.92)
Living alone				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	0.94 (0.80-1.11)	0.94 (0.79-1.12)	0.98 (0.82-1.17)	1.03 (0.86-1.24)
Marital status				
Married	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Widowed or divorced	1.09 (0.96-1.24)	1.09 (0.96-1.24)	1.06 (0.92-1.21)	1.00 (0.86-1.15)
Never married	1.28 (0.92-1.78)	1.22 (0.87-1.73)	1.24 (0.87-1.76)	1.25 (0.87-1.79)
Other/Missing	1.12 (0.80-1.56)	1.13 (0.80-1.58)	1.09 (0.77-1.56)	1.09 (0.76-1.57)
Education (years)				
≧13	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
10-12	0.89 (0.74-1.08)	0.89 (0.74-1.08)	0.89 (0.73-1.08)	0.92 (0.75-1.13)
6-9	0.96 (0.80-1.15)	0.95 (0.79-1.14)	0.95 (0.79-1.15)	0.96 (0.79-1.16)
＜6	1.29 (1.02-1.63)	1.24 (0.97-1.57)	1.22 (0.95-1.57)	1.23 (0.95-1.61)
Other/Missing	0.89 (0.57-1.40)	0.82 (0.51-1.33)	0.80 (0.48-1.33)	0.86 (0.51-1.45)
Present illness				
No	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Yes	1.15 (1.02-1.30)	1.13 (1.00-1.28)	1.13 (1.00-1.28)	1.10 (0.96-1.26)
Missing	0.96 (0.75-1.24)	0.98 (0.75-1.27)	0.99 (0.75-1.29)	1.01 (0.76-1.33)
GDS-15				
0-4	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
5-9	1.54 (1.37-1.73)	1.54 (1.37-1.74)	1.48 (1.31-1.68)	1.49 (1.30-1.69)
10-15	2.33 (1.96-2.77)	2.18 (1.82-2.62)	2.16 (1.79-2.62)	2.17 (1.78-2.66)
Missing	1.47 (1.28-1.68)	1.43 (1.25-1.64)	1.41 (1.22-1.63)	1.41 (1.22-1.64)
Smoking status				
Never	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Former	0.99 (0.85-1.16)	1.00 (0.86-1.18)	0.99 (0.84-1.17)	1.02 (0.86-1.21)
Current	1.34 (1.12-1.60)	1.32 (1.10-1.59)	1.39 (1.15-1.68)	1.40 (1.15-1.71)
Missing	0.86 (0.65-1.15)	0.90 (0.67-1.20)	0.85 (0.63-1.15)	0.91 (0.67-1.24)
Alcohol consumption				
Non	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Does not drink every_day	0.96 (0.82-1.13)	0.96 (0.81-1.13)	0.97 (0.82-1.15)	0.96 (0.80-1.15)

Drinks every_day ≦ 35 g/day	0.98 (0.84-1.15)	0.99 (0.84-1.16)	1.02 (0.86-1.20)	1.03 (0.87-1.22)
Drinks every_day > 35 g/day	0.86 (0.64-1.17)	0.90 (0.66-1.21)	0.92 (0.68-1.26)	0.91 (0.66-1.26)
Missing	1.14 (0.78-1.66)	1.14 (0.78-1.67)	1.24 (0.84-1.83)	1.22 (0.82-1.83)
Random effects				
Community level variance (SE)	0.06 (0.05)	0.04 (0.06)	0.04 (0.07)	0.09 (0.04)

*HR for one point increment of community social support (range: 0-100)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	6-9
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-10
		(*b*) Describe any methods used to examine subgroups and interactions	6-10
		(*c*) Explain how missing data were addressed	6-10
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	10

Continued on next page

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	5-6
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	6
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
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	10-12
		(*b*) Report category boundaries when continuous variables were categorized	10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-15
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	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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 www.strobe-statement.org.