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Social disconnection and suicide mortality among Japanese older adults: A seven-year follow-up study

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ABSTRACT

Background: Few prospective studies have examined the association between social disconnection and late-life suicide. Therefore, we conducted a large-scale prospective study of older adults in Japan to examine differences in suicide mortality according to specific aspects of social disconnectedness.

Methods: We conducted a nationwide baseline survey of functionally independent older adults (age ≥65 years) from 12 municipalities in Japan from 2010 to 2011. We followed the participants (n = 46,144) for cause of death through December 2017 using vital statistics. Social disconnection was assessed based on the indicators of eating alone, a lack of instrumental/emotional support, no participation in community activities, and no contact with friends. We adopted Cox regression models with multiple imputation for missing values and calculated the population-attributable fraction (PAF).

Results: A total of 55 suicide deaths were recorded during an average follow-up of 7 years. Older adults with social disconnection had a marginally increased risk of suicide. The hazard ratio for eating alone vs. eating together was 2.81 (95% confidence interval [CI]: 1.47–5.37). The direction of these associations and point estimations did not largely change after controlling for depressive symptoms, an evident risk factor for suicidal behavior. The PAF indicated that eating alone was attributable to around 1800 (29%) of the suicide deaths among older adults annually in Japan.

Conclusion: Avoidance of not only depressive symptoms, but also social disconnection including eating alone, is useful in suicide prevention among older adults.

1. Introduction

Suicide is a serious public health problem and one of leading causes of premature death around the world. Globally, more than 700,000 people die by suicide every year, and late-life suicide continues to show the highest rates virtually everywhere in the world (De Leo and Viecelli, 2021; De Leo, 2022). In Japan, which has one of the highest suicide rates in the world, 21,881 suicide deaths were reported in 2021, and the suicide rate per 100,000 people from 2000 to 2019 was 22.0 ± 3.2, compared with the global average of 10.8 ± 1.2 (Claveria, 2022). One estimates suggests that reducing the number of suicides to an average level could result in an economic impact of approximately one trillion JPY per year (Kaneko et al., 2004). According to vital statistics in Japan, although suicide mortality among older adults decreased markedly for recent seventy year, it remains the second highest after the fifties (Ministry of Health, Labour and Welfare. 2022a).

Suicide is inversely associated with the degree of integration of social groups to which the individual belongs (Durkheim, 1952). On the

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community level, indicators of social disintegration and socioeconomic deprivation, such as the unmarried rate, divorce rate, single-person household rate, school enrollment rate, unemployment rate, relative poverty rate, economic uncertainty, high alcohol consumption, residential turnover, and urbanicity, are associated with suicide mortality (Okada and Samreth, 2013; Cai et al., 2022; Claveria, 2022; Hagedoorn and Helbich, 2022; Jakobsen and Lund, 2022). Other studies (Nishio et al., 2009; Hyodo et al., 2010; Chen et al., 2016) have reported lower rates of suicide in the aftermath of severe disasters, suggesting that natural disasters may foster social cohesion and mitigate the negative effects of a traumatic event.

On the individual level, according to Joiner's interpersonal theory of suicide, a serious attempt or death by suicide occurs when failed belongingness and perceived burdensomeness generate a suicidal desire, and through habituation, individuals acquire the capability for suicide (Joiner, 2005). Several studies have reported that having no close friends (Hall-Lande et al., 2007), no instrumental support (Awata et al., 2005), smaller social networks (Kurimoto et al., 2011), loneliness (Badcock et al., 2021), or early maladaptive schemas (Ahmadpanah et al., 2017) is associated with suicide attempts and/or ideation. These lack of social connections may itself be a direct motivation for suicide, but it may also linked with increase suicide risk through biological and behavioral mechanisms, psychological distress and mental disorders (Lutz et al., 2021). For instance, a lack of social connections can put the neurological system into an alert state, which, when prolonged, can increase the risk of suicide risk by depleting neurological and physical resources and functions. It has also been linked to a higher incidence of risky and/or unhealthy behaviors such as disengagement in social activities, substance use, and poor sleep patterns/habits, which in turn, are associated with a higher incidence of suicide-related thoughts and behaviors. Furthermore, it may lead to a reduction in help-seeking behaviors and disrupt decision making.

The association between social disconnection and suicide risk may vary by life course. Prospective cohort studies of middle-aged adults on suicide deaths have also reported associations with social disconnection, including a 1.3-times higher suicide risk among those with no friends in a study of 50,000 Swedish adults aged <65 years who were followed for 14 years (Allebeck et al., 1988), a three-times lower suicide risk among female nurses who were more socially integrated in a study of 72,000 nurses aged 46–71 years who were followed for 18 years (Tsai et al., 2015), a 3.1-times higher suicide risk among women with no peer support, and a 1.8-times higher suicide risk among men who had three friends or fewer in a study of 56,000 Japanese adults aged 40–69 years who were followed for 12 years (Poudel-Tandukar et al., 2011).

However, the association between the risk of suicide death in old age and a lack of social connections remains unclear, even though it is a factor amenable to intervention. Old age is a time when people experience changes in social roles, friendships, and household composition, such as retirement, bereavement of a spouse or close friends, and independence of children. Social disconnection specific to old age, such as loss of opportunity of participation, loss of contact with close relationship, and eating alone in daily life (solitary diner), may associated with suicide mortality. Therefore, we conducted a large-scale prospective cohort of Japanese older adults to investigate differences in the risk of suicide mortality according to several indicators of social disconnection. We also estimated the population-attributable fraction (PAF) of social disconnection for late-life suicide in Japan to interpret the role of social disconnection for suicide prevention.

2. Methods

2.1. Participants

Baseline data were collected using a self-administered questionnaire from August 2010 to December 2011 as part of the Japan Gerontological Evaluation Study (JAGES). Data were obtained from 46,616 older individuals in 12 municipalities of Japan who were aged ≥65 years, physically and cognitively independent, and living independently in the community (response rate: 64.7%). The municipalities covered a wide range of characteristics in terms of region and population size, but were not randomly selected. The study areas included both urban and rural areas in Hokkaido, Chiba, Yamanashi, Aichi, Mie, and Nagasaki Prefectures. In nine relatively small municipalities, the questionnaire was conducted by complete enumeration, and in three municipalities, random sampling was adopted. Information on the date of death was obtained from the public long-term care insurance system database run by the municipal governments. Next, using the vital statistics data, this study assessed the causes of death of the participants. To merge the datasets, sex, date of birth, date of death, and municipality name were used as key variables, finally, 46,144 respondents were included in the analysis (follow-up rate: 98.9%).

2.2. Ethical approval

This study was performed through a collaborative research agreement with the associated municipalities. Ethical approval (No. 2493) was provided by the Ethics Board at Chiba University. JAGES participants were informed that participation in the study was voluntary and that completing and returning the questionnaire via mail indicated their consent to participate in the study. We created an anonymized dataset. All methods were carried out in accordance with relevant guidelines and regulations or in accordance with Declaration of Helsinki.

2.3. Measures

2.3.1. Outcome: Suicide death

Mortality data for persons in the residential registry are forwarded to the Ministry of Health, Labour and Welfare and coded for inclusion in the national vital statistics. We followed deceased cases up to December 31, 2017 (n = 6312) for cause of death using the national vital statistics. Sex, date of birth, date of death, and municipality were merged as key variables. Suicide death was identified using the corresponding causes of death code in the vital statistics data.

2.3.2. Social disconnection

As indicators of social disconnection, we focused on solitary diner, none of social support, never participation in community activities, and none of contact with friends. Solitary diner was assessed using the question: "Who do you usually have meals with?", for which the responses were dichotomized as "eating alone" (for the response "no one") or "eating together" (for the responses "spouse", "children", "grandchildren", "friends", or "other"). Social support was measured by four types of indices: receiving/giving emotional support and receiving/giving instrumental support. These were assessed using the questions: "Do you have someone who listens to your concerns and complaints?", "Do you listen to someone's concerns and complaints?", "Do you have someone who looks after you when you are sick for a few days?", and "Do you look after someone when he/she is sick for a few days?", respectively. The responses were dichotomized as "none" or "presence" (for the responses "spouse", "children living together", "children or relatives living apart", "neighbor", "friends", or "other"). Participation in community activities focused on the three major types of activities confirmed to be associated with healthy longevity among older adults: participation in a hobby activities group, a sports group or club, or a volunteer group (Lum and Lightfoot, 2005; Kanamori et al., 2012; Ashida et al., 2016; Saito et al., 2019; Saito et al., 2021). The respondents were asked how often they took part in these activities by rating their frequency of participation on a five-point scale, and then differences in "never" or "participated" (for the responses over "a few times a year") were compared for each community activity. Contact with friends was assessed using the question, "How often do you see your friends?", for which the responses were dichotomized as "none" (for the

Table 1
Incidence of suicide mortality by social disconnection among older adults.[a].

		n	Number of suicide	Follow-up period (person year)	Suicide rate (per 100,000 person-year)
	Total	46,144	55	290,112	18.96
Solitary diner	Eating together	33,761	33	213,902	15.43
	Eating alone	9910	19	61,090	31.10
Receiving emotional support	Presence	40,684	46	256,876	17.91
	None	2754	6	16,685	35.96
Giving emotional support	Presence	39,749	44	251,592	17.49
	None	3234	7	19,208	36.44
Receiving instrumental support	Presence	41,335	48	260,577	18.42
	None	2336	4	14,135	27.94
Giving instrumental support	Presence	37,091	41	235,635	17.40
	None	5224	9	31,013	29.02
Participating volunteer groups	Participated [b]	6273	2	40,999	4.88
	Never	28,158	35	176,707	19.81
Participating sports group or club	Participated [b]	10,328	9	66,742	13.48
	Never	25,922	32	162,425	19.70
Participating hobby activites group	Participated [b]	17,712	8	113,903	7.02
	Never	19,862	29	123,476	23.49
Contact with friends	Presence [c]	39,053	41	247,714	16.55
	None	3777	8	22,218	36.01
Social disconnection score	0–1	6368	3	41,802	7.18
(Number of applicable above nine variables)	2–3	15,634	15	99,889	15.02
	4–6	6634	10	40,029	24.98
	7–9	745	3	4381	68.48
Depressive symptoms (GDS)	0–4	27,094	19	172,917	10.99
	5+	11,114	26	68,158	38.15

Notes.
[a] The observations that had missing values in each independent variable were removed.
[b] Respondents who participating more than a few times a year were classified as participated category.
[c] Respondents who contacted with friends more than a few times a year were classified as presence category.

Table 2
Cox proportional hazard ratios for suicide mortality in association with social disconnection among older adults.

			Model 1 [c]			Model 2 [c,d]	
		HR	**(95%CI)**	**p**	**HR**	**(95%CI)**	**p**
Solitary diner	Eating together	ref.			ref.		
	Eating alone	2.81	(1.47–5.37)	0.002	2.49	(1.32–4.72)	0.005
Receiving emotional support	Presence	ref.			ref.		
	None	1.92	(0.81–4.56)	0.141	1.58	(0.66–3.79)	0.309
Giving emotional support	Presence	ref.			ref.		
	None	1.85	(0.82–4.14)	0.136	1.51	(0.66–3.48)	0.332
Receiving instrumental support	Presence	ref.			ref.		
	None	1.57	(0.56–4.45)	0.396	1.25	(0.43–3.57)	0.682
Giving instrumental support	Presence	ref.			ref.		
	None	1.56	(0.68–3.58)	0.299	1.34	(0.58–3.10)	0.487
Participating volunteer groups	Participated[a]	ref.			ref.		
	Never	2.35	(0.69–7.98)	0.170	2.01	(0.59–6.87)	0.261
Participating sports group or club	Participated[a]	ref.			ref.		
	Never	1.37	(0.62–3.03)	0.436	1.18	(0.53–2.60)	0.688
Participating hobby activities group	Participated[a]	ref.			ref.		
	Never	1.71	(0.90–3.24)	0.103	1.46	(0.78–2.75)	0.240
Contact with friends	Presence [b]	ref.			ref.		
	None	1.91	(0.87–4.20)	0.109	1.56	(0.71–3.41)	0.268
Social disconnection score	0–1	ref.					
(Number of applicable above nine	2–3	1.83	(0.69–4.84)	0.223	1.61	(0.61–4.28)	0.336
variables)	4–6	2.61	(0.88–7.78)	0.085	1.98	(0.66–5.90)	0.222
	7–9	7.03	(1.87–26.49)	0.004	4.63	(1.22–17.59)	0.024
Depressive symptoms (GDS)	0–4	ref.					
	5+	2.61	(1.47–4.63)	0.001	*omit*[e]	–	–

Notes: HR: Hazard ratio, CI: Confidence interval.
Model 1: Sex, age, years of education, marital status, living situation, equivalent income, and presence of treatment disease and disability at baseline were controlled. Model 2: Model 1 + depressive symptoms at baseline were controlled.

[a] Respondents who participating more than a few times a year were classified as participated category.

[b] Respondents who contacted with friends more than a few times a year were classified as presence category.

[c] Multiple imputation by chained equations was performed using sex, age, years of education, marital status, living situation, equivalent income, presence of treatment disease and disability, depressive symptoms, and all independent variables (m = 20).

[d] Solitary diner, receiving emotional support, giving emotional support, participating volunteer groups, participating sports group or club, participating hobby activities group, contact with friends, and social disconnection score were included separately in the model.

[e] The coefficients of depressive symptoms were omitted because it was imputed in all Model 2 as a control variable. HRs of them were from 2.28 (95%CI: 1.28–4.05) to 2.56 (95%CI: 1.44–4.53), all p-values were from .005 to .001.

Table 3
Population-attributable fraction for annual suicide mortality by social disconnection among older adults.

	Proportion of exposure[a]	HR[b] (95% CI)	PAF[c] (95% CI)	Number of annual suicide mortality [estimate][d] (95% CI)
Solitary diner (eating alone)	22.7%	2.81 (1.47–5.37)	29.1% (9.6–49.8)	1816 (601 - 3106)
Social disconnection score (7–9)	2.5%	7.03 (1.87–26.49)	13.1% (2.1–38.9)	817 (133 - 2428)
Deppressive symptoms (GDS: 5+)	29.1%	2.61 (1.47–4.63)	31.9% (12.0–51.4)	1990 (750 - 3204)

Notes: HR: Hazard ratio, CI: Confidence interval, PAF: Population-attributable fraction.
[a] The proportion of exposed is based on our analyzed dataset.
[b] Hazard ratios are based on Model 1 in Table 2.
[c] PAF(%) = *Pe* (*HR*-1)/*Pe* (*HR*-1) +1 (Pe, the proportion of exposure in the target population).
[d] The denominator is the annual number of suicide death in 2021 among people 65 years and older, which obtained from Japanese vital statistics: N = 6238.

response "rarely") or "presence" (for the responses indicating more than "a few times a year"). Additionally, as a comprehensive index of social disconnection, we counted the number of applicable variables out of the nine mentioned, even though the Cronbach's alpha coefficient is not high ($\alpha = 0.628$).

2.3.3. Covariates

Sociodemographic variables as potential confounders included sex, age, years of education, marital status, living situation, equivalent income, and presence of treatment disease and disability. These basic variables are considered social determinants of health and have been reported to be associated with suicidal behavior (De Leo and Viecelli, 2021; Motillon-Toudic et al., 2022). Age was categorized as follows: 65–74, 75–84, and ≥85 years. Years of education was categorized as ≤ 9, 10–12, and ≥13. Marital status consisted of married, widowed, and divorced or unmarried. Living situation was dichotomized into living alone or not. We equivalized household income by the square root and classified it as < 2 million, 2–3 million, or >3 million JPY. Presence of treatment disease and disability was inquired by currently receiving any medical treatment including mental disease, impaired vision, and impaired hearing. To account for mental health status at baseline, depressive symptoms were also considered. We used the short version of the Geriatric Depression Scale (GDS-15), the validity and reliability of which has been confirmed in Japanese older people (Sheikh and Yesavage, 1986; Watanabe and Imagawa, 2013). The scores of ≥5 on the GDS-15 indicate the presence of depressive symptoms (from mild to severe depression).

2.4. Statistical analysis

After calculating the descriptive statistics, we performed Cox regression analysis, to estimate the associations between the indicators of social disconnection and suicide mortality after controlling for baseline covariates. Depressive symptoms are an evident risk factor for suicidal behavior, and each indicator of social disconnection might mediate the depressive symptoms and suicidal behavior association. Therefore, in the first model (model 1), to clarify the total association, including the mediating effect from depressive symptoms, we did not include depressive symptoms as a covariate. Next, to exclude the mediating effect from depressive symptoms, we included depressive symptoms as a covariate in model 2. We then performed a multiple imputation using chained equations under a missing-at-random assumption, which means there might be systematic differences between the missing and observed values. We created 20 imputed datasets and performed estimations with the robust variance estimator. As a robustness check, we employed the inverse probability weighting (IPW) estimator with imputed datasets to control for potential unmeasured confounders. Propensity scores for each individual variables were calculated using logistic regression analysis and confirmed the C-statistic, incorporating all previously listed covariates. In addition, given the rarity of suicide as an outcome in the data and its low statistical power, we have also analyzed the association between social disconnection and a portion of the GDS, considered as putative measures of suicidal ideation, using a Poisson regression analysis controlling for baseline covariates. Finally, we estimated the PAF percentages of annual suicide death among Japanese older adults. This is a crude estimate with several limitations and potential errors, as it assumes that the adjusted hazard ratios (HRs) reflect causal effects and that our results are representative of the entire older population. As the denominator (N = 6238), data on annual suicide deaths among those aged ≥65 years were obtained from Japanese Vital Statistics (2021); Ministry of Health, Labour and Welfare (2022b).

3. Results

A total of 55 suicide cases were recorded during 290,112 person-years of follow-up (suicide rate: 18.96 per 100,000 person-years).

Table 1 shows that the suicide rate was remarkably higher in older adults with social disconnection as indicated by eating alone, not receiving/providing emotional or instrumental support, no participation in community groups, no contact with friends, and having depressive symptoms. For example, the suicide rate among those who ate alone was 31.10 per 100,000 person-years, whereas that of those not eating alone was 15.43. Similarly, we observed a dose-dependent relationship, with a remarkably higher suicide rate of 68.48 per 100,000 for individuals scoring 7 to 9 on the social disconnection score, compared to 7.18 for those scoring 0 to 1. In addition, the suicide rate was higher for men, old-older adults, people with less education, widowed people, those living alone, those in the low-income group, and people with treatment disease and disability (see Supplementary Table 1). It was also higher in all GDS-15 indicators. In particular, the values are significantly higher in indicators closely related to suicidal ideation, such as those responding positively to the question "Do you sometimes feel there is no point in living?" and "Do you feel your life is empty?", and negatively to "Do you think life is wonderful?" (see, Supplementary Table 2).

Model 1 in Table 2 shows that even after controlling for baseline covariates, the suicide mortality risk was 2.81 (95% confidence interval [CI]: 1.47–5.37) times higher among older adults who ate alone. Each point estimator in the other indicators of social disconnection was also positively associated with suicide mortality, although these associations were not statistically significant. In total score of social disconnection, the suicide mortality risk was 7.03 (95%CI: 1.87–26.49) times higher for those with 7–9 points compared to those with a score of 0–1. In addition, depressive symptoms were significantly associated with suicide mortality among older adults (HR = 2.61, 95%CI: 1.47–4.63). The point estimators were largely unchanged, even after adjusting for individual attributes and depressive symptoms (Model 2). The HR of people who ate alone was attenuated by about 11% after adjusting for depressive symptoms, but was still 2.49 (95%CI: 1.32–4.72). When we switched to the IPW estimation method utilizing propensity scores, the overall direction of the association did not largely change (see, Supplementary Table 3). Additionally, all indicator of social disconnection were also significantly associated with portion of depression scale, considered as putative measures of suicidal ideation (see, Supplementary Table 4).

The crude estimation of PAF indicates that 29.1% of suicide deaths among the older adults in Japan, i.e. around 1800 per year, may be related to having been in an eating alone in daily living (Table 3). Similarly, approximately 800 suicide death in older adults per year (13.1%) may have resulted from a condition applicable to seven or more of the nine social disconnection indicators. In addition, depressive symptoms may be linked to about 2000 suicides (31.9%) annually among older adults.

4. Discussion

To our knowledge, this is the first large-scale prospective cohort study conducted to examine the association between social disconnection and late-life suicide mortality. As expected, we found that each indicator of social disconnection is marginally associated with high suicide rate, those who met seven or more of the nine indicators had significantly higher suicide rates. Especially eating alone, which was associated with a higher suicide mortality risk among older adults. According to our crude estimation, eating alone (solitary diner) may linked to about 1800 suicide deaths (29.1% of suicide death) per year among Japanese older adults, it cannot be ignored as a leading indicator of suicide. In addition, similar to our results, a Japanese national survey conducted at the same period reported that 22.8% of individuals aged 60 and over mentioned they sometimes eat all their daily meals alone (Cabinet Office, 2012).

The present study addresses the proximate causes of suicide. Our longitudinal findings were consistent with Joiner's interpersonal theory of suicide, and previous reports suggesting that social disconnection might be an important risk factor for suicidal behavior (De Leo and Viecelli, 2021; Lutz et al., 2021; Wyman et al., 2022), although the present mental health service paradigm is not designed to address this challenge. As mentioned above, a lack of social connections might increase suicide risk through biological and psychosocial pathways. The fact that this association largely remained unchanged even after adjusting for depressive symptoms suggests that among older adults, social disconnection not only increases the risk of suicide through depressive symptoms, but that other factors, such as suicidal triggers when painful life events occur during the aging process. An intervention study conducted on Air Force personnel found that social integration and group bonds can be strengthened even among groups with a high suicide risk (Wyman et al., 2022). The present findings also indicate that social disconnection is a modifiable factor with regard to suicide among older adults. Simultaneously, as part of suicide prevention, there are gatekeepers in the community. In Japan, guidelines and/or handbooks for gatekeepers are provided by the government. According to one systematic review on the effectiveness of training for gatekeepers, it has been reported that their knowledge and skills are significantly improved through the training (Morton et al., 2021). However, it is often observed that isolated individuals are more likely to be overlooked in preventive interventions. Our results suggest that social disconnections, including eating alone, can be one of the signs of suicide risk, indicating the need for appropriate interventions for individuals potentially at risk of suicide.

Among the factors investigated in the present study, eating alone was clearly associated with late-life suicide. There are several possible reasons for this. First, the eating alone might represent a measure of alienation. A previous neuroimaging study revealed that an activation pattern very similar to physical pain emerged during the experience of alienation (Eisenberger et al., 2003). Alienation at mealtime, an important time for human beings, might thus lead to physical and mental pain. Eating alone in particular might be perceived as a sad or hopeless situation, which in turn, could increase the risk of suicide among adults in Japan, where a norm of "a pleasurable happy home around the dinner table" has been in place since the end of World War II (Omote, 2007). Second, it may reflect self-neglect or inadequate care. Many previous studies have suggested that shared meals are associated with better nutritional health, including a lower prevalence of eating disorders, throughout one's lifespan (Hammons and Fiese, 2011; Fulkerson et al., 2014). Other studies involving older adults have reported that eating alone is associated with unhealthy dietary behaviors, obesity and underweight, and subsequent mortality (Tani et al. 2015, 2018). If eating alone is associated with poor dietary intake or severe eating disorders, it might also be associated with alcohol and substance abuse, which are well-known risk factors of suicide deaths. Third, the characteristics of the indicator may have influenced the results. Compared with other indicators such as receiving/providing social support or contact with friends, the question item regarding with whom the participants ate asked about more specific situations and behaviors. One cross-sectional study reported a strong association between eating alone, an aspect of social disengagement, and depressive symptoms among older adults (Kuroda et al., 2015). Consequently, this indicator may capture severe social isolation and failed belongingness more clearly than the others.

A recent meta-analysis reported that the population-attributable risk of suicide for lower socio-economic status (SES) was of a similar magnitude to affective and substance use disorders, and noted the importance of strategies that target a wider range of psychiatric risk factors than only those that are most proximal for the control and prevention of suicide (Li et al., 2011). Furthermore, about 30% of the annual late-life suicide deaths were associated with social disconnection, which suggests that social participation should be promoted, and social isolation should be reduced among older adults not only for general health policy, but also suicide prevention. Social connection is amenable to change, and there are several promising interventions, including those that directly target individual social connection, such as increasing social engagement, improving social support, and reducing

loneliness (Lutz et al., 2021). One Japanese quasi-experimental study, based on a population strategy that included group activities, psychoeducation, and self-assessment of depression for older adults, has reported a decrease in suicide rates among women in the intervention areas over seven years (Oyama et al., 2005). Particularly concerning eating alone, while meal delivery services for older adults have come to be generally prevalent in Japan as a result of various government measures, promoting eating with others rather than use of meal delivery services may be an effective suicide prevention strategy among older adults.

Although the number of suicide occurrences is small (55 cases), this study is based on a large scale prospective follow-up study over a seven-year period. We believe that the fact that suicide rates were remarkably higher among people with closely associated with suicidal ideation, and that social disconnection was similarly associated with putative measures of suicidal ideation in addition to suicide, suggests the validity of our using data. However, this study has several limitations. First, the suicide rate in the present data was slightly lower than that according to national statistics at same period (23.84 per 100,000 persons aged ≥65 years from 2010 to 2017). One major reason for this might be that our baseline study excluded older adults with physical and cognitive disabilities, and further, because this was a self-reported questionnaire survey, there may have been a bias toward healthy and high SES individuals. However, as in previous prospective cohort studies (Kposowa, 2000; Olfson et al., 2022), the fact that suicide rates were higher among those living alone, and widowed, male, old-old, and low SES individuals, suggests the validity of our findings. If older adults with severe social disconnection were less likely to participate in this survey, our findings might be underestimated. Second, our results have low statistical power because of the small number of suicide cases during the follow-up period. It would therefore be meaningful to reexamine the data with a longer follow-up period. The effects of community-level characteristics, such as anomie or social capital, on suicide also need to be investigated in future studies. Third, as this was an observational study, we cannot address causality or underlying mechanisms. Future studies should aim to confirm the presence of a dose-response relationship with regard to information on the frequency of eating alone, and to examine the interaction effects of social disconnection and loneliness and the heterogeneity in effects of social disconnection for suicide. However, it is important to note that even simple measurements of social disconnection that can be captured in a self-administered survey were associated with subsequent suicide mortality. Therefore, the present findings could be important in terms of identifying potential targets for interventions aimed at promoting suicide prevention.

CRediT authorship contribution statement

Masashige Saito: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ryota Watanabe:** Writing – review & editing, Supervision, Methodology. **Yudai Tamada:** Writing – review & editing, Supervision. **Kenji Takeuchi:** Writing – review & editing, Supervision, Methodology. **Yukako Tani:** Writing – review & editing, Supervision. **Katsunori Kondo:** Writing – review & editing, Investigation, Funding acquisition, Data curation, Conceptualization. **Toshiyuki Ojima:** Writing – review & editing, Supervision, Investigation, Data curation.

Declaration of competing interest

The authors declare that they have no competing interests.

Data availability

The data that has been used is confidential.

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Appendix B. Supplementary data

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