An improvement in the treatment rate of pneumonia was not observed in each sex. Despite the largely unchanged treatment rate of pneumonia, pneumonia-specific mortality rate declined over time. This suggests stable occurrence of pneumonia, but possibly of a less severe form, and improved management of pneumonia. Because effective preventive measures for pneumonia, such as pneumococcal or influenza vaccination, are already widely available for old adults, further improvement in the prevention of pneumonia may be hard to achieve.

Only a few studies have provided descriptive epidemiological data on disability and chronic diseases among older adults in Japan. The Analysis of National Survey of Japanese Elderly, a nationally representative six-wave panel study, reported that six out of ten measures of Activity of Daily Living (ADL) and instrumental ADL improved significantly after adjustment for age from 1993 to 2002 [27]. A study of the Comprehensive Survey of Living Conditions reported that the number of expected years of life without activity limitation increased from 1995 to 2004 [7]. These studies reported data more than 10 years ago, but the results are consistent with our findings, implying that the improvement in health conditions started earlier than our data coverage.

Our study has some limitations that need to be acknowledged. First, the Patient Survey collected information on diseases and injuries from physicians, but the diagnostic criteria were not standardized and their severity was not included in the questionnaire. All medical conditions may not be captured by the questionnaire in the case of patients with multiple comorbidity, which is particularly concerning for older adults because older adults tend to have an increased number of comorbid conditions [28]. Second, the Patient Survey is conducted every three years in October, and therefore seasonal variation in the treatment rate is not accounted for. However, because each survey was conducted in a standardized manner at the same time of the year, the survey at least can provide valid estimates of the trends in the treatment rates over years. Third, some medical conditions may be underdiagnosed and not well captured by the survey. We did not include Alzheimer's disease in our analysis because it appears to be consistently underdiagnosed, and the change in the treatment rate of Alzheimer's disease does not seem to reflect the true change in prevalence. Last, the Patient Survey data in 2011 did not include data from medical institutions in Fukushima prefecture and the Ishinomaki and Kesennnuma medical areas of Miyagi prefecture. However, the populations in these areas comprised less than 3% of the population of Japan, and exclusion of data from these areas was unlikely to bias our findings and alter our conclusion.

Despite these limitations, our study has a number of strengths. The databases we utilized are nationally representative, containing large numbers of participants. The Vital Statistics in Japan is highly reliable, and the ascertainment of causes of death was based on death certificates issued by physicians. The data were collected in a standardized manner over a couple of decades, providing a unique opportunity to obtain descriptive epidemiological data of disability, comorbid medical conditions and mortality.

Our findings have several implications. First, even though our findings indicate overall improvement in health conditions in the population aged between 65 and 84, the absolute number of older adults with chronic medical conditions or disability will continue to increase as a result of increase in older adults [3]. This will be a great challenge for the National Health Insurance system and the Long-Term Care Insurance system in Japan. Second, considering the downward trajectory of the treatment rates observed in many medical conditions, it is important to keep raising the general public's awareness of taking preventive measures to help stave off these conditions. This is a particular priority when we consider the ramifications of the increasing number of older adults with disability. Third, the baby boomers, who were born after the Second World War, are now entering old age. It is important to carefully monitor their health conditions to see if the improvement in health conditions observed in this study

will continue. Lastly, our findings do not explain the widening gap between life expectancy and healthy life expectancy. Further research focusing on very old adults is warranted.

We conclude that the prevalence of many chronic medical conditions has declined among old adults over time in Japan. Coupled with the decline in disability rate and mortality rate, our findings may signify overall improvement in health conditions among old adults. This is consistent with improving healthy life expectancy and supports the hypothesis that biological age may be getting lower compared with chronological age. Nonetheless, the increase in number of older adults will offset the improvement in health conditions, and older adults with chronic medical conditions or disability will continue to increase. Therefore, continuous public health efforts to prevent chronic medical conditions and a roadmap for a health care system to meet the increasing health care needs of older adults are still warranted.

Supporting Information

S1 Fig. Trends in treatment rates of Alzheimer's disease in men and women from 1996 to 2011. The treatment rate is calculated as the estimated number of patients divided by the estimated population x 100,000. The black line represents those aged 80–84 years, the blue line represents those aged 75–79 years, the green line represents those aged 70–74 years and the red line represents those aged 65–69 years. The p values signify statistical significance for the trends in each age stratum.
(TIF)

S1 Table. Trends in treatment rates of Alzheimer's disease in men and women from 1996 to 2011. The treatment rate is calculated as the estimated number of patients divided by the estimated population x 100,000.
(DOCX)

S2 Table. Trends in disability rate in men and women from 2001 to 2013. The disability rate is the rate of persons certified for long-term care under the Long-Term Care Insurance System per 100,000 population.
(DOCX)

S3 Table. Trends in treatment rates of nine selected medical conditions in men and Women from 1996 to 2011. The treatment rate is calculated as the estimated number of patients divided by the estimated population x 100,000.
(DOCX)

S4 Table. Trends in total mortality rate and mortality rates from specific causes in men and women from 1995 to 2010. The mortality rate is calculated as the number of deceased divided by the estimated population x 100,000.
(DOCX)

Author Contributions

Conceived and designed the experiments: SI MA. Analyzed the data: SI. Wrote the paper: SI. Reviewed the manuscript and provided advice and suggestions: MA SO SI.

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RESEARCH ARTICLE

Hypnotics and the Occurrence of Bone Fractures in Hospitalized Dementia Patients: A Matched Case-Control Study Using a National Inpatient Database

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Abstract

Background

Preventing falls and bone fractures in hospital care is an important issue in geriatric medicine. Use of hypnotics is a potential risk factor for falls and bone fractures in older patients. However, data are lacking on the association between use of hypnotics and the occurrence of bone fracture.

Methods

We used a national inpatient database including 1,057 hospitals in Japan and included dementia patients aged 50 years or older who were hospitalized during a period of 12 months between April 2012 and March 2013. The primary outcome was the occurrence of bone fracture during hospitalization. Use of hypnotics was compared between patients with and without bone fracture in this matched case-control study.

Results

Of 140,494 patients, 830 patients suffered from in-hospital fracture. A 1:4 matching with age, sex and hospital created 817 cases with fracture and 3,158 matched patients without fracture. With adjustment for the Charlson comorbidity index, emergent admission, activities of daily living, and scores for level walking, a higher occurrence of fractures were seen with short-acting benzodiazepine hypnotics (odds ratio, 1.43; 95% confidence interval, 1.19–1.73; $P<0.001$), ultrashort-acting non-benzodiazepine hypnotics (1.66; 1.37–2.01; $P<0.001$), hydroxyzine (1.45; 1.15–1.82, $P=0.001$), risperidone and perospirone (1.37; 1.08–1.73; $P=0.010$). Other drug groups were not significantly associated with the occurrence of in-hospital fracture.

educational lectures by Abbott and Daiichi-Sankyo. Other authors declare no conflict of interest. This does not alter the authors' adherence to PLOS ONE policies on sharing data and materials.

Conclusions

Short-acting benzodiazepine hypnotics and ultrashort-acting non-benzodiazepine hypnotics may increase risk of bone fracture in hospitalized dementia patients.

Introduction

Bone fracture following falls in hospitalized patients is an unresolved problem in geriatric medical management. Older patients, especially dementia patients, have higher risks of delirium, insomnia and day—night reversal with environmental changes related to hospital admission. Hypnotics and psychoactives are sometimes used to relieve these symptoms.

Studies have examined the risk of hypnotic drug use on fall and fracture. In a meta-analysis of 22 studies, fall was significantly associated with use of sedatives and hypnotics, neuroleptics and antipsychotics, antidepressants, and benzodiazepines, but was not associated with narcotics [1]. A retrospective analysis of 3683 patients demonstrated that fall was associated with use of hypnotics [2]. Several studies showed that zolpidem was significantly associated with a higher risk of fall and fracture [3, 4]. Another study showed a hip fracture risk associated with non-benzodiazepine hypnotics [5]. These previous studies were mostly performed in nursing homes or in the community in older patients. Falls in the acute care hospital setting occur at a higher rate than falls in nursing home settings [6–9]. Moreover, hospital falls are also most frequent in safety incident reports, and sometimes lead to negligence suits [10]. However, to our knowledge, there has been no study that simultaneously assessed various types of hypnotics and their risk of in-hospital fracture in a nationwide clinical setting. In this study, we performed a matched case-control study to analyze the association between use of various types of hypnotics and the occurrence of bone fracture in hospitalized dementia patients, using a national inpatient database in Japan. We focused on dementia for several reasons. First, older patients with dementia have a fall risk twice or more than that of older patients without dementia [11, 12]. Second, older patients with dementia also have three to eight times more injuries with falls and more often have a bad prognosis [13–15]. Third, wandering, as well as other behavioral and psychological symptoms of dementia, along with hypnotic and psychoactive agents used to relieve these symptoms, increases fall risks [16, 17]. The medications tend to become the problem in acute care hospitals in trying to prevent falls in dementia patients.

Methods

Setting and Participants

For this study, we used the Diagnosis Procedure Combination database. The details of the database have been described elsewhere [18–20]. Briefly, the database includes administrative claims data and discharge abstract data, collected from about 1000 participating hospitals across Japan. The database includes the following information: patient age and sex; main diagnoses, comorbidities at admission and complications after admission recorded according to the International Classification of Diseases, 10th Revision (ICD-10) and text data in Japanese; medical procedures; medicines and devices used; length of stay; activities of daily life (ADL) scores at admission; and discharge status. A unique identifier was used for each hospital. All patient identifiers were removed from this database. Because of the anonymous nature of the data, the Institutional Review Board of The University of Tokyo waived the need for written

informed consent from the participants. Study approval was also obtained from the Institutional Review Board of The University of Tokyo.

Among approximately 7 million inpatients over 12 months between April 1, 2012 and March 31 2013, we identified patients aged 50 years or older. Of these, we selected patients who were diagnosed with dementia or dementia-related diseases, including dementia in Alzheimer disease (ICD-10 code, F00), vascular dementia (F01), dementia in Pick disease (F02.0, G31.0), dementia in Creutzfeldt—Jakob disease (F02.1, G810), dementia in Huntington disease (F02.2, G10), dementia in Parkinson disease (F02.3, G20), dementia in human immunodeficiency virus disease (F02.4, B220), dementia in other specified diseases classified elsewhere (F02.8), unspecified dementia (F03), alcoholic dementia (F107), dementia in cerebral lipidosis (F028, E756), Lewy bodies dementia (F028, G318), and mild cognitive disorder (F06.7).

We extracted data on the following 17 types of hypnotics (or sedatives used as hypnotics) for each patient: benzodiazepine anxiolytics; diazepam; ultrashort-acting benzodiazepine hypnotics; short-acting benzodiazepine hypnotics; middle- to long-acting benzodiazepine hypnotics; ultrashort-acting non-benzodiazepine hypnotics; melatonin-receptor agonists; hydroxyzine; phenothiazine antipsychotics; haloperidol; sulpiride; risperidone and perospirone; multi-acting-receptor-targeted antipsychotics used as a hypnotic; antidepressants used as a hypnotic; Japanese *kampo* herbal medicine used as a hypnotic and in the treatment of behavioral and psychological symptoms of dementia; and other neurological drugs used as hypnotics.

Comorbidities were assessed by ICD-10 codes and converted into scores to calculate the Charlson comorbidity index (CCI) based on Quan's algorithm [21]. ADL scores for walking on a flat floor were also extracted including bedridden (Score 0), totally assisted (Score 1), partially assisted (Score 2) and without disability (Score 3).

Outcomes

The outcome in this study was in-hospital fracture. In the database, comorbidities already present at admission are clearly differentiated from complications that occurred after admission. In-hospital fracture was defined as fracture that occurred after admission and was determined according to the following ICD-10 codes: fracture of skull and facial bones (S02); fracture of neck (S12); fracture of rib(s), sternum and thoracic spine (S22); fracture of lumbar spine and pelvis (S32); fracture of shoulder and upper arm (S42); fracture of forearm (S52); fracture at wrist and hand level (S62); fracture of femur (S72); fracture of lower leg, including ankle (S82); fracture of foot, except ankle (S92); fractures involving multiple body regions (T02); fracture of spine, level unspecified (T08); fracture of upper limb, level unspecified (T10); and fracture of lower limb, level unspecified (T12).

Statistical Analyses

We performed a matched case—control study. First, we identified cases with in-hospital fracture. For each case, we selected four controls of similar age (±5 years) and the same sex from the same hospital. When there were more than four matched-control candidates to each case, we randomly selected four control patients. Specifically, control cases were sorted by randomly generated values from a Microsoft SQL server and the top four were selected. There are two ways to conduct matching: matching with replacement; and matching without replacement [22]. Matching with replacement means that controls can be used as matches for more than one treated individual; matching without replacement signifies that controls cannot be used as matches for more than one treated individual. Though the statistical analysis becomes more complex, matching with replacement can often decrease bias because controls that resemble

many treated individuals can be used multiple times [23, 24]. Moreover, the order of matching the treated individuals is immaterial in the case of matching with replacement. One methodological paper compared matching with and without replacement in three matching methods, and it found that matching with replacement had a smaller bias among all three methods [25]. Thus, we chose matching with replacement for the present study. If a control case was a candidate for more than one case, we included both matches. In the following analysis, one control was selected three times, 95 controls were selected twice, and they were weighted using frequency weights. If the number of matched-control candidates for each case was less than four, we also included both the corresponding case (62 cases) and control (138 controls) in the analytical group subset to avoid selection bias, unless no control subjects were assigned (13 cases).

Descriptive statistics were presented for the matched patients. Categorical variables were compared using the chi square test. We performed multivariable logistic regression for the occurrence of in-hospital fractures fitted with a generalized estimating equation to account for the clustered nature of the cases and controls. There are two ways to cluster in matched case-control studies: generalized estimating equations (GEEs) and conditional logistic analysis. Both methods can make consistent estimates. As GEE is more robust in terms of the specification of matching effect, we chose GEEs [26]. The dependent variable was in-hospital fracture, and independent variables included, emergent admission, ADL score for walking on a flat floor, CCI and 17 classes of drugs. All statistical analyses were conducted using IBM SPSS version 22.0 (IBM SPSS, Armonk, NY, USA).

Results

Among 140,494 eligible patients, 830 patients suffered from in-hospital fracture.

Using 1:4 matching, we obtained a case group of 817 patients and a control group of 3158 patients. Table 1 shows the baseline characteristics of the matched patients (n = 3975). As a result of matching, there was no significant difference in age ($P = 0.582$) or sex ($P = 0.728$) between the case and control groups. To exclude the possibility that controls may have been matched to cases with a larger age difference than to cases with a smaller age difference, we also compared the distribution of age in the case and control groups. Mean, median, standard deviation, range and interquartile range of age (years) in the case and control groups were 81.5 vs. 81.8, 82.0 vs. 82.0, 7.9 vs. 7.5, 50–103 vs. 50–103, 11.0 vs. 10.0, respectively. The age distributions of the case and control groups were also similar. No significant difference in CCI or emergent admission was present between the cases and controls. The ADL score for walking on a flat floor on admission was significantly different between the groups.

Table 2 shows 17 types of hypnotics (or sedatives used as hypnotics) used for the case and the control groups. The most frequently used drugs in both groups were ultrashort-acting non-benzodiazepine hypnotics, followed by short-acting benzodiazepine hypnotics. The proportion of patients who used any of the 17 types of drugs was significantly higher in the case than the control group (66.8% vs. 51.9%, $P<0.001$) (Table 2). The proportion of patients who used more than three types of hypnotics (or sedatives used as hypnotics) was also higher in the case than the control group (24.2% vs. 14.6%, $P<0.001$). The case group was significantly more likely to use benzodiazepine anxiolytics; ultrashort-acting benzodiazepine hypnotics; short-acting benzodiazepine hypnotics; middle- to long-acting benzodiazepine hypnotics; ultrashort-acting non-benzodiazepine hypnotics; melatonin-receptor agonists; hydroxyzine; phenothiazine antipsychotic; haloperidol; sulpiride; risperidone and perospirone; multi-acting-receptor-targeted antipsychotics used as a hypnotic; and an antidepressant used as a hypnotic. The proportion of patients who used Japanese *kampo* herbal medicine was not significantly different between the cases and controls.

Table 1. Characteristics of patients in the matched case and control groups.

		Cases (n = 817)		Controls (n = 3158)		*P*
Charlson comorbidity index	0	141	17.3%	526	16.7%	0.971
	1	264	32.3%	1013	32.1%	
	2	199	24.4%	805	25.5%	
	3	115	14.1%	435	13.8%	
	≥4	98	12.0%	379	12.0%	
Emergent admission		415	50.8%	1538	48.7%	0.286
ADL score (walking on flat floor)	0 (bedridden)	459	56.3%	1773	56.3%	0.001
	1 (totally assisted)	59	7.2%	208	6.6%	
	2 (partially assisted)	105	12.9%	382	12.1%	
	3 (without disability)	113	13.9%	588	18.7%	
	Unknown	81	9.9%	207	6.5%	

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Table 3 shows the results of the multivariable logistic regression analysis. A higher occurrence of in-hospital fracture was significantly associated with use of a short-acting benzodiazepine hypnotic, an ultrashort-acting non-benzodiazepine hypnotic, a hydroxyzine, risperidone and perospirone. Neither melatonin agonists nor Japanese *kampo* herbal medicine was associated with the occurrence of in-hospital fracture.

Table 2. Comparison of drug use between matched case and control groups.

	Case (n = 817)		Control (n = 3158)		*P*
benzodiazepine anxiolytic	98	12.0%	279	8.8%	0.006
diazepam	46	5.6%	171	5.4%	0.809
ultrashort-acting benzodiazepine hypnotic	24	2.9%	55	1.7%	0.029
short-acting benzodiazepine hypnotic	173	21.2%	460	14.6%	<0.001
middle- to long-acting benzodiazepine hypnotic	57	7.0%	159	5.0%	0.029
ultrashort-acting non-benzodiazepine hypnotic	194	23.7%	461	14.6%	<0.001
melatonin-receptor agonist	34	4.2%	83	2.6%	0.021
hydroxyzine	119	14.6%	288	9.1%	<0.001
phenothiazine antipsychotic	25	3.1%	58	1.8%	0.029
haloperidol	124	15.2%	314	9.9%	<0.001
sulpiride	26	3.2%	54	1.7%	0.008
risperidone and perospirone	144	17.6%	343	10.9%	<0.001
multi-acting-receptor-targeted antipsychotics used as hypnotic	77	9.4%	217	6.9%	0.013
antidepressant used as hypnotic	50	6.1%	103	3.3%	<0.001
Japanese *kampo* herbal medicine used as hypnotic and in treatment of BPSD	50	6.1%	192	6.1%	0.966
other neurological drugs used as hypnotic	31	3.8%	91	2.9%	0.178
Number of drugs					
0	271	33.2%	1519	48.1%	<0.001
1	201	24.6%	746	23.6%	
2	147	18.0%	433	13.7%	
≥3	198	24.2%	460	14.6%	

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Table 3. Generalized estimating equation analysis result.

	odds ratio	95% confidence interval			P
Type of admission					
Non-emergent	Reference				
Emergent	1.03	0.88	–	1.20	0.712
ADL score of walking on flat floor					
0 (bedridden)	Reference				
1 (totally assisted)	1.01	0.75	–	1.37	0.924
2 (partially assisted)	1.00	0.79	–	1.27	0.989
3 (without disability)	0.67	0.54	–	0.85	0.001
Unknown	1.42	1.08	–	1.86	0.011
Charlson comorbidity index					
0	Reference				
1	0.91	0.72	–	1.16	0.461
2	0.88	0.69	–	1.12	0.296
3	0.93	0.71	–	1.22	0.609
≥4	0.91	0.68	–	1.22	0.526
benzodiazepine anxiolytic	1.15	0.90	–	1.47	0.250
diazepam	0.91	0.65	–	1.29	0.608
ultrashort-acting benzodiazepine hypnotic	1.53	0.94	–	2.50	0.086
short-acting benzodiazepine hypnotic	1.43	1.19	–	1.73	0.000
middle- to long-acting benzodiazepine hypnotic	1.01	0.70	–	1.45	0.977
ultrashort-acting non-benzodiazepine hypnotic	1.66	1.37	–	2.01	0.000
melatonin-receptor agonist	1.25	0.84	–	1.88	0.273
hydroxyzine	1.45	1.15	–	1.82	0.001
phenothiazine antipsychotic	1.06	0.57	–	2.00	0.847
haloperidol	1.16	0.91	–	1.48	0.244
sulpiride	1.57	0.95	–	2.57	0.077
risperidone and perospirone	1.36	1.08	–	1.73	0.010
multi-acting-receptor-targeted antipsychotics used as hypnotic	1.07	0.79	–	1.44	0.654
antidepressant used as hypnotic	1.38	0.97	–	1.98	0.077
Japanese *kampo* herbal medicine	0.72	0.52	–	1.00	0.052
other neurological drugs used as hypnotic	1.10	0.62	–	1.96	0.736

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Discussion

The present study showed an increased risk for in-hospital fracture with several hypnotics and psychoactives used as hypnotics in dementia patients who were admitted to acute care hospitals. In-hospital fracture risk was associated with a short-acting benzodiazepine hypnotic, an ultrashort-acting non-benzodiazepine hypnotic, and risperidone and perospirone.

A previous US study of nursing home residents demonstrated a fracture risk with ultrashort-acting non-benzodiazepine hypnotics [5]. The present study also showed a risk with ultrashort-acting non-benzodiazepine hypnotics. A new finding in the present study is that shorter-acting drugs had relatively higher odds ratios for in-hospital fracture than longer-acting drugs. A possible explanation for this may be that patients are more likely to fall when drowsy soon after taking hypnotics. Another possible reason is that physicians may have avoided prescribing long-acting hypnotics for frail patients.

To our knowledge, the present study is the first to show that hydroxyzine may increase the risk of fracture in dementia patients. Hydroxyzine has been shown to be as effective as bromazepam, one of the benzodiazepines, in the treatment of generalized anxiety disorder [27]. Because hydroxyzine has a half-life of around 3 hours, it may act like a short-acting benzodiazepine.

Our results showed that a melatonin agonist was not significantly associated with the occurrence of in-hospital fracture. Melatonin-receptor agonists including ramelteon are new types of hypnotics. They act on the $GABA_A$ receptor-independent pathway in contrast to most of hypnotics that act on the $GABA_A$ receptor. The present study suggests that a melatonin agonist may be safer than other hypnotics in terms of fall and fracture risk.

Japanese *kampo* herbal medicines, which are often used as sedatives or hypnotics in Japan, have beneficial effects on the behavioral and psychological symptoms of dementia [28–30]. Our results suggest that these drugs would be good alternatives to conventional hypnotics or sedatives in dementia patients and may reduce fracture risk.

This study has several limitations. First, recorded diagnoses in an administrative claims database are less well validated than those in planned prospective studies. Second, the time interval between drug administration and related in-hospital fracture cannot be identified from the database and its causal relationship remains to be clarified. We have information on the timing and use of these agents, but not on the timing of fracture. Consequently, we are not certain as to whether the agent was prescribed before or after the fracture, or if it was not used for a short period of time for weeks to months prior to fracture. Third, it is difficult to distinguish the deleterious effect of hypnotic use itself from underlying conditions, including night delirium and insomnia requiring prescription of hypnotics. Fourth, there was no information about previous falls, and so we were unable to examine this relationship owing to the lack of data.

In light of these findings, it is preferable to avoid prescribing short-acting benzodiazepines and ultrashort-acting non-benzodiazepine hypnotics, risperidone or perospirone, hydroxyzine, or multi-acting-receptor-targeted antipsychotics to in-hospital dementia patients. Melatonin-receptor agonists or Japanese *kampo* herbal medicine may be preferable to these drugs.

Conclusion

Short-acting benzodiazepines and ultrashort-acting non-benzodiazepine hypnotics were associated with an increase in in-hospital fractures in dementia patients, while no significant association with an increase in in-hospital fractures was seen with middle- to long-acting benzodiazepine hypnotics, melatonin-receptor agonists, or Japanese *kampo* herbal medicine.

Author Contributions

Conceived and designed the experiments: HT HY SO. Performed the experiments: HT HY SO. Analyzed the data: HT HY SO. Contributed reagents/materials/analysis tools: HM KF HY. Wrote the paper: HT HY MA SO.

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Original Study

Eating Alone as Social Disengagement is Strongly Associated With Depressive Symptoms in Japanese Community-Dwelling Older Adults

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Eating alone
depressive symptoms
social engagement

ABSTRACT

Objectives: Depression in later life poses a grave challenge for the aging countries. The reported key risk factors include social disengagement, but the lack of social companionship during mealtimes, namely eating alone, has not been examined extensively, especially in relation to living arrangement. Past studies on changes along geriatric trajectories in the association between social engagement and depression also remain inadequate. This study aims to examine the association between social engagement and depressive symptoms with a particular focus on eating alone and how the association changes along the aging and mental frailty trajectories.
Design: A cross-sectional study.
Setting: Kashiwa-city, Chiba-prefecture in Japan.
Participants: A total of 1856 community-dwelling older adults.
Measurements: The 15-item Geriatric Depression Scale was used to measure depressive symptoms. The indicators used to assess social engagement included eating alone, living arrangement, reciprocity of social support, social participation, social stressors and social ties.
Results: Social engagement was significantly associated with depressive symptoms. Those who live with their families yet eat alone were found to be at particular risk (odds ratio = 5.02, 95% confidence interval 2.5–9.9 for young-old; odds ratio = 2.41, 95% confidence interval 1.2–4.8 for old-old). Younger and less mentally frail populations showed stronger associations.
Conclusions: Eating alone was a key risk factor for depressive symptoms in community-dwelling older adults. The living arrangement in which they eat alone is important in identifying those with the greatest risk. Mental health management for older adults requires comprehensive assessment of their social relations that takes into account their companionship during mealtimes. Social preventive measures need to involve early interventions in order to augment their effectiveness against mental frailty.

The problem of depression in later life has become a pressing global concern, as the population aging continues worldwide.[1] It undermines well-being and quality of life while adding to healthcare costs, with potential consequences on a wide range of health outcomes.[2] The problem poses a grave socioeconomic burden on aging countries, not least in Japan where the unprecedented level of aging threatens to undermine its social security system.[3] The prevalence of

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depression among community-dwelling older adults varies enormously and has been reported to be as high as 35%.[4]

The key reported predictors of depressive symptoms include female gender, cognitive and functional impairments, medical disorders, low level of education, and social disengagement.[1,5–10] Social engagement is an "umbrella concept for the various components of an individual's social behavior and social structure"[11] and its different aspects have consistently been found to predict mortality, disease outcomes, disability, cognitive decline as well as depressive symptoms.[12–16] While the conceptualization of social engagement lacks a strong consensus,[17] this should not be viewed as a weakness but as an invitation to explore its unexamined aspects in a search for the most relevant screening questions to identify older adults at risk.[11] This study, thus, aims to examine new concepts and ideas that remain under-explored, especially in relation to depression.

One such aspect is the social behavior during mealtimes. Commensality (ie, the act of eating with others) provides opportunities for social interactions and exchange of information and support by facilitating participation in shared social activities of mealtimes.[18] Eating alone deprives older adults such valuable social opportunities. Eating alone has been studied in relation to dietary intake, but research in relation to depression and wider health outcomes remains limited.[19] To our knowledge, none has examined its association with depression in combination with other components of social engagement nor investigated it in relation to the living arrangement. Living alone is often cited as a key risk factor for older adults, as does the Ministry of Health, Labor and Welfare, Japan, but eating alone is rarely discussed. A shared living arrangement may result in increased opportunities for commensality, but does not guarantee it,[18,19] requiring independent considerations.

Furthermore, past studies have not adequately examined how the association between social engagement and depression changes along geriatric trajectories such as aging and frailty. Frailty is not only a physical but a multidimensional concept,[20] and mental frailty, one important dimension, may manifest as depressive states. The role of social engagement vis-à-vis depression is expected to change as older adults age or become more mentally frail, influencing the effectiveness of social intervention measures.

The purpose of the present study is 2-fold. The first objective is to examine whether social engagement is associated with depressive symptoms with a particular focus on eating alone and its relation to the living arrangement. Second, effects of geriatric trajectories, namely aging and mental frailty trajectory on the above association, are examined in order to better identify the most effective social intervention sites for depressive symptoms.

Methods

Study Design

The study was cross-sectional.

Setting and Participants

This study was based on data from 1856 randomly selected community-dwelling older adults (independent or those requiring support), aged 65–94, who participated in the first year health assessment of a 3-year cohort study between 2012 and 2014 in Kashiwa city, Japan. A total of 2044 persons participated in the assessment and 188 persons were excluded due to missing items of data.

Measurements

Depressive symptoms

The 15-item Geriatric Depression Scale (GDS) was used. Scores of ≥6 were defined as "depressive symptoms,"[21] 6–9 as "mild depression," and ≥10 as "severe depression."[4]

Social engagement

Seven components were assessed: (1) living arrangement; (2) eating arrangement; (3) reciprocal social support; (4) social participation; (5) social stressors; (6) social ties with family; and (7) social ties with friends. The following questions were asked regarding each item: (1) Do you live with your family: yes or no? (No = living alone); (2) Do you eat your meals with anyone else, at least once a day: yes or no? (No = eating alone); (3) Do you give advice and a helping hand to your family or friends: yes or no? (No = low reciprocal social support); (4) Are you going out less frequently compared to last year: yes or no? (The Kihon Check List, Ministry of Health, Labor and Welfare) (No = fewer frequency of going out); and (5) Did you experience any major changes in life in the past year, such as moving home, retirement, loss of relatives, financial troubles, troubles in the relationships with people: yes or no? (Yes = major change in life). For (6) and (7), the abbreviated Lubben Social Network Scale-6 and its Family and Friends subscales[22,23] were used. Living arrangement and eating arrangement were crossed to construct 4 dummy variables: "living and eating alone," "living alone yet eating with others," "living with others yet eating alone," and "living and eating with others" (reference).

Sociodemographic variables

Age and the years of education were included in the analysis as continuous variables. Health literacy was measured by 5 items developed for Japanese persons.[24] Information on economic status was obtained as income ranking based on long-term care insurance premiums. Logistic regression was performed with the income ranking and depressive symptoms as the independent and dependent variables, respectively. The odds ratios were plotted to observe changes in the trend and those with less than 1.4 million Japanese Yen per person were categorized as the "low income" group.

Medical histories

Medical histories of hypertension, osteoporosis, cerebrovascular diseases, diabetes, heart diseases, and malignant neoplasm were obtained through medical interviews by nurses.

Number of medications

The total number of oral medications was recorded as a continuous variable, as polypharmacy is known to be associated with increased depressive symptoms.[25]

Physical health and functions

Instrumental activities of daily living (IADL) was measured using the Tokyo Metropolitan Institute of Gerontology index of competence.[26] Mobility was assessed by Life-Space Assessment,[27,28] measured with the Elderly-Status Assessment Set.[29,30] The highest level of life-spaces (level 5) was used. To assess usual and maximum gait speeds, participants were instructed to walk over an 11-m course and the time spent in the middle 5 m was recorded.[31]

Cognitive function

The Mini-Mental State Examination was used, and its score was included in the analysis as a continuous variable.

Oral health and functions

The Japanese version of the General Oral Health Assessment Index (GOHAI)[32,33] was used to measure the oral health-related quality of

Table 1
Geriatric Characteristics of Normal (Nondepressed) and Depressed Study Participants* (n = 1856)

Variables	Young-Old (65–74 Years Old)			Old-Old (≥75 Years Old)		
	Normal (n = 1033)	Depressive Symptoms (n = 168)		Normal (n = 551)	Depressive Symptoms (n = 104)	
	Mean ± SD or n (%)		*P* Value	Mean ± SD or n (%)		*P* Value
Sociodemographic variables						
Sex (male)	519 (50.2)	71 (42.3)	.055	282 (51.2)	56 (53.8)	.618
Age	69.6 ± 2.7	69.6 ± 2.6	.969	79.0 ± 3.7	79.4 ± 4.0	.294
Education (years)	13.0 ± 2.5	12.6 ± 2.6	.089	12.4 ± 3.1	11.7 ± 3.3	.056
Health literacy	4.03 ± 0.61	3.71 ± 0.67	<.001	4.07 ± 0.60	3.64 ± 0.70	<.001
Low income	598 (57.9)	126 (75.0)	<.001	293 (53.2)	62 (59.6)	.227
Social engagement						
Living alone	77 (7.5)	20 (11.9)	.050	84 (15.2)	15 (14.4)	.830
Eating alone	91 (8.8)	42 (25.0)	<.001	104 (18.9)	34 (32.7)	.002
Living and eating with others	929 (89.9)	124 (73.8)	<.001	428 (77.7)	68 (65.4)	.007
Living and eating alone	64 (6.2)	18 (10.7)	.031	65 (11.8)	13 (12.5)	.839
Living alone yet eating with others	13 (1.3)	2 (1.2)	1.000	19 (3.4)	2 (1.9)	.555
Living with others yet eating alone	27 (2.6)	24 (14.3)	<.001	39 (7.1)	21 (20.2)	<.001
Low reciprocal social support	45 (4.4)	29 (17.3)	<.001	34 (6.2)	18 (17.3)	<.001
Fewer frequency of going out	127 (12.3)	65 (38.7)	<.001	107 (19.4)	47 (45.2)	<.001
Major change in life	225 (21.8)	62 (36.9)	<.001	85 (15.4)	28 (26.9)	.004
Social ties with family	8.33 ± 3.1	6.58 ± 3.1	<.001	8.21 ± 3.2	6.91 ± 3.0	<.001
Social ties with friends	8.43 ± 3.5	6.23 ± 3.4	<.001	8.43 ± 3.6	6.30 ± 3.4	<.001
Medical histories						
Hypertension	388 (37.6)	78 (46.4)	.029	270 (49.0)	69 (66.3)	.001
Cerebrovascular diseases	36 (3.5)	16 (9.5)	<.001	47 (8.5)	13 (12.5)	.198
Diabetes	116 (11.2)	17 (10.1)	.671	68 (12.3)	14 (13.5)	.752
Osteoporosis	77 (7.5)	21 (12.5)	.027	79 (14.3)	23 (22.1)	.045
Heart diseases	151 (14.6)	28 (16.7)	.489	111 (20.1)	32 (30.8)	.016
Malignant neoplasm	152 (14.7)	16 (9.5)	.072	92 (16.7)	23 (22.1)	.183
Number of medications	2.21 ± 2.5	2.85 ± 2.9	.008	3.80 ± 3.3	5.72 ± 3.9	<.001
Physical health and functions						
IADL	4.90 ± 0.36	4.77 ± 0.63	.013	4.85 ± 0.50	4.61 ± 0.89	.007
Mobility	25.8 ± 9.8	21.1 ± 10	<.001	24.1 ± 9.9	20.9 ± 11	.003
Cognitive function: MMSE	28.5 ± 1.7	28.0 ± 1.9	.002	28.0 ± 1.9	27.3 ± 2.3	.006
Oral health and functions: GOHAI	55.8 ± 5.4	51.3 ± 7.1	<.001	54.5 ± 6.3	49.5 ± 8.9	<.001
Nutritional and dietary status						
BMI (kg/m^2)	23.0 ± 2.9	22.6 ± 3.0	.071	22.7 ± 3.1	22.6 ± 3.0	.625
Food variety	3.63 ± 2.0	3.04 ± 1.9	<.001	4.23 ± 2.1	3.72 ± 2.1	.021
MNA-SF	12.7 ± 1.3	12.1 ± 1.8	<.001	12.4 ± 1.5	11.8 ± 1.8	.004

BMI, body mass index; MMSE, Mini-Mental State Examination; SD, standard deviation.
*χ^2 test or Fisher exact test was used for categorical variables and nonpaired *t*-test was used for continuous variables.

life. Numbers of remaining teeth were counted by dental hygienists. Occlusal force was assessed by Dental Prescale (Fujifilm, Shizuoka-prefecture, Japan).

Nutritional and dietary status

BMI was calculated by dividing the weight by the square of height. Food variety score was calculated from a 10-item questionnaire.[34] Nutritional status was assessed by Mini-Nutrition Assessment-Short Form (MNA-SF), with scores ≤ 11 indicating possible malnutrition.[35]

Statistical Analysis

Binomial multiple logistic regression analysis was performed with depressive symptoms as the dependent variable, stratified by the age groups (65–74 years old indicating "young-old" and ≥75 years old indicating "old-old"). Multinomial multiple logistic regression analysis was performed with different degrees of depressive states ("mild depression" and "severe depression") as the outcome. The characteristics of the 4 groups by eating and living arrangement were also compared, to explore the reasons behind their differing associations with depressive symptoms. For continuous variables only, multiple comparison test (Dunnett T3) was used to test whether there were significant differences between "living with others yet eating alone" and "living and eating with others." IBM SPSS statistics v 22 for Windows (IBM Japan, Tokyo, Japan) was used to perform statistical analysis. *P* value of <.05 was considered to indicate statistical significance.

Ethical Considerations

The study was approved by the Ethics Committee of the University of Tokyo. Data received for analysis had the participants' names substituted with ID numbers, and confidential information was excluded to ensure protection of personal information.

Results

Sample Characteristics

Of the total 1856 participants (928 male and 928 female, mean age was 72.9 ± 5.5 years), 1201 (64.7%) were young-old whereas 655 (35.3%) were old-old. Furthermore, 14.7% showed depressive symptoms (14.0% of young-old and 15.9% of old-old, 15.6% of women and 13.7% of men); 10.6% were living alone (8.1% of young-old and 15.1% of old-old, 15.4% of women and 5.7% of men); 14.6% were eating alone (11.1% of young-old and 21.1% of old-old, 17.9% of women and 11.3% of men); and 6.0% were eating alone despite living with family members (4.2% of young-old and 9.2% of old-old, 5.2% of women and 6.8% of men).

Table 2
Association Between Depressive Symptoms and Risk Factors by Binomial Multiple Logistic Regression

Variables	Young-Old (65–74 Years Old) (n = 1201)			
	Model 1		Model 2	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Social engagement				
Living and eating with others (ref)	–		–	
Living and eating alone	1.94 (1.1–3.6)	.034	1.53 (0.79–2.9)	.204
Living alone yet eating with others	1.59 (0.32–7.9)	.569	1.14 (0.19–6.8)	.885
Living with others yet eating alone	6.33 (3.3–12)	<.001	5.02 (2.5–9.9)	<.001
Low reciprocal social support	2.57 (1.5–4.6)	.001	2.41 (1.3–4.5)	.006
Fewer frequency of going out	3.79 (2.6–5.6)	<.001	2.57 (1.7–3.9)	<.001
Major change in life	1.78 (1.2–2.6)	.004	1.72 (1.1–2.6)	.009
Social ties with family	0.901 (0.84–0.96)	.002	0.905 (0.84–0.97)	.005
Social ties with friends	0.911 (0.86–0.96)	.001	0.940 (0.88–1.0)	.049
Sociodemographic variables				
Sex (male)			1.29 (0.77–2.2)	.334
Health literacy			0.691 (0.52–0.93)	.013
Low income			1.77 (1.0–3.0)	.038
Medical histories				
Hypertension			1.17 (0.75–1.8)	.486
Cerebrovascular diseases			1.99 (0.89–4.4)	.094
Osteoporosis			1.38 (0.74–2.6)	.308
Number of medications			1.03 (0.96–1.1)	.402
Physical health and functions				
IADL			0.824 (0.54–1.3)	.369
Mobility			0.973 (0.96–0.99)	.007
Cognitive function: MMSE			1.04 (0.92–1.2)	.521
Oral health and functions: GOHAI			0.944 (0.92–0.97)	<.001
Nutritional and dietary status				
Food variety			0.929 (0.84–1.0)	.163
MNA-SF			0.870 (0.76–0.99)	.038
Variables	Old-Old (≥75 Years Old) (n = 655)			
	Model 1		Model 2	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Social engagement				
Living and eating with others (ref)	–		–	
Living and eating alone	1.01 (0.51–2.0)	.968	1.06 (0.48–2.4)	.889
Living alone yet eating with others	0.753 (0.17–3.4)	.712	0.979 (0.19–5.0)	.980
Living with others yet eating alone	2.45 (1.3–4.7)	.006	2.41 (1.2–4.8)	.014
Low reciprocal social support	1.91 (0.95–3.9)	.071	1.04 (0.48–2.3)	.917
Fewer frequency of going out	2.97 (1.9–4.7)	<.001	2.09 (1.2–3.6)	.008
Major change in life	1.98 (1.2–3.4)	.012	2.18 (1.2–3.9)	.009
Social ties with family	0.981 (0.90–1.1)	.651	0.972 (0.89–1.1)	.548
Social ties with friends	0.880 (0.82–0.94)	<.001	0.895 (0.83–0.97)	.006
Sociodemographic variables				
Sex (male)			1.56 (0.88–2.8)	.126
Health literacy			0.499 (0.34–0.74)	<.001
Medical histories				
Hypertension			1.46 (0.83–2.6)	.185
Osteoporosis			1.27 (0.63–2.5)	.505
Heart diseases			1.21 (0.68–2.1)	.525
Number of medications			1.10 (1.0–1.2)	.010
Physical health and functions				
IADL			0.842 (0.59–1.2)	.340
Mobility			1.00 (0.98–1.0)	.990
Cognitive function: MMSE			0.919 (0.82–1.0)	.160
Oral health and functions: GOHAI			0.935 (0.90–0.97)	<.001
Nutritional and dietary status				
Food variety			0.982 (0.87–1.1)	.770
MNA-SF			0.929 (0.79–1.1)	.365

CI, confidence interval; MMSE, Mini-Mental State Examination; OR, odds ratio.
Model 1: social engagement.
Model 2: social engagement, sociodemographic variables, medical histories, number of medications, physical health and functions, cognitive function, oral health and functions, and nutritional and dietary status.

Social Engagement and Depressive Symptoms by Age Groups

Table 1 shows the comparison of the geriatric characteristics between normal and depressed participants for young-old and old-old, respectively. Based on this result, logistic regression was performed to identify the key risk factors for depressive symptoms (Table 2). The variables independently associated with depressive symptoms for both age-groups were "living with others yet eating alone," social participation (fewer frequency of going out), social stressors (major change in life), and social ties of friends, health literacy, and GOHAI. Those unique to young-old were low reciprocal social support, social ties with family, low income, mobility, and MNA-SF scores. Risk factor unique to old-old was the number of medications.

Table 3
Geriatric Characteristics of Normal, Mildly Depressed and Severely Depressed Participants* (n = 1856)

Variables	Normal (n = 1584)	Mild Depression (n = 193)	Severe Depression (n = 79)	*P* Value
	Mean ± SD or n (%)			
Sociodemographic variables				
Sex (male)	801 (50.6)	84 (43.5)	43 (54.4)	.601
Age	72.8 ± 5.4	72.7 ± 5.6	74.8 ± 6.0	.201
Education (years)	12.8 ± 2.7	12.3 ± 2.9	12.2 ± 3.1	.007
Health literacy	4.04 ± 0.61	3.75 ± 0.67	3.52 ± 0.70	<.001
Low income	891 (56.3)	137 (71.0)	51 (64.6)	.001
Social engagement				
Living alone	161 (10.2)	19 (9.8)	16 (20.3)	.031
Eating alone	195 (12.3)	47 (24.4)	29 (36.7)	<.001
Living and eating with others (ref)	1357 (85.7)	146 (75.6)	46 (58.2)	<.001
Living and eating alone	129 (8.1)	19 (9.8)	12 (15.2)	.031
Living alone yet eating with others	32 (2.0)	0 (0.0)	4 (5.1)	.681
Living with others yet eating alone	66 (4.2)	28 (14.5)	17 (21.5)	<.001
Low reciprocal social support	79 (5.0)	30 (15.5)	17 (21.5)	<.001
Fewer frequency of going out	234 (14.8)	75 (38.9)	37 (46.8)	<.001
Major change in life	310 (19.6)	66 (34.2)	24 (30.4)	<.001
Social ties with family	8.29 ± 3.1	6.82 ± 3.1	6.42 ± 3.0	<.001
Social ties with friends	8.43 ± 3.5	6.42 ± 3.4	5.86 ± 3.4	<.001
Medical histories				
Hypertension	658 (41.5)	107 (55.4)	40 (50.6)	.001
Cerebrovascular diseases	83 (5.2)	17 (8.8)	12 (15.2)	<.001
Diabetes	184 (11.6)	23 (11.9)	8 (10.1)	.805
Osteoporosis	156 (9.8)	31 (16.1)	13 (16.5)	.003
Heart diseases	262 (16.5)	43 (22.3)	17 (21.5)	.043
Malignant neoplasm	244 (15.4)	27 (14.0)	12 (15.2)	.739
Number of medications	2.77 ± 2.9	3.84 ± 3.4	4.20 ± 3.9	<.001
Physical health and functions				
IADL	4.88 ± 0.42	4.73 ± 0.70	4.66 ± 0.83	<.001
Mobility	25.2 ± 9.8	21.0 ± 10	20.9 ± 11	<.001
Cognitive function: MMSE	28.3 ± 1.8	27.7 ± 2.0	27.7 ± 2.2	<.001
Oral health and functions: GOHAI	55.4 ± 5.8	51.1 ± 7.4	49.2 ± 8.7	<.001
Nutritional and dietary status				
BMI (kg/m^2)	22.9 ± 3.0	22.7 ± 3.1	22.3 ± 2.9	.163
Food variety	3.84 ± 2.0	3.34 ± 2.0	3.20 ± 2.1	<.001
MNA-SF	12.6 ± 1.4	12.1 ± 1.7	11.7 ± 1.9	<.001

BMI, body mass index; MMSE, Mini-Mental State Examination; SD, standard deviation.
*Cochran-Armitage trend test was used for categorical variables and Jonckheere-Terpstra trend test was used for continuous variables.

Social Engagement and Different Degrees of Depression

Table 3 shows the comparison of the geriatric characteristics between "normal," "mildly depressed" and "severely depressed" participants. Based on this result, multinomial logistic regression was performed, as shown in Table 4. The variables independently associated with both degrees of depression were eating alone, social participation (fewer frequency of going out), social ties with friends, health literacy, the number of medications, and GOHAI. Those unique for "mild depression" were living alone; they had low reciprocal social support, social stressors (major change in life), social ties with family, age, low income, and mobility. Risk factors unique for "severe depression" were male gender, history of cerebrovascular diseases, and MNA-SF scores.

Living Arrangement and Eating Arrangement

To examine further the role of eating alone and its potential risk factors, living arrangement and eating arrangement were crossed and the physical, mental, oral, cognitive, nutritional and dietary as well as social characteristics of the 4 resultant groups [living and eating alone (n = 160), living alone yet eating with others (n = 36), living with others yet eating alone (n = 111), living and eating with others (n = 1549)] were compared. The results are shown in Table 5.

The participants "living with others yet eating alone" had the poorest scores of social ties with family and friends, years of education, health literacy, physical health and functions (normal and maximum gait speeds, IADL and mobility), cognitive function, oral health and functions (GOHAI, number of remaining teeth, and occlusal force), and nutritional and dietary status (MNA-SF and food variety).

Furthermore, greater proportion of those who "live with others yet eat alone" live with their children, children-in-law, and grandchildren, compared with those who "live and eat with others," most of whom live with their spouse.

Discussion

The main aim of the present study was to examine the association between social engagement and depressive symptoms in community-dwelling Japanese older adults, with a particular focus on eating alone and on the changes in the association along geriatric trajectories of aging and mental frailty.

The study was carried out on a population sample of Japanese older adults, of whom 14.7% showed depressive symptoms (GDS ≥6). This is on the lower end compared with previous studies that used the same GDS cut-off point, in which the prevalence ranged between 14% and 40%.[4]

The results highlighted a significant association between depressive symptoms and social engagement variables such as social ties, eating alone, social participation, social stressors and reciprocity of social support. Of particular interest was eating alone, which to our knowledge has not been assessed before in combination with different components of social engagement and in relation to the

Table 4
Association Between Mild and Severe Depression and Their Risk Factors by Multinomial Multiple Logistic Regression (n = 1856)

	Mild Depression (n = 193)		Severe Depression (n = 79)	
Variables	OR 95%CI	*P* Value	OR 95%CI	*P* Value
Social engagement				
Living alone	0.374 (0.19–0.74)	.005	0.777 (0.33–1.8)	.566
Eating alone	2.96 (1.8–5.0)	<.001	3.33 (1.6–6.8)	.001
Low reciprocal social support	1.73 (1.0–2.9)	.045	1.66 (0.80–3.4)	.172
Fewer frequency of going out	2.21 (1.5–3.2)	<.001	2.79 (1.6–4.8)	<.001
Major change in life	1.78 (1.2–2.6)	.002	1.63 (0.93–2.9)	.091
Social ties with family	0.940 (0.88–1.0)	.046	0.935 (0.85–1.0)	.162
Social ties with friends	0.929 (0.88–0.98)	.007	0.895 (0.82–0.97)	.009
Sociodemographic variables				
Sex (male)	1.27 (0.78–2.1)	.335	2.46 (1.2–5.0)	.013
Age	0.950 (0.92–0.98)	.005	0.998 (0.95–1.0)	.943
Education (years)	1.05 (0.98–1.1)	.190	1.03 (0.93–1.1)	.582
Health literacy	0.670 (0.52–0.87)	.003	0.440 (0.31–0.63)	<.001
Low income	1.72 (1.1–2.8)	.024	1.65 (0.84–3.3)	.145
Medical histories				
Hypertension	0.743 (0.51–1.1)	.118	1.14 (0.64–2.0)	.655
Cerebrovascular diseases	1.38 (0.74–2.6)	.312	2.36 (1.1–5.2)	.033
Osteoporosis	0.712 (0.43–1.2)	.184	0.839 (0.39–1.8)	.652
Heart diseases	1.00 (0.65–1.5)	.994	1.28 (0.67–2.5)	.461
Number of medications	1.08 (1.0–1.1)	.017	1.10 (1.0–1.2)	.027
Physical health and functions				
IADL	0.834 (0.63–1.1)	.215	0.862 (0.59–1.3)	.446
Mobility	0.983 (0.97–1.0)	.044	0.988 (0.96–1.0)	.327
Cognitive function: MMSE	0.927 (0.85–1.0)	.103	0.994 (0.87–1.1)	.930
Oral health and functions: GOHAI	0.943 (0.92–0.97)	<.001	0.928 (0.90–0.96)	<.001
Nutritional and dietary status				
Food variety	0.959 (0.88–1.0)	.344	0.960 (0.84–1.1)	.531
MNA-SF	0.936 (0.84–1.0)	.251	0.839 (0.72–0.98)	.029

CI, confidence interval; MMSE, Mini-Mental State Examination; OR, odds ratio.

living arrangement. "Living with others yet eating alone" was a significant predictor of depression for both age groups, with odds ratio reaching as high as 5 times for the young-old. This suggests that eating alone acts as stronger risk factor than living alone, and that the living arrangement in which older adults eat alone can act as a critical determinant of depressive risks. Meals are an important location of socialization whereby older adults enjoy intimate interactions, and when shared with others, they can provide valuable opportunities for companionship and social support.[18] A lack of communication during meals may result in feelings of loneliness and depressed moods.[19]

Table 5 suggests that those who eat alone despite living with their families tend to be the most socially withdrawn, with least awareness of their health conditions and the poorest physical, oral, and cognitive functions as well as nutritional status. The fact that they do not share a single meal with their families despite living together suggests that they have distant relationships with them. Compared with those who eat with others, a greater proportion of those who eat alone live with their children, children-in-law or grandchildren, and less with their spouse. This suggests that they may be eating alone because they lead different life styles, suffer from emotional distance, concerns that they will add burdens on their families if they eat together, or from uncomfortable relationships with family members such as children-in-law. This is supported by the fact that they have the weakest social ties with family. This may result in lower interest in their health shown by their families, as well as in lower self-interest. The fact that they show the lowest health literacy also supports this hypothesis. They also exhibit the lowest mobility and social ties with friends, suggesting that they are the most socially isolated not only at home but also outside. The fact that their gait speeds and IADL are the lowest imply that their poor physical functions play a role in limiting their social activities. GOHAI scores, number of remaining teeth and occlusal force are lowest in this group, indicating the possibility that they eat alone because they eat too slowly, require different menus, or because they have concerns about their oral appearance. The poor oral functions and nutritional/dietary status (low food variety and MNA-SF scores) may also be another manifestation of the lack of interest in their health shown by their families as well as by themselves.

In any case, the sentiments or perceptions that lead them to eat alone despite living with their families are likely to be negative in nature and may be internally conceived by the older adults themselves, or externally imposed by families living together or the wider society. The functional decline, which may be a cause as well as a result from eating alone, may also contribute to the depressive outcomes.

Stratification by age groups and multinomial regression analysis by different severities of depression revealed that fewer variables of social engagement were associated with depressive outcomes as the population ages or becomes more mentally frail. This suggests that social engagement is a more powerful predictor of mental health at earlier points along geriatric trajectories, and, thus, that effective social preventive measures require early interventions. Lower down the geriatric trajectories, social factors fall in their relative importance and the role of health and functional factors increase. This is suggested by the fact that the number of medications becomes a significant predictor for old-old, and the history of cerebrovascular diseases and MNA-SF scores become significant for severe depression.

Outside the domain of social engagement, the independent risk factors for depressive symptoms in both age groups included GOHAI and health literacy, supporting the findings of previous studies.[36–38] Uniquely for young-old, mobility, MNA-SF, and income were associated. For old-old only, the number of medications remained a predictor of depressive symptoms.

This study elucidates that reducing the risk of depression requires much more than medical care and that preventive measures need to be introduced early on in the geriatric trajectories, before frailty sets in. The present study shows that social factors such as eating alone pose substantial risk for mental health. Comprehensive assessment that covers a wide range of health-related domains including physical health, oral functions, nutritional, and dietary status as well as social relations will be necessary to identify those at risk effectively.

Table 5
Characteristics by Living and Eating Arrangement (n = 1856)

Variables	Living and Eating Alone (n = 160)	Living Alone Yet Eating With Others (n = 36)	Living with Others Yet Eating Alone (n = 111)	Living and Eating With Others (n = 1549)	*P* Value*
	Mean ± SD or n (%)				
Social engagement					
Live with spouse	–	–	61 (55.0)	1393 (89.9)	<.001
Live with children	–	–	74 (66.7)	627 (40.5)	<.001
Live with children-in-law	–	–	21 (18.9)	117 (7.6)	<.001
Live with grand-children	–	–	29 (26.1)	171 (11.0)	<.001
Social ties with family	7.24 ± 3.4	8.83 ± 3.5	7.19 ± 3.2	8.19 ± 3.1	<.001*
Social ties with friends	8.08 ± 3.4	8.86 ± 2.9	6.86 ± 4.0	8.19 ± 3.6	.003*
Sociodemographic variables					
Sex (male)	42 (26.3)	11 (30.6)	63 (56.8)	812 (52.4)	<.001
Age	74.6 ± 6.0	75.4 ± 5.2	75.3 ± 5.7	72.5 ± 5.3	<.001*
Education (years)	11.9 ± 2.7	12.0 ± 2.7	11.8 ± 3.2	12.9 ± 2.7	<.001*
Health literacy	3.87 ± 0.71	4.13 ± 0.71	3.86 ± 0.66	4.01 ± 0.62	.015
Number of medications	3.50 ± 3.5	4.17 ± 4.3	3.76 ± 3.7	2.79 ± 2.9	.004
Physical health and functions					
Usual gait speed (m/s)	1.43 ± 0.25	1.44 ± 0.26	1.41 ± 0.27	1.48 ± 0.25	.026
Max gait speed (m/s)	2.05 ± 0.38	2.03 ± 0.46	2.01 ± 0.36	2.17 ± 0.39	<.001*
IADL	4.94 ± 0.30	4.94 ± 0.23	4.69 ± 0.84	4.86 ± 0.46	.007
Mobility	23.9 ± 10	27.3 ± 11	21.0 ± 11	24.9 ± 9.9	<.001*
Mental health					
GDS	3.18 ± 3.4	2.86 ± 3.2	4.83 ± 4.1	2.39 ± 2.7	<.001*
Depressive symptoms: GDS ≥6	31 (19.4)	4 (11.1)	45 (40.5)	192 (12.4)	<.001
Severe depression: GDS ≥10	12 (7.5)	4 (11.1)	17 (15.3)	46 (3.0)	<.001
Cognitive function: MMSE	28.3 ± 1.8	28.0 ± 1.6	27.8 ± 1.9	28.2 ± 1.8	.029
Oral health and functions					
GOHAI	53.8 ± 7.3	53.3 ± 7.8	53.1 ± 6.6	54.9 ± 6.2	<.001*
Number of remaining teeth	20.5 ± 8.0	19.2 ± 8.4	17.8 ± 9.7	21.0 ± 8.3	.003*
Occlusal force (N)	496 ± 333	522 ± 365	478 ± 345	585 ± 361	<.001*
Nutritional and dietary status					
BMI (kg/m^2)	22.3 ± 3.3	24.3 ± 3.6	22.8 ± 3.3	22.9 ± 2.9	.002
Food variety	3.74 ± 2.0	3.89 ± 2.0	3.26 ± 2.1	3.79 ± 2.0	.037
MNA-SF	12.2 ± 1.6	12.4 ± 1.6	12.1 ± 1.7	12.5 ± 1.4	.007

Those continuous variables that showed significant difference between "living with others yet eating alone" and "living and eating with others" in the multiple comparison test (Dunnett T3) are highlighted with "*".

*Kruskal-Wallis test for continuous variables and χ^2 test for categorical variables.

The limitations of our study are mainly 4-fold. First, the cross-sectional nature of the study prevents it from making any conclusive comments about the causality between independent variables and the outcome. Second, data on household income were not available, and instead, individual income was used. Given that the older adults in the present study grew up in a period when it was rare for women to work after marriage, household income would have been a better indicator of the economic environment for women. Third, depressive symptoms were measured using self-administered GDS questionnaire rather than diagnosis by physicians. Fourth, the participants inevitably comprised those who had greater degrees of interest in health and lower barriers to participation in the study. This may have skewed the nature of participants, to those who were more socially active and interested in health, missing out those who were most socially disengaged.

Conclusions

For community-dwelling Japanese older adults, depressive symptoms were significantly associated with social engagement, with greater associations in younger and less mentally frail populations. Eating alone was identified as a key risk factor for depressive symptoms, and those who live with their families yet eat their meals alone were at highest risk. Mental health management for older adults, therefore, requires comprehensive assessment of their social relations, taking into account their companionship during mealtimes. Social preventive measures need to involve early interventions in order to augment their effectiveness against mental frailty.

Given that depression can lay the ground for further frailty and various detrimental health outcomes, further study with a longitudinal design, with more detailed data collection on social predictors of depression, may play a pivotal role in identifying possible intervention opportunities to prevent not only mental but also physical frailties.

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