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Effect of eating alone and depression symptoms on incident disability among community-dwelling older adults

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ABSTRACT

Objectives: The intent of the present study was to elucidate the association of eating alone and depressive symptoms with the development of disability among community-dwelling older adults, using a longitudinal study.
Method: Participants included 4648 Japanese older adults (mean age 73.8 ± 5.4 years; 44.3% men) aged ≥ 65 years at the time of the examination. Eating status was divided into two categories: "Eating with others at least once a day" and "Other." The 15-item Geriatric Depression Scale was used to measure depressive symptoms. Incident disability was certified by long-term care insurance (median duration: 36 months).
Results: During a median follow-up at 36 months, 8.0% of the participants developed an incident disability. Adjusted for covariates, the participants who ate alone were associated with a higher hazard ratio of incident disability compared to those who ate with others (hazard ratio: 1.36, 95% confidence interval: 1.05−1.75). However, adjusted for the covariate depressive symptoms, eating alone was not significantly associated with incident disability. Structural equation models revealed that the indirect model confirmed eating alone habits were associated with disability via depressive symptoms.
Conclusions: This study confirmed that eating alone was associated with an incident disability after adjusting for the covariates. Furthermore, the present study suggests an indirect relationship between eating alone and incident disability via depressive symptoms, the result of the structural equation model.

Introduction

Population aging is a critical issue in the world [1]. Japan's aging population has finally reached 28.9%, which is increasingly putting pressure on the sustainability of its health system [2]. With an aging population, the prevention of functional disability is an important issue for public health in Japan. To establish intervention and prevention of the disability, risk factors and mechanisms of the disability need to be identified.

Social isolation, including eating alone in late life, has recently received attention in the field of disability prevention for older adults. Social isolation has been shown to cause a variety of health problems, including mortality [3], and has been associated with depression, which is defined by the Centre for Epidemiologic Studies Depression Scale and Geriatric Depression Scale [4],

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malnutrition [5], and physical dysfunction [6]. Among social isolation factors, eating alone habits in old age negatively affect psychological and nutritional status. Thus, addressing depression and malnutrition, which are factors in disability, in advance will lead to a reduction in the development of the disability. Investigating the association and pathways between eating alone and the incidence of disability, an upstream factor in the issues that contribute to disability, is necessary to establish and develop interventions to prevent the problem.

When considering the pathway to incident disability due to eating alone habits, it is conceivable that this is potentially harmful to one's mental health and can contribute to such issues as depression using the Geriatric Depression Scale [7,8]. The previous cross-sectional study showed that eating alone was associated with depressive symptoms in Japanese community-dwelling older adults [7]. Another longitudinal study elucidated that those who ate alone with men and those living alone were at risk factor for depressive symptoms [8]. Furthermore, several longitudinal studies have shown that depressive symptoms had a significant impact on the incidence of disability [9,10].

Whether the eating alone habits and depression symptoms among older adults have an effect on the incident disability has not been fully examined. This study investigates whether there is a direct association between eating alone and future disability or an indirect association with disability via depressive symptoms by using prospective longitudinal data.

Material and methods

Participants

This longitudinal study utilized a dataset from a Japanese population-based cohort study conducted by the National Center for Geriatrics and Gerontology Study of Geriatric Syndromes, the details of which have been described in a previous study [11].

Participants were community residents dwelling in Tokai, Japan aged ≥ 65 years at the examination time. Of the 5,563 potential participants, 915 were excluded (e.g., missing values, severe disease, and disability), and the remaining 4,648 older adults were analyzed. The mean age was 73.8 ± 5.4 years, and 44.3% were men. Exclusion criteria in the present study were those who possessed health problems, such as the need for support or a case resulting in disability (n = 41); severe neurological disease (i.e., dementia, Parkinson's disease, or cardiovascular disease) (n = 358); an inability to perform basic daily living tasks (n = 7); severe cognitive impairment (as indicated by a Mini-Mental State Examination [MMSE] score < 19) (n = 25) [12]; and depression (n = 91). These excluded diseases that would cause a bias in the relationship between eating alone, depression, and disability. This medical information was self-reported, and a trained nurse interviewed participants. We also excluded those with missing data for the variables used in this study (n = 273) and those who were lost to follow-up (e.g., death and relocation) (n = 120).

All participants provided written informed consent, and the National Center for Geriatrics and Gerontology Ethics Committee approved the study and protocol.

Measurements

Definition of eating alone

Those eating alone underwent face-to-face interviews by well-trained interviewers. Do you eat your meals with anyone else, at least once a day each week: yes or no? (No = eating alone) [7,13]. The definition of eating alone used in this study was evaluated based on previous published studies [7,13], assuring the validity and reliability of this evaluation method [7,13].

Disability

Incident disability was monitored monthly to be certified in LTCI; the process of LTCI certification was described elsewhere [14]. A medical doctor of primary care evaluates the need for LTCI and a trained local government healthcare official evaluates the need for nursing care using a questionnaire that assessed current physical and mental status and utilized information about medical conditions. The results are entered into a computer to calculate the applicant's standardized scores for the seven dimensions of physical and mental status, estimate time-of-care, and assign a care-needs level based on the total estimated minutes of required care. The Nursing Care Needs Certification Board reviews whether the initial assessment is appropriate in each assessed individual, considering the applicant's primary care physician's statements and notes written by the assessor during the home visit. In this study, the outcome of disability was a new requirement to be LTCI service certified at any support or care level over the study follow-up. During the median duration of 36.0 months (Interquartile range [IQR] = 32.0, 39.0), moving out of the city and death were treated as censoring events.

Operational definition of depression symptoms

We used the Geriatric Depression 15-Item Scale (GDS-15) to assess depressive mood. The GDS-15 has been widely recommended as a brief screening measurement for late-life depression and has been useful in detecting late-life major depression in primary care settings [15]. We selected the cutoff point of 5/6 in the GDS-15, because for screening purposes, cutoff points that yield high levels of sensitivity and negative predictive value are preferred, and a previous study revealed that the use of a cutoff point of 5/6 (non-case/case) for the GDS-15 produced robust results [9,15].

Covariates

In face-to-face interviews, participants were asked their sociodemographic characteristics (i.e., age, sex, educational level, and household income (¥ 3 999 999 or lower)); clinical history (e.g., hypertension, diabetes, hyperlipidemia); smoking habits (i.e., current smoker or not); and alcohol use (i.e., current drinker or not). Cognitive function was assessed using the MMSE [12]. Physical activity was evaluated using two questions: "Do you engage in moderate levels of physical exercise or sports aimed at health?" and "Do you engage in low levels of physical exercise aimed at health?" Those who responded "no" to both questions were classified as being physically inactive [16].

To evaluate walking speed, participants walked on a 6.4 m flat, straight surface at a comfortable pace. After they walked for 2 meters, they passed a marker indicating the start of the timed sector; a second marker 2.4 meters further on indicated the end of the timed sector. The final 2 meters were intended for them to slow down and stop. Walking times were measured in seconds using a stopwatch, and the participants' walking speeds were calculated in meters-per-second (m/s).

Statistical analysis

Statistical analyses were performed using R Version 4.2.1 and AMOS 20 Graphics (IBM Japan Tokyo, Japan); statistical significance was set at $p < 0.05$. First, the participants were grouped according to whether or not they were eating alone. Results were then compared using the Student's t-test for continuous variables and the chi-square test for categorical variables. Effect size (ES) was estimated using Cohen's d or Cramér'sV to assess the degree of difference. Second, Cox proportional hazard regression models were constructed to calculate hazard ratios (HRs) with a 95% confidence interval (CI) to determine the association between eating alone habits, depressive symptoms, and the risk of incident disability.

The present study devised two models to elucidate whether depressive symptoms affected the association between eating alone and disability. Model 1 was adjusted for age, sex, education, body mass index (BMI), hypertension, hyperlipidemia, diabetes mellitus, physical inactivity, current drinking habit, current smoking habit, MMSE, income, and gait speed, with exceptions for depressive symptoms. Model 2 was adjusted for all covariates and mediator factor which depressive symptoms. Of these covariates could have had an influence on both eating alone and incident disability. These covariates were scrutinized and selected from previous studies [7,17,18].

Finally, structural equation modeling (SEM) is an optimal statistical technique to test hypotheses, as it can evaluate a priori models, identify mediators, and clarify direct and indirect paths between variables. Two types of models were considered: first, a direct effects model had direct paths from eating alone and depression on incident disability, and second, an indirect effects model had the effects of eating alone on incident disability be transmitted indirectly through depressive symptom status. The model examined whether the effect of eating alone habits on incident disability is indirectly transmitted through depressive symptoms or whether the effect of eating alone is directly related to incident disability. The model-fit index included the root mean square error of approximation (RMSEA), the adjusted goodness-of-fit index (AGFI), the goodness-of-fit index (GFI), Akaike Information Criterion (AIC) and chi-square. According to conventional criteria, a "good fit" is indicated by GFI > 0.95, AGFI > 0.90, and RMSEA < 0.05; and an "acceptable fit" by GFI > 0.90, AGFI > 0.85, and RMSEA < 0.08 [19]. The standardized partial regression coefficient (β) was calculated to determine the association between eating alone and depressive symptoms and incident disability. The AIC of a good fit model is smaller than the comparison model.

Results

Data from 4648 participants (mean age 73.8 ± 5.4 years; 44.3% men) were included in this study. The participants were classified into the "eating together" group (n = 4,012 [86.3%]) and the "eating alone" group (n = 636 [13.6%]). Table 1 presents each group's

Table 1
Participants' characteristics

Characteristic	Overall N = 4648	Eating together n = 4,012	Eating alone n = 636	*p*-value	Effect size
Age	73.8 ± 5.4	73.5 ± 5.4	75.4 ± 5.6	< 0.01	5.403
Sex				< 0.01	0.102
Women	2587 (55.7%)	2152 (53.6%)	435 (68.4%)		
Men	2061 (44.3%)	1860 (46.4%)	201 (31.6%)		
Education	11.7 ± 2.3	11.8 ± 2.3	11.4 ± 2.3	< 0.01	2.271
Hypertension				0.99	0.001
Absence	2476 (53.3%)	2138 (53.3%)	338 (53.1%)		
Presence	2172 (46.7%)	1874 (46.7%)	298 (46.9%)		
Hyperlipidemia				0.20	0.018
Absence	2852 (61.4%)	2476 (61.7%)	376 (59.1%)		
Presence	1796 (38.6%)	1536 (38.3%)	260 (40.9%)		
Diabetes mellitus				0.09	0.025
Absence	4007 (86.2%)	3445 (85.9%)	562 (88.4%)		
Presence	641 (13.8%)	567 (14.1%)	74 (11.6%)		
Living status				< 0.01	0.697
Living alone	652 (14.0%)	176 (4.4%)	476 (74.8%)		
Live with others	3996 (86.0%)	3836 (95.6%)	160 (25.2%)		
Alcohol				< 0.01	0.062
No drinking	2695 (58.0%)	2277 (56.8%)	418 (65.7%)		
Current drinking	1953 (42.0%)	1735 (43.2%)	218 (34.3%)		
Smoking				0.14	0.022
No smoking	4451 (95.8%)	3849 (95.9%)	602 (94.7%)		
Current smoking	197 (4.2%)	163 (4.1%)	34 (5.3%)		
Physical exercise				0.99	0.002
No	3609 (77.6%)	3114 (77.6%)	495 (77.8%)		
Yes	1039 (22.4%)	898 (22.4%)	141 (22.2%)		
MMSE	27.4 ± 2.3	27.4 ± 2.3	27.3 ± 2.4	0.50	2.337
Income				< 0.01	0.209
Low	2445 (52.6%)	1944 (48.5%)	501 (78.8%)		
High	2203 (47.4%)	2068 (51.5%)	135 (21.2%)		
Body mass index	23.2 ± 3.1	23.2 ± 3.1	23.1 ± 3.2	0.22	3.108
Gait speed	1.2 ± 0.2	1.2 ± 0.2	1.1 ± 0.2	0.01	0.211
Geriatrics depression scale	2.4 ± 2.4	2.3 ± 2.3	3.3 ± 3.0	0.01	2.371
Depression status				< 0.01	0.120
Non-depressed	4168 (89.7%)	3656 (91.1%)	512 (80.5%)		
Depression	480 (10.3%)	356 (8.9%)	124 (19.5%)		
Disability				< 0.01	0.063
Absence	4278 (92.0%)	3720 (92.7%)	558 (87.7%)		
Presence	370 (8.0%)	292 (7.3%)	78 (12.3%)		

Continuous variance is presented as means ± SD; categorical variables are presented as number (%) of SD. MMSE; Mini-Mental State Examination. Effect size was estimated using Cohen's d for continuous variance and Cramér's V for categorical variables.

demographic characteristics divided according to their dining situation. Participants who ate alone were older, more likely to be women, more likely to be living alone, not drinkers, low income, and had slower gait speed than those who ate together ($p < 0.05$). The prevalence of depressive symptoms was observed in 480 persons (10.3%), and the participants who ate alone had a higher prevalence (19.5%) compared to those who ate together (8.9%). During a median follow-up of 36 months (IQR = 32, 39), 370 (8.0%) participants developed an incident disability. Participants who ate alone had a higher proportion of disability (12.3%), compared to those who ate together (7.3%).

Figure 1 shows the association between depressive symptoms at baseline and incident disability. The incident disability rate and without incident disability rate were 19.0% and 6.7%, respectively, in participants with depressive symptoms and those who were not depressed.

Table 2 delineates the results of the Cox proportional hazard regression models to examine the association between eating alone, depressive symptoms, and incident disability. In Model 1, after adjusting for potential confounding factors – age, sex, education, income, medical history (e.g., hypertension, diabetes mellitus, hyperlipidemia), MMSE, alcohol and smoking habits, physical inactivity, and gait speed—participants who ate alone at baseline were associated with incident disability (HR 1.36, 95% CI 1.05–1.75; $p = 0.020$). Model 2 showed that depressive symptoms (GDS score 5/6) at baseline were associated with higher hazard ratio of incident disability (HR 1.819, 95% CI 1.420–2.330; $p < 0.001$), but no significant association was observed between eating alone and incident disability (HR 1.286, 95% CI 0.997–1.659; $p = 0.053$). In addition, these covariates (age, MMSE, physical inactivity and gait speed) were associated with incident disability ($p < 0.05$)).

Figure 2 depicts the SEM results, which examined whether the effect of eating alone habits on incident disability is indirectly transmitted through depressive symptoms, or whether the effect of eating alone is directly related to incident disability. The direct effect model indicated that the GDS-15 score associated with incident disability ($\beta = 0.130$, $p < 0.001$) and eating alone was associated with incident disability ($\beta = 0.044$, $p = 0.002$). However, the direct effect model indicated a poorly fit model (GFI = 0.986, AGFI = 0.915, RMSEA = 0.147, AIC = 111.624, *df* (degree of freedom) = 1 and $\chi^2 = 101.624$). The indirect effect model, revealed that eating alone was associated with a GDS-15 (score) ($\beta = 0.147$, $p < 0.001$) and GDS-15 (score) ($\beta = 0.137$, $p < 0.001$) leads to incident disability. The result of the indirect effects model provided a better fit to the data, compared to the direct effect model (GFI = 0.999, AGFI = 0.992, RMSEA = 0.042, AIC = 19.039, *df* = 1 and $\chi^2 = 9.039$). The indirect model confirmed eating alone habits were

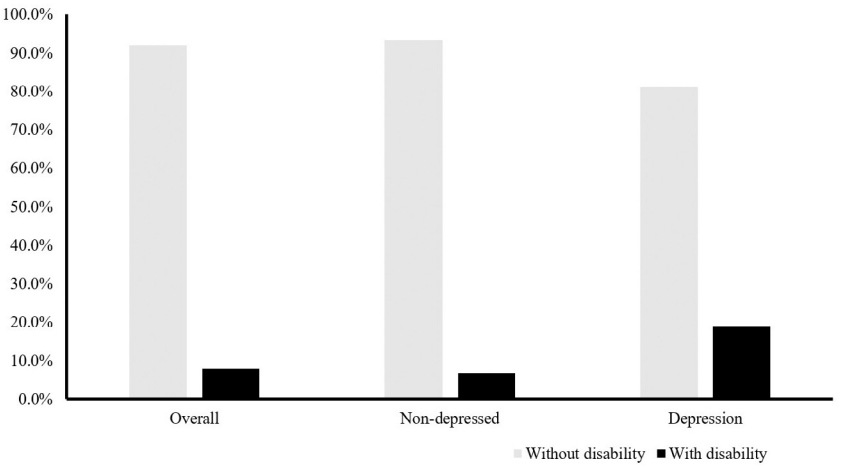

Fig. 1. Depression symptoms at baseline and prevalence of disability during the follow-up period.

associated with disability via depressive symptoms. Notably, the AIC of the indirect effect model was smaller than that of the direct effect model.

Discussion

This longitudinal study showed that community-dwelling older adults who ate alone had a higher proportion of depressive symptoms and incident disability compared to those who ate together. Using structural equation modeling, the main findings of the present study were that eating alone indirectly affects incident disability via depression status.

This study suggests that the older adults who eat alone have a higher proportion of incident disability, compared to those who eat together. Malnutrition for older adults is one of the most important factors in onset of disability [20]. According to a previous study, eating alone is associated with low dietary diversity and malnutrition, which may lead to incident disability. Nutritional status has been associated with many non-communicable diseases associated with dementia, such as diabetes and cardiovascular disease [21,22]. A longitudinal study have identified associations between certain nutrients or dietary patterns and brain volume loss [23,24]. Multifactorial disability and the association between eating alone and disability may be exacerbated by a range of other disability risk factors. Eating alone is thought to be an upstream factor in certain issues, including depression, dementia, frailty, and cardiovascular risk, which contribute to incident disability. We believe other pathways should be clarified in the future regarding eating alone and the onset of disability in community-dwelling older adults.

The present study found that eating alone habits in late life had an impact on incident disability, which was provoked by depressive symptoms. A large Asian cohort study that recruited 2702 community-dwelling older adults showed that eating alone was a key risk factor for depressive symptoms in community-dwelling older adults, regardless of their physical frailty status [17]. The negative impact of eating alone on mental health has been suggested not only in late life but also in the late middle ages [25]. These findings and the present study indicate that eating alone should be prevented in all age groups to maintain and improve mental health.

The contribution of depressive symptoms to incident disability has been widely investigated [9,10,26]. Researchers have hypothesized about biologically mediated pathways and psychological mechanisms and a link between depressive symptoms and physical dysfunction. Animal and human studies have determined that

Table 2
Association between eating alone and disability incident adjusted for covariates including depressive symptoms status

	Model 1				Model 2			
		95% CI				95% CI		
	HR	Lower	Upper	*p* value	HR	Lower	Upper	*p* value
Age	1.13	1.11	1.15	<0.01	1.130	1.108	1.152	<0.001
Sex	0.89	0.71	1.13	0.34	0.880	0.698	1.110	0.281
Education	1.04	1.00	1.09	0.08	1.048	0.999	1.098	0.053
Body mass index	0.99	0.96	1.03	0.63	0.996	0.964	1.029	0.808
Hypertension	0.97	0.78	1.21	0.77	0.985	0.790	1.227	0.891
Hyperlipidemia	0.86	0.68	1.07	0.17	0.820	0.653	1.028	0.085
Diabetes mellitus	1.23	0.93	1.62	0.14	1.256	0.954	1.654	0.104
MMSE	0.90	0.86	0.94	0.00	0.903	0.867	0.940	< 0.001
High income	0.83	0.66	1.03	0.09	0.842	0.675	1.051	0.128
Current drink of alcohol	1.01	0.80	1.28	0.93	1.011	0.797	1.281	0.931
Current Smoking	1.24	0.71	2.18	0.45	1.211	0.690	2.124	0.505
Physically inactive	1.29	1.03	1.61	0.03	1.273	1.017	1.593	0.035
Gait speed	0.11	0.07	0.18	0.00	0.124	0.076	0.203	< 0.001
Eating alone	1.31	1.01	1.69	0.04	1.247	0.963	1.616	0.095
Depressive symptoms					1.814	1.415	2.325	< 0.001

CI, confidence interval; HR, hazard ratio; MMSE, Mini Mental State Examination.

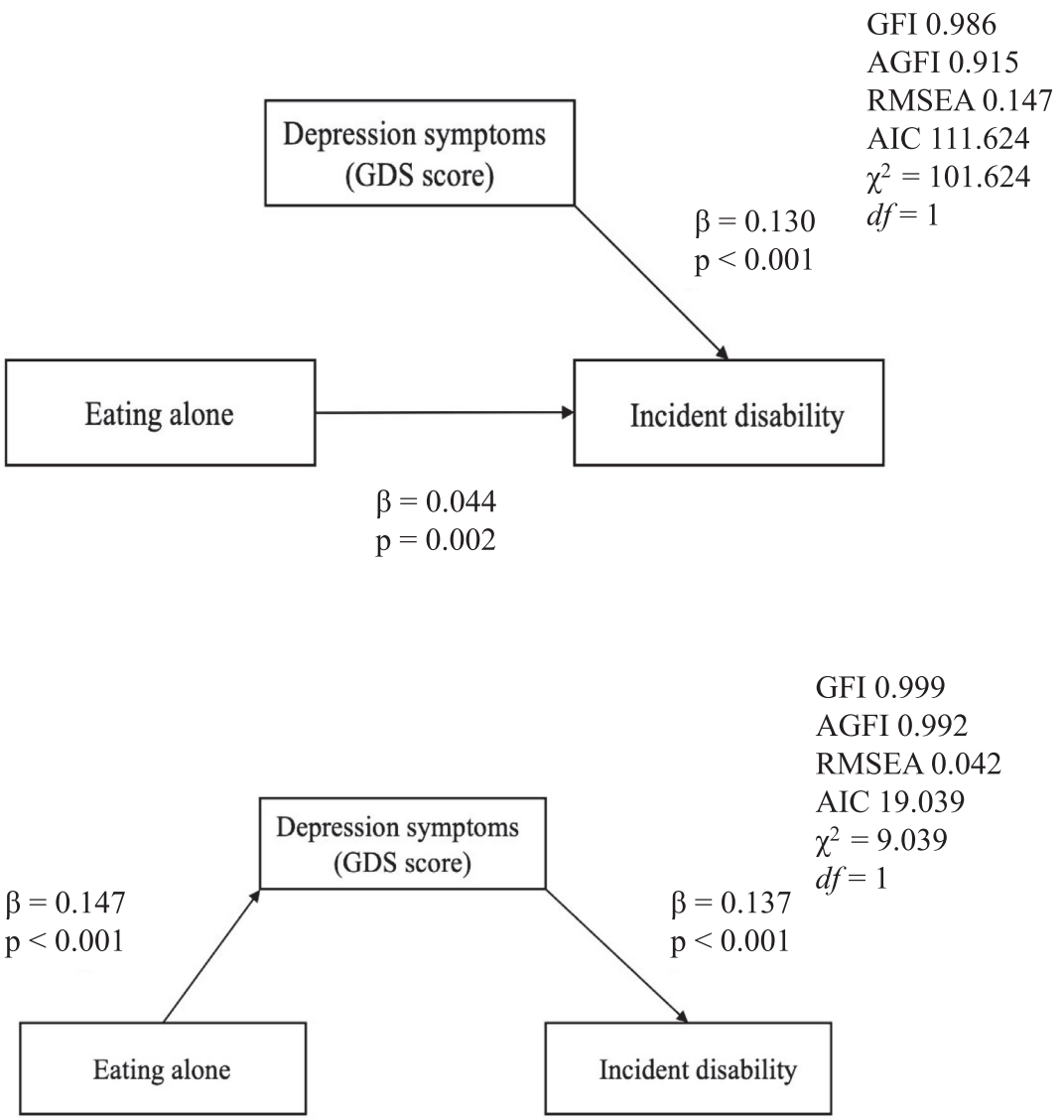

Fig. 2. Structural equation modelling for direct/indirect effect model between eating alone, depressive symptoms status and incident disability. GFI, the goodness-of-fit index; RMSEA, the root mean square error of approximation; AGFI, the adjusted goodness-of-fit index; AIC, Akaike Information Criterion; β, standardized partial regression coefficient; df, degree of freedom; GDS, geriatrics depression scale.

psychological distress causes neural, hormonal, and immunological alterations. By increasing the sympathetic tone, decreasing the vagal tone, and causing immunosuppression, depressed moods may enhance susceptibility to disease and decrease physical health in general [27–29].

An observational study reported that loneliness may explain the mechanism by which social engagement deficits exert their effect on depressive symptoms [30]. Eating habits serve as an important factor for maintaining social interactions in older adults [31]. In older adults, eating alone is not common compared to young adults and may increase loneliness [32]. Based on previous studies, it is closely linked to social isolation and social participation in older adults, and these mechanisms may explain the association between eating alone and depression. It is a risk factor for depressive symptoms, and contributes to incident disability; thus, as a pathway to disability, the flow from eating alone to depression and from depression to disability can be inferred from previous studies. The present study elucidated that eating alone is a risk factor for incident disability and depression can aggravate those associations.

The incidence of disability is multifactorial and has been reported to be caused by frailty and decline of cognitive function, dementia, and cardiovascular events [33-36]. The increased risk of disability among older adults who eat alone may involve other pathways. Eating alone can also be attributed to skipping meals, low frequency of fruit and vegetable intake, and being underweight [37]. Other common factors include frailty, dementia, and cardiovascular events [38-40]. Eating alone has also contributed to malnutrition and poor appetite [41]. A 2-year longitudinal study showed that anorexia of aging indirectly affected incident disability via frailty status in community-dwelling older adults [42].

There are some limitations, however. First, although participants were randomly recruited through a direct mailing process, only those that could perform health checkups at home were selected for participation. This may have led to the recruitment of relatively healthy older people and thus resulted in an

underestimation of incident disability. Second, some variables were self-reported, including depressive symptoms and eating alone. Third, disability is a multifactorial phenomenon. The present study failed to address other covariates and may be mediated by several different covariates related to eating alone, depressive symptoms, and disability. Future studies should confirm the association between eating alone, depressive symptoms, and disability after overcoming these limitations. Our study indicated that eating alone is associated with disability and provides hope that avoiding this could reduce the risk of disability. Interventions can be conducted at a low cost. Future intervention studies should elucidate whether avoiding eating alone can reduce the risk of developing disability.

Conclusion

The present study showed that older adults who eating alone had a higher proportion of depressive symptoms and a higher prevalence proportion of disability compared with those eating together. In addition, this study elucidated that eating alone was associated with disability via depressive symptoms.

Declaration of competing interest

The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

CRediT authorship contribution statement

Yuto Kiuchi: Writing – original draft, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Kota Tsutsumimoto:** Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization. **Kazuhei Nishimoto:** Writing – review & editing, Formal analysis. **Yuka Misu:** Writing – review & editing, Formal analysis. **Tomoka Ohata:** Writing – review & editing, Methodology. **Hyuma Makizako:** Writing – review & editing, Formal analysis. **Hiroyuki Shimada:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Ethics approval and informed consent

All participants provided written informed consent, and the ethics committee of the National Center for Geriatrics and Gerontology approved the study. The study protocol was approved by the ethics committee of the National Center for Geriatrics and Gerontology. All human studies have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Data availability

The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

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The authors would like to thank the Tokai City office for help with participant recruitment. The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to restrictions, e.g., containing information that could compromise the privacy of research participants.

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