Associations of eating out and dietary diversity with mild cognitive impairment among in community-dwelling older adults

Eating out, dietary diversity and cognition

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

Data Availability

The data supporting the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

AUTHOR CONTRIBUTIONS
Conceptualization, YK, HM; Data curation, YN, YT, MK, TT, TK, MO; Formal analysis, YK, HM; Investigation, YN, YT, SA, MT, MK, TT, TK, MO; Writing-original draft, YK, HM; Writing-review & editing, HM, YN, YT, SA, MT, MK, TT, TK, KT, HS, MO.
Abstract

Background: Dementia is a critical later life health issue that occurs among members of aging societies. This study examined the relationships between eating out, dietary diversity, and mild cognitive impairment (MCI) among community-dwelling older adults.

Method: We analyzed data from 597 older adults (median age 73.0 years [interquartile range 69.0–78.0] and 62.6% females). We applied the Food Frequency Score (FFS) to evaluate diet variety and the weekly consumption frequencies of ten food items were determined. The Functional Assessment Tool from the National Center for Geriatrics and Gerontology was used to evaluate MCI. Finally, we asked the participants how often they ate out each month; those who replied ‘none’ were categorized into the “non-eating out” group.

Results: The overall prevalence of MCI was 122 (20.4%), with a higher prevalence in the low dietary diversity group than in the high dietary diversity group (28.6% vs. 18.6%). After adjusting for covariates, the participants who self-described as not eating out were independently associated with low dietary diversity (odds ratio [OR]: 1.97, 95% confidence interval [CI]: 1.20–3.20), while low dietary diversity was associated with MCI (OR: 1.72, 95% CI: 1.02–2.87). Structural equation models revealed that not eating out had no direct effect on MCI but was associated with MCI via low dietary diversity (root mean square error of approximation = 0.030, goodness-of-fit index=0.999, and adjusted goodness-of-fit index = 0.984).
Conclusions: Although non-eating out may not have a direct effect on MCI, an indirect relationship may exist between eating-out habits and MCI via dietary diversity status.

Keywords: dementia, aging, eating behavior, cognitive function
1. Introduction

Dementia is a serious health issue that occurs in later life in the aging population. Global estimates indicate that the number of older adults suffering from dementia will rise (1) and a decline in cognitive function attributes to adverse health outcomes (2). According to the 2020 report of the Lancet Commission on Dementia Prevention, Intervention, and Care, 40% of global dementia cases are attributable to modifiable risk factors. Therefore, the identification of modifiable risk factors for cognitive decline is critical (3). Mild cognitive impairment (MCI) is a condition that occurs between dementia and age-related cognitive decline. Interventions to prevent and postpone dementia onset aimed at older adults with MCI have been developed (4). Among the modifiable factors for dementia in the lifestyles of older adults are dietary patterns (5).

Several studies have examined the relationship between dietary factors and cognitive function. Otuska et al. reported that ingesting a variety of foods was positively associated with cognitive function (6). The World Health Organization’s guidelines recommend healthy and balanced dietary patterns to prevent cognitive decline and enhance cognitive function (7). A prospective study of 11,179 Chinese community-dwelling older adults also showed that low dietary diversity increases the risk of cognitive impairment (8). Other studies have shown that ingesting a variety of foods contributes to the maintenance and improvement of cognitive function.
Dietary habits, such as eating out, eating prepared, and home-cooked food helps maintain dietary diversity (9). Individuals who eat home-cooked meals are more likely to have a high-quality diet than those who eat meals cooked outside (10). However, Lachat et al. reported that eating outside was positively associated with dietary diversity and better dietary intake in terms of energy supply from fat among Vietnamese adolescents (11). Thus, the association between eating out and dietary diversity remains controversial. Particularly, any association between eating out and dietary diversity among community-dwelling older adults remains unclear.

Therefore, this study examined the association between eating out and dietary diversity among community-dwelling older adults. We also investigated the direct or indirect associations of eating-out habits with MCI based on dietary diversity. Clarifying these relationships may provide a better understanding of the association between these factors to develop intervention strategies to prevent cognitive decline.
2. Methods

2.1 Participants

This cross-sectional study examined data from the Tarumizu Study, which included a community-based health survey conducted since 2017 in partnership with Tarumizu Chuo Hospital, Tarumizu City Office, and Kagoshima University’s Faculty of Medicine (12). The participants were individually chosen from Tarumizu City, a residential subdivision of Kagoshima City in Japan. To recruit participants for the Tarumizu study in 2019, we issued invitations to every inhabitant in Tarumizu City aged 40 years or older. Additionally, we recruited locals by running community campaigns and placing advertisements in the local newspaper. Data from a health check survey performed between June and December of 2019 were used in this investigation and 1,024 people aged ≥40 years participated in the 2019 Tarumizu study. We excluded individuals under the age of 65, with a history of serious neurological illness such as dementia or stroke, depression, an inability to perform basic daily tasks; missing data were also excluded. Finally, we analyzed data from 597 older adult community-dwelling participants (median age, 73.0 years; women, 62.0%) (Figure 1). The Ethics Committee of Kagoshima University's Faculty of Medicine approved this study (Ref no. 170351), and all participants provided written informed consent before being included in the study.
2.2 Assessment of dietary diversity

The Food Frequency Score (FFS) was used to evaluate diet variety [12]. Ten food groups’ one-week intake frequency was evaluated by the self-reported Food Frequency Survey (FFS). Meat, fish and shellfish, eggs, dairy products, green and yellow vegetables, potatoes, fruits, seaweed, fats and oils, and soy products are all included in the FFS. Based on the following answers, the FFS assigned a score of 0–3 points for each meal category: three points: almost every day; two points: 3–4 days per week; one point: 1–2 days per week; and 0 points: seldom eaten. The scores were added to the FFS, with lower scores (0–30) denoting less diet variety. Other studies have shown that the FFS is a simple and convenient tool for assessing dietary diversity (13). We defined older adults with an FFS of ≤16 points as having low dietary diversity, as previously described (14).

2.3 Assessment of eating out

During the in-person interviews, the participants were asked how frequently they went out to eat each month. The choices were (1) every day, (2) 10–20 times, (3) 1–5 times, and (4) never. We categorized those who responded “none” as non-eating out.

2.4 Assessment of MCI
The National Center for Geriatrics and Gerontology–Functional Assessment Tool (NCGG–FAT) was used to evaluate MCI status. The NCGG–FAT consists of the following domains: (1) memory (word list memory–I [immediate recognition] and word list memory–II [delayed recall]); (2) attention (a tablet version of the Trail Making Test (TMT)–Part A); (3) executive function (a tablet version of the TMT–Part B); and (4) processing speed (a tablet version of the Digit Symbol Substitution Test). Among older community-dwelling adults, the NCGG–FAT has moderate to high validity and high test-retest reliability (15). All tests conducted in this study with a population-based cohort of older community-dwelling adults were conducted using established standardized thresholds to define impairment in the corresponding domain (scores >1.5 standard deviations below age- and education-specific means). MCI was identified in participants who scored lower on one or more tests of the NCGG-FAT (15).

2.5 Covariates

During face-to-face interviews, the participants were asked about their age, sex, body mass index [BMI], educational attainment, number of current medications, and living arrangements (living alone or not).

2.6 Statistical analysis
Statistical analyses were performed using AMOS 20.0 Graphics and IBM SPSS Statistics for Windows, version 26.0, (IBM Japan, Tokyo, Japan). We compared categorical values between the two dietary diversity statuses (high and low) using chi-squared tests. We applied the Kolmogorov–Smirnov test to confirm the normal distributions of continuous variables and compared the two dietary diversity statuses using the Mann–Whitney U test and described median and interquartile range (IQR). The relationship between not eating out and low dietary diversity, and MCI was also investigated using binary logistic regression. Dietary diversity status (low dietary diversity) and MCI were set as the dependent variables for calculating the odds ratio (OR) with 95% confidence intervals (CI). We adjusted for covariates including age, sex, education, medications, BMI, and living alone. Furthermore, we applied structural equation modeling (SEM), which can assess a priori models, identify mediators, and clarify direct and indirect paths between variables. Thus, this was the best statistical method for testing our hypotheses. The model examined whether eating out had a direct relationship with MCI, or whether it was a result of the indirect effect of dietary diversity. The model fit index included the goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), root mean square error of approximation (RMSEA), and Akaike Information Criterion (AIC). Conventional criteria state that GFI >0.95, AGFI >0.90, and RMSEA <0.05 indicate a “good fit,” while GFI >0.90, AGFI >0.85, and RMSEA <0.08 indicate an “acceptable fit” (16).
3. Results

This study included data from 597 older adults with a median age of 73.0 years (IQR 69.0 – 78.0), 62.6% of whom were women. According to the Kolmogorov–Smirnov test, the continuous variables in the present study were not normally distributed (p < 0.01). Table 1 shows the participants’ demographic characteristics. The participants were divided into high (n = 485 [81.2%]) and low (n = 112 [18.7%]) dietary diversity groups. Compared with participants with high dietary diversity, those with low dietary diversity were less likely to be women, have less education, and have a higher BMI (all p < 0.05). The overall prevalence of MCI was 20.4% (n = 122). The prevalence was higher among participants with low dietary diversity than those with high dietary diversity (28.6% vs. 18.6%, p < 0.05). Furthermore, we classified 23.8% (n = 142) of participants as not eating out, with a higher proportion in the low dietary diversity group than in the high dietary diversity group (33.0% vs. 21.6%, p < 0.05).

The results of the adjusted multiple logistic regression analysis, which examined the relationship among MCI, not eating out, and low dietary diversity, are presented in Table 2. After adjusting for confounding variables such as age, sex, education, medication, BMI, and single status, participants who did not eat out had low dietary diversity (OR 1.97, 95% CI 1.20–3.20).

Second, we examined the association between not eating out and MCI using a logistic regression analysis. The proportion of participants who did not eat out was not significantly associated with...
MCI (OR 0.76, 95% CI 0.46–1.25). Multiple logistic regression analysis indicated an association between low dietary diversity and MCI. The results showed that low dietary diversity at baseline was associated with a higher odds ratio of MCI compared with participants with high dietary diversity (OR 1.72, 95% CI 1.02–2.87).

Figure 2 shows the results of the SEM, which examined whether the effect of not eating out on MCI was indirectly transmitted through dietary diversity status, or was directly related to MCI. This model indicated that not eating out was not directly associated with MCI ($\beta = -0.037$, $p = 0.36$) but contributed significantly to low dietary diversity ($\beta = 0.108$, $p < 0.01$). Furthermore, low dietary diversity was significantly and directly associated with MCI ($\beta = 0.101$, $p < 0.05$). Moreover, not eating out was associated with MCI via low dietary diversity and provided an excellent fit to the data (GFI = 0.999, AGFI = 0.984, RMSEA = 0.030, AIC = 29.549).
4. Discussion

The results of the present study indicated that older adults with non-eating out habits had low dietary diversity patterns, and that low dietary diversity was associated with MCI. Analysis of the SEM showed that not eating out was not directly associated with MCI but was indirectly associated with MCI through low dietary diversity.

Multiple analyses in the present study revealed low dietary diversity among community-dwelling older adults who did not eat out. Food literacy might explain these findings. To define the term “food literacy,” Vidgen et al. identified an effect that was related to the areas of preparation, eating, planning and management, and selection (17). In a nationwide cross-sectional study in Japan, high food literacy was associated with high scores on the National Cancer Institute’s Healthy Eating Index 2015, which indicated high diet quality (18). In another study, individuals with a low frequency of eating out demonstrated lower food literacy compared with those with a higher frequency (19). Thus, older adults who do not eat out have lower food literacy, and therefore, may have lower dietary diversity.

The present cross-sectional study examined the association between low dietary diversity and MCI among community-dwelling older adults. The potential mechanisms of the present findings may involve the complex effects of various nutrients on cognitive function due to dietary diversity. First, calcium and magnesium have favorable effects against vascular diseases.
by inhibiting free radical formation and platelet aggregation, improving dyslipidemia, and
increasing insulin sensitivity (20-22). Calcium and magnesium are abundant in milk and dairy
products. A prospective cohort study showed that ingesting milk and dairy products reduced the
risk of developing dementia after a follow-up of >17 years (23). Second, the intake of diverse
amino acids has protective effects on cognitive function. A longitudinal study showed that very
low meat consumption increases the long-term risk of dementia (24) and that the intake of amino
carbons, especially lysine, phenylalanine, threonine, and alanine, is positively associated with
cognitive function in late life (25). Thus, the intake of foods containing proteins and amino acids,
such as meat, is important to enhance cognitive function. One potential explanation for these
effects is that the ingestion of amino acids contributes to neurotransmitter synthesis and growth
hormone levels (26, 27). A previous large prospective cohort study reported that high fish
consumption was associated with a lower risk of dementia (28). Fish contain nutrients, including
eicosapentaenoic acid (29), docosahexaenoic acid (30), vitamins B (31, 32), and D (33).
Furthermore, vitamins C (34) and E (35), and carotenoids (36) are also present in green and yellow
vegetables and fruits. However, because food and nutrients are consumed in combination rather
than separately, increasing and improving dietary diversity may be a more successful strategy for
delaying cognitive decline.

In the current study, we used structural equation modeling to clarify whether not eating
out was directly or indirectly associated with MCI. Our results indicated that not eating out was not directly associated with MCI. However, it did have an indirect effect owing to low dietary diversity. Nutritional knowledge is an important factor in maintaining dietary diversity and balance (37). A previous cross-sectional study reported that lower nutritional knowledge was associated with a lower frequency of eating out (38), in which older adults with a high frequency of eating out may be more nutritionally knowledgeable. Lee et al. reported higher dietary diversity and intake of protein, fat, calcium, phosphorus, iron, potassium, vitamin B<sub>1</sub>, vitamin B<sub>2</sub>, and niacin among adults who favored non-homemade meals, including eating out (9). Furthermore, social isolation, including eating alone, was associated with a decline in cognitive function in a three-year prospective study (39). Moreover, eating outside the home was positively associated with dietary diversity and better dietary intake in terms of energy supply from fat among Vietnamese adolescents (11). Thus, eating out could be a key factor in ensuring a positive nutritional status and dietary diversity. A positive nutritional status and consumption of a variety of foods have favorable effects on cognitive function (5). According to these findings and those in the present study, eating-out behavior was associated with nutritional status and dietary diversity and may be related to MCI through nutritional status. The present study examined the association between participants who did not eat out and social relationships (going out less frequently than the previous year, visiting friends
sometimes, and talking with someone every day) (40) (Supplementary Table 1). The results suggest that non-eating out participants were less likely to visit friends and converse with others compared with older adults who ate out. A previous large cohort study showed that persistent loneliness in midlife is an independent risk factor for dementia and Alzheimer’s disease (41) and that social relationships such as social networks, social activity participation, and social support were negatively related to incident dementia (42). Based on previous studies and our results, we believe that similar aspects may link eating habits to social relationships and loneliness. Future research should further clarify the relationship between eating habits, social engagement, and MCI among community-dwelling older adults.

This study has several limitations. First, although we evaluated the frequency of intake, we could not assess the quantity of each food item. Future studies should consider the quantity of food ingested. Second, because this was a cross-sectional study, we were unable to determine the causal relationships between MCI, eating-out practices, and dietary diversity. Third, we excluded socioeconomic and economic status domains from the multivariate analyses. Other possible covariates (e.g., lifestyle activity and socioeconomic status) should also be considered as they may be connected to eating out, dietary diversity, and MCI. Fourth, this cohort study used self-reported diet assessments. Although we excluded older adults with dementia and severe cognitive impairment, recall bias was still possible. Additional research using objective food records such
as pictures is required. Fifth, while we asked participants about the frequency of their eating-out habits, we could not evaluate what they ate when eating out. Eating habits such as meal content, frequency of eating out, food environment, and the cost of meals vary by country and region. Our sample was obtained from a single country (Japan) and the target population was older adults living in Tarumizu City, Japan. Further investigation is required to clarify whether our findings can be generalized to other countries and regions.

5. Conclusion

The results of this cross-sectional study revealed that non-eating habits were not directly associated with MCI. In addition, we applied structural equation models to identify that non-eating habits were indirectly associated with MCI due to low dietary diversity. These findings suggest that promoting eating-out behaviors may lead to enhanced dietary diversity, resulting in positive effects on cognitive function.
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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

Data Availability

Data supporting the findings of this study are available upon request from the corresponding author. The data are not publicly available because of privacy and ethical restrictions.
AUTHOR CONTRIBUTIONS

Conceptualization: YK, HM; Data curation: YN, YT, MK, TT, TK, and MO; Formal analysis: YK, HM, and KT; investigation: YN, YT, SA, MT, MK, TT, TK, and MO; writing–original draft: YK and HM; writing–review and editing: HM, YN, YT, SA, MT, MK, TT, TK, KT, HS, and MO.