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Low dietary diversity among older Japanese adults with impaired dentition

Masanori Iwasaki[1,5]*, Yumi Kimura[2], Akihiro Yoshihara[4], Hiroshi Ogawa[1], Takayuki Yamaga[1], Taizo Wada[2], Ryota Sakamoto[2], Yasuko Ishimoto[2], Eriko Fukutomi[3], Wenling Chen[3], Hissei Imai[3], Michiko Fujisawa[2], Kiyohito Okumiya[2], Michael C. Manz[6], Toshihiro Ansai[5], Hideo Miyazaki[1] and Kozo Matsubayashi[2,3]

[1]Division of Preventive Dentistry, Department of Oral Health Science, Niigata University, Graduate School of Medical and Dental Sciences, 2-6-1 Manazuru, Kokurakita-ku, Kitakyushu 803-8580, Japan.
[2]Center for Southeast Asian Studies, Kyoto University, 2-6-1 Manazuru, Kokurakita-ku, Kitakyushu 803-8580, Japan.
[3]Department of Field Medicine, School of Public Health, Kyoto University, 2-6-1 Manazuru, Kokurakita-ku, Kitakyushu 803-8580, Japan.
[4]Division of Oral Science for Health Promotion, Department of Oral Health and Welfare, Niigata University Graduate School of Medical and Dental Sciences, 2-6-1 Manazuru, Kokurakita-ku, Kitakyushu 803-8580, Japan.
[5]Division of Community Oral Health Development, Kyushu Dental University, 2-6-1 Manazuru, Kokurakita-ku, Kitakyushu 803-8580, Japan.
[6]Department of Cariology, Restorative Sciences and Endodontics, School of Dentistry, University of Michigan, 2-6-1 Manazuru, Kokurakita-ku, Kitakyushu 803-8580, Japan.

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The aim of this cross-sectional study was to investigate the relationship of dentition status, defined by the number of occluding pairs of natural teeth (OPNT) and removable denture fit, to food diversity among older Japanese adults. The study participants were 268 Japanese (mean age: 81.7 years) classified into four groups: (i) good dentition (*n* = 91; ≥5 OPNT), (ii) compromised dentition (*n* = 43; <5 OPNT), (iii) well-fitting dentures (*n* = 104; self-reported), and (iv) ill-fitting denture (*n* = 30; self-reported). Food diversity was assessed as a measure of dietary quality using the 11-item Food Diversity Score Kyoto (FDSK-11), which evaluates frequency of consumption of 11 main food groups (grains, potatoes, beans and soybean products, meat, fish and shellfish, eggs, milk and dairy products, vegetables, seaweed, nuts and fruits). Multivariable analysis of the differences in FDSK-11 score ranging from 0 to 11, with a higher score indicating greater food diversity, among the four groups was conducted using linear regression models with robust standard errors. The compromised dentition and self-perceived ill-fitting denture groups had significantly lower FDSK-11 scores than the good dentition group after adjusting for confounders (P < 0.05). A less-varied diet, as indicated by low FDSK-11 score, was observed in participants with fewer OPNT or ill-fitting dentures. Impaired dentition was associated with poor diet quality among older Japanese.

Key words: Epidemiology, elderly, diet, dental health.

INTRODUCTION

Food diversity is an important dietary factor reflecting dietary quality. Dietary variety has previously been found

to be associated with better energy intake, nutrient intake and biochemical measures of nutritional status in the elderly (Mirmiran et al., 2006). The overall nutritional quality of the diet was improved by a diverse diet. Diversity in the diet is a simple tool for screening and identifying people at nutritional risk (Oldewage-Theron and Kruger, 2008). In addition, previous studies have reported that intake of a variety of foods is significantly associated with lower risk of mortality in elderly individuals (Huang et al., 2014).

Older adults are especially at increased risk of dietary deficiencies due to age-related physiologic changes, loss of appetite associated with sensitivity decline in taste and smell, economic limitations, illnesses, and medications (Ahmed and Haboubi, 2010). Oral health is significantly associated with geriatric nutrition, and impaired dentition and chewing ability can limit the type and quantity of food consumed (Samnieng et al., 2011; Yoshida et al., 2011). Previous research suggested that the location and function of the teeth is more related to masticatory ability than merely the total number of teeth (Moriya et al., 2012). Furthermore, the quality of fit of dentures was also reported to be associated with dietary intake. Well-fitting dentures can correct nutritional problems, whereas ill-fitting dentures cannot (Iwasaki et al., 2014; Sahyoun and Krall, 2003).

To date, epidemiological evidence has accumulated to support the association of dentition status with specific food, nutrient or energy intakes among older adults (Ervin and Dye, 2012). However, little is known about the association of functional dentition status with overall diet quality among community-based older adults, especially in Asian populations. Therefore, this study was planned with the purpose of assessing whether dentition status, defined as the number of functional occluding pairs of teeth and self-reported adequacy of fit of removable dentures, was related to food diversity among older Japanese adults.

MATERIALS AND METHODS

Study design

This study is a cross-sectional study carried out to investigate the relationship of dentition status, defined by the number of occluding pairs of natural teeth (OPNT) and removable denture fit, to food diversity among older Japanese adults

Selection of study participants

In April 2011, all 994 individuals aged ≥75 years currently residing in the town of Tosa, Kochi Prefecture, Japan, except for 128 individuals living in hospitals or nursing homes, were sent a written request to participate in a geriatric health survey. Subsequently, 305 responded positively to participating in the survey. In August 2011, study participants underwent dental examination, dietary assessment, interview and anthropometric evaluation at a community center. Thirty-seven individuals did not submit complete data. Data were, therefore, available from 268 participants (95 men and 173 women, mean age = 81.7 years).

This study was conducted in accordance with the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Ethical Committee of the Faculty of Medicine, Kyoto University, Kyoto, Japan (E-514). Written informed consent was obtained from all study participants.

Dental examination

Two trained dentists, under sufficient illumination using artificial light, determined the number of OPNT (range 0 to 7, excluding the third molar) (Morita et al., 2007) and the use of dentures for each participant. No study participant had dental implants. Participants who wore at least a complete denture in the upper or lower jaw were classified as denture wearers (Sahyoun and Krall, 2003). Subjective sense of denture fit was assessed by asking denture wearers to respond to the question, “In general, would you say the fit of your denture is excellent, good, poor, or very poor?” The answer was treated as a dichotomous variable with good fit encompassing the first two responses and poor fit, the last two responses.

Dietary assessment

Food diversity was assessed as a measure of dietary quality using the 11-item Food Diversity Score Kyoto (FDSK-11) (Kimura et al., 2013). This validated retrospective method of dietary diversity assessment evaluates frequency of consumption of 11 main food groups (grains, potatoes, beans and soybean products, meat, fish and shellfish, eggs, milk and dairy products, vegetables, seaweed, nuts and fruits) during the previous 6 months. After the participants had rated their frequency of consumption of each group with a score of 1 (consumption once or more per week) or 0 (consumption less than once per week), the individual scores were summed to obtain a FDSK-11 score ranging from 0 to 11, with a higher score indicating greater food diversity. A more precise assessment of the frequency of food intake was carried out by asking the participants the question “How often do you eat these foods each week?”, using the same 11 food groups, to which they responded by assigning a score of 4 (every day), 3 (often or 3 to 5 days/week), 2 (sometimes or 1 to 2 days/week) or 1 (hardly ever) (Kimura et al., 2013).

Geriatric assessment and anthropometric evaluation

Activity of daily living (ADL) was assessed using the Tokyo Metropolitan Institute of Gerontology index (TMIG index; range 0 to 13) with low scores indicating disability (Koyano et al., 1991). Decreased ADL was defined as the lowest quartile of TMIG index (TMIG index <11). The presence of depressive symptoms was assessed using the Japanese version of the 15-item Geriatric Depression Scale (GDS-15; range 0 to 15) with higher scores indicating more severe depression. Depression was defined by a GDS-15 score of 6 or greater (Wada et al., 2003). An interview was conducted to obtain data on age, years of education, smoking status, drinking frequency and current medical treatment of

*Corresponding author. E-mail: r14iwasaki@fa.kyu-dent.ac.jp. Tel: +81-93-582-1131/2103. Fax: +81-93-591-7736.

hypertension, diabetes, dyslipidemia, stroke, coronary heart disease, bone and joint disease, and cancer. Anthropometric evaluation included measurements of height and weight to calculate body mass index (BMI).

Description of main exposure variable

The principal exposure variable included functional dentition status, which was defined by the number of OPNT and self-reported adequacy of complete denture fit. First, participants were classified into two groups based on the presence of complete dentures. Participants with complete dentures were then further divided into two groups based on the self-perceived quality of fit of their dentures, as either well-fitting or ill-fitting. Participants without full dentures were divided into two groups based on the number of OPNT; ≥5 OPNT (good dentition) and <5 OPNT (compromised dentition). Less than 5 OPNTs was defined as compromised dentition because it was reported to be associated with chewing difficulty (Hildebrandt et al., 1997). Overall, four groups used to specify the main exposure variable for this study were: (i) good dentition (n = 91, 34%), (ii) compromised dentition (n = 43, 16%) (iii) well-fitting dentures (n = 104, 39%), and (iv) ill-fitting dentures (n = 30, 11%).

Description of outcome variables

FDSK-11 score and its components (that is, food frequency scores) were used as outcome variables.

Furthermore, to compare nutritional status among the four dentition groups, underweight was included as secondary outcome measure. Participants with a BMI lower than 20 kg/m^2 were defined as underweight, because this value was reported to be an independent predictive factor of mortality in older adults (Tamakoshi et al., 2010).

Statistical analyses

Initially, analysis of variance for continuous variables and Chi-square test for categorical variables were used to test differences in the means and percentages of selected characteristics among the four different study groups. Post-hoc tests were conducted using Pairwise comparisons with Bonferonni's correction for continuous variables and Pairwise comparisons of marginal linear predictions, which were calculated subsequent to the regression model, for categorical variables.

Because outcome variables were not normally distributed, robust statistical procedures were conducted. Multivariable analysis of differences in FDSK-11 score and its components among the four dentition status groups (referent category = good dentition) was conducted using linear regression models with robust standard errors. Multivariable models were adjusted for potential confounders based on previous studies: age (continuous), gender (categories: men or women), education (categories: school attendance: ≥7 or <7 years), decreased ADL (categories: yes or no), depression (categories: yes or no), number of present illness (continuous), smoking status (categories: never, former or current smoker), alcohol use (categories: never or rarely, sometimes, usually or always), and BMI (continuous). Effect modification was evaluated using interaction terms. Least-square means (LSMs) of FDSK-11 score and its components were obtained across categories of dentition status.

Univariable and multivariable Poisson regression models with robust error variance assessed the association of dentition status with underweight status. Crude and adjusted relative risks (RRs) with 95% confidence intervals (CIs) were calculated. Age, gender, education, ADL, depression, present illness, smoking status, and alcohol use were tested as potential confounders in the multivariable model.

The level of significance was set at $\alpha = 0.05$. All calculations and statistical analyses were performed using the statistical software package STATA (version 13) (Stata Corp., TX, USA).

RESULTS

Table 1 shows study participants' characteristics by dentition status. Significant differences were observed in age, BMI, ADL, depression and number of natural teeth. Full denture users were older and had fewer natural teeth than participants with good dentition ($P < 0.05$). The compromised dentition and ill-fitting denture group had lower BMI than the good dentition group ($P < 0.05$). Compared with good dentition group, higher percentages of decreased ADL and depression were found among compromised dentition and ill-fitting denture groups ($P < 0.05$). The compromised dentition group had fewer natural teeth than the good dentition group ($P < 0.05$), although they had a greater number of natural teeth than full denture users ($P < 0.05$).

Table 2 shows the estimated LSMs and 95% CIs of the FDSK-11 score and its components by dentition status. There were no interactions of the dentition status with covariates. The compromised dentition and self-perceived ill-fitting denture groups had significantly lower FDSK-11 scores than the good dentition group after adjusting for confounders ($P < 0.05$). Furthermore, food frequency scores of meat, fish and shellfish, milk and dairy products, and vegetables for the compromised dentition group were significantly lower than those for the good dentition group ($P < 0.05$). Food frequency scores for potatoes, beans and soybean products, meat, fish and shellfish, vegetables, seaweed, and fruits for the self-perceived ill-fitting denture group were significantly lower than for the good dentition group ($P < 0.05$). The food frequency score of milk and dairy products tended to be lower in individuals with self-perceived ill-fitting dentures than those with good dentition ($P = 0.05$).

Table 3 shows the results of the Poisson regression analyses for the associations of dentition status with underweight status. There were no interactions of dentition status with any third variable. In the crude model, the compromised dentition and self-perceived ill-fitting denture groups were at significantly higher risk of being underweight compared with the reference group (good dentition). The crude RR was 2.8 (95% CI = 1.3 to 6.2) for the compromised dentition group and 4.0 (95% CI = 1.9 to 8.7) for the ill-fitting denture group. This association remained significant after multivariable adjustment (adjusted RR = 2.5, 95% CI = 1.1 to 5.3 for the compromised dentition group and adjusted RR = 3.6, 95% CI = 1.7 to 7.6 for the ill-fitting denture group).

DISCUSSION

To the best of our knowledge, this is the first study to

Table 1. Selected characteristics of study participants by dentition status.

Demographic and socio-economic status	All participants (n = 268)	Good dentition (n = 91)	Compromised dentition (n = 43)	Well-fitting denture (n = 104)	Ill-fitting denture (n = 30)	P†
Age, mean (SD)	81.7 (4.8)	79.6 (3.7)[a]	81.7 (4.4)	83.2 (5.2)[b]	83.0 (5.0)[b]	<0.01
Gender, n. (%)						
Men	95 (35.5)	34 (37.4)	21 (48.8)	32 (30.8)	8 (26.7)	0.14
Women	173 (64.5)	57 (62.6)	22 (51.2)	72 (69.2)	22 (73.3)	
School attendance years<7 years, n (%)	38 (14.2)	6 (6.6)	8 (18.6)	17 (16.4)	7 (23.3)	0.06
Health status and health behavior						
BMI, mean (SD), (kg/m^2)	23.0 (3.3)	23.7 (3.2)[a]	22.1 (2.9)[b]	23.2 (3.3)	21.9 (3.3)[b]	<0.01
Decreased ADL, n (%)	66 (24.6)	16 (17.6)[a]	16 (37.2)[b]	23 (22.1)	11 (36.7)[b]	0.03
Depression, n (%)	83 (31.0)	21 (23.1)[a]	19 (44.2)[b]	29 (27.9)	14 (46.7)[b]	0.02
Number of present illness, mean (SD)	1.7 (1.3)	1.7 (1.3)	1.6 (1.2)	1.6 (1.4)	1.9 (0.9)	0.75
Smoking status, n (%)						
Never smoked	190 (70.9)	66 (72.5)	31 (72.1)	71 (68.3)	22 (73.3)	0.90
Previous or current smoker	68 (26.1)	25 (27.5)	12 (27.9)	33 (31.7)	8 (26.7)	
Drinking behavior, n (%)						
Never or rarely	160 (59.7)	51 (56.0)	23 (53.5)	64 (61.5)	22 (73.4)	0.30
Sometimes, usually or always	108 (40.3)	40 (44.0)	20 (46.5)	40 (38.5)	8 (26.7)	
Oral health status						
Number of natural teeth, mean (SD)	10.1 (10.0)	22.7 (3.5)[a]	9.8 (4.2)[b]	1.6 (2.8)[c]	2.3 (3.7)[c]	<0.01

SD: Standard deviation, BMI: body mass index. †P value for the comparison of selected characteristics among different study groups.
[a-c]Values in a row without a common superscript letter significantly differ as detected by multiple comparison tests.

investigate the association between functional dentition status and food diversity among older adults in Japan. A less-varied diet, which was indicated by low FDSK-11 score, was observed in participants with fewer OPNT or ill-fitting dentures after controlling for other important characteristics. Furthermore, these participants tended to have a higher risk of being underweight.

A previous study indicated that dentition status was associated with overall diet quality among US populations. Savoca et al. (2011) investigated the association between dental status and Healthy Eating Index (HEI) score, a measure of the overall quality of an individual's diet, among adults aged ≥60 years in the rural United States. They observed that individuals with fewer than 11 teeth present without dentures, and individuals with complete dentures in one or both jaws had significantly lower HEI scores than all other groups. Sahyoun and Krall (2003) reported, in a cross-sectional study of the third National Health and Nutrition Examination Survey participants, that the HEI score was significantly lower in the group with self-perceived ill-fitting dentures. Our results were consistent with these findings and further confirmed that: (1) the association between dentition status and diet quality existed in a Japanese older population as well after adjusting for relevant confounders including ADL and depression, and (2) impaired dentition status was associated with malnutrition indicated by low BMI in older adults.

When the components of FDSK were examined separately, the results suggested that lower FDSK score in the current study population was attributed to less frequent intake of certain food groups including potatoes, beans and soybean products, meat, fish and shellfish, milk and dairy products, vegetables, seaweed, and fruits. Potatoes, vegetables, seaweed, and fruits are one of the important sources of many vitamins, minerals, and fiber. Beans, meat, fish, and milk are recognized as foods with plenty of protein. Fish and shellfish are rich sources of polyunsaturated fatty acids as well. An inverse association was found between the consumption of these food groups and the development of systemic diseases such as cardiovascular disease (He et al., 2006), diabetes (Mahoney and Loprinzi, 2014), and others. In addition, a low BMI was found to be associated with increased risk of mortality, even among those with a lower normal BMI range (BMI = 18.5 to 19.9) (Tamakoshi et al., 2010). Thus,

Table 2. Associations between dentition status and food diversity score[†].

FDSK-11 component (range 1 to 4)	Good dentition (Referent) (n = 91)		Compromised dentition (n = 43)			Well-fitting denture (n = 104)			Ill-fitting denture (n = 30)		
	LSM	95% CI	LSM	95% CI	P[‡]	LSM	95% CI	P[‡]	LSM	95% CI	P[‡]
Grains	3.9	3.8 - 4.0	3.8	3.6 - 3.9	0.10	3.9	3.7 - 4.0	0.22	3.8	3.7 - 4.0	0.22
Potatoes	2.7	2.5 - 2.9	2.5	2.2 - 2.7	0.13	2.7	2.5 - 2.9	0.65	2.2	2.0 - 2.5	<0.01
Beans and soybean products	3.1	2.9 - 3.3	3.0	2.7 - 3.2	0.29	3.1	2.8 - 3.3	0.71	2.7	2.3 - 3.0	0.012
Meat	2.7	2.5 - 2.9	2.3	2.0 - 2.5	<0.01	2.5	2.3 - 2.7	0.22	2.2	1.9 - 2.4	<0.01
Fish and shellfish	3.0	2.8 - 3.2	2.6	2.4 - 2.9	<0.01	3.0	2.8 - 3.2	0.69	2.5	2.2 - 2.8	<0.01
Egg	3.0	2.7 - 3.2	2.8	2.4 - 3.1	0.23	2.8	2.6 - 3.1	0.27	2.6	2.2 - 3.0	0.08
Milk and dairy products	2.9	2.6 - 3.2	2.4	2.0 - 2.8	0.03	2.8	2.5 - 3.1	0.70	2.4	1.9 - 2.8	0.05
Vegetables	3.5	3.3 - 3.7	3.2	2.9 - 3.5	<0.01	3.5	3.4 - 3.7	0.99	3.2	2.8 - 3.5	0.02
Seaweed	2.9	2.7 - 3.1	2.7	2.5 - 3.0	0.22	2.8	2.6 - 3.0	0.38	2.5	2.2 - 2.8	0.02
Nuts	2.4	2.2 - 2.6	2.1	1.9 - 2.4	0.05	2.3	2.1 - 2.5	0.28	2.1	1.8 - 2.4	0.07
Fruits	2.8	2.6 - 3.0	2.5	2.1 - 2.8	0.05	2.7	2.5 - 2.9	0.56	2.4	2.0 - 2.7	0.02
FDSK-11 (range 0 to 11)	10.7	10.5 - 11.0	9.9	9.4 - 10.4	<0.01	10.6	10.4 - 10.8	0.10	9.6	9.1 - 10.1	<0.01

FDSK-11: 11-item food diversity score Kyoto; LSM: least square mean; CI: confidence interval. [†]Adjusted for age, gender, education, activity of daily living, depression, present illness, smoking status, alcohol use, and body mass index. [‡]Comparison to referent category. Bold text highlights statistically significant findings (P<0.05).

oral functional limitations associated with lower OPNTs and self-perceived ill-fitting dentures might lead to the avoidance of certain foods, which can lead to decreased dietary diversity and ultimately, lead to an increased risk of systemic diseases, malnutrition and mortality among older Japanese.

In contrast, dietary diversity in individuals with well-fitting dentures was not significantly different from individuals with good dentition. Therefore, regular dental care to maintain intact dentition, as well as dental treatment to replace missing teeth and ensure adequate denture fit and function, may be important for the dietary diversity of older Japanese.

The FDSK-11 is a useful and validated tool to assess dietary quality among the Japanese population. In addition, the FDSK-11 is associated with ADL and quality of life (QOL) (Kimura et al., 2013, 2012). The FDSK-11 was used to examine the association of food diversity with ADL and QOL in highlanders in Qinghai, China, as well (Kimura et al., 2009). However, it should be noted that it is not an international index. The dietary questionnaire used in the current study is specially designed for FDSK-11 and does not allow us to estimate other international criteria such as HEI and oral nutritional supplements (Volkert et al., 2006) to assess dietary quality and malnutrition in older adults. This may limit the generalizability of the current study results. Additional well-controlled studies are needed to elucidate whether there may be a possible association of other international criteria with FDSK-11 and dental/oral health.

Our findings suggest that oral health status can influence an individual's food choice and food diversity; however, it is important to note that there are several other factors that influence food choice, such as food preferences, dietary habits, nutritional knowledge, cooking skills and available food sources (Hildebrandt et al., 1997). The current study does not include data to address such factors; consequently, was not include them in the analyses.

Although this study provides a novel finding that an association between functional dentition status and food diversity was observed in an Asian (Japanese) older population, there is potential that our final sample analyzed may not be representative of the target study population, community-based older Japanese. Only 268 participants of all the 994 individuals aged ≥75 years currently residing in the town of Tosa in 2011 were analyzed. Because there was no information on the food diversity and dental health of the older general population in the town of Tosa, the characteristics between the current study population and the general population were not compared.

Table 3. Poisson regression models of the effect of dentition status on underweight.

Good dentition (reference)	Outcome = Underweight					
	Crude model			Multivariable adjusted model†		
	RR	95% CI	P‡	RR	95% CI	P‡
Compromised dentition	2.8	1.3 to 6.2	0.01	2.5	1.1 to 5.3	0.02
Well-fitting denture	1.8	0.9 to 3.9	0.11	1.3	0.6 to 2.6	0.52
Ill-fitting denture	4.0	1.9 to 8.7	<0.01	3.6	1.7 to 7.6	<0.01

RR: Relative risk; CI: confidence interval. †Adjusted for age, gender, education, activity of daily living, depression, present illness, smoking status, and alcohol use. ‡Comparison to referent category.

The mean number of teeth present was 10.1 (standard deviation [SD] = 10.0) among study population. In the national dental survey, mean number of teeth present in adults aged ≥80 years was 11.1 (The Ministry of Health, Labour, and Welfare, 2011). Although, no great gap was observed in dental characteristics, it can be assumed that those who declined to participate in the survey or who did not submit complete data might be more likely to be less concerned with their diet and overall health. In this context, the results based on this single study should be interpreted with some caution, because selection bias may lead to over- or under-estimation of the true association. There are several other limitations to the present study. First, this study had a cross-sectional design, which prevented the assessment of a temporal relationship and establishing causality. Second, information on fixed dental prostheses was not available; therefore, we could not determine whether the partially edentulous space was restored by pontics, artificial teeth in partial dentures, or no replacement. Information on present natural teeth and complete denture status were included in the current analyses. One large population-based survey evaluating the association between dental status and diet (Nowjack-Raymer and Sheiham, 2007) also does not include dental prostheses information. Third, information on participants' serum nutritional biomarkers such as albumin and vitamin levels was not available to the investigators; therefore, we were unable to fully assess participants' nutritional status. Finally, swallowing difficulties can influence dietary outcomes in older adults (Mann et al., 2013); however, information on participants' swallowing function was not collected, hence this potentially important factor could not be assessed in the analyses. Future work with larger, more diverse samples and more complete information would be necessary to substantiate our findings.

Conclusion

Conclusively, in this older Japanese population, poor dietary diversity and underweight were observed in impaired dentition. Accumulating evidence by cohort, intervention, and other highly reliable studies is an important future task to further elucidate the associations between dental/oral health and nutrition.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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