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Risk factors for oral frailty among community-dwelling pre-frail older adults in Japan: A cross-sectional analysis

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Objectives: Oral frailty is a well-established risk factor for frailty and plays a significant role in progression to frailty. However, the association between oral frailty and pre-frailty in elderly individuals remains unclear. This cross-sectional study aimed to clarify the characteristics and risk factors of pre-frailty in elderly individuals with oral frailty. ***Methods:*** A total of 377 elderly individuals participated. Oral examinations comprised simple and non-invasive measures of chewing function, self-reported swallowing function, and oral moisture. The frailty screening index was used to assess frailty phenotypes. ***Results:*** The overall prevalence of pre-frailty was 63.1%, after excluding 40 frail and 99 robust individuals. The mean age of the pre-frail participants was 76.6 ± 5.8 years; 70.6% were women. 10.5% of the pre-frail elderly participants had oral frailty. In multivariate analysis diabetes mellitus, history of cancer, denture wearing, and malnutrition were independently associated with oral frailty among pre-frail elderly individuals (adjusted odds ratio (OR) 3.8, 95% confidence interval (CI) 1.06–13.54; OR 4.5, CI 1.32–15.36; OR 8.8, CI 1.76–43.78; and OR 3.6, CI 1.30–9.67; respectively). ***Conclusions:*** The prevalence of oral frailty was low among community-dwelling pre-frail elderly individuals. Early interventions involving oral, nutritional, and disease management may prevent or improve oral frailty in pre-frail elderly individuals and may prevent progression to frailty. Further studies are required to elucidate the underlying mechanisms.

Keywords: *malnutrition, oral health, frailty, Japan, elderly, cross-sectional analysis*

Background

Frailty is a crucial health issue that increases the need for care of the elderly, particularly in countries such as Japan with an aging population. Frailty is characterized by a decline in mental and physical vitality with age, that hinders activities of daily living. Frail elderly individuals have a high risk of falls, disability, long-term care needs, dementia, and mortality (Kojima *et al*., 2017). Therefore, prevention of frailty may extend healthy life expectancy. Frailty is reversible; therefore, appropriate intervention and care for elderly individuals at the point of pre-frailty can prevent disability progression and prompt reversal to robustness (Tani *et al*., 2022). Pre-frailty, a transitional state between healthy and frail, carries a high risk of progression to frailty (Tani *et al*., 2022). A systematic review reported a pre-frailty prevalence of 48.1% in Japan (Kojima *et al*., 2017). Hence, considering the large number of pre-frail older adults, appropriate interventions to prevent transition to frailty and restore robustness are required.

A major factor associated with pre-frailty is malnutrition (Soysal *et al*., 2019). Maintaining oral function is important to ensure a balanced diet and prevent a decline in nutritional status (Tani *et al*., 2022). Although several studies have shown that interventions involving exercise and nutrition improve frailty and pre-frailty (Tani *et al*., 2022), few studies have focused on oral function. Factors associated with poor oral function include living alone and tooth loss (Kim & Jin, 2018). Additionally, improper or irregular tooth brushing, alcohol consumption, smoking, and polypharmacy contribute to dryness of the mouth (Inenaga *et al*., 2017).

Oral function encompasses the basic functions of the oral cavity including mastication, swallowing, gustation, and saliva secretion. Broadly, oral health refers to the comprehensive health of the oral cavity, including the total number of teeth present and absence of oral pain and periodontal disease. Recently, "oral frailty" has been proposed as a concept to describe age-related decline in oral function (Tanaka *et al*., 2021; Nishimoto *et al*., 2020). Oral frailty has been defined as a series of phenomena in which the deterioration of the oral cavity results in reduced physical and mental function (Watanabe *et al*., 2020). Although there are no currently standardized diagnostic criteria for oral frailty, diagnosis is commonly based on factors such as the number of remaining teeth, dryness of the mouth, and subjective difficulty in swallowing (Tanaka *et al*., 2021).

The prevalence of oral frailty among community-dwelling elderly individuals in Japan is estimated to be 16.0–19.3% (Tanaka *et al*., 2021; Ohara *et al*., 2020). The only study of oral frailty in Europe reported a 17.8% prevalence among Finnish long-term care residents (Hiltunen *et al*., 2021). Oral frailty reduces appetite and food diversity, affects social functions, increases the risk of malnutrition and physical frailty in community-dwelling elderly individuals, and reduces social interaction (Hiltunen *et al*., 2021; Tanaka *et al*., 2021; Ohara *et al*.,

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2020). This suggests that decline in oral function may have an effect on the progression from pre-frailty to frailty. However, oral frailty is difficult to detect, making effective maintenance and improved oral function in older adults crucial for healthy life expectancy.

Denture wearing, eating alone, lack of enjoyment from eating, malnutrition, and depression have been recently reported as factors associated with oral frailty in community-dwelling elderly individuals (Nishimoto *et al*., 2020; Ohara *et al*., 2020). However, in these studies, the target population was not restricted to those who were or were not frail. Nevertheless, oral frailty is a risk factor for physical frailty, and may increase the risk of pre-frail elderly individuals transitioning to frailty. Hence, it is important to understand the characteristics of oral frailty and associated risk factors among pre-frail elderly individuals, to prevent transitioning to frailty through improved oral function.

Therefore, this study aimed to assess oral frailty using a simple test and to identify characteristics and risk factors among community-dwelling elderly individuals with pre-frailty and oral frailty.

Methods

This cross-sectional study examined the physical and mental health of community-dwelling elderly individuals in Japan to enhance their quality of life, as part of the Community-Based Aging and Nutrition (CBAN) Study. This study was conducted in a single city in Sapporo Hokkaido Prefecture, Japan, between August, 2018 and August, 2019. Regular attendees of two senior citizen welfare facilities served as the recruitment pool for participants. Sapporo is a core city in Hokkaido with 27.8% of its residents aged 65 or older. There are 10 welfare centers for the elderly, providing educational, exercise, health courses and recreational events with the aim of improving health and communication and extending healthy life expectancy. Elderly people choose the courses they wish to attend and participate on their own.

Convenience sampling identified community-dwelling elderly individuals who were independent in their daily functioning, aged ≥65 years, and provided consent to participate. Previous studies on the association between oral frailty and pre-frailty reported an effect size of 0.25 (Tanaka *et al*., 2021). Using G*Power software (Kenkmann *et al*., 2010), the minimum sample size required was calculated to be 126 (effect size = 0.25 ; $\alpha = 0.05$; power = 0.8); the required final total sample size, after accounting for a 20% non-response rate, was 151. The study received ethics approval from the Ethics Committee of the Faculty of Health Sciences, Hokkaido University (Reference No: 18-22, 19-20). All the participants provided written informed consent.

A comprehensive concept of oral frailty considers a variety of oral functions (Tanaka *et al*., 2021). Therefore, oral examination comprised simple and non-invasive measures of chewing function, self-reported swallowing function, and oral moisture. Previous studies have confirmed the reliability and validity of these methods to assess oral frailty (Tanaka *et al*., 2021; Nishimoto *et al*., 2020; Ohara *et al*., 2020).

The number of teeth present, dichotomised as ≤19 and ≥20 teeth was used to determine chewing function. Parts without a tooth root were not considered teeth (Tanaka *et al*., 2021).

The 15-item Seirei Dysphagia Screening Questionnaire (Ohkuma & Kojima, 2002) was used to measure eating and dysphagia without the risk of aspiration, and thereby assess swallowing function. Responses to items included: A, severe symptoms; B, mild symptoms; and C, no symptoms (Ohkuma & Kojima, 2002). In this survey, participants who marked "A" to one or more items were included in the dysphagia group.

An oral moisture-checking tool (Mucus®; serial number 401398; Life Co., Ltd., Saitama, Japan) (Fukushima *et al*., 2017) with a sensitivity and specificity of approximately 80% was used to measure oral moisture. Readings of ≥29.6, 28.0–29.5, and ≤27.9 were regarded as normal, borderline dry mouth, and dry mouth, respectively. Oral moisture values varied from 0 to 99.9 (Fukushima *et al*., 2017); values ≤29.5 were considered indicative of a risk of dry mouth (Tanaka *et al*., 2021).

Frailty was assessed using the Frailty Screening Index (FSI)(Yamada & Arai, 2015) that consists of five items: "Have you lost >2 kg of weight in the past 6 months?"; "Do you think your walking speed has decreased?"; "Do you exercise at least once a week to maintain health?"; "Can you remember what just occurred 5 min ago?" and "In the last 2 weeks, did you feel tired for no reason?" All answered "yes" or "no". The total score ranged between 0–5; a score of 0 represented robust, 1–2 represented pre-frailty, and 3–5 represented frailty (Yamada & Arai, 2015). This study surveyed pre-frail participants. The FSI can determine the risk of frailty based on simple questions and is recommended for frailty assessment in the 2017 Asia Pacific Regional Clinical Practice Guidelines. Its reliability and validity have previously been reported (Murayama *et al*., 2021). Furthermore, its use in frailty assessment studies in Japan (Yamada & Arai, 2015) allowed comparison with our results. FSI is also valid for use outside Japan because it is not based on Japanese culture and lifestyles (Yamada & Arai, 2015).

Demographic data included sex, age, household composition (living alone or with others), taking four or more prescription drugs per day, current disease status, history of the disease, denture wearing, eating type (eating alone or with others), food satisfaction, tooth brushing, alcohol consumption, and smoking. Current disease status included comorbidities such as hypertension, diabetes mellitus, osteoporosis, hyperlipidemia, kidney disease, and heart disease; disease history included a history of cancer or stroke. The Mini Nutritional Assessment-Short Form (MNA®-SF) was used to assess nutritional status, with a score ≤11 indicating malnutrition (Kaiser. *et al*., 2009); depression was determined as a score ≥5 on the 15-item Geriatric Depression Scale (GDS-15) (Japanese version)(Yasavage & Sheikh, 1986).

All data analyses were conducted using IBM SPSS Statistics version 26.0 (Armonk, NY: IBM Corp). Results with a p-value <0.05 were considered statistically significant.

Oral frailty was defined as a poor status in all three measures, while non-oral frailty did not reflect a poor status in any of them. After simple tabulation of all data, comparisons were made between the oral frailty and non-

oral frailty groups for each variable. The Mann-Whitney U-test was employed for non-normally distributed data (age, MNA-SF score, GDS-15 score). The chi-square test was performed to compare categorical variables (including sex, household composition, hypertension, and diabetes mellitus). Fisher's exact test was performed if the anticipated frequencies exceeded 20% of the cells and were ≥5 (takes > four prescription drugs per day for osteoporosis and hyperlipidemia). Finally, multivariate logistic regression was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs) for oral frailty. The presence or absence of oral frailty was considered the objective variable.

Results

A total of 377 participants who regularly attended two senior citizen welfare centers were screened, of whom 238 (63.1%) were included in this analysis, excluding 40 frail (10.6%) and 99 robust (26.3%) participants. The mean age of the pre-frail elderly individuals was 76.6 ± 5.8 years, and 70.6% were women (Table 1). Among them, 55.0% had fewer than 20 teeth, dysphagia was suspected in 18.1% of patients, and dryness of the mouth was suspected in 81.1%. On average, the participants had 16.1 ± 9.8 teeth and dryness of the mouth was present in 27.5 ± 2.5% of the participants. Oral frailty was detected in 10.5% of pre-frail elderly individuals.

Table 1. Characteristics of 238 participants

	Overall N=238 %	*Men n=70 %*	*Women n=168 %*
Oral frailty	10.5	15.7	8.3
Chewing function			
Number of teeth present (mean (sd))	16.1 (9.8)	15.2 (10.1)	16.5 (9.7)
≥19 teeth	55.0	61.4	52.4
Swallowing function			
Dysphagia	18.1	28.6	13.7
Dry mouth (mean (sd))	27.5 (2.5)	27.5 (2.1)	27.5 (2.6)
≤29.5	81.1	81.4	81.0
Sex, women	70.6	—	—
Age, years (mean (sd))	76.6 (5.8)	78.4 (5.7)	75.9 (5.7)
Household composition			
Living alone	33.6	21.4	38.7
Takes > four prescription drugs per day	18.5	20.0	17.9
Current disease status			
Hypertension	31.1	30.0	31.5
Diabetes mellitus	8.4	15.7	5.4
Osteoporosis	4.6	1.4	6.0
Hyperlipidemia	15.1	8.6	17.9
Kidney disease	4.2	5.7	3.6
Heart disease	8.8	7.1	9.5
History of disease			
Cancer	9.7	10.0	9.5
Stroke	6.3	68.6	5.4
Denture wearing	71.0	70.0	71.4
Tooth brushing	97.9	94.3	99.4
Eating type			
Eating alone	39.1	28.6	43.5
Food satisfaction			
High	96.6	95.7	97.0
Alcohol consumers	15.1	32.9	7.7
Smokers	5.5	7.1	4.8
Nutritional status (mean (sd))	12.4 (1.7)	12.8 (1.3)	12.2 (1.8)
Malnutrition	23.9	14.3	28.0
Geriatric Depression Scale -15 (mean (sd))	3.1 (2.5)	3.0 (2.5)	3.2 (2.5)
Depression	23.5	20.0	25.0

Table 2 shows the characteristics of the participants with oral frailty included in the univariate analysis. Diabetes mellitus and denture wearing were more common in the oral frailty group than in the non-oral frailty group ($p = 0.04$ and $p = 0.01$, respectively).

The multivariate logistic regression model included only variables with $p \leq 0.20$ in bivariate analysis (Table 3). The Hosmer–Lemeshow test of the multivariate logistic regression yielded a p-value of 0.783. After adjusting for sex, age, tooth brushing, and GDS-15 score, the results showed that diabetes mellitus, history of cancer, denture wearing, and nutritional status were independently associated with oral frailty (OR 3.8, 95% CI 1.06–13.54; OR 4.5, CI 1.32–15.36; OR 8.8, CI 1.76–43.78; and OR 3.6, CI 1.30–9.67; respectively).

Discussion

This study focused on pre-frailty and examined factors related to oral frailty, as these could aid the development of early interventions to avoid progression to frailty. Only 10.5% of participants had oral frailty despite assessing pre-frail elderly individuals. Assessment comprised chewing function, self-reported swallowing function, and oral moisture. The validity of these measures in the assessment of oral frailty has been previously reported (Tanaka *et al*., 2021). Previous studies on oral frailty including pre-frail, frail, and robust older adults reported oral frailty rates ranging from 16.0–19.3% in Japan (Tanaka *et al*., 2021; Ohara *et al*., 2020). A 17.8% prevalence was found among long-term care residents in Finland (Hiltunen *et al*., 2021). Thus, the prevalence of oral frailty among our participants appears to be low. Meals provide valuable social opportunities for elderly individuals to build intimate relationships with others. By contrast, while eating alone, oral function is decreased due to a lack of conversation and fewer chewing actions (Ohara *et al*., 2020). Additionally, the reduced emotional expression, resulting from less conversation, may affect oral function (Ohara *et al*., 2020). Our sample comprised regular attendees of welfare centers; thus, even in a pre-frail state, the oral function of most participants may have been maintained by habitual conversation and regular eating with others. However, if pre-frail elderly individuals

Table 2. Characteristics of 238 participants with oral frailty.

	Total n=238 %	*Oral frailty n=25 %*	*Non-oral frailty n=213 %*	*p*
Sex, women	70.6	56.0	72.3	0.09 (Chi-Sq.)
Age, years (Mean (sd))	76.6 (5.8)	77.4 (6.6)	76.5 (5.7)	0.51 (MWU)
Household composition				
Living alone	33.6	40.0	32.9	0.48 (Chi-Sq.)
Takes > four prescription drugs per day	18.5	16.0	18.8	0.49 (Fisher)
Current disease status				
Hypertension	31.1	24.0	31.9	0.42 (Chi-Sq.)
Diabetes mellitus	8.4	20.0	7.0	**0.04*** (Chi-Sq.)
Osteoporosis	4.6	0.0	5.2	0.29 (Fisher)
Hyperlipidemia	15.1	8.0	16.0	0.23 (Fisher)
Kidney disease	4.2	8.0	3.8	0.28 (Fisher)
Heart disease	8.8	8.0	8.9	0.62 (Fisher)
History of disease				
Cancer	9.7	20.0	8.5	0.08 (Chi-Sq.)
Stroke	6.3	4.0	6.6	0.52 (Fisher)
Denture wearing	71.0	92.0	68.5	**0.01*** (Chi-Sq.)
Tooth brushing	97.9	92.0	98.6	0.09 (Chi-Sq.)
Eating type				
Eating alone	39.1	44.0	38.5	0.59 (Chi-Sq.)
Food satisfaction				
High	96.6	96.0	96.7	0.59 (Fisher)
Alcohol consumers	15.1	20.0	14.6	0.32 (Chi-Sq.)
Smokers	5.5	8.0	5.2	0.41 (Fisher)
Nutritional status (Mean (sd))	12.4 (1.7)	11.9 (2.3)	12.5 (1.6)	0.47 (MWU)
Malnutrition	23.9	36.0	22.5	0.14 (Chi-Sq.)
Geriatric Depression Scale -15 (Mean (sd))	3.1 (2.5)	3.8 (2.9)	3.1 (2.5)	0.20 (MWU)
Depression	23.5	32.0	22.5	0.29 (Fisher)

*: $P < 0.05$

Table 3. Logistic regression model for predictors of oral frailty.

Variable	*Odds ratio*	*95% CI*
Diabetes mellitus	3.8	1.06–13.54
History of cancer	4.5	1.32–15.36
Denture wearing	8.8	1.76–43.78
Malnutrition	3.6	1.30–9.67

Note: Model adjusted for sex, age, diabetes, cancer, denture wearing, tooth brushing, nutritional status, and GDS-15 score.

from the entire region were included in the analysis, a greater prevalence of oral frailty may have been observed. Socioeconomic factors such as income, education, and family/marital status have been reported to be associated with oral function in the elderly (Tanaka *et al*., 2021; Watanabe *et al*., 2020; Kim *et al*., 2018). However, these have not been examined in detail, potentially affecting the reported prevalence of oral frailty.

Comparisons between the oral frailty and non-oral frailty groups showed no differences in age or sex. However, there were more people with diabetes mellitus and with dentures in the oral frailty group, indicating differences according to disease and oral status. Xerostomia is a widely known symptom of diabetes mellitus. As individuals with diabetes mellitus tend to be inactive (Jang, 2016), their overall muscle strength may deteriorate, leading to weakening of musculature related to swallowing. Furthermore, a link between diabetes mellitus and reduced masticatory function has recently been described (Jang, 2016). Therefore, diabetes mellitus may be an influential factor in impaired salivary and swallowing function. Moreover, diabetes mellitus is believed to cause sarcopenia and frailty in older adults (Jang, 2016), suggesting that symptoms of diabetes mellitus in older adults may also affect their general health through a decline in oral function, highlighting the importance of countermeasures.

Consistent with the present results, the association between oral frailty and denture use has been described (Watanabe *et al*., 2020). Having fewer teeth decreases masticatory force, which affects salivary flow and masticatory function, and the use of dentures has been suggested to cause xerostomia (Tanaka *et al*., 2021). Conversely, it has been reported that salivary flow and masticatory function are ensured by the use of appropriate dentures (Nishimoto *et al*., 2020). It is possible that the oral frailty group in this study used inappropriate dentures, which were associated with dryness of the mouth and impaired masticatory function. Consequently, it dentures could be checked regularly by a dentist for appropriate fit and use.

Denture use, diabetes mellitus, malnutrition, and a history of cancer were shown to be independent risk factors for oral frailty. Adequate nutrition is essential for healthy living, and the nutritional status of older adults is related to the oral environment and function. Reduced chewing ability associated with tooth loss also influences food choices *(*Kim & Jin, 2018). Specifically, oral health and adequate nutritional intake are interrelated. Regarding the relationship between a history of cancer and oral frailty, anticancer treatment is reported to reduce saliva production (List *et al*., 1997). Reduced saliva secretion allows bacteria to multiply, thereby increasing the risk of periodontal disease (Hirotomi *et al*., 2006). Periodontitis can lead to tooth loss, which is a component of oral frailty. These findings show that the prevention of oral frailty in elderly individuals requires an detailed consideration of history of present illness in addition to past medical history.

Our findings suggest that oral frailty among the pre-frail elderly individuals is associated not only with oral problems, but also with factors that interfere with healthy living, such as disease and malnutrition. To our knowledge, no previous study has described the relationship between disease control and oral frailty. Since chronic disease control has been reported to be important in preventing frailty (Xue *et al*., 2008), it is suggested that disease control is crucial in both preventing and improving oral frailty, as well as frailty. Accordingly, multifaceted interventions, including oral function, in the pre-frailty stage may improve oral frailty and prevent the transition from pre-frailty to frailty. Moreover, these findings suggest a case for support that focuses not only on nutrition and exercise, but also on oral health, to prevent transition from pre-frailty to frailty.

Our study had limitations. First, the cross-sectional design prevents causal inference. Future studies should examine the process of oral frailty among pre-frail elderly individuals in longitudinal research. Second, we used only subjective indicators of swallowing function. Finally, the convenience sampling may have introduced sampling bias. The study population consisted of elderly individuals who regularly attended welfare centers, many of whom were independent, socially active, and in relatively good physical and psychosocial health. Thus, the sample may not represent the general elderly population of Japan.

In conclusion, oral frailty was uncommon among pre-frail elders was low and showed no age or sex differences. Denture wearing, diabetes mellitus, malnutrition, and a history of cancer were independent risk factors for oral frailty. Oral management, nutrition, and disease management may prevent and improve oral frailty in pre-frail elderly individuals. Addressing oral frailty may not simply be a matter of maintaining and improving oral function. Multifaceted interventions involving factors such as nutritional status and disease management may be of value, and if implemented in the pre-frailty stage may aid the prevention of frailty. Future intervention studies examining the effects of nutritional, oral, and disease management on oral frailty, and prevention of frailty, are required.

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Conflict Of Interest

The authors declare no conflicts of interest.

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