The association between objective and subjective oral health conditions and the presence of anorexia of aging among Japanese older Adults[1]

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ABSTRACT

Anorexia of aging is a risk factor for malnutrition among older adults. This study aimed to evaluate the association between objective and subjective oral health and anorexia among independent older adults. This cross-sectional study targeted independent older adults aged ≥65 years who participated in the Japan Gerontological Evaluation Study conducted in 2022. The outcome variable was the presence of anorexia, as assessed by the Simplified Nutritional Appetite Questionnaire. Exposure variables were dental status (≥20 teeth, 10–19 teeth with/without dentures, and 0–9 teeth with/without dentures) as objective oral health and oral health-related quality of life measured by five items of the short version of the Oral Impacts on Daily Performances (OIDP) (eating, speaking, smiling, emotional stability, and enjoying with others) as subjective oral health. We fitted the Poisson regression model, including possible confounders, and estimated prevalence ratios (PRs) and 95% confidence intervals. Among 19,787 participants (mean age: 74.6 years [1SD = 6.2], male: 48.5%), 9.0% were classified as having anorexia. After adjusting possible confounders, those with ≤19 teeth had a higher proportion of experiencing anorexia compared to those with ≥20 teeth; however, the association was less pronounced among those with dentures (0−9 teeth with dentures: PR = 1.48 [1.31−1.68], and 0−9 teeth without dentures: PR = 2.08 [1.65−2.63]). Even after adjusting for dental status, each item of OIDP was significantly associated with the presence of anorexia (all $p < 0.05$). The results showed that both objective and subjective poor oral health were significantly associated with a higher probability of developing anorexia of aging. Therefore, improving both objective and subjective oral health through appropriate dental care could contribute to maintaining appetite in later life.

1. Introduction

Malnutrition, especially undernutrition, is one of the most critical health problems among older adults (Dent, Wright, Woo, & Hoogendijk, 2023). A major risk factor for undernutrition among older adults is anorexia of aging (i.e., lack of appetite) (Fielding, Landi, Smoyer, Tarasenko, & Groarke, 2023). This condition, which is prevalent among older adults, is mainly due to physiological changes caused by aging (Landi, et al., 2016). Previous studies revealed that older adults with anorexia are at a higher risk of various health problems, including

increased mortality (Fielding, et al., 2023).

The risk of anorexia of aging is affected by physical and social factors (Landi, et al., 2016). Oral health is essential for eating and social activities (Glick, et al., 2016). The number of remaining teeth is correlated with chewing efficacy, affecting eating behavior (Naka, Anastassiadou, & Pissiotis, 2014). Therefore, poor oral health could affect the appetite of older adults. Actually, previous studies revealed that poor oral health was associated with malnutrition among older adults (Kusama, et al., 2021; Shiota, Kusama, Takeuchi, Kiuchi, & Osaka, 2023). However, few previous studies evaluated the association between oral health and

anorexia among older adults (Kimura, et al., 2019; Nomoto et al., 2022).

Oral health consists of multiple aspects, including diseases (e.g., dental caries, periodontal diseases, and tooth loss), physiological function (e.g., chewing, speaking, and smiling), and psycho-social function (Glick, et al., 2016). Not only are these aspects thoroughly evaluated on the basis of objective indices, such as dental status or oral functioning, but the application of subjective indices, such as oral health-related quality of life (OHRQoL), is also considered a requirement for a comprehensive understanding of oral health. Therefore, using objective and subjective measures to evaluate multiple aspects of oral health in association with the anorexia of aging is also considered essential. We hypothesized that different elements of oral health would, respectively, affect the risk of anorexia among older adults. In this study, we employed dental status as objective oral health and OHRQoL as subjective oral health to evaluate the association between oral health and anorexia among older adults. This study aimed to 1) investigate the association between dental status and anorexia of aging and 2) evaluate the association between OHRQoL and anorexia of aging, considering dental status.

2. Methods

2.1. Study design and participants

This was a cross-sectional study based on self-reported questionnaires. We used data from the Japan Gerontological Evaluation Study, a large cohort study conducted in 2022 targeting adults aged ≥65 years in 71 municipalities in Japan (Kondo, 2016). The questionnaire, including the questions related to appetite and OHRQoL, was distributed randomly with a probability of one-eighth to the targeted population. The response rate of the survey was 67.2%. Those who were certified in long-term care insurance services (n = 10,491) or did not provide consent for research use were excluded from the study (n = 25,763). Additionally, we excluded those who provided invalid ID, sex, or age information (n = 3289). For eligibility in the present study, we targeted independent older adults of ≥65 years of age. Therefore, those whose activities of daily living were not independent (i.e., needed any help or care in daily life (n = 10,963)) and those who had dementia (n = 347) were excluded from the analysis.

2.2. Outcome variable

We used the presence of anorexia as the outcome variable. The presence of anorexia was assessed by the Simplified Nutritional Appetite Questionnaire (SNAQ). SNAQ was originally created to evaluate appetite among older adults, and low SNAQ scores predict the incidence of future weight loss (Wilson, et al., 2005). The validity and reliability of the Japanese version of SNAQ were confirmed in a previous study (Nakatsu, Sawa, Misu, Ueda, & Ono, 2015). SNAQ comprises four questions related to appetite, and responses to each question are assigned points ranging from 1 to 5. The sum of the SNAQ responses ranges from 4 to 20, and those with SNAQ ≤13 are classified as having anorexia and considered to be at a high risk of malnutrition (Wilson, et al., 2005). We employed a binary variable of SNAQ with a cut-off point (SNAQ ≤13/≥14).

2.3. Exposure variables

We used dental status as an objective measure of oral health. Dental status was categorized based on the combination of the number of remaining teeth and the use of dentures, including removable dentures, dental bridges, and dental implants. The accuracy and validity of self-reported tooth counts have been previously reported (Sekundo, Stock, Jürges, & Listl, 2019). We created five categories of dental status as follows: "≥20 teeth," "10–19 teeth with dentures," "10–19 teeth without dentures," "0–9 teeth with dentures," and "0–9 teeth without dentures."

This categorization of the number of remaining teeth is based on consensus from previous reports (Kassebaum, et al., 2014; Watanabe et al., 2020).

For subjective oral health, we used the components of OHRQoL measured by the short version of the Oral Impacts on Daily Performances (OIDP) questionnaire as exposure variables (Tsakos, Marcenes, & Sheiham, 2001). The OIDP was developed to evaluate the oral impacts on a person's ability to perform daily activities and has demonstrated appropriate psychometric properties in a previous population-based survey of older adults. The OIDP item covers the physiological and psycho-social aspects of oral health, enabling the evaluation of social impacts of poor oral health on daily living. The participants were asked, "In the past 6 months, have any problems with your mouth, teeth, or dentures caused you to have any of the following?" They answered "Yes" or "No" by following each of the five items as follows (multiple responses allowed): "Difficulty eating food," "Difficulty speaking clearly," "Problems with smiling, laughing, and showing teeth without embarrassment," "Problems with emotional stability, for example, becoming more easily upset than usual," "Problems enjoying the company of other people such as family, friends, or neighbors." We treated the presence of each OHRQoL problem as a binary variable. Additionally, we used the applicable number of OIDP items to evaluate the cumulative impact of poor OHRQoL on anorexia.

2.4. Covariates

We included possible confounders as covariates based on the previous studies (Aprahamian, et al., 2021; Kusama et al., 2021; Landi et al., 2016; Mikami et al., 2022; Shiota et al., 2023). They included sex (male/female), age (65–69/70–74/75–79/80–84/≥85), equivalent income (<2.00/2.00–3.99/≥4.00 million JPY), education (≤9/10–12/≥13 years), frequency of eating together (>1/≤1 time/month), frequency of meeting friends (≥1/<1 time/week), number of comorbidities of any diseases (0/1/2/≥3), and depressive symptoms measured by geriatric depression scale-15 (<5/≥5) (Pocklington, Gilbody, Manea, & McMillan, 2016).

2.5. Statistical analysis

We employed the Poisson regression model with sandwich estimators for standard errors and estimated prevalence ratios (PRs) and 95% confidence intervals (CIs) (Naimi & Whitcomb, 2020). We built two models: The crude model includes each exposure only, whereas the adjusted model includes each exposure variable and all covariates. In the model employing OHRQoL as exposure, we also adjusted for dental status and all covariates to control the effect due to objective oral health. To reduce selection bias, we also conducted multiple imputations (MI) to address missing values (Lee, et al., 2021). Missing values were imputed based on multivariate imputation by chained equations, and 20 imputed data sets were created. The estimates obtained from each imputed data set were combined based on Rubin's rule. For sensitivity analysis, we also conducted a complete record analysis by eliminating those with any missing values in the used variables. To identify the strength of the unmeasured covariates that affected the estimates, we also calculated the E-values. The E-value represents the minimum strength of the association required for the unmeasured confounder to have both exposure and outcome conditional on the measured covariates to explain away the association (VanderWeele & Ding, 2017). We used Stata/MP version 17.0 (Stata Corp., College Station, TX, USA) to perform the statistical analysis.

3. Results

Fig. 1 shows the detail of participants' inclusion. Finally, 19,787 participants were included in the analysis (mean age: 74.6 years [1SD = 6.2], male: 48.5%). The participant characteristics before MI are
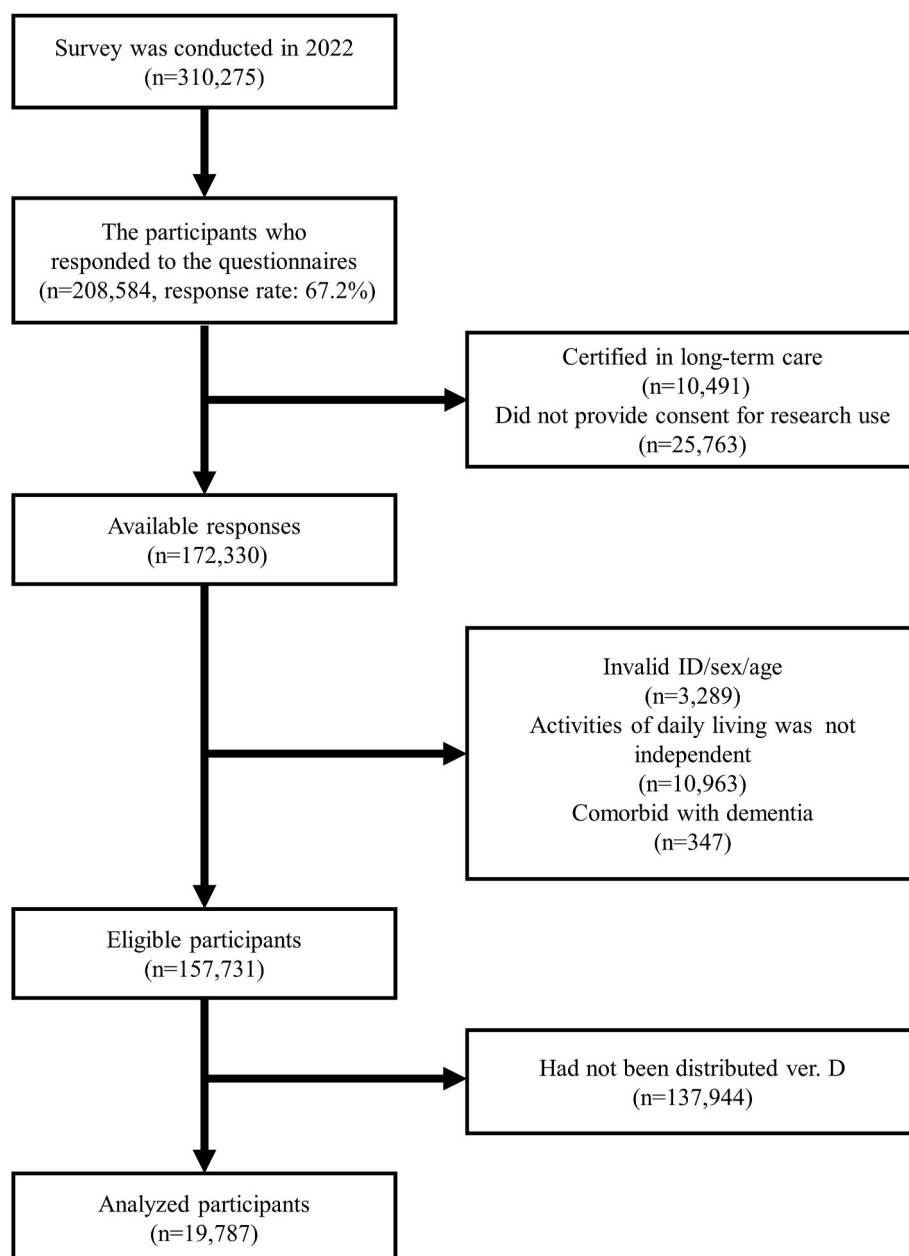
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┌─────────────────────────────────┐
│    Survey was conducted in 2022  │
│          (n=310,275)             │
└─────────────────────────────────┘
              │
              ▼
┌─────────────────────────────────┐
│      The participants who        │
│  responded to the questionnaires │
│  (n=208,584, response rate: 67.2%)│
└─────────────────────────────────┘
              │         ┌─────────────────────────────────┐
              ├────────▶│   Certified in long-term care    │
              │         │          (n=10,491)              │
              │         │ Did not provide consent for research use │
              │         │          (n=25,763)              │
              ▼         └─────────────────────────────────┘
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│       Available responses        │
│          (n=172,330)             │
└─────────────────────────────────┘
              │         ┌─────────────────────────────────┐
              │         │       Invalid ID/sex/age         │
              │         │          (n=3,289)               │
              ├────────▶│ Activities of daily living was not│
              │         │          independent             │
              │         │          (n=10,963)              │
              │         │     Comorbid with dementia       │
              │         │          (n=347)                 │
              ▼         └─────────────────────────────────┘
┌─────────────────────────────────┐
│       Eligible participants      │
│          (n=157,731)             │
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              │         ┌─────────────────────────────────┐
              ├────────▶│  Had not been distributed ver. D │
              │         │          (n=137,944)             │
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┌─────────────────────────────────┐
│       Analyzed participants      │
│          (n=19,787)              │
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Fig. 1. Flow chart of the participants inclusion.
Note. The questions related Simplified Nutritional Appetite Questionnaire and Oral Impacts on Daily Performances were only included in ver. D of JAGES questionnaire.

presented in Supplementary Table S1. After MI, any missing values for 7803 participants were imputed. Table 1 shows the distribution of the participants' characteristics after MI. The prevalence of anorexia (SNAQ ≤13) was 9.0% (n = 1769) among the participants of the present study. Fig. 2 shows the prevalence of anorexia by dental status and the presence of poor OHRQoL after MI. For dental status, we observed the tendency that among those with fewer remaining teeth, the proportion of having anorexia is higher; however, among those with 10–19 and 0–9 remaining, the proportion of having anorexia was lower among those who used any dentures, respectively. The prevalence of anorexia was higher among those with problems in each item of OHRQoL in OIDP.

Table 2 shows the results from the Poisson regression model. We observed significant associations between poor dental status and anorexia. Those with fewer remaining teeth and without dentures were at a higher proportion of having anorexia than those with more remaining teeth or with dentures as follows: among 10–19 teeth, those
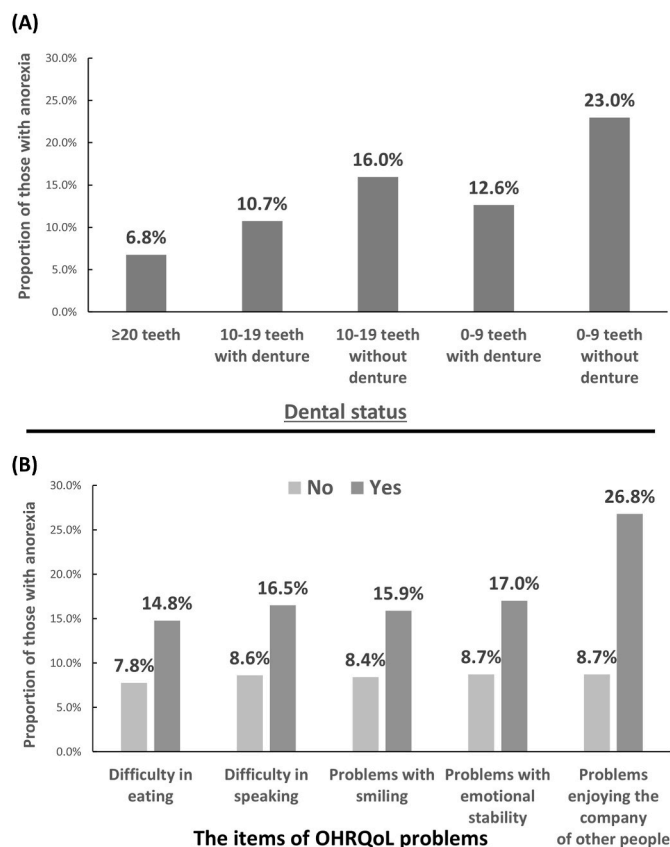
with dentures (PR = 1.44 [95% CI = 1.27–1.63]) vs. those without dentures (PR = 1.80 [95% CI = 1.47–2.22]), and among 0–9 teeth, those with dentures (PR = 1.48 [95% CI = 1.31–1.68]) vs. those without dentures (PR = 2.08 [95% CI = 1.65–2.63]). We also observed a negative interaction effect between fewer remaining teeth and denture use on multiplicative scales: for 10–19 teeth, PR = 0.80 [95% CI = 0.61–1.04] and for 0–9 teeth, PR = 0.71 [95% CI = 0.54–0.94].

We observed significant positive associations between poor OHRQoL in each OIDP item and anorexia even after adjusting for possible confounders and dental status as follows: Difficulty in eating (PR = 1.43 [95% CI = 1.28–1.60]), Difficulty in speaking (PR = 1.21 [95% CI = 1.01–1.46]), Problems with smiling (PR = 1.26 [95% CI = 1.10–1.46]), Problems with emotional stability (PR = 1.32 [95% CI = 1.07–1.62]), and Problems enjoying the company of other people (PR = 1.67 [95% CI = 1.32–2.11]). With regard to the cumulative impact of poor OHRQoL on anorexia, those for whom more OIDP items applied had a higher

Table 1
The characteristics of participants after multiple imputations.

Characteristics		All participants (n = 19,787)%	SNAQ	
			≥14 (n = 18,018)%	≤13 (n = 1769)%
Oral health				
Dental status	≥20 teeth	62.3	63.8	47.2
	10–19 teeth with dentures	15.6	15.2	18.7
	10–19 teeth without dentures	2.9	2.7	5.2
	0–9 teeth with dentures	17.6	16.9	24.8
	0–9 teeth without dentures	1.6	1.4	4.1
Difficulty in eating	No	83.3	84.4	72.4
	Yes	16.7	15.6	27.6
Difficulty in speaking	No	95.8	96.2	92.3
	Yes	4.2	3.8	7.7
Problems with smiling	No	93.0	93.5	87.5
	Yes	7.0	6.5	12.5
Problems with emotional stability	No	97.4	97.6	95.1
	Yes	2.6	2.4	4.9
Problems enjoying the company of other people	No	98.8	99.0	96.4
	Yes	1.2	1.0	3.6
Socio-demographic factors				
Sex	Male	48.5	48.5	48.8
	Female	51.5	51.5	51.2
Age	65–69 y	24.2	24.2	24.0
	70–74 y	30.4	30.6	28.1
	75–79 y	22.9	22.0	21.7
	80–84 y	15.2	15.1	16.4
	≥85 y	7.3	7.1	9.8
Equivalent income	<2.00 million JPY	48.0	46.9	59.7
	2.00–3.99 million JPY	39.6	40.3	32.4
	≥4.00 million JPY	12.4	12.8	7.9
Education	≤9 years	19.7	19.1	26.5
	10–12 years	44.6	44.6	44.8
	≥13 years	35.7	36.3	28.7
Marital status	Without a spouse	26.9	25.9	37.9
	With a spouse	73.1	74.1	62.1
Living arrangement	Living with others	85.0	85.6	78.3
	Living alone	15.0	14.4	21.7
Health behavior				
Smoking status	Never	57.7	58.3	52.0
	Past	32.0	32.2	28.8
	Current	10.3	9.4	19.2
Frequency of eating together	>1 time/ month	84.9	86.0	74.5
	≤1 time/ month	15.1	14.0	25.5
Frequency of meeting friends	≥1 time/ week	46.2	47.1	36.8
	<1 time/ week	53.8	52.9	63.2
Health status				
Number of comorbidities	0	19.3	19.6	16.2
	1	36.7	37.0	33.5
	2	25.7	25.5	26.8
	≥3	18.3	17.8	23.4
Depressive symptoms	GDS <5	76.8	79.1	54.1
	GDS ≥5	23.2	20.9	45.9

Abbreviations: SNAQ, Simplified Nutritional Appetite Questionnaire; GDS, geriatric depression scale-15.

Fig. 2. (A) The prevalence of anorexia by the dental status (n = 19,787). (B) The prevalence of anorexia by the component of OHRQoL (n = 19,787). *Abbreviation*: OHRQoL, Oral health-related quality of life.

prevalence of anorexia (*p* for trend <0.001) (Supplementary Table S2).

In the sensitivity analysis among complete records, we observed similar results (Supplementary Table S3). The estimated E-values are presented in Supplementary Table S4. E-values for point estimates were relatively large and varied from 1.71 to 3.58 in risk ratio scales.

4. Discussion

4.1. Summary of the results

This study evaluated the association between the presence of anorexia and both objective and subjective oral health among independent older adults. The results suggested that poor objective oral health, measured by dental status, was associated with a higher prevalence of anorexia of aging. Specifically, those with fewer remaining teeth and without dentures had a higher probability of having anorexia. In addition, each item of subjective poor oral health measured by OIDP was also associated with a higher prevalence of anorexia of aging, even after adjusting for objective oral health.

4.2. Comparison with previous findings and possible explanation

The results of the present study were in line with previous findings related to poor oral health and anorexia among older adults. Previous studies revealed that those with low chewing efficiency and poor comprehensive oral health scores were associated with higher proportions of anorexia among older adults (Kimura, et al., 2019; Nomoto et al., 2022). In the previous studies, oral health was evaluated only objectively (Kimura, et al., 2019; Nomoto et al., 2022); however, our study employing OHRQoL as subjective oral health also showed a positive association between poor subjective oral health and anorexia, even

Table 2
The association between oral health and anorexia after multiple imputations (n = 19,787).

Exposure	Crude model [a]	Adjusted model [b]
	PR (95% CI)	PR (95% CI)
Dental status		
≥20 teeth	1 (Ref.)	1 (Ref.)
10-19 teeth with dentures	1.59 (1.39, 1.82) ***	1.44 (1.27, 1.63) ***
10-19 teeth without dentures	2.35 (1.92, 2.90) ***	1.80 (1.47, 2.22) ***
0-9 teeth with dentures	1.86 (1.66, 2.10) ***	1.48 (1.31, 1.68) ***
0-9 teeth without dentures	3.39 (2.70, 4.26) ***	2.08 (1.65, 2.63) ***
Exposure	Crude model [a] PR (95% CI)	Adjusted model [c] PR (95% CI)
Each item of OHRQoL problems (Ref. "No")	1 (Ref.)	1 (Ref.)
Difficulty in eating	1.90 (1.71, 2.12) ***	1.43 (1.28, 1.60) ***
Difficulty in speaking	1.91 (1.59, 2.31) ***	1.21 (1.01, 1.46)*
Problems with smiling	1.89 (1.63, 2.18) ***	1.26 (1.10, 1.46) **
Problems with emotional stability	1.95 (1.56, 2.43) ***	1.32 (1.07, 1.62)*
Problems enjoying the company of other people	3.07 (2.42, 3.88) ***	1.67 (1.32, 2.11) ***

Note: [a] Not adjusted for any covariates. [b] Adjusted for age, sex, equivalent income, education, comorbidities, marital status, living arrangement, smoking status, frequency of eating together, frequency of meeting friends, depressive symptoms. [c] Adjusted for age, sex, dental status, equivalent income, education, marital status, living arrangement, smoking status, frequency of eating together, frequency of meeting friends, comorbidities, depressive symptoms.
Abbreviations: PR, prevalence ratio; 95% CI, 95% confidence interval; OHRQoL, Oral health-related quality of life; Ref., reference.
*p < 0.05; **p < 0.01; ***p < 0.001.

after adjusting objective oral health.

In this study, we observed a positive association between fewer remaining teeth and the presence of anorexia. A previous study also reported that low chewing efficiency was associated with the presence of anorexia among older adults (Kimura, et al., 2019), and chewing efficiency and the number of remaining teeth are strongly correlated (Naka, et al., 2014). Therefore, those with fewer remaining teeth were at a higher risk of anorexia due to lowered chewing efficiency. In contrast, the use of dentures increases the chewing efficiency of those with tooth loss (Liang, Zhang, Witter, Wang, & Creugers, 2015). In our results, those with dentures had a lower proportion of anorexia compared to those without dentures among those with 0–19 remaining teeth. The use of dentures contributes to maintaining appetite by recovering chewing efficiency.

For OHRQoL as subjective oral health, we also observed positive associations between the items of OIDP and anorexia. A previous review on the anorexia of aging suggested that social factors also affect the risk of anorexia. Oral health is essential for communication and social activities (Glick, et al., 2016). In this study, all items of OIDP were significantly associated with anorexia, respectively. OIDP was created to evaluate the multiple aspects of OHRQoL (Tsakos, et al., 2001); therefore, each aspect of oral health could affect the risk of anorexia. Especially among the items of OIDP, having problems enjoying the company of other people was associated with anorexia stronger than the other items. A previous review emphasized the importance of social facilitation of eating, the phenomenon where eating with others increases the appetite, in preventing anorexia (Landi, et al., 2016). Although we included the frequency of meeting friends and eating together as covariates, having problems enjoying the company of other people was associated with anorexia. Poor oral health may also have affected the

qualitative aspects of social interaction and led to anorexia, irrespective of the quantitative exposure to social interaction.

4.3. Implications

Our study suggested the possibility that maintaining favorable objective and subjective oral health is important for preventing malnutrition in later life. Additionally, our results revealed that subjective oral health (i.e., OHRQoL) was significantly associated with anorexia, irrespective of the number of remaining teeth or use of dental prostheses. Previous systematic reviews have suggested that prosthodontic treatments, such as dentures or dental implants, can improve subjective oral health. However, the degree of improvement varies depending on the type of dental prosthesis used (Ali, Baker, Shahrbaf, Martin, & Vettore, 2019). Therefore, when treating patients for oral health issues, dental professionals may need to focus not only on the recovery of structural or functional problems but also on improving deteriorated subjective oral health. To promote oral health and prevent subsequent nutritional problems, evaluating subjective oral health indices, such as OHRQoL, is considered important.

4.4. Limitations of the present study

The present study had several limitations. First, regarding the representativeness of the participants, the distribution of participants' characteristics may differ from the targeted population. However, we collected data from 71 municipalities by distributing questionnaires to all or randomly selected residents eligible for the survey. Therefore, the violation of the participants' representativeness was considered small in the present study. Second, our study was based on a self-reported questionnaire; therefore, information bias is possible due to the employed measurements. However, the variables we employed as outcome and exposure variables were previously validated elsewhere (Nakatsu, et al., 2015; Sekundo et al., 2019; Tsakos et al., 2001). Therefore, the bias due to measurement by self-reported questionnaires was considered to be small. In particular, anorexia and OHRQoL are originally subjective health conditions, and we considered the self-reported measurement to be appropriate in light of the aim of this study. Third, although we included possible confounders in the statistical model, the results may be influenced by unmeasured confounding. We calculated E-values to evaluate the magnitude of the unmeasured confounder, which explains the present result (Supplementary Table S3). Although we cannot deny the existence of residual confounding from unmeasured confounders, we consider that the influence is relatively small based on the E-values. Fourth, reverse causation is a potential consideration. Although it is not likely that anorexia leads to tooth loss, a future cohort study is required to confirm the temporal association between oral health and anorexia. Finally, the questions included in SNAQ and OIDP seem to be similar from a psychological perspective. This is because oral health and eating are strongly linked. A comprehensive understanding of the link between oral health and eating behavior from psycho-social perspectives is desired through future research.

4.5. Conclusion

The results of this study demonstrated that both poor objective and subjective oral health conditions are significantly associated with the prevalence of anorexia among independent older adults. urthermore, as a measure of subjective oral health, the OHRQoL index was significantly related to the presence of anorexia, regardless of dental status. Improving both subjective and objective oral health through appropriate dental care could contribute to maintaining appetite in later life.

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Sponsor's role

None.

Ethical approval statement

The JAGES survey in 2022 was approved by the Ethics Committee on Research of Human Subjects at Chiba University Graduate School of Medicine (No. M10460).

Patient consent statement

Informed consent was obtained from all participants.

Permission to reproduce material from other sources

Not applicable.

CRediT authorship contribution statement

Taro Kusama: Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **Kenji Takeuchi:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Sakura Kiuchi:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Jun Aida:** Writing – review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Ken Osaka:** Writing – review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107332.

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