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The Relationship between Oral Frailty and Nutritional Status in the Elderly: A Systematic Review and Meta-Analysis

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Abstract: A systematic review assessing the association of deteriorating oral function with nutrient intake in older adults. Methods Comprehensive evidence gathering from CBMdisc, CNKI, Wanfang Database, PubMed, Embase, Web of Science, and Cochrane Library, to examine how oral frailty relates to dietary inadequacy among seniors. Retrieval period from June 30, 2014 to June 30, 2024.Two researchers independently screened the literature, extracted data, and assessed the quality of the included studies, using Revman 5.4 and Stata 16.0 for the systematic review. Results With an aggregate sample of 7,234 subjects across eight selected studies, the analysis contained seven cross-sectional designs and a single prospective cohort. Meta-analysis results demonstrate that malnutrition susceptibility rises markedly in the elderly with compromised masticatory capacity. (OR=1.93, 95% CI:1.62−2.30), with a statistically significant difference (Z=7.27, P<0.001).Subgroup assessments confirmed stable nutritional indicators in orally frail elderly populations across studies of varying publication dates and participant numbers(P > 0.05); The study area for the Japanese subgroup showed statistical significance [OR=1.43, 95% CI:1.08−1.89, P=0.01].Conclusions Although nutritional status correlates with oral frailty in the elderly population, equivocal evidence persists regarding how tooth retention and oromotor skill deterioration impact nutritional outcomes. This necessitates greater attention to the collaborative management of oral health and nutritional status, which in turn can provide clinical decision-making and intervention strategies for preventing and controlling oral frailty in the elderly.

Keywords: Oral; Oral Frailty; Nutrition; Nutritional Status; meta-analysis.

1. Introduction

With the intensification of population aging, the prevalence of age-related health issues is rising year by year, such as oral health problems in the elderly, including tooth loss, decreased chewing function, and reduced tongue pressure[1]. Emphasizing oral health's foundational contribution to holistic health outcomes, WHO has mandated the establishment of evidence-based oral care programmes across nations, operationalizing its commitment to health equity [2]. WHO's seminal 2003 report on global oral health established comprehensive policy frameworks and prioritized action items for achieving perpetual advancement in population-level oral health outcomes[3].Strengthening and preventing oral health issues among the elderly population has become a key focus for governments worldwide.

The concept of oral frailty caused by population aging has been introduced as a new idea in the field of frailty and has attracted significant attention from researchers[4].Oral frailty encompasses progressive deterioration in oral anatomy and physiological functions associated with aging, which correlates with multidimensional degradation in physical vitality, cognitive capacity, nutritional status, and social engagement capabilities. This phenomenon or process is often accompanied by a deterioration in overall physical, cognitive, nutritional, and social functions[5, 6].The increase in the global elderly population is accompanied by a rise in the prevalence of malnutrition. As an intervenable determinant of morbidity progression and fatal risk in seniors, nutritional deficiency profoundly compromises oro-dental health status[7, 8].Research shows that there is a certain correlation between oral function decline, poor oral health, and oral frailty in the elderly and nutritional disorders[9-11].

While empirical evidence on oral-nutritional interplay accumulates, substantial heterogeneity exists across studies examining correlations between distinct masticatory dysfunction indices and nutritional adequacy measures. Research by Nomura et al. indicates that the number of remaining teeth is not related to nutritional intake, and there is no direct relationship between oral function and nutrition consumption[12].A systematic review overview published by Kaurani et al. also indicated a high degree of methodological heterogeneity in articles on tooth loss and nutritional status, with inconsistencies in the results of various studies[13].This systematic evidence synthesis examines epidemiological data to elucidate associations between stomatognathic impairment and nutritional status, thereby informing targeted prophylactic strategies against age-related oro-functional decline.

2. Methods

2.1. Literature Search

The databases searched include the CBM, CNKI, Wanfang Data, PubMed, Embase, Web of Science, and the Cochrane Library. Search operations utilized dual-term sourcing from both predefined conceptual classifications and open syntactic units. The search term is aged, elderly, Oral Frailty, Oral Weakness, Oral Function, OF, Nutrition, Nutritional Status, Malnutrition, Nutrition Assessment, Nutrition Surveys, et al.

The retrieval period is from June 30, 2014, to June 30, 2024. At the same time, manually search relevant domestic and international journals, and trace the references of the included literature to expand the scope of the search. The following is the search strategy for PubMed, as shown in Table 1.

Table 1. PubMed Search Strategy

Steps	Search Strategy
#1	("aged"[MeSH Terms]OR"aged"[Title/Abstract]OR"elderly"[Title/Abstract])
#2	("oral frailty"[MeSH Terms]OR"oral frailty"[Title/Abstract]OR"oral weakness"[Title/Abstract]OR"oral function"[Title/Abstract] OR "OF"[Title/Abstract])
#3	("Nutrition"[MeSH Terms]OR"Nutrition"[Title/Abstract] OR"Nutritional status"[Title/Abstract]OR"Malnutrition"[Title/Abstract]OR"Nutrition Assessment"[Title/Abstract] OR"Nutrition Surveys"[Title/Abstract])
#4	#1AND#2AND#3

2.2. Inclusion and Exclusion Criteria

(1) Inclusion criteria:1) Study type: cohort studies, case-control studies, or cross-sectional studies;2) Study subjects: patients diagnosed with oral frailty;3) Exposure factor: nutritional status;4) Outcome measure: effect size of the relationship between oral frailty and nutritional status (odds ratio (OR) and corresponding 95% confidence interval (CI)). (2) Exclusion criteria:1) Inability to access the full text, studies with design flaws, and low-quality literature;2) Reviews, case reports, conference papers, etc;3) Duplicate publications and unpublished grey literature;4) Non-Chinese or non-English literature.

2.3. Literature Screening and Data Extraction

The initial screening was conducted independently by two researchers through reviewing the titles and abstracts of the literature. Full-text reading was performed for the studies included after the initial screening to identify those meeting the inclusion criteria. For inclusion criteria discrepancies, an independent arbitrator conducted literature adjudication, with final determinations reached via structured deliberation. Data extraction was carried out for the final included studies, focusing mainly on the following: first author, publication year, region, study design type, age, sample size, outcome indicators, etc. If a study reported effect sizes estimated using different statistical methods, the result from the most complex statistical method was selected.

2.4. Quality Assessment

This study involved two researchers independently assessing the risk of bias in the included studies. The Newcastle-Ottawa Scale (NOS) was applied to conduct multidimensional evaluation of selection bias, comparability, and outcome ascertainment within observational designs including cohort and case-control studies. The NOS consists of three dimensions and eight items, with a total score of 9 points. Scores of 0-4, 5-6, and 7-9 correspond to low, medium, and high quality, respectively[14, 15].Methodological rigor of cross-sectional investigations was appraised employing the standardized assessment framework endorsed by the Agency for Healthcare Research and Quality (AHRQ).The AHRQ scale consists of 11 items, each answered with "Yes","No"or "Unclear". Scores of 0-3, 4-7, and 8-11 correspond to low, medium, and high quality, respectively[16].

2.5. Statistical Analysis

Data analysis was performed using RevMan 5.4 and Stata software. The measurement data are expressed as mean difference (*MD*), binary classification variables are represented using odds ratios (*OR*), each effect size is expressed with a 95% confidence interval (CI). A P-value of less than 0.05 indicates statistical significance. Using I-square (I^2) and Chi-square (X^2) to analyze the heterogeneity of the studies included in the research, when $P \geq 0.1$ and $I^2 < 50\%$, the studies can be considered homogeneous, and a fixed-effect model can be used for analysis; When $P < 0.1$ and $I^2 \geq 50\%$, it is considered that there is substantial heterogeneity among studies; therefore, a random-effects model is used for analysis, and heterogeneity is examined through subgroup analysis; In addition, sensitivity analysis is used to evaluate the stability of the research results. Analysis of publication bias using funnel plots and Egger's test[17]. Egger's test with $P < 0.1$ is considered indicative of publication bias.

3. Results

3.1. Literature Screening Process and Results

A preliminary search of various literature databases yielded a total of 1095 relevant articles, including 59 in Chinese and 1036 in English; After removing duplicate studies, 546 articles remained; 459 articles were excluded after reviewing the titles and abstracts, leaving 87 articles. Following a full-text review and step-by-step screening, 8 articles were ultimately included[11, 18-24].The literature screening process and results are shown in Figure 1.

3.2. Basic Characteristics and Quality Assessment

This study included 8 articles, consisting of 2 in Chinese[23, 24]and 6 in English[11, 18-22];7 cross-sectional studies and 1 cohort studies, with a total sample size of 7234;The research areas are primarily focused on Japan and China; Methodological rigor appraisal outcomes across included studies ranged from 6 to 9 points, indicating intermediate to superior quality levels with controlled bias susceptibility. The basic characteristics and quality assessment results of the included articles are shown in Table 2

3.3. Results of the Meta-Analysis

The heterogeneity test of the included 8 studies showed significant heterogeneity among the studies(I^2=91%, P<0.001), as shown in Figure 2.A sensitivity analysis was conducted by sequentially excluding studies, revealing that Nakagawa 2024[18], Hironaka 2020[19], and Wei 2024[24] were the main sources of heterogeneity.

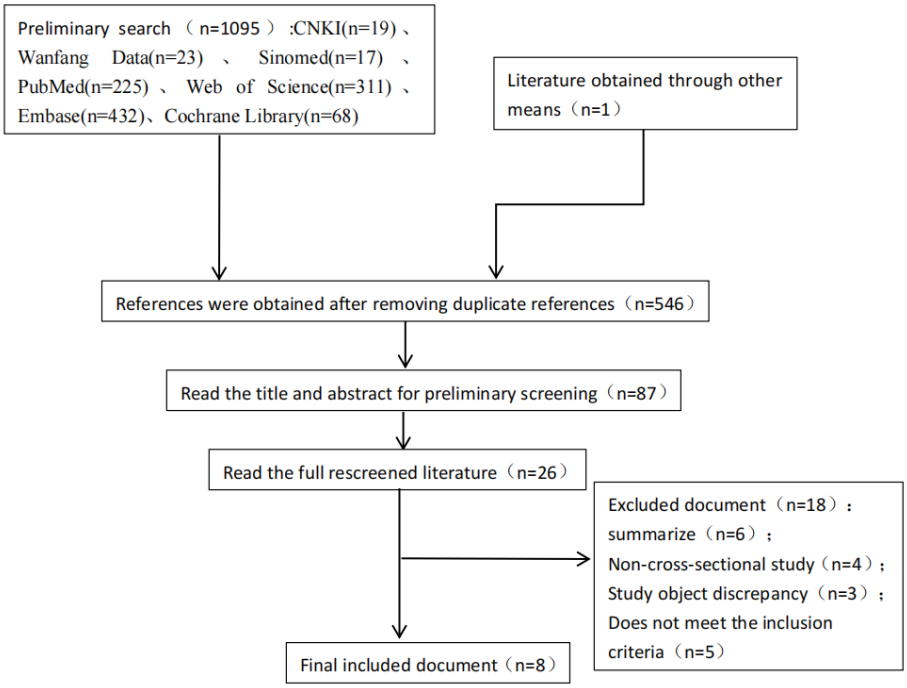

Figure 1. Flow chart of literature screening

Table 2. Basic Characteristics and Quality Assessment of Included Studies

Study	Year	Country	Type of study	Age	N	Oral Frailty assessment method	Nutritional assessment method	Result	Quality assessment
Iwasaki 1[11]	2020	Japan	Cross-sectional study	77.0±4.8	1054	OFI-6	MNA-SF	Oral frailty was associated with nutritional status among Japanese older adults. Oral frailty was significantly associated with the level of malnutrition based on the MNA®-SF score.	7
Iwasaki 2[20]	2020	Japan	Cohort study	76.4±4.1	466	OFI-6	MNA-SF	Community-dwelling older adults with oral frailty had an increased risk of deteriorating nutritional status.	8
Hoshino[22]	2021	Japan	Cross-sectional study	75.9±6.3	481	OFI-6	DVS	The severity of OF was significantly associated with DVS in community-dwelling older persons. DVS may be useful for identifying the effects of OF on nutritional status.	7
Hironaka[19]	2020	Japan	Cross-sectional study	73.3±6.6	682	OFI-6	MNA-SF	Analysis revealed significant associations between OF and decline in social function, physical function, and nutritional status, and an increase in the number of medications used.	9
Iwasaki 3[21]	2024	Japan	Cross-sectional study	74.7±5.5	1206	OF-5	DVS	oral frailty was significantly associated with low dietary variety.	6
Nakagawa[18]	2024	Japan	Cross-sectional study	79.9±4.3	2727	OFI-6	SNAQ/DVS	Oral frailty was associated with decreased appetite and dietary variety in late stage older adults.	6
Jiao[23]	2023	China	Cross-sectional study	79.49±10.50	270	OFI-8	MNA-SF	MNA is contributing factors to oral frailty (P <0.05).	6
Wei[24]	2024	China	Cross-sectional study	77.11±9.65	348	OFI-6	SNAQ/DVS/MNA-SF	Multivariate logistic regression analysis showed that high dietary diversity score (OR = 0.199,95%CI: 0.069-0.530, P=0.002) protected the elderly from oral weakness	7

OFI-8=Oral Frailty Index-8, **OFI-6**=Oral Frailty Index-6, **OF-5**=Oral Frailty 5-Item Checklist, **MNA-SF**=Mini Nutritional Assessment-Short Form, **BDHQ**=Brief-Type Self-Administered Diet History Questionnaire, **DVS**=Dietary Variety Score, **SNAQ**=Simplified Nutritional Appetite Questionnaire

This may be due to the relatively high loss-to-follow-up rates in Nakagawa 2024 and Hironaka 2020, as well as their focus on path analysis; Wei 2024's research may be related to the reverse scoring method as a tool for assessing nutritional status. After the aforementioned literature, a meta-analysis was conducted again, and the results showed no significant heterogeneity among the studies(I^2=10%,P=0.35).Therefore, using a fixed-effects model for analysis, the results indicate that compared to older adults with good oral health, those with oral frailty have a significantly increased risk of malnutrition (*OR*=1.93, 95% *CI*: 1.62-2.30), with the difference being statistically significant (Z=7.27, P<0.001), as shown in Figure 3.

3.4. Subgroup Analysis

Subgroup analysis of the 8 included studies was conducted based on publication time, research region, research methods, and sample size. The results showed that the research method of cohort studies showed no significant heterogeneity; the main sources of heterogeneity include studies published in

2020 or later, studies conducted in Japan, cross-sectional research methods, and sample sizes greater than 1000, as shown in Table 3.

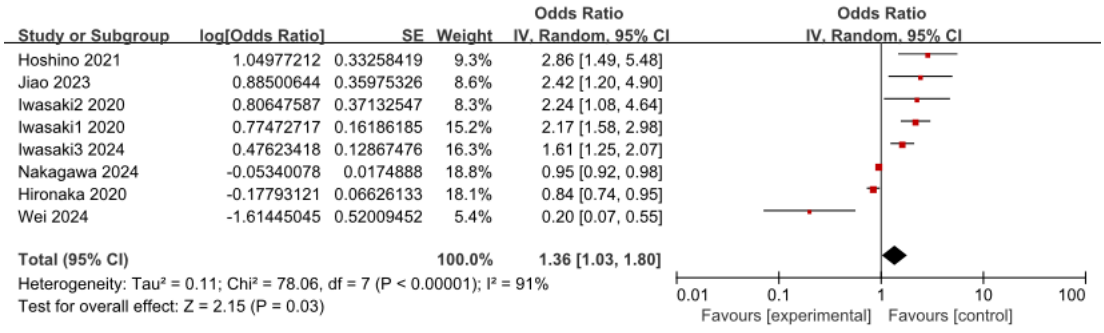

Figure 2. Forest plot of oral frailty and nutritional status in the elderly

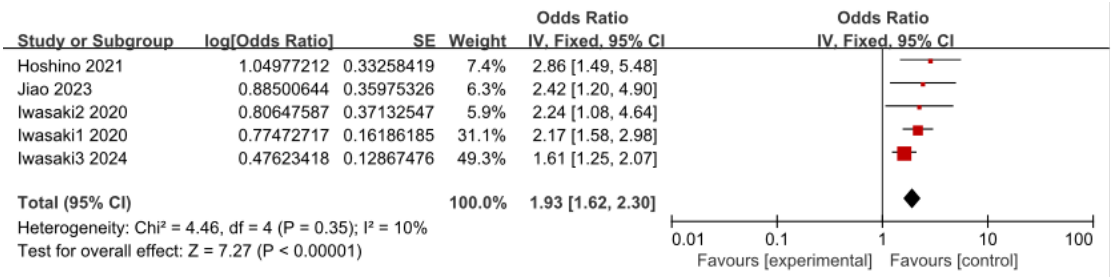

Figure 3. Forest plot of oral frailty and nutritional status in the elderly

Table 3. Subgroup Analysis of the Correlation Between Oral Frailty and Nutritional Status

Subgroup	Number of studies	Heterogeneity Test		Effect Model	Effect size	
		I2(%)	P-value		OR (95%CI)	P-value
Publication time						
≤2020	3	94	<0.001	Random	1.54 [0.71−3.35]	0.27
>2020	5	91	<0.001	Random	1.28 [0.77−2.12]	0.34
Study area						
China	2	94	<0.001	Random	0.71 [0.06−8.27]	0.79
Japan	6	92	<0.001	Random	1.43 [1.08−1.89]	0.01
Sample size						
≤1000	3	89	<0.001	Random	1.27 [0.60−2.67]	0.54
>1000	5	95	<0.001	Random	1.47 [0.86−2.50]	0.16

3.5. Sensitivity Analysis and Publication Bias

Sensitivity analysis of the included literature showed no significant changes in the I^2 value and *OR* value, indicating good stability of the meta-analysis results in this study. The funnel plot indicates a certain degree of asymmetry in the included studies, as shown in Figure 4. Therefore, Egger's test was conducted using Stata software, and the results indicate a low likelihood of publication bias (t=1.59, P=0.164).

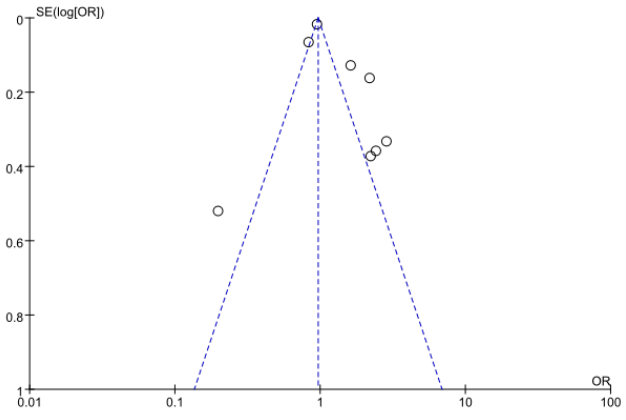

Figure 4. Funnel Plot Assessing Publication Bias

4. Discussion

The study included a total of 8 articles, with 7,234 participants, most of which were from China and Japan. Controlling for multiple potential confounders, the meta-analytic findings demonstrate a statistically significant association between oral frailty and nutritional indicators among older adults. (*OR*=1.93, 95% *CI*:1.62–2.30). Nutritional status is a risk factor for oral frailty among the elderly, as supported by Liu's study[25].

A bidirectional causal pathway exists between deteriorating oral function and compromised nutritional metrics in geriatric populations, mediated by sarcopenia and systemic inflammation. Malnutrition can severely impact the oral health and quality of life of older adults, while oral health, in turn, may affect their dietary intake and nutritional status[26]. On one hand, elderly individuals with oral frailty experience physiological changes such as reduced tongue pressure and decreased chewing ability, leading to changes in dietary preferences, reduced intake of vitamins, proteins, trace elements, and minerals, ultimately increasing the risk of malnutrition[27-30].From a pathophysiological perspective, as factors such as the decline in immunity and the increase in medication use among the elderly occur, symptoms like dry

mouth and periodontal disease frequently arise. This leads to an increased risk of infections and inflammation in older adults, thereby affecting immune responses[31, 32].Nutrition is a key factor in immune response, and nutritional deficiencies can impair immune responses and make individuals more susceptible to infections[33, 34].

On the other hand, nutritional status affects the occurrence of oral frailty. Nutrient intake influences immune regulation in the elderly[35].Nomura et al shows that nutritional intake, particularly the consumption of vitamins, affects oral health behaviors in the elderly population[12].Tani et al found in a randomized controlled trial that increasing the intake of animal protein in orally frail elderly individuals can improve their tongue pressure status[36].Song et al.'s research indicates that 48.8% of the effect of oral frailty on behavior is mediated through nutritional pathways. The decreased consumption of nutrient-dense, harder-to-chew foods such as meat, fruits, and vegetables among the elderly may lead to deficiencies in essential nutrients required for muscle protein synthesis and overall muscle mass maintenance. This nutritional insufficiency can subsequently contribute to a decline in muscle strength and mass, thereby increasing the risk of adverse health outcomes in older adults[37]. The survey results for special populations also indicate that hemodialysis patients have low energy intake and low serum albumin levels, which contribute to a widespread state of malnutrition among these patients, leading to approximately 60% of hemodialysis patients experiencing oral frailty[38].

This subgroup analysis reveals heterogeneity in various aspects such as publication year, publication region, and sample size. The reasons for this heterogeneity may include: First, inconsistencies in baseline screening and investigation methods among the included populations. Six of the included studies utilized the OFI-6 for evaluation; however, the subgroup analysis results indicated considerable heterogeneity. This presence of heterogeneity raises concerns about the research quality of the included studies and the results obtained. For instance, in two articles published by Iwasaki[20], one conducted nutritional status screening while the other did not; Hoshino[22] research screened the baseline population for oral health status; Hironaka[19] study selected data from health check-ups at an elderly research institute, while Nakagawa[18] study involved data collection through distributing flyers, insurance cards, and displaying posters to elderly individuals. Second, the literature included in this study was published in China and Japan, which only covers Asian populations. There are differences in the understanding and emphasis on dietary habits and oral hygiene care between Chinese and Japanese people[39, 40].Research on oral frailty in Japan began early and has a high level of awareness. Japans health insurance covers dental treatment costs, placing greater emphasis on oral health status[41].Third, there is a significant variation in the sample sizes included in this study, and larger sample sizes generally enhance the accuracy of research and affect the power of statistical tests. Fourth, this paper predominantly includes cross-sectional studies, where data collection is influenced by various confounding factors, and the research tools are mostly subjective, leading to considerable heterogeneity in the results.

5. Limitations

The number of studies included in this research is relatively limited, and the majority of them are cross-sectional in design. Such study types do not allow for an in-depth analysis or exploration of oral frailty and nutritional status. Furthermore, the sources of the included literature are not sufficiently diverse, and populations in regions such as Europe and America remain underrepresented, limiting the understanding of oral frailty and nutritional conditions in these areas. Lastly, the heterogeneity in research methodologies and the variation in confounding factors adjusted across studies may have introduced certain discrepancies in the reported findings.

6. Conclusion

This quantitative synthesis substantiates that geriatric nutritional risk escalates concomitantly with progressive decline in masticatory efficiency, necessitating integrated interventions targeting both domains within age-related frailty syndromes. However, the association between specific factors such as the number of remaining teeth and the decline in oral articulatory motor function with nutritional status remains unclear. Implementing standardized evaluative frameworks in subsequent research, alongside geriatrically optimized nutritional protocols, could mitigate population-level orofacial vulnerability prevalence.

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