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Original Research

Association between Poor Oral Health and Frailty in Middle-Aged and Older Individuals: A Cross-Sectional National Study

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Abstract

OBJECTIVES: Older adults with poor oral health may be at higher risk of being pre-frail or frail. However, very few studies have examined this association in Latin American countries and middle-aged individuals. Therefore, we aimed to investigate the association between oral health and frailty status among Chilean adults ≥40 years.

DESIGN: Cross-sectional study.

SETTING AND PARTICIPANTS: We included 3,036 participants ≥40 years from the Chilean National Health Survey 2016–2017.

METHODS: Frailty status was assessed with a 49-item frailty index, while the number of teeth, self-reported oral health, tooth decay, use of prostheses, and oral pain were the oral health conditions included. To assess the association between oral health conditions and frailty, we used multinomial logistic regression models status adjusted for sociodemographic and lifestyle variables.

RESULTS: Overall, 40.6% and 11.8% of individuals were classified as pre-frail and frail, respectively. After adjusting for confounders, individuals with ≤20 teeth had a higher likelihood of being frail (odds ratio (OR): 1.94 [95% CI: 1.18-3.20]) than people with >20 teeth. Moreover, people with bad or very bad oral health, as well as oral pain, had a higher likelihood of being pre-frail (OR: 2.04 [95% CI: 1.40-2.97] and OR: 2.92 [95% CI: 1.58-5.39], respectively). Middle-aged individuals with fewer teeth and poor self-reported oral health had a higher likelihood of being pre-frail and frail than people ≥60.

CONCLUSIONS AND IMPLICATIONS: Individuals with poor global oral health were more likely to be pre-frail or frail. This association seems to be stronger in people <60 years old. Our results are consistent with previously published reports.

Key words: Frail, oral health, middle-aged, older adults.

Introduction

While many definitions of frailty are available (1), there is a consensus to describe frailty as a biological syndrome characterized by reduced physiological reserve and higher vulnerability to stressors (2). This, in turn, leads to adverse health outcomes, including dependency, functional impairment, cognitive decline, and death (3, 4). Similarly, pre-frailty is hypothesized as an intermediate state between robustness and frailty and predisposes older adults to an increased risk of developing frailty (2).

Two of the most common instruments used to measure frailty are the Frailty Phenotype (FP) (3) and the Frailty Index (FI) (5). The FI is based on a detailed assessment by counting the number of accumulated deficits, and it is operationalized as a collection of symptoms and clinical signs, health behaviours, chronic diseases, psychosocial risk factors, cognitive impairments, and functional limitations (6). The FP, developed by Fried et al. (3) in 2001, identifies specific parameters that translate into a clinically relevant reduced physiological function. These five parameters are weakness, slowness, low level of physical activity, exhaustion/poor endurance, and unintentional weight loss. One remarkable weakness of the FP is that cognitive impairment – associated with functional decline and disability – is not included among its components (7).

Several chronic conditions are associated with frailty, including hypertension (8), chronic kidney disease (9), depression (10), diabetes mellitus (11), stroke (12), heart failure (13), coronary heart disease (14), myocardial infarction (15), respiratory diseases (16), among others. Poor oral health (refers to the health of the teeth, gums, and the entire oral-facial system related to smiling, speaking and chewing (17)) has also been linked to frailty, being highly prevalent in Asia, Europe, and North America among pre-frail and frail individuals (18, 19). However, the association with other components of oral health, such as the number of teeth, cavities, periodontal disease, and oral pain, remains controversial (20). Moreover, frailty and poor oral health are becoming more prevalent in middle-aged individuals, but evidence regarding its association with FI is limited (21, 22). In addition, previous studies used mainly the FP instead of the FI (19). Lastly, most of the evidence available to date comes from developed countries with limited evidence from developing economies such as Chile. Therefore, this study investigated the association between oral health conditions and frailty status among Chilean adults ≥40 years.

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Material and methods

Participants

This cross-sectional study was based on data from the Chilean National Health Survey conducted between 2016 and 2017 (CNHS 2016–2017). The CNHS 2016-2017 is a large, nationally representative population-based study of biological and lifestyle risk factors, dietary status, and health status conducted every six years in urban and rural zones. Data for this survey were collected by trained staff, where participants were administered questionnaires, and anthropometrical and physiological measures were obtained. The CNHS 2016–2017 was funded by the Chilean Ministry of Health and approved by the Ethics Research Committee of the School of Medicine at the Pontificia Universidad Católica de Chile (No. 16–019) (23).

In brief, 3,036 (74.7%) out of 4,063 participants older than 40 years had complete data for all the variables and were included in the analysis. To weight the sample at the national level, expansion factors suggested by the CNHS 2016–2017 were applied, resulting in an expanded sample of 6,572,447 individuals. All participants provided written consent before participation (23).

Frailty index

We developed a 49-items frailty index following standard procedures described by Searle et al. (24). Briefly, to be considered a deficit, a variable must satisfy the following criteria: i) their prevalence should increase with age; ii) be associated with health status; iii) not saturate too early or have a very low prevalence. The FI included deficits that covered multiple systems: comorbidities, functional limitations, self-report of mental health, health and status, physical activity, and others. All deficits were scored between 0 and 1, where 0 indicates the absence of the deficit and 1 the presence of a deficit. In addition, when an intermediate category was identified, this was categorized as 0.5. A frailty score was calculated for each participant by dividing the sum of the health deficit scores by the total number of health deficits assessed. The resulting value represents the FI, expressed as a fraction. From the continuous score, we created three categories following the cut-off points proposed by Rockwood et al. (25): i) <0.12 points, "robust"; ii) >0.12 to 0.24 points, "pre-frail"; and iii) >0.24 "frail". More information about all the variables and cut-off points included is available in Table A1.

Oral health conditions

In this version of the CNHS, nurses were trained by nine dentists – through a demonstration, a dental examination practice, and a final test with twenty clinical cases. Individuals underwent a comprehensive interview and clinical evaluation, including examining oral conditions performed by trained professionals. The average test score was 49.95 (2.74) and interexaminer reliability was substantial (kappa=0.85, p-value <0.01) (26).

The clinical examination included the count of remaining natural teeth in the mouth (0-32 teeth). The number of teeth was categorized as the presence of i) 0 to 20 teeth, and ii) more than 20 teeth. Self-reported Oral Health was assessed based on the following question: 'in general, would you say your oral health is?' The answers were dichotomized as: i) very good, good, or fair, and ii) bad, or very bad. Dental Prostheses Use (yes/no), and Tooth Decay (yes/no) were obtained from the clinical examination performed by the health professional. Oral pain was assessed using the following question: 'are my teeth the cause of suffering and pain?' The answers were codified as yes or no. Each of these variables was used independently to assess oral health.

Sociodemographic and lifestyle covariates

Self-reported data for sociodemographic characteristics, including age, sex, education, and place of residency, were collected from all participants using questionnaires previously validated for the CNHS 2016–2017 (23). The following categories were derived for the sociodemographic variables: age (40-49, 50-59, 60-69, 70-79, and ≥80), sex (men and women), education level (≤8 years, 9-12 years, and >12 years), and smoking (never, former, and current). A healthy eating score was created to assess diet quality based on the consumption of six food items: seafood, whole grain, dairy products, fruits, vegetables and legumes (27). The answers for each item were scored according to the recommendations of national dietary guidelines, from zero (for no compliance) to two points (for complete compliance) (27). The healthy eating score ranged from 0 to 12 points and was categorized into three levels: healthy adherence to a healthy diet (≥9), average adherence (5–8) and unhealthy adherence to a healthy diet (≤4). Alcohol consumption was self-reported and collected using the "Alcohol Use Disorders Identification Test" (AUDIT) questionnaire developed by the World Health Organization (WHO) (24) and adapted for the Chilean population (25).

Statistical analyses

Descriptive characteristics were stratified by frailty status and reported as percentages with their 95% confidence intervals (95% CI) for categorical variables. Continuous variables were expressed as the mean and standard deviation with their respective 95% CI. Multinomial logistic regression models were performed to assess the association between oral health conditions and frailty status. We used the "robust" category as the reference in all the models (pre-frail vs robust and frail vs robust). Three models were performed: Model 1: unadjusted: Model 2, adjusted for sex, age, level of education, and Model 3: as per model 2 and additionally adjusted for smoking status, alcohol intake, and diet quality.

Finally, multinomial regression logistics stratified by age (<60 and ≥60 years) were carried out to assess the differences between oral health conditions and frailty status (pre-frail vs. frail individuals). All statistical analyses were performed using STATA V17 software and survey weights provided by the

Table 1. Demographic characteristics and oral health conditions of study participants according to frailty status

	Robust % (95%CI)	Pre-Frail % (95%CI)	Frail % (95%CI)
All Age groups (%)	47.6 (44.2-50.9)	40.6 (37.3-44.1)	11.8 (10.1-13.8)
40-49	41.9 (37.3-46.7)	22.6 (18.7-27.2)	8.4 (4.7-14.6)
50-59	30.4 (26.2-35.1)	33.6 (28.8-38.8)	25.7 (18.6-34.4)
60-69	19.7 (16-24)	26.1 (22.2-30.5)	28.9 (21.8-37.2)
70-79	6.8 (5.1-9.1)	12.8 (10.5-15.4)	17.8 (13-23.9)
80 and older	1.1 (0.6-2.1)	4.9 (3.4-7.1)	19.1 (13.1-26.9)
Mean age (SD) Sex (%)	55.4 (10.8)	62.2 (11.9)	67.8 (12.2)
Female	41.5 (36.9-46.3)	58.2 (53.4-62.9)	69.8 (61.1-77.3)
Male	58.4 (53.6-63.1)	41.7 (37.1-46.5)	30.1 (22.7-38.9)
Educational Level (%)			
≤8 years	17.8 (14.7-21.3)	32.6 (28.3-37.3)	48.6 (40.2-57.1)
9-12 years	57.6 (53.1-62.2)	52.2 (46.9-57.5)	41.6 (33.1-50.6)
>12 years	24.5 (20.4-29.2)	15.2 (11.2-20.1)	9.7 (5.8-15.9)
Smoking Status (%)			
Never	29.9 (25.6-34.6)	23.4 (19.3-28.1)	18.9 (13.2-26.21)
Previous	29.6 (25.1-34.5)	34.6 (29.8-39.7)	32.2 (25.2-40.1)
Current	32.2 (25.2-40.1)	41.9 (37.1-47.1)	48.8 (40.3-57.5)
Urban vs Rural (%)			
Urban	87.1 (84.3-89.3)	86.1 (83.2-88.6)	87.8 (83.4-91.1)
Rural	12.9 (10.7-15.6)	13.9 (11.4-16.7)	12.2 (8.9-16.5)
Diet Quality (%)			
Unhealthy	36.6 (32.1-41.4)	35.8 (31.1-40.9)	32.6 (25.3-40.8)
Average	51.6 (46.7-56.5)	54.7 (49.5-59.9)	62.7 (54.4-70.3)
Healthy	11.7 (8.7-15.3)	9.3 (6.5-13.1)	4.6 (2.7-7.7)
Alcohol Intake (%)			
Low Intake	71.1 (66.5-75.1)	61.8 (56.9-66.4)	51.1 (42.6-59.5)
High Intake	28.9 (24.8-33.4)	38.2 (33.5-43.1)	48.8 (40.4-57.3)
Self-rated oral health (%)			
Very good	2.5 (1.4-4.4)	1.7 (1.1-3.1)	1.3 (0.2-7.9)
Good	45.8 (41.1-50.7)	28.5 (24.2-33.3)	29.5 (21.6-39.1)
Fair	40.1 (35.2-45.1)	45.3 (40.4-50.3)	40.1 (32.4-48.6)
Bad	10.4 (8.1-13.2)	20.7 (17.1-24.9)	24.3 (18.5-31.2)
Very Bad	1.2 (0.5-2.4)	3.5 (1.9-6.4)	4.5 (2.2-8.9)
Number of teeth (mean, SD)	19 (8.9)	14.8 (9.6)	10.9 (9.4)
Edentulous (%) Number of teeth (%)	4.9 (3.3-7.1)	8.7 (6.6-11.6)	20.2 (13.9-28.5)
0 to 20 teeth	35(30.6-39.6)	55.1 (49.9-59.9)	72.1 (63.4-79.4)
More than 20	64.9(60.4-69.3)	44.9 (40-50)	27.8 (20.5-36.6)
Dental Protheses Use (%)	29.1(24.9-33.8)	44.4 (39.2-49.7)	61.7 (53.5-69.3)
Tooth decay, yes (%)	56.6(51.5-61.6)	56.1 (51.1-60.7)	47.5 (39.1-56.2)
Tooth pain, yes (%)	2.1(1.3-3.6)	7.1 (5.2-9.8)	14.5 (9.9-20.6)

Continuous variables are expressed as mean and standard deviation (SD). Categorical variables as percentages with their 95% confidence intervals (95%CI).

Table 2. Multinomial logistic regression model for oral health conditions and their association with frailty status

	Pre-Frail vs. Robust								
	Model 1			Model 2			Model 3		
	OR	95%CI	p-value	OR	95%CI	P-value	OR	95%CI	p-value
Number of teeth									
>20 teeth		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
0 to 20 teeth	2.27	(1.71-3.01)	<0.001	1.51	(1.09-2.10)	0.009	1.50	(1.09-2.09)	0.012
Self-rated oral health									
Very good, good, fair		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
Bad, very bad	2.44	(1.72-3.47)	<0.001	2.03	(1.39-2.97)	<0.001	2.04	(1.40-2.97)	<0.001
Tooth decay									
No		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
Yes	0.97	(0.73-1.29)	0.861	1.25	(0.92-1.72)	0.149	1.26	(0.92-1.73)	0.137
Oral pain, yes									
No		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
Yes	3.46	(1.87-6.38)	<0.001	2.95	(1.59-5.48)	0.001	2.92	(1.58-5.39)	<0.001
	Frail vs. Robust								
	Model 1			Model 2			Model 3		
	OR	95%CI	p-value	OR	95%CI	P-value	OR	95%CI	p-value
Number of teeth									
>20 teeth		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
0 to 20 teeth	2.27	(1.71-3.01)	<0.001	1.97	(1.20-3.23)	0.018	1.94	(1.18-3.20)	0.031
Self-rated oral health									
Very good, good, fair		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
Bad, very bad	3.08	(2.04-4.67)	<0.001	2.7	(1.69-4.32)	0.001	2.61	(1.63-4.18)	<0.001
Tooth decay									
No		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
Yes	0.69	(0.46-1.02)	0.069	1.26	(0.82-1.92)	0.282	1.28	(0.84-1.96)	0.253
Oral pain, yes									
No		1.00 (Ref.)			1.00 (Ref.)			1.00 (Ref.)	
Yes	7.62	(3.87-14.9)	<0.001	5.97	(2.75-12.96)	0.001	5.96	(2.78-12.76)	<0.001

N= 3,306, representing 6,527,448 individuals aged 40 years and older; Model 1: Unadjusted; Model 2: Adjusted for sex, age, and level of education; Model 3: Additionally adjusted for smoking status, alcohol intake and diet quality.; A p-value below 0.05 was considered statistically significant.

CNHS 2016–2017 (StataCorp; College Station, TX). A p-value below 0.05 was considered statistically significant.

Results

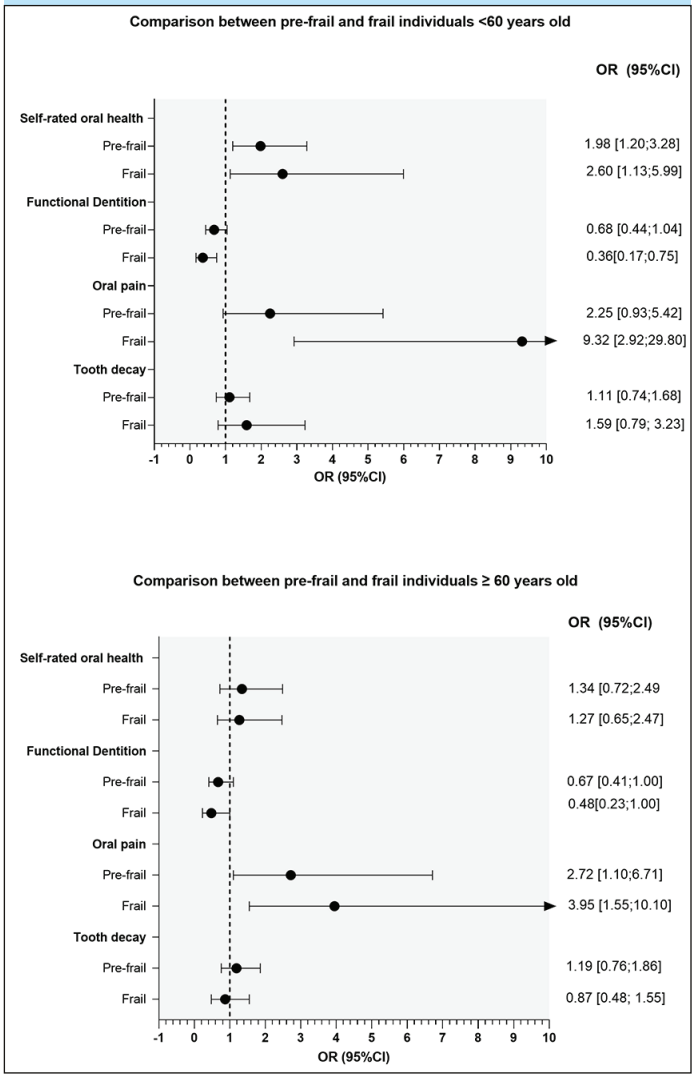
Table 1 shows the general demographic characteristics and oral health conditions by the frailty categories. Briefly, 40.6% (95% CI: 37.3-44.1) and 11.8% (95% CI: 10.1-13.8) were classified as pre-frail and frail, respectively. Pre-frail and frail individuals were older, more likely to be women, current smokers and had ≤8 years of formal education than robust individuals. Pre-frail and frail individuals also showed lower diet quality and high alcohol intake. Regarding oral conditions, more than 28% of frail individuals reported having bad or very bad oral health, while this was self-reported in only 11% of robust people. The number of teeth was also fewer in pre-frail, and frail people, while the prevalence of oral pain was twice as high in frail than pre-frail individuals and seven times higher than robust people (Table 1).

The associations between oral health and frailty status are presented in Table 2. Compared to those with >20 teeth, people with ≤20 teeth were more likely to be pre-frail (OR: 2.27 [95% CI: 1.71 to 3.01]) in the unadjusted model. After adjustment for sociodemographic and lifestyle factors (models 2 and 3), the associations were attenuated but remained significant (OR model 3: 1.50 [95% CI: 1.09-2.09]). Likewise, individuals with a bad or very bad self-rated oral health, as well as those with oral pain, had a 2.04 [95% CI: 1.40 to 2.97] and 2.92-times [95% CI: 1.58 to 5.39] higher likelihood of being pre-frail that their respective counterparts (Model 3).

People with ≤20 teeth had a higher odd of being frail in the fully adjusted models (OR model 3: 1.94 [95% CI: 1.18 to

3.20]). Similarly, people who rated their oral health as bad or very bad (OR model 3: 2.61 [95% CI: 1.63 to 4.18]) and those who reported having oral pain (OR model 3: 5.96 [95% CI: 2.78 to 12.76]) had higher odds of being frail in the fully adjusted models. No association was observed between tooth decay, use of prostheses, and the odds of being pre-frail and frail, as shown in Table 2.

Figure 1. Comparison between pre-frail and frail individuals and oral health conditions by age group



Robust category used as reference group; Model adjusted for sex, level of education, smoking status, alcohol intake, and diet quality; OR: odds ratio, 95%CI: confidence intervals

Figure 1 compares pre-frail and frail individuals by oral health according to age (≥ and <60 years). Overall, younger individuals who reported bad or very bad oral health had a higher likelihood of being pre-frail and frail than those ≥60 years. Moreover, oral pain was associated with frailty both in younger and older than 60 years individuals, the likelihood was higher in people younger than 60 (OR: 9.32 [95% CI: 2.92 to 29.8]).

Discussion

Main findings

To the best of our knowledge, this is the first study exploring the association between oral health conditions and frailty status among the Chilean population. The results of this study highlighted that – in a nationally representative sample of Chilean people aged 40 and older – having less than 20 teeth, self-rated oral health (bad or very bad), and oral pain were associated with pre-frail and frail individuals. Moreover, these associations seem to be stronger in those <60 years.

One of the main findings of this study is the association between poor oral health and being pre-frail and frail in individuals <60 years. Few studies have analyzed this association in middle-aged people (28), focusing on older adults; however, poor oral health conditions, such as missing teeth, dental prostheses, and oral pain, may be prevalent in middle-aged people (21, 22). These findings emphasize that poor oral health may be a risk factor for being frail for older individuals and middle-aged individuals. Therefore, early detection of oral health problems, specifically in pre-frail individuals, may represent an opportunity to introduce effective management to improve outcomes in middle-aged individuals (29).

What is already known in this topic?

Even though the association between the number of teeth and frailty remains controversial, our study found that individuals with less than 20 teeth had higher odds of being pre-frail and frail. Similarly, positive associations between the number of teeth and frailty status are published (30–32). De Andrade et al. (30), in 1,374 older individuals from Brazil, found that people with more than 21 teeth had a lower chance of being frail (OR 0.25; 95% CI: 0.07 to 0.91). Likewise, Ramsay et al. (31) reported (N=1,622) that edentulous (absence of teeth) people had a higher odds of being frail (OR 1.63; 95% CI: 1.18 to 2.23) in their maximally adjusted model, whilst Gu et al. (32), identified that people without teeth, and those with 1 to 10 teeth, had significantly higher odds of being frail than those with 20 or more teeth after adjusting for confounders (OR 2.07 (95% CI: 1.53 to 2.80 and OR 1.77 (95% CI: 1.31 to 2.38), respectively). However, after adjustment for different covariates, no association between the number of teeth and being frail was reported by Watanabe et al. (33) nor Valdez et al. (34) using Fried´s criteria. In general, limited sample sizes, lack of control for important confounders, and different methods to assess exposure and outcome are some reasons that explain the discrepancies between these studies.

Our results agree with previous studies where self-rated oral health and oral pain were associated with frailty status. For instance, Kamdem et al. (35) and Everaars et al. (36) reported that older subjects with oral pain had significantly higher odds of being frail (OR: 1.72 (95% CI: 1.17 to 2.53) and OR 2.07 (95% CI: 1.52-2.81), respectively). Similarly, Shwe et al. (37), after adjusting for comorbidities and nutrition in the

multivariate analysis, showed that self-reported oral health was significantly associated with being frail (estimate -0.08, p-value= 0.019). In the United States, Hakeem et al. (38), analyzing older individuals, showed that for those who rated their oral health as fair and poor, the risk ratio of being frail was 1.30 (95% CI: 1.17-1.45) and 1.41 (95% CI: 1.28-1.54) respectively, compared to those who reported their oral health as excellent.

Potential mechanisms and implications

Although there is still no evidence of a causal effect between poor oral health and frailty, some variables are identified as potential mediators in this association (39). Theoretically, two mechanisms may serve as possible pathways through which some poor oral health conditions may lead to frailty: poor nutrition and chronic inflammation (20). Our study found a strong association between functional dentitions, self-rated oral health, oral pain, and frailty. The nutritional pathway may partially explain this since people who present fewer teeth, or have bad or very bad perceptions of their oral health as well as report oral pain, are more likely to change their food selection than people who do not report these issues (28). These changes in food selection translate into a limitation in the consumption of essential food groups and inadequate nutritional intake, which may harm health, leading to poor nutritional status and risk of malnutrition. The latter may progress to comorbidities and, consequent, frailty (40).

On the other hand, chronic inflammation is another mechanism that may serve as a potential pathway through which some oral health conditions may lead to frailty (41). Tooth loss may result from a previous or current oral bacterial infection, such as periodontal disease or tooth decay. Thus, the number of missing or remaining teeth may reflect the cumulative level of oral inflammation. A common source of low-grade chronic systemic inflammation leads to increased inflammatory cytokines and, finally, a link to pre-frailty and frailty (41, 42).

Finally, these findings highlighted the importance of oral health conditions when an exhaustive clinical examination might be limited or inexistent. In Chile, public dental care access is limited and unavailable for everyone. Data from the CNHS 2016-2017 showed that only 7.5% of older adults regularly attend dental visits, and we do not possess complete data for those who live in rural zones (43).

Strengths and Limitations

This is the first report exploring the association between oral health conditions and FI in Chile. Moreover, this study used representative data from the Chilean population, which allows generalizing the results of this article to all populations older than 40 years old. Frailty status was assessed using a FI that included questionaries and scales validated in the country and following standard procedures previously described (24), ensuring the validity and replicability of these findings.

However, this study has some limitations. First, due to the cross-sectional nature of this research, we cannot rule out reverse causation between oral health conditions and frailty status. Second, some variables such as comorbidities, functional limitations, diet quality, and oral health conditions were self-reported, which might be subject to recall bias and underestimate the prevalence of frailty and the consequent association with oral health conditions. However, trained health professionals assessed many of the oral health conditions in this study. Finally, although we tried to include as many confounders to adjust the models, we could not account for the potential unmeasured confounders, such as a detailed assessment of cognitive decline or the assessment of sarcopenia in the present study.

Conclusions and future research

This study showed that people with ≤20 teeth, with poor self-rated oral health, and oral pain were associated with pre-frailty and frailty in individuals aged 40 and older. This association seems to be stronger in people <60 years old. This study highlighted the importance of self-reported oral health and oral pain when a clinical examination is limited or inexistent, but also the importance of early detection of oral health problems in middle-aged people. Oral health may be an important predictor of being pre-frail and frail. More longitudinal studies, including younger people, potential mediators as biomarkers and nutritional variables, and using different ways to assess frailty are needed to understand the nature of this relationship.

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