

Determinants of anterior tooth loss in Chilean adults: data from the Chilean National Health Survey 2016–2017.

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Objective: To describe prevalence of anterior tooth loss and its determinants among Chilean people aged over 15 years. **Methods:** Cross-sectional study, using the sampling frame of the Chilean National Health Survey 2016–2017 (n=5473 participants). Multivariate logistic regressions were performed to obtain the prevalence and odds ratio (OR) for anterior tooth loss using a complex sampling method. We described anterior tooth loss affecting each jaw according to sex, age, educational level, urban/rural residence and having health insurance. **Results:** The odds of anterior tooth loss were 7.11 (95%CI: 4.57 – 10.78) and 4.84 (95%CI: 3.02 – 7.72) times higher for low-educated subjects compared to those with more educational, for the upper and lower jaw respectively. Also, the odds of anterior tooth loss for the upper jaw was 1.34 (CI 95%: 1.07 – 1.66) times higher in women, whereas for the lower jaw, no significant differences by sex were found (p-value 0.14). Adults having only the National Health Fund B insurance (FONASA B) had odds of losing one or more anterior teeth 2.43 (CI 95%: 1.34 – 4.39) times higher in the upper jaw and 2.08 (CI 95%: 1.03 - 4.20) in the lower jaw compared with those having Health Insurance Institutions (ISAPREs). **Conclusion:** Our study showed for the first time that anterior tooth loss is a widespread condition in Chile, with marked inequities by sex, age, educational level, and geographical area. People in the public health insurance system have a higher odds of anterior tooth loss.

Keywords: Prevalence, Educational level, Chile, Anterior tooth loss, National Health Survey

Introduction

Diseases of the oral cavity affect about 3.58 billion people worldwide, with untreated caries having the highest prevalence according to the last Global Burden of Disease Study (GBD 2016 Disease and Injury Incidence and Prevalence Collaborators, 2017). In adults, the main oral conditions are dental caries and periodontitis, which are chronic and multifactorial in nature. These conditions may progress over time and result in tooth loss. Worldwide, edentulism is the main cause of burden of disease due to oral conditions, and it impacts on the years lived with disability, having a burden similar or even higher than other non-communicable chronic conditions (GBD 2016 Disease and Injury Incidence and Prevalence Collaborators, 2017).

Tooth loss is a consequence of multiple causes including individual behaviours, such as poor oral hygiene or dietary habits. Some socioeconomic and political factors also explain tooth loss in populations, these are known as social determinants of health (Marmot and Bell, 2011). The socioeconomic and political context with social position and living/working/aging conditions results in social inequities (Peres *et al.*, 2019). Inequities in tooth loss have been reported in Chile (Margozzini *et al.*, 2020). The difference in health indicators is explained by the social gradient seen between and within countries, including oral conditions such as tooth loss (Marmot and Bell, 2011). Although tooth loss has decreased in

the general population over time, there are still differences in the distribution between sex, age, educational and socioeconomic level, which is explained by social determinants (Jordan *et al.*, 2021).

Tooth loss involves a diminution of the masticatory efficiency, capacity to smile, personal appearance, and social interaction (Friedman *et al.*, 2014). The presence of nine or fewer teeth can impact on the quality of life more than other conditions, such as cancer, arterial hypertension, and other non-communicable diseases (Kassebaum *et al.*, 2017). Similarly, fewer teeth are considered a risk marker for systemic conditions, such as cardiovascular diseases (Joshy *et al.*, 2016).

Tooth loss should not only be measured as the number of missing teeth but should also consider variables such as the position of missing teeth (Gerritsen *et al.*, 2010). The absence of one or more anterior teeth has a higher impact on the quality of life than the loss of premolars and molars (Worsley *et al.*, 2016). Anterior tooth loss directly influences physical appearance and facial aesthetics (Gerritsen *et al.*, 2010). People with fewer anterior teeth have difficulty chewing, talking, smiling, and communicating, thus reducing their chances of employment (Halasa-Rappel *et al.*, 2019). For these reasons, the number and distribution of missing teeth become an effective indicator of the health status of a specific population, and it should be incorporated in the formulation of health policies (Bernabé and Sheiham, 2014).

In Chile, the first cause of tooth loss among young people is tooth decay, whereas, for adults, it is chronic periodontitis (Arteaga *et al.*, 2009). As age advances, tooth loss also increases, with people aged 65 to 74 years reaching a mean of 15.8 missing teeth (Ministry of Health of Chile, 2010). According to the first Chilean dental survey and examination, the high prevalence of tooth loss is associated with age, educational level, income, and depression (Urzua *et al.*, 2012).

The Chilean national health system is mixed. A public health insurance called National Health Fund (FONASA) and a private health insurance referred to as Health Insurance Institutions (ISAPREs) coexist. FONASA offers a single package with coverage defined according to beneficiary groups classified by ascending level of income, beginning with group A, non-contributing because of lack of resources, to group D, the group with the highest contribution (Castillo-Laborde *et al.*, 2017). Most dental care treatments for edentulism are covered in Primary Health Care (PHC), which is part of the public health system, through dental programmes that provide removable dentures. However, it is unknown whether they are sufficient to cover the high-risk population with anterior tooth loss, since, according to our knowledge, there is no published evidence on anterior tooth loss and its determinants in Chile.

Research in other countries has determined the burden and determinants of anterior tooth loss in adults (NHANES, 2013; Jordan *et al.*, 2021). In Chile, three national health surveys (NHS) that included oral health status have been conducted (NHS, 2003; 2009-2010; 2016-2017). The last survey was the first that measured the absence of anterior teeth in Chile (Margozzini *et al.*, 2018). As the extent of this problem remains unknown, the aim of this study was to describe the prevalence of anterior tooth loss and to identify its determinants among Chilean people aged over 15 years.

Methods

The sampling frame of this cross-sectional study was obtained from the database of the 2016-2017 National Health Survey (NHS 2016-2017), which is freely available in the sectorial repository of population-based surveys at the Department of Epidemiology, in the Ministry of Health of Chile (MINSAL) (<http://epi.minsal.cl/encuestas-poblacionales/>). The sample size was 5473 participants, aged 15 years or over, who responded to the NHS 2016-2017 and submitted to a complete oral examination. Pregnant women and people that declined to participate during the house visit were excluded from the survey.

The NHS 2016-2017 applied a complex multi-stage cluster, stratified and random oversampling technique with national representativeness. Our analysis followed this complex sampling method and was performed by using the complex sample module of the software *Statistical Package for the Social Sciences* (IBM® SPSS®) v. 26.0 (Mac OS X) (SPSS Inc., Chicago IL, USA).

As compared with the first survey (NHS 2003), the NHS 2016-2017 incorporated an oral examination conducted by nurses who were previously calibrated by nine dentists selected by the Ministry of Health of Chile (kappa 0.85, value- $p < 0.01$). The oral examination included

an assessment of the number of remaining teeth in both jaws. Also, for the first time, the absence of anterior teeth in each jaw (yes/no) was recorded.

The following independent variables were considered as determinants: 1-sex: dichotomous variable registered according to the interviewer's perception of the participant's sex; 2- age: ordinal variable calculated based on the participant's birth date and grouped as '15 to 24 years', '25 to 44 years', '45 to 64 years' and '65 years and over'; 3- educational level: ordinal variable grouped into three categories, low (under 8 years of study), middle (from 8 to 12 years of study) and high (more than 12 years of study); 4- geographical area: dichotomous variable registered as urban or rural, according to the National Statistics Institute of Chile (INE), 5- health insurance: categorical variable consisting of five groups (FONASA A, B, C or D, and ISAPRE). The dependent variables were anterior tooth loss in each jaw. Also, we included the following adjustment variables: diabetes mellitus (yes/no), smoking (yes/no), and time since the last dental visit (months).

Prevalences and their confidence intervals of 95% (95% CI) were calculated with the SPSS program (IBM® SPSS®) v. 26.0 (Mac OS X) (SPSS Inc., Chicago IL, USA), using the Taylor linearization method (Wolter, 1985). First, crude prevalences of tooth loss and the corresponding confidence intervals (95% CI) were determined. Then, these values were compared with the proportions obtained by logistic regression models. Odds ratios (OR) were also calculated with multivariate models. The Chi-square test was performed to compare prevalences. A 2-tailed p -value of <0.05 was considered statistically significant.

The Scientific Ethics Committee of the Faculty of Medicine of Pontificia Universidad Católica de Chile, CEC-MedUC, approved the informed consent of the NHS 2016-2017, project number: 16-019. This committee (CEC-MedUC) also authorized the conduct of this study, protocol ID: 191122004. The confidentiality of personal information of the NHS 2016-2017 participants was duly protected during the analysis. In the case of participants under the age of 18, written informed consent was obtained from a responsible adult.

Results

A total of 5473 participants were included in the study, of which 3470 were female. Table 1 summarises the prevalence of anterior tooth loss in the upper jaw and its determinants. A significant association was found between each independent variable and the prevalence of anterior tooth loss. Women had an odds of 1.36 (CI 95%: 1.07 – 1.66) times higher of losing at least one or more upper anterior teeth than men. Anterior tooth loss was more common as age advanced, achieving 75.4% (95% CI: 70.0% - 80.1%) missing an anterior tooth in participants aged 65 years and over. The prevalence of anterior tooth loss in the upper jaw increased with fewer years of education, with the odds being 7.02 (95%CI: 4.57 – 10.78) times higher for low-educated subjects than those with a high educational level. Participants who lived in rural areas had odds of 1.97 (95% CI: 1.44 – 2.69) times higher of losing an upper anterior tooth than those living in urban areas.

Table 2 summarises the results for anterior tooth loss in the lower jaw. Age, educational level, and geographical area were related to anterior tooth loss. There were no significant differences in the odds for losing a lower anterior tooth between men and women ($p = 0.14$). People aged over 65 years had odds for losing a lower anterior tooth of 19.06 (95% CI: 9.55 – 38.04) times greater than people aged 15 to 24 years. Higher prevalence of anterior tooth loss in the mandible was observed with lower educational level. Participants with a low educational level had an odds for losing a lower anterior tooth of 4.83 (CI 95%: 3.02 – 7.72) times greater than those with high educational attainment. Participants who lived in rural areas had an odds for losing at least one lower anterior tooth of 1.76 (95% IC: 1.20 – 2.58) times greater than participants living in an urban area.

The distribution of anterior tooth loss in both jaws by health insurance is shown in Table 3. After adjustments by sex, age, educational level, geographical area, diabetes mellitus, smoking, and time since the last dental visit, participants affiliated to the FONASA B level of

insurance had odds for losing an anterior tooth of 2.43 (CI 95%: 1.34 – 4.39) times greater in the upper jaw and 2.08 (CI 95%: 1.03 - 4.20) in the lower jaw compared with the ISAPRE group.

Discussion

In this study, anterior tooth loss was more common in the upper jaw in women, older people, those with a low educational level or living in rural geographical areas. The risk factors were similar in the lower jaw, except for the variable sex, which was unrelated to anterior tooth loss. Our findings agree with other studies supporting that women and older people have a higher prevalence of tooth loss (Ministry of Health of Chile, 2010). Furthermore, we found a gradient concerning educational achievement, as previously reported, even considering the position of missing teeth (Espinoza *et al.*, 2012; Margozzini *et al.*, 2020). The greater risk for anterior tooth loss in rural areas coincided with recent longitudinal studies in Chile (Ferreo *et al.*, 2020).

Table 1. Prevalence of anterior tooth loss in the upper jaw by age, sex, educational level, and geographical area. NHS 2016-17, Chile.

	<i>Sample size</i>	<i>Prevalence</i>	<i>CI 95%</i>	<i>OR*</i>	<i>CI 95% OR</i>
Men	200	25.4%	22.6% - 28.4%	1	-
Women	3470	32.6%	30.0% - 35.3%	1.34	1.07-1.66
15 – 24 years	728	4.2%	2.4% - 7.5%	1	-
25 – 44 years	1561	11.9%	9.7% - 14.5%	3.11	1.56-6.19
45 – 64 years	1836	45.6%	41.6% - 49.7%	14.13	7.48-26.6
65 years and over	1348	75.4%	70.0% - 80.1%	39.760	19.81-79.79
Low educational level	1329	71.1%	65.6% - 76.0%	7.02	4.57-10.78
Middle Educational level	2948	26.4%	23.8% - 29.2%	2.94	1.99-4.34
High educational level	1196	9.5%	7.1% - 12.6%	1	-
Urban	4602	26.8%	24.5% - 29.2%	1	-
Rural	871	47.7%	42.6% - 52.9%	1.97	1.44-2.69
Total	5473	29.1%	27.0% - 31.3%	-	-

*Multivariate logistic regression

Table 2. Prevalence of anterior tooth loss in the lower jaw by sex, age, educational level, and geographical area. NHS 2016-17, Chile.

	<i>Sample</i>	<i>Prevalence</i>	<i>CI 95%</i>	<i>OR*</i>	<i>CI 95% OR</i>
Men	2003	16.3%	13.9% - 19.1%	1	-
Women	3470	20.2%	18.2% - 22.5%	1.20	0.94-1.54
15 – 24 years	728	3.8%	2.1% - 7.0%	1	-
25 – 44 years	1561	5.8%	4.2% - 7.9%	1.50	0.72-3.10
45 – 64 years	1836	25.7%	22.2% - 29.5%	6.30	3.33-11.92
65 years and over	1348	57.6%	52.4% - 62.6%	19.06	9.55-38.04
Low educational level	1329	51.5%	46.5% - 56.5%	4.83	3.02-7.72
Middle educational level	2948	14.7%	12.5% - 17.2%	2.25	1.47-3.44
High educational level	1196	5.8%	4.0% - 8.3%	1	-
Urban	4602	16.6%	14.7% - 18.6%	1	-
Rural	871	32.5%	26.7% - 38.8%	1.76	1.20-2.58
Total	5473	18.3%	16.5% - 20.3%	-	-

*Multivariate logistic Regression

Table 3. Prevalence of anterior tooth loss in maxilla and mandible by type of health insurance. NHS 2016-17, Chile.

		<i>Sample</i>	<i>Prevalence</i>	<i>CI 95%</i>	<i>OR*</i>	<i>CI 95% OR</i>
Upper jaw	FONASA A¶	1342	37.7%	33.4% - 42.2%	1.78	0.96-3.33
	FONASA B¶	1484	44.3%	40.3% - 48.4%	2.43	1.34-4.39
	FONASA C¶	552	22.0%	17.1% - 27.8%	1.61	0.83-3.12
	FONASA D¶	532	17.7%	13.7% - 22.4%	0.95	0.50-1.78
	ISAPRE∞	499	13.3%	8.9% - 19.3%	1	-
	Total	5456	29.1%	27.1% - 31.5%	-	-
Lower jaw	FONASA A¶	1342	23.9%	20.3% - 27.8%	1.80	0.91 - 3.54
	FONASA B¶	1484	28.0%	24.2% - 32.2%	2.08	1.03-4.20
	FONASA C¶	552	12.9%	9.2% - 17.6%	1.80	0.83- 3.95
	FONASA D¶	532	12.6%	8.9% - 17.5%	1.47	0.68-3.19
	ISAPRE∞	499	6.7%	3.9% - 11.3%	1	-
	Total	5456	18.3%	16.5% - 20.3%	-	-

*Multivariate logistic regression

¶ FONASA: National Health Fund (public health system)

∞ ISAPRE: Health Insurance Institutions (private health insurance).

One explanation for the high prevalence of anterior tooth loss in Chile may be the dental coverage of public programmes that include removable prostheses. More accessible supply of prostheses has been associated with tooth loss due to extractions in interventionism and invasive care, especially in lower-middle- and low-income countries (Bernabé *et al.*, 2020). High-income countries have a greater burden of edentulism as prostheses may be more available and affordable (GBD 2016 Disease and Injury Incidence and Prevalence Collaborators, 2017). This trend may be expected to continue in developing countries such as Chile.

The gender difference for anterior tooth loss could be related to women having greater access to dental healthcare programmes (Ortuno *et al.*, 2020); therefore, having a greater likelihood of the ‘tooth death spiral’ (Bernabé *et al.*, 2020)

The FONASA B insurance group had higher odds of anterior tooth loss in both jaws. Two possible factors may explain these results. First, individuals in FONASA B are older than those from other FONASA groups (FONASA, 2019). Secondly, most FONASA B beneficiaries receive dental prostheses with tooth extraction as part of pre-prosthetic treatments (Ortuno *et al.*, 2020). Also, previous studies have compared the burden of disease between FONASA and ISAPRE and concluded that the need for dental prostheses was higher in individuals affiliated to FONASA, and that the beneficiaries of public health insurances were less inclined to access to specialized dental care than those affiliated to ISAPRE (Castillo-Laborde *et al.*, 2017). As determinants of tooth loss, they should be monitored through future versions of the national health surveys, both in Chile and in countries with mixed health systems.

In Chile and countries with similar health systems, programs focusing on anterior tooth loss should be implemented, targeting high-risk groups. These programmes should aim to rehabilitate anterior tooth loss, and prevent oral diseases in their early stages, with non-invasive strategies such as atraumatic restorative treatment or

silver diamine fluoride (Innes *et al.*, 2019). Our results suggest that there is a need for public policies focused on preventive strategies to reduce social gradients in the number of missing anterior teeth, especially in women, people of low educational level, older age, and/or who live in rural areas (Fukuhara *et al.*, 2020). Alternative treatments for anterior tooth loss should be evaluated at clinical level, including the use of fixed dentures or implant-supported removable dentures (Zahedi, 2016).

A limitation of the NHS 2016-2017 was that it recorded anterior tooth loss dichotomously (yes/no) without specifying the number or position of the missing teeth, unlike other population-based studies, for example, the Maule Population Cohort (MAUCOS) (Ferrecio *et al.*, 2020) and the National Health and Nutrition Examination Survey (NHANES), whose unit of analysis was the tooth (NHANES, 2013). This dichotomous recording underestimates the extent of damage, because it assigns the same probability of being included in the group with tooth losses to an individual having one or more missing anterior teeth. A strength of this survey was that it recorded anterior tooth loss for each jaw, thus allowing to future analyses about the impact on the quality of life and functionality (Graziani *et al.*, 2020). Since this study has a cross-sectional design, it was not possible to attribute causal pathways. Another limitation is that the cause of anterior tooth loss, such as periodontal disease, tooth decay or trauma, was not determined.

Conclusion

Our study showed for the first time that anterior tooth loss is a widespread condition in Chile, with remarked inequities by sex, age, education level, and geographical area. Also, it reported that people in the public health insurance system, have higher odds of anterior tooth loss. We suggest that future population-based studies in Chile and other countries continue measuring anterior tooth losing order to facilitate multinational comparisons.

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