Number of remaining teeth and its association with educational level in Chilean adults: data from the National Health Survey 2016-2017

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Paula Margozzini
Pontificia Universidad Catolica de Chile

Rodrigo Berrios
Pontificia Universidad Catolica de Chile

Rosario García-Huidobro
Pontificia Universidad Catolica de Chile

Claudia Véliz
Pontificia Universidad Catolica de Chile

Carolina del Valle
Gobierno de Chile Ministerio de Salud

Juan Pablo Vargas
Pontificia Universidad Catolica de Chile

Oslando Padilla
Pontificia Universidad Catolica de Chile

Duniel Ortuno    drortuno@uc.cl
Pontificia Universidad Catolica de Chile

Corresponding Author
ORCID: 0000-0001-5425-5779

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Abstract

**Background:** Several population studies have addressed oral health inequity-related issues. Edentulism, functional dentition and number of remaining teeth have been linked to different socioeconomic level measurements. The aim of this study was to evaluate the association between educational level (EL) and tooth loss in the Chilean population aged 15 years old and above, based on the recent data collected from the 2016-2017 National Health Survey (ENS 2016-2017).

**Methods:** The sample for this cross-sectional study comprised 5473 subjects. The main independent variable in the study was educational level (LEL: low, MEL: medium, HEL: high). In order to measure tooth loss number of remaining teeth, edentulism and functional dentition were considered. Based on a multivariate logistic regression, it was possible to obtain *odds ratios* (OR) and, therefore, to assessing the condition of dentition according to the subject’s EL. As to the number of teeth variable, multiple linear regressions were conducted. The analyses were carried out in the SPSS 24.0 program considering the complex sampling design of ENS 2016-2017.

**Results:** When comparing LEL subjects with HEL subjects, the adjusted difference in the number of remaining teeth was 3.11 for maxilla and 1.72 for mandible. An individual with a LEL had a 7.51 [3.50-16.10] and 6.06 [2.68-13.68] times higher risk of upper edentulism and lower edentulism than a HEL individual respectively. Regarding functional dentition, the adjusted OR in HEL subjects was 13.33 [8.02-22.15] and in MEL subjects was 2.81 [2.03-3.87], compared to LEL results.

**Conclusions:** LEL was associated with a significant tooth loss in the Chilean population. Regardless of age, subjects with a LEL obtained a lower mean of number of remaining teeth, higher prevalence of edentulism and lower prevalence of functional dentition.
Background

Tooth loss is the main cause of burden of disease due to oral conditions in the world (1). As a result of the progression of untreated tooth decay or periodontitis, this problem has arisen (2). Tooth loss has been related to coronary artery disease (3), metabolic syndrome (4), obesity (5), diabetes (6), dementia (7) and some types of cancer (8-10). The consequences of tooth loss depend on the severity and intraoral location of the lost teeth (11). A lower number of teeth reduces the capacity for social interaction and the quality of life (12,13).

In order to measure tooth loss, a variety of parameters are used, including edentulism, functional dentition and number of remaining teeth (14). Edentulism is considered “the dental equivalent of mortality” (15) and also an independent factor to predict general mortality (16). The prevalence of edentulism is an independent indicator of oral health at the population level (17). Functional dentition is defined as the presence of at least twenty permanent teeth in an individual (18). Epidemiological surveillance of the number of teeth is essential for designing public policies (14). Also, this parameter is a strong predictor of the future need of professional attention (19).

In the last two decades, a decrease in the prevalence of severe tooth loss (having between 1 and 9 remaining teeth) has been reported (20). However, in USA and other countries, demographic growth and population ageing will have an effect on the slow reduction of the prevalence of edentulism (21). In Brazil, the rates of edentulism have continued almost unchanged between 2003 and 2010, whereas non-functional dentition is present in about a quarter of the older population (22). According to the first National Health Survey (ENS 2003) in Chile, the prevalence of edentulism was 5.5% [4.6-6.4], where women showed a higher tooth loss (23). Only 20% of the adult population between 35 and 44 y in Chile still has a complete denture, whereas in those subjects aged from 65
to 74 y, the prevalence was 1% (23). In Chilean women between 45 and 59 y, edentulism is the third specific cause of burden of disease, being 2.8 times higher than in men (24). Several population studies have addressed oral health inequity-related issues (25). Edentulism, functional dentition and number of remaining teeth have been linked to different socioeconomic level measurements (14,26-28). As to number of teeth, relevant socioeconomic gradients have been found in the United States (29) and other countries (30-31). According to Elani et al., Chile had a higher inequity gradient in terms of educational level (EL), functional dentition and the mean number of teeth (11), in comparison with Australia, Canada, New Zealand and the United States. EL is a determining factor for health level of the adult population (32). Individuals with a higher EL, self-report a better quality of oral health and have less risk of tooth loss (30). According to ENS 2003, tooth losses varied significantly according to EL (23). Population surveys have revealed socioeconomic inequalities in oral health; therefore, it is necessary to perform a new analysis in Chile, considering the recent publication of the results from the National Health Survey (ENS 2016-2017) (33). The aim of this study was to analyse the association between EL and tooth loss of the Chilean population, aged 15y and above, based on the ENS 2016-2017 data.

Methods

Survey overview:
This study worked on the data obtained from the ENS 2016-2017, which was conducted by the Ministry of Health of Chile. The ENS 2016-2017 is a tool for objective national epidemiological surveillance that focuses on noncommunicable diseases. This survey is a cross-sectional design, consisting of a complex random stratified and multistage cluster oversampling representative of Chilean national, regional and location levels. A number of
72 health problems and their determinants were assessed in the ENS 2016-2017, also providing information on the magnitude and distribution by sex, age, location and EL.

**Subjects:**

Data on all subjects recruited for the oral examination stage in the ENS 2016-2017 was used for this study, having a final sample size of 5473 subjects (missing data 47/5520). It included people aged 15y and above who were permanent residents of the selected households and had undergone a complete dental examination. Pregnant women and people with violent behaviour during on-site visits were excluded from the survey.

**Dental examination:**

The dental examination was performed by trained and calibrated nurses in their second home visit to the respondents, where the presence of cavitated caries, use of prosthesis and number of teeth were measured. A dental mirror, dental explorer and standard operation lamp were used. According to the pilot study ENS 2003 (n=105), sensitivity level to detect missing teeth and dental fillings was 70% (23) and inter-examiner reliability was substantial (kappa=0.75, p-value<0.01) (34).

In the ENS 2016-2017, nurses were trained by nine dentists, by means of a demonstration, a dental examination practice and a final test with twenty clinical cases. The test average score was 49.95 (+/- 2.74) and inter-examiner reliability was substantial (kappa=0.85, p-value<0.01) (34). The Nurses Manual and the Training Report for nurses are both available in the population survey repository of the Department of Epidemiology of the Ministry of Health of Chile: [http://epi.minsal.cl/encuestas-poblacionales/](http://epi.minsal.cl/encuestas-poblacionales/).

**Statistical Analysis:**

The analysis was carried out based on the ENS 2016-2017 data, available at [http://epi.minsal.cl/encuestas-poblacionales/](http://epi.minsal.cl/encuestas-poblacionales/). The estimations were performed using the complex sampling module of the program Statistical Package for the Social Sciences
The main independent variable of this study was EL. Based on the data obtained from the household socioeconomic module in the ENS 2016-2017, values for the highest EL or current EL and subjects’ last approved course were known. All this information was used to establish the total number of years of study, variable that was then categorized into: LEL (low educational level = less than 8 years), MEL (medium educational level = between 8 and 12 years) and HEL (high educational level = more than 12 years). For the adjusted comparisons, we included the variables sex, age and location (rural or urban levels).

The three dependent variables were number of remaining teeth in the maxilla and mandible, edentulism (total absence of teeth) in the maxilla and mandible and functional dentition. For the variables edentulism and functional dentition, adjusted prevalence with their respective 95% confidence intervals [CI 95%] were occupied, while for the variable number of remaining teeth the means were obtained with the respective standard errors.

To analyse the association between EL and edentulism, EL and functional dentition, Pearson’s chi-squared test and logistic regressions were employed. These models provided adjusted odds ratios (OR) with confidence intervals of 95% each. By using multiple linear models, it was possible to compare the mean number of remaining teeth by EL.

Results

Summary statistics of the participants are shown in Table 1. A number of 5473 subjects was included in the study, reporting a mean of 43.13 y, of which 63.4% were female. The respondent distribution by EL was 24.3% for LEL, 53.9% for MEL and 21.8% for HEL.

Table 1: Survey respondent general characteristics, (mean age: 43.13 y). ENS 2016-2017, Chile.
| Variables | (n, %) |
|-----------|--------|
| Gender    |        |
| Men       | 2003 (36.6) |
| Women     | 3470 (63.4) |
| Total     | 5473    |
| Age (years) |      |
| 15-24 y   | 728 (13.3) |
| 25-44 y   | 1561 (28.5) |
| 45-64 y   | 1836 (33.5) |
| 65 and above y | 1348 (24.7) |
| EL        |        |
| Low (LEL) | 1329 (24.3) |
| Medium (MEL) | 2948 (53.9) |
| High (HEL) | 1196 (21.8) |

EL Educational Level, n Sample Size.

1 - Number of remaining teeth:

The adjusted mean number of teeth in the maxilla was 10.88 [10.68-11.10] and in the mandible was 11.86 teeth [11.51-11.86]. In men, the mean number of upper teeth was 10.97 [10.65-11.28] and 12.0 [11.73-12.27] of lower teeth. In women, the mean number of upper teeth was 10.29 [9.99-10.58] and the mean number of lower teeth was 11.35 [11.09-11.6].

The adjusted difference in the number of teeth in the maxilla was 1.59 when comparing LEL with MEL subjects (p-value<0.001), whereas this difference increases up to 3.11 (p-value<0.001) between LEL and HEL subjects. A comparison between MEL and HEL subjects resulted in a difference of 1.52 teeth in the maxilla (p-value<0.001) (Table 2).

Table 2: Number of teeth in the maxilla and mandible according to EL, n=5473.

ENS 2016-2017, Chile.
| EL       | Number of teeth in the maxilla | Number of teeth in the mandible |
|----------|-------------------------------|---------------------------------|
|          | Mean  | Error  | CI 95%          | Mean  | Error  | CI 95%          |
| Low      |       |        |                 |       |        |                 |
|          | 9.06  | 0.321  | [8.43-9.69]     | 10.82 | 0.271  | [10.29-11.36]   |
| M (n=414)| 9.40  | 0.330  | [8.76-10.05]    | 11.15 | 0.280  | [10.60-11.70]   |
| W (n=915)| 8.72  | 0.325  | [8.08-9.36]     | 10.50 | 0.275  | [9.96-11.04]    |
| Medium   |       |        |                 |       |        |                 |
| M (n=1106)| 10.99 | 0.159  | [10.68-11.30]   | 11.98 | 0.133  | [11.71-12.25]   |
| W (n=1842)| 10.30 | 0.137  | [10.04-10.57]   | 11.33 | 0.124  | [11.09-11.59]   |
| High     |       |        |                 |       |        |                 |
| M (n=483)| 12.51 | 0.189  | [12.14-12.88]   | 12.87 | 0.142  | [12.59-13.15]   |
| W (n=713)| 11.83 | 0.190  | [11.46-12.20]   | 12.22 | 0.143  | [11.94-12.56]   |

Adjusted models by age, sex and location. M men, W women, EL educational level.

With respect to the mandible, the adjusted difference was 0.83 when comparing LEL and MEL subjects (p-value<0.001). Between LEL and HEL subjects, the difference was 1.72 teeth (p-value<0.001). When MEL and HEL subjects, the mean difference obtained was 0.89 teeth in the mandible (p-value<0.001) (Table 2).

In men with a HEL, the adjusted mean of upper teeth was 12.51 [12.14-12.88], whereas in those with a LEL it was 9.40 [8.76-10.05]. In women with a HEL, the mean of upper teeth was 11.83 [11.46-12.20], but in those with a LEL decreased to 8.72 [8.08-9.36]. In men with a HEL, the mean of lower teeth was 12.87 [12.59-13.15], and in those with a LEL it was 11.15 [10.60-11.70]. In women, the difference in lower teeth between HEL with LEL (p-value<0.001) amounted to 1.72. When comparing the number of remaining teeth between men and women, according to EL, statistically significant differences were found in both, the maxilla and mandible (p-value<0.001) (Table 2).

2 - Edentulism:

The adjusted prevalence of edentulism in the maxilla was 8.92% [8.25-9.59], whereas in the mandible it was 5.36% [4.91-5.81]. The prevalence of upper edentulism was 9.60% [8.82-10.38] in men and 16.56% [15.58-17.54] in women. As to the mandible, the
prevalence of edentulism was 5.67% [5.06-6.28%] and 9.84% [9.05-10.63%] in men and in women, respectively. Women showed an edentulism OR of 2.42 [1.71-3.42] for the maxilla and 2.30 [1.50-3.53] for the mandible in relation to men.

A MEL individual had a 3.36 [1.50-7.52] times higher risk of edentulism than a HEL individual, while a LEL individual had a 7.51 [3.50-16.10] times higher risk of having no teeth than a HEL individual (Table 3). As to the mandible, a MEL individual had a 3.07 [1.33-7.09] times higher risk of edentulism than a HEL individual. Moreover, the same risk increases up to 6.06 [2.68-13.68] in a LEL subject compared to a HEL individual (Table 4).

In men with LEL, the prevalence of upper edentulism was 23.41% [19.56-27.26], whereas in those with a MEL and HEL it was 3.8% [3.34-4.43] and 1.50% [0.09-2.08], respectively.

In women, the prevalence of upper edentulism was 42.35% [38.71-45.99] for LEL, 6.30% [5.55-7.05] for MEL and 1.02% [0.07-1.30] for HEL. All differences in the prevalence described above were statistically significant (p-value<0.001) (Table 3).

In men with LEL, the prevalence of lower edentulism was 15.12% [12.31-17.94], in those with a MEL was 1.83% [1.56-2.10] and to those with a HEL it was only 0.06% [0.03-0.08].

The prevalence of lower edentulism in women was 25.40% [22.82-27.9] for LEL, 4.03% [3.53-4.5] for MEL and 0.09% [0.07-1.18] for HEL. All differences were statistically significant after the adjustments (p-value<0.001) (Table 4).

**Table 3: Prevalence of edentulism in the maxilla according to EL, n=5473, ENS 2016-2017, Chile.**

| EL     | Prevalence | CI 95%      | OR     | CI 95%      |
|--------|------------|-------------|--------|-------------|
| Low    | 32.88      | [31.63-34.12]| 7.51   | [3.50-16.10]|
Adjusted models by age, sex and location. M men, W women, EL educational level.

**Table 4: Prevalence of edentulism in the mandible according to EL, n=5473. ENS 2016-2017, Chile.**

| EL   | Prevalence | CI 95%      | OR  | CI 95%      |
|------|------------|-------------|-----|-------------|
| Low  | 21.19      | [19.24-23.14] | 6.06 | [2.68-13.68] |
| M (n=414) | 15.12    | [12.31-17.94] |      |             |
| W (n=915) | 25.40    | [22.82-27.98] |      |             |
| Medium | 2.97      | [2.65-3.28]  | 3.07 | [1.33-7.09] |
| M (n=1106) | 1.83     | [1.56-2.10]  |      |             |
| W (n=1842) | 4.03     | [3.53-4.53]  |      |             |
| High  | 0.07      | [0.05-0.09]  | 1   |             |
| M (n=483) | 0.06     | [0.03-0.08]  |      |             |
| W (n=713) | 0.09     | [0.07-1.18]  |      |             |

Adjusted models by age, sex and location. M men, W women, EL educational level.

### 3 - Functional Dentition:

The adjusted prevalence of functional dentition was 75.30% [73.98-76.62] and the OR between men and women was 1.50 [1.14-1.96]. In terms of EL, the prevalence was 28.82% [25.51-32.13] for LEL, 79.53% [78.18-80.88] for MEL and 94.42% [93.23-95.61] for HEL. Comparing LEL subjects (OR=1) with MEL and HEL subjects, the obtained OR were 2.81 [2.03-3.87] and 13.33 [8.02-22.15], respectively (Table 5).

In men, the prevalence of functional dentition was 31.83% [26.04-37.61] for LEL, 82.20% [80.36-84.04] for MEL and 94.50% [92.83-96.15] for HEL. In women, the prevalence of functional dentition was 26.74% [22.86-30.62] for LEL and amounted to 94.34% [93.06-95.63] in those with a HEL (Table 5).

**Table 5: Prevalence of functional dentition according to EL, n=5473. ENS 2016-2017, Chile.**
Adjusted models by age, sex and location. M men, W women, EL educational level.

**Discussion**

The aim of this study was to assess the effect of EL on tooth loss based on the ENS 2016-2017 data. The results confirmed the hypothesis that there is an educational gradient, where individuals with a LEL have the worst levels of edentulism, number of teeth and functional dentition. This tendency was observed in men and women, reporting a major difference in the maxilla. Our findings confirm results of many other studies where an increase in EL was inversely associated with tooth loss (35-37).

Subjects with a HEL showed better conditions in terms of number of teeth. This is consistent with that a HEL relates to a higher self-control of health behaviours (38). Knowledge and skills acquired through years of study have a positive influence on how people consider educational information and access to health services (39). In this study, education was measured as a categorical variable, thereby acknowledging the relevance of educational achievements, which in turn would explain the better oral health levels (40). One limitation of our study was that this variable does not measure the quality of educational experiences, which is quite important to specify the role of education in health outcomes (40).

Other studies have concluded that inequities in oral health are not limited to individual factors, such as treatment adherence or self-care behaviours (41). Preventive interventions based on an individual approach have not been sufficient to reduce...
inequities relating to tooth loss (42). On the other hand, preventive interventions that focus on population aim at addressing disease causes, changing determinants concerning environmental, psychosocial, economic and political aspects (43). A strategical combination of high-risk and population preventive approaches, is necessary to reduce inequities in oral health in Chile and the world (44).

According to the ENS 2003, the prevalence of edentulism for LEL subjects was 10.30%, whereas for MEL and HEL individuals were 1.60% and 0.30%, respectively (23). These trends agree with the results of our study, which means that inequities have persisted despite the implementation of new oral health programs. Although the national prevalence of non-functional dentition decreased from 32.30% to 24.70% between 2003 and 2017, the differences in oral health outcomes according to EL, have increased. This situation of strong inequities in Chile, presents the challenge of establishing a major approach on the social determinants of oral health.

On the other hand, dental extraction continues to be a common alternative of dental care in the Chilean oral health programs. It is the same reality that can be found in other countries, where despite the reduction of the prevalence and severity of caries, excessive indications for dental extractions lead to a lower number of teeth (45). In addition, the educational items of oral health programs impact differently on the varied social groups, increasing inequities in oral health (46).

The observed educational gradient is also visible in other chronic conditions, such as hypertension, dyslipidaemia, obesity, among others, in Chile (33). The mean higher age of people with LEL could partially explained the social gradient in the dental outcomes. However, our analyses showed significant gradients even after adjusting for age. It is necessary to study other factors that determine that the socially more vulnerable strata have a higher burden of morbidity in Chile. Moreover, there is a need to implement
comprehensive public health policies which focus on risk factors shared with chronic disease, and thus consider oral health as an integral part of the general health (47). The main limitation of this study was the impossibility of establishing strong causation. Education, unlike occupation or income, is a stable indicator of socioeconomic position, less prone to the reverse causation phenomenon. Another limitation was that other indicators of socioeconomic position were not included. The use of different indicators of socioeconomic position probably would result in gradients with similar slopes (40). A third limitation was that although the participants were classified into three groups of EL, the specific effect according to birth cohort has not been established. This fact may produce a bias of overrepresentation of subjects that belong to higher age cohorts with LEL (48). Finally, we recognised that analyses of population data will never provide a perfect explanation of inequalities (49).

Conclusions

The results of this study showed that LEL was associated with an increased burden of tooth loss in the Chilean population. Subjects with a LEL had a lower mean number of remaining teeth, higher prevalence of edentulism and lower prevalence of functional dentition, independent of age. The educational gradient relating to oral health still remains in Chilean individuals; therefore, it is necessary to reorient public health policies for arrest inequities.

Abbreviations

EL, Educational Level; LEL, Low Educational Level; MEL, Medium Educational Level; HEL, High Educational Level; ENS, National Health Survey; WHO, World Health Organization; MINSAL, Ministry of Health of Chile.

Declarations
Ethics approval and consent to participate: This study was nested in the ENS 2016-2017 whose protocols and informed consents were approved by the Scientific Ethics Committee of the Faculty of Medicine of Pontificia Universidad Católica de Chile (CEC-MEDUC), project number: 16-019). Written consent was obtained in all cases. For participants under 16 years old, a written informed consent was obtained from their parent or guardian.

Consent for publication: Not applicable.

Availability of data and material: The analysis was carried out based on the ENS 2016-2017 data, available in the Population Survey repository of the Department of Epidemiology, Ministry of Health of the Government of Chile, 
http://epi.minsal.cl/encuestas-poblacionales/

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Authors’ contributions: PM, contributed to conception, data acquisition, analysis and interpretation, and drafting of the manuscript. RB, contributed to data analysis and interpretation, critically reviewed the manuscript. RGH contributed to data analysis and interpretation, critically reviewed the manuscript. CV contributed to conception, data analysis, critically reviewed the manuscript. CdV contributed to data acquisition and interpretation of results, critically reviewed the manuscript. JPV contributed to data interpretation and critically reviewed the manuscript. OP contributed to analysis of data. DO contributed to conception, design, analysis and interpretation, drafting the manuscript, critically reviewed the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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