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Clinical oral health indicators and self-rated oral health in Chile: effect modification by educational attainment in a cross-sectional study of the 2016–2017 National Health Survey

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Abstract

Background

Self-rated oral health (SROH) is widely used in population surveillance, but its correspondence with clinical oral status may differ across socioeconomic groups. We examined whether educational attainment modifies the association between clinically assessed oral health indicators and SROH in Chile.

Methods

Cross-sectional analysis of 5520 participants aged ≥ 15 years who underwent a standardized oral examination in the 2016–2017 Chilean National Health Survey. The indicators were the number of missing teeth, the number of teeth with cavitated carious lesions, maxillary and mandibular anterior tooth loss, and removable denture use. SROH was dichotomized as good (very good/good) or not good (fair/poor/very poor). Separate logistic regression models, adjusted for sex, age, time since the last dental visit, anxiety/depression symptoms and, in three models, smoking, estimated odds ratios (ORs). Effect modification by educational attainment (< 8, 8–12 and ≥ 13 years of schooling) was assessed using stratum-specific ORs, Mantel–Haenszel tests of homogeneity and product terms; additive interaction was quantified with the relative excess risk due to interaction (RERI).

Results

Not-good SROH was reported by 55.1% of participants. All indicators were associated with not-good SROH, most strongly maxillary anterior tooth loss (adjusted OR 2.02; 95% CI 1.76–2.33), followed by removable denture use (1.28; 1.11–1.48), mandibular anterior tooth loss (1.25; 1.09–1.44), each tooth with cavitated caries (1.16; 1.12–1.20) and each missing tooth (1.03; 1.02–1.04). For all five indicators, stratum-specific ORs increased with educational attainment. Effect modification was clearest for removable denture use (ORs 0.87, 1.36 and 1.76 for low, intermediate and high attainment; Mantel–Haenszel p = 0.020). It was statistically significant but of negligible magnitude for missing teeth, and inconsistent for mandibular anterior tooth loss (RERI 0.34; 95% CI − 0.01 to 0.70). No modification was observed for cavitated caries or maxillary anterior tooth loss.

Conclusions

Clinical oral conditions were reflected less strongly in the self-ratings of people with fewer years of schooling, particularly for conditions whose appraisal depends on social norms and expectations rather than on visibility or symptoms. Surveillance that relies exclusively on SROH may therefore underestimate educational inequalities in oral health; self-reported and clinical indicators should be monitored together.

Background

Oral diseases are among the most prevalent noncommunicable conditions worldwide. Untreated dental caries, severe periodontitis and edentulism affect about 3.5 billion people, and their burden falls disproportionately on socially disadvantaged groups [1–3]. Population monitoring of oral health draws on two complementary sources: clinical examinations, which provide normative assessments of disease, and self-reports, which capture how people experience and appraise their own oral health. The most parsimonious self-report is the single global question asking individuals to rate their oral health, or self-rated oral health (SROH). It is inexpensive and easily added to general health surveys, it shows consistent gradients with clinical indicators of caries, tooth loss and periodontitis, and it correlates with oral health-related quality of life [4–6]. SROH also matters in its own right, because perceived need is a proximal determinant of care seeking [7].

Contemporary definitions conceive of oral health as more than the absence of disease. The FDI World Dental Federation describes it as multifaceted, encompassing disease and condition status, physiological function and psychosocial function, and moderated by individual perceptions and expectations and by the social, economic and physical environment [8]. In the Wilson and Cleary model and its oral health adaptations, biological variables are linked to symptoms, functional status and general health perceptions, but each link is shaped by characteristics of the individual and the environment [9–11]. It follows that the same clinical condition need not be appraised in the same way by everyone: values, expectations, social reference groups and the ability to recognize and interpret oral problems may all intervene between the clinical state and the self-rating [12–14].

Socioeconomic position is a plausible source of such heterogeneity. In the literature on general self-rated health, self-ratings of people with lower socioeconomic position are less strongly anchored to objective health and less predictive of mortality, so self-reported measures may underestimate the magnitude of health inequalities [15, 16]. In oral health, socioeconomic gradients in self-perceived oral health persist after accounting for clinical status [17, 18], older adults with poor clinical conditions frequently rate their oral health favourably [19], higher educational attainment has been associated with less favourable self-ratings in older age [20], and education moderates the association between SROH and oral health-related quality of life [21]. Whether education modifies the association between clinically assessed oral conditions and SROH at the population level, however, has seldom been examined, and evidence from Latin America is scarce.

Chile offers a relevant setting for this question. Despite its high-income status, the country has marked socioeconomic inequalities and a segmented health system, and its education-based inequalities in tooth loss are among the widest reported internationally [22–24]. Low educational attainment is strongly associated with fewer remaining teeth, edentulism and anterior tooth loss [25, 26], and disparities in oral health-related quality of life have been documented among Chilean adults [27]. The 2016–2017 National Health Survey (ENS 2016–2017) combined a standardized oral examination with a global self-rating of oral health in a nationally representative sample [28]. Previous analyses of this survey showed that the

number and position of missing teeth are associated with health-related and oral health-related quality of life [29] but did not examine whether the correspondence between clinical status and self-ratings differs by educational attainment.

We therefore aimed (i) to estimate the associations between five clinically assessed oral health indicators (number of missing teeth, number of teeth with cavitated carious lesions, maxillary and mandibular anterior tooth loss, and removable denture use) and not-good SROH, and (ii) to evaluate whether these associations are modified by educational attainment on the multiplicative and additive scales. We hypothesized that the magnitude of the associations would differ across levels of educational attainment.

Methods

Study design and data source

This cross-sectional study is a secondary analysis of the ENS 2016–2017, a household survey commissioned by the Chilean Ministry of Health and conducted by the Pontificia Universidad Católica de Chile between August 2016 and March 2017 [28, 30]. The survey used a stratified, multistage, clustered probability sample that is representative of the population aged 15 years and older at the national, regional and urban–rural levels. Trained interviewers administered standardized questionnaires during a first household visit, and trained nurses conducted a second visit that included physical measurements, biological sampling and an oral examination. Of the 6233 participants who completed the survey questionnaire, 5520 completed the nurse examination visit [25, 30]. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [31]; the completed checklist is provided as Additional file 1.

Ethical considerations

The ENS 2016–2017 protocol and informed consent procedures were approved by the Scientific Ethics Committee of the Faculty of Medicine of the Pontificia Universidad Católica de Chile (project number 16–019). All participants provided written informed consent; for participants younger than 16 years, written informed consent was obtained from a parent or legal guardian [25]. The present analysis used the anonymized database released by the Ministry of Health (https://epi.minsal.cl/encuesta-ens-descargable/). Its protocol was submitted to the Scientific Ethics Committee of the Pontificia Universidad Católica de Chile (protocol code 230627005), which exempted it from review because it involved only the analysis of previously collected, de-identified data, without contact with participants or access to personally identifiable information. The study was conducted in accordance with the Declaration of Helsinki.

Study population

The analytic sample comprised the 5520 participants who underwent the oral examination and had complete data on SROH and covariates. Completely edentulous participants (n = 484) were retained in the analyses of tooth loss and removable denture use but were excluded from the analysis of cavitated carious lesions, which can only be assessed in dentate individuals (n = 5036). Participants without information on educational attainment (n = 47) were excluded from the effect-modification analyses (n = 5473; n = 4993 for cavitated carious lesions). Participant flow is summarized in Fig. 1.

Oral examination

Oral examinations were performed in participants' homes during the second household visit, following World Health Organization (WHO) diagnostic criteria [32], using a dental mirror, a dental explorer and a head-mounted light. Examiners recorded the number of permanent teeth present in each arch, anterior tooth loss, the use of removable prostheses in each arch and the presence of cavitated carious lesions [25, 29]. The examinations were performed by nurses who had been trained by nine dentists from the Ministry of Health through demonstrations, supervised practice and a final test with 20 clinical cases, in which inter-examiner agreement was substantial (kappa = 0.85) [25]. In a previous pilot study of the survey, nurse examinations showed a sensitivity of 70% for detecting missing and filled teeth compared with examinations by dentists [25]. Further details of the examination procedures have been reported elsewhere [29, 33].

Clinical oral health indicators

Five clinical indicators were analysed as exposures, each in a separate model: (i) the number of missing permanent teeth, derived from the number of teeth present; (ii) maxillary anterior tooth loss, defined as the absence of at least one of the six maxillary anterior teeth (central incisors, lateral incisors and canines) [26, 29]; (iii) mandibular anterior tooth loss, defined analogously for the mandibular arch; (iv) the number of teeth with cavitated carious lesions, recorded according to WHO criteria; and (v) use of a removable dental prosthesis in either arch (yes/no), as recorded by the examiner. Count variables were modelled as linear terms (per additional tooth). Dentition status was described as functional (≥ 20 teeth present), non-functional (1–19 teeth) or complete edentulism [34, 35], but was not analysed as an exposure.

Self-rated oral health (SROH)

SROH was assessed with the question “In general, how would you rate your oral health?”, with five response options: very good, good, fair, poor and very poor. Responses were dichotomized as good (very good or good) and not good (fair, poor or very poor); not-good SROH was the outcome.

Educational attainment

Years of schooling were derived from the highest educational level that participants had completed or were currently attending and the last grade approved [25]. Following the structure of the Chilean educational system, attainment was categorized as low (< 8 years; incomplete primary education), intermediate (8–12 years; complete primary up to complete secondary education) and high (≥ 13 years; any post-secondary education). Education was chosen as the indicator of socioeconomic position because it is generally completed in early adulthood, is available for almost all participants, is less susceptible to reverse causation than income and plausibly shapes health knowledge, expectations and the interpretation of symptoms [36].

Covariates

Covariates were selected a priori as potential common causes of clinical oral status and SROH: sex; age group (15–24, 25–44, 45–64 and ≥ 65 years); smoking status (current, former or never); time since the last dental visit (≤ 6 months, > 6 months or never); and anxiety or depression symptoms (none, moderate or extreme), assessed with the anxiety/depression dimension of the three-level EQ-5D [37, 38]. Depression is associated with dental caries and tooth loss [39] and contributes to poorer self-perceived oral health independently of oral status [17]. Smoking status was included in the models for the number of missing teeth and for maxillary and mandibular anterior tooth loss, but not in the models for cavitated carious lesions and removable denture use (Additional file 2).

Statistical analysis

Categorical variables are presented as frequencies and percentages, and count variables as medians with interquartile ranges (IQR). Participants with good and not-good SROH were compared using the chi-square test for categorical variables and Student's t-test for count variables.

Logistic regression was used to estimate crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for not-good SROH. A separate model was fitted for each clinical indicator, adjusted for the covariates described above. Educational attainment was not entered as a covariate in these overall models, because it was examined as an effect modifier. Covariate coefficients are reported in Additional file 2 for completeness but are not interpreted as effect estimates [40].

Effect modification by educational attainment was evaluated in three complementary ways, following current recommendations for reporting interaction [41]. First, adjusted ORs were estimated within each educational stratum. Second, homogeneity of the crude stratum-specific ORs was assessed with the Mantel–Haenszel test of homogeneity. Third, multiplicative interaction was assessed by adding product terms between each indicator and educational attainment to the adjusted models, tested with a Wald test. For mandibular anterior tooth loss, the indicator for which the stratified and product-term tests disagreed, additive interaction between tooth loss and high (versus low) educational attainment was also evaluated. Joint exposure categories were compared with a single reference category (low attainment without anterior tooth loss), and the relative excess risk due to interaction (RERI = OR_{11} –

$OR_{10} - OR_{01} + 1$) was estimated with a delta-method 95% CI [41, 42]. ORs were used as approximations of relative risks for this purpose.

All tests were two-sided, with statistical significance set at $p < 0.05$. Because the objective was to estimate associations conditional on covariates rather than population prevalence, the main analyses were unweighted and did not incorporate the stratification and clustering of the survey design; the implications of this choice are considered in the Discussion [43, 44]. Analyses were performed with Stata/MP version 17 (StataCorp LLC, College Station, TX, USA).

Use of large language models

Claude (Anthropic; model claude-opus-5-5) was used to assist with language editing, restructuring of the manuscript and identification of relevant literature. The authors reviewed and edited all content, verified the references and data, and take full responsibility for the manuscript.

Results

Participant characteristics

Of the 5520 participants, 3501 (63.4%) were women, 33.6% were aged 45–64 years and 24.7% were 65 years or older (Table 1). More than half had intermediate educational attainment (53.4%), whereas 24.1% had low and 21.7% high attainment. Nearly half had never smoked (47.9%), most had last visited a dentist more than 6 months before (69.4%) and most reported no anxiety or depression symptoms (67.8%).

Table 1
Characteristics of the study sample, 2016–2017 Chilean National Health Survey (n = 5520)

Characteristic	n	%
Sex		
Male	2019	36.6
Female	3501	63.4
Age group, years		
15–24	729	13.2
25–44	1571	28.5
45–64	1857	33.6
≥ 65	1363	24.7
Educational attainment, years of schooling		
Low (< 8)	1329	24.1
Intermediate (8–12)	2948	53.4
High (≥ 13)	1196	21.7
Missing	47	0.9
Smoking status		
Current	1698	30.8
Former	1180	21.4
Never	2642	47.9
Time since last dental visit		
≤ 6 months	1503	27.2
> 6 months	3831	69.4
Never	186	3.4
Anxiety/depression symptoms		
None	3745	67.8
Moderate	1530	27.7
Extreme	245	4.4

Unweighted counts. IQR, interquartile range. [a]Among dentate participants (n = 5036).

Characteristic	n	%
Sex		
Number of missing teeth, median (IQR)	9	4–19
Teeth with cavitated carious lesions, median (IQR)[a]	1	0–2
Maxillary anterior tooth loss	2255	40.9
Mandibular anterior tooth loss	1523	27.6
Removable denture use	1739	31.5
Dentition status		
Functional (≥ 20 teeth)	3458	62.6
Non-functional (1–19 teeth)	1578	28.6
Complete edentulism (0 teeth)	484	8.8
Self-rated oral health		
Very good	171	3.1
Good	2306	41.8
Fair	2126	38.5
Poor	803	14.5
Very poor	114	2.1
Unweighted counts. IQR, interquartile range. [a]Among dentate participants (n = 5036).		

The median number of missing teeth was 9 (IQR 4–19), and the median number of teeth with cavitated carious lesions was 1 (IQR 0–2). Maxillary and mandibular anterior tooth loss were present in 40.9% and 27.6% of participants, respectively, and 31.5% used a removable dental prosthesis. A functional dentition was observed in 62.6% of participants, and 8.8% were completely edentulous. Good SROH was reported by 44.9% (very good 3.1%; good 41.8%) and not-good SROH by 55.1% (fair 38.5%; poor 14.5%; very poor 2.1%). When the survey expansion factors were applied, the estimated population prevalence of good SROH was 45.8%.

Clinical oral health indicators and self-rated oral health (SROH)

Compared with participants reporting good SROH, those reporting not-good SROH had more missing teeth (median 11 vs. 7) and more teeth with cavitated lesions (median 1 vs. 0), and more frequently had maxillary anterior tooth loss, mandibular anterior tooth loss and removable dentures (all $p < 0.001$; Table 2). After adjustment, all five indicators remained associated with higher odds of not-good SROH.

The strongest association was observed for maxillary anterior tooth loss (adjusted OR 2.02; 95% CI 1.76–2.33), followed by removable denture use (OR 1.28; 1.11–1.48) and mandibular anterior tooth loss (OR 1.25; 1.09–1.44). Each additional tooth with cavitated caries was associated with 16% higher odds of not-good SROH (OR 1.16; 1.12–1.20), and each additional missing tooth with 3% higher odds (OR 1.03; 1.02–1.04). Adjustment attenuated the associations of mandibular anterior tooth loss and denture use (crude ORs 1.48 and 1.53, respectively) more than those of the other indicators. Covariate estimates are shown in Additional file 2.

Table 2
Clinical oral health indicators according to self-rated oral health, and crude and adjusted odds ratios

Indicator	Good SROH (n = 2477)	Not-good SROH (n = 3043)	p[a]	Crude OR (95% CI)	Adjusted OR (95% CI)[b]
Number of missing teeth, median (IQR)	7 (4–14)	11 (5–21)	< 0.001	1.03 (1.02–1.03)	1.03 (1.02–1.04)
Teeth with cavitated carious lesions, median (IQR)[c]	0 (0–1)	1 (0–3)	< 0.001	1.17 (1.13–1.20)	1.16 (1.12–1.20)
Maxillary anterior tooth loss, n (%)					
No	1702 (52.1)	1563 (47.9)	< 0.001	1 (reference)	1 (reference)
Yes	775 (34.4)	1480 (65.6)		2.08 (1.86–2.32)[d]	2.02 (1.76–2.33)
Mandibular anterior tooth loss, n (%)					
No	1899 (47.5)	2098 (52.5)	< 0.001	1 (reference)	1 (reference)
Yes	578 (38.0)	945 (62.0)		1.48 (1.31–1.67)[d]	1.25 (1.09–1.44)
Removable denture use, n (%)					
No	1820 (48.1)	1961 (51.9)	< 0.001	1 (reference)	1 (reference)
Yes	657 (37.8)	1082 (62.2)		1.53 (1.36–1.72)[d]	1.28 (1.11–1.48)

Unweighted counts (n = 5520). Percentages are row percentages. CI, confidence interval; IQR, interquartile range; OR, odds ratio; SROH, self-rated oral health. [a]Chi-square test for categorical variables; Student's t-test for count variables. [b]Each indicator was analyzed in a separate logistic regression model adjusted for sex, age group, time since the last dental visit, anxiety/depression symptoms and, for missing teeth and anterior tooth loss, smoking status; ORs for count variables are per additional tooth. [c]Dentate participants only (n = 5036). [d]Crude ORs for binary indicators calculated from the cell counts shown.

Effect modification by educational attainment

For all five indicators, the stratum-specific ORs increased from low to high educational attainment (Table 3; Fig. 2), although the strength of the evidence for effect modification differed across indicators.

Table 3
Adjusted odds ratios for not-good self-rated oral health by clinical indicator and educational attainment

Indicator	Low	Intermediate	High	p_{MH} [a]	$p_{interaction}$ [b]
Number of missing teeth (per tooth)	1.00 (0.99–1.02)	1.03 (1.02–1.04)	1.03 (1.00–1.06)	0.033	< 0.05
Teeth with cavitated carious lesions (per tooth)[c]	1.13 (1.02–1.25)	1.14 (1.09–1.20)	1.21 (1.13–1.30)	0.444	> 0.05
Maxillary anterior tooth loss (yes vs. no)	1.69 (1.23–2.33)	1.78 (1.48–2.14)	1.90 (1.33–2.72)	0.805	> 0.05
Mandibular anterior tooth loss (yes vs. no)	0.84 (0.65–1.09)	1.22 (1.00–1.49)	1.31 (0.84–2.02)	0.069	< 0.05
Removable denture use (yes vs. no)	0.87 (0.67–1.13)	1.36 (1.08–1.62)	1.76 (1.16–2.68)	0.020	< 0.05

Adjusted ORs (95% CI) of not-good self-rated oral health within strata of educational attainment; covariates as in Table 2. Participants without data on education (n = 47) were excluded (n = 5473). Low, < 8 years of schooling; intermediate, 8–12 years; high, ≥ 13 years. CI, confidence interval; MH, Mantel–Haenszel; OR, odds ratio. [a]Mantel–Haenszel test of homogeneity of the crude stratum-specific ORs. [b]Wald test of the product terms between the indicator and educational attainment in the adjusted model. [c]Dentate participants only (n = 4993).

Removable denture use showed the clearest effect modification. It was not associated with not-good SROH among participants with low attainment (OR 0.87; 0.67–1.13), whereas the association was positive among those with intermediate (OR 1.36; 1.08–1.62) and high attainment (OR 1.76; 1.16–2.68). Both the Mantel–Haenszel test (p = 0.020) and the product-term test were statistically significant.

For the number of missing teeth, both tests were also statistically significant (Mantel–Haenszel p = 0.033), but the stratum-specific ORs were nearly identical (1.00, 1.03 and 1.03), indicating heterogeneity of negligible magnitude.

For mandibular anterior tooth loss, the stratum-specific ORs were 0.84 (0.65–1.09), 1.22 (1.00–1.49) and 1.31 (0.84–2.02) for low, intermediate and high attainment, respectively. The product-term test was statistically significant, but the Mantel–Haenszel test was not (p = 0.069), and the CIs overlapped substantially.

No effect modification was observed for the number of teeth with cavitated carious lesions (Mantel–Haenszel p = 0.444) or for maxillary anterior tooth loss (p = 0.805); their associations with not-good SROH were positive and of similar magnitude in all strata (ORs 1.13–1.21 and 1.69–1.90, respectively).

Additive interaction for mandibular anterior tooth loss

Table 4 presents the joint associations of mandibular anterior tooth loss and educational attainment (low vs. high) with not-good SROH. Compared with participants with low attainment and no anterior tooth loss, those with high attainment and no tooth loss had lower odds of not-good SROH (OR 0.56; 0.45–0.70), whereas mandibular anterior tooth loss was not associated with the outcome among participants with low attainment (OR 0.83; 0.65–1.07). The OR for participants with both high attainment and tooth loss was 0.73 (0.48–1.11). The ratio of ORs (multiplicative interaction) was 1.58 (0.97–2.56), and the RERI was 0.34 (− 0.01 to 0.70). Thus, for the low-versus-high contrast, neither multiplicative nor additive interaction could be established with confidence.

Table 4
Joint associations of mandibular anterior tooth loss and educational attainment with not-good self-rated oral health

Educational attainment	No mandibular anterior tooth loss, OR (95% CI)	Mandibular anterior tooth loss, OR (95% CI)
Low	1.00 (reference)	0.83 (0.65–1.07)
High	0.56 (0.45–0.70)	0.73 (0.48–1.11)
Multiplicative interaction, ratio of ORs (95% CI)[a]: 1.58 (0.97–2.56)		
Additive interaction, RERI (95% CI)[b]: 0.34 (− 0.01 to 0.70)		
Adjusted ORs (95% CI) of not-good self-rated oral health, adjusted for sex, age group, smoking status, time since the last dental visit and anxiety/depression symptoms. Low, < 8 years of schooling; high, ≥ 13 years. Each OR is relative to the single reference category (low attainment without mandibular anterior tooth loss). Stratum-specific ORs for mandibular anterior tooth loss within each educational level are shown in Table 3. CI, confidence interval; OR, odds ratio; RERI, relative excess risk due to interaction. [a]Ratio of ORs: $OR_{11}/(OR_{10} \times OR_{01})$. [b]RERI = $OR_{11} - OR_{10} - OR_{01} + 1$; 95% CI by the delta method.		

Discussion

Principal findings

In this national sample of Chileans aged 15 years and older, all five clinical indicators were independently associated with not-good SROH, and maxillary anterior tooth loss showed the strongest association. The central finding concerns educational attainment: for every indicator, the association with SROH was weaker among participants with fewer years of schooling and stronger among those with post-secondary education. This gradient was statistically robust for removable denture use, of negligible

magnitude for the number of missing teeth and imprecise for mandibular anterior tooth loss, whereas the associations with cavitated caries and maxillary anterior tooth loss were similar across educational strata.

Clinical indicators and self-rated oral health

The associations observed are consistent with evidence that the global self-rating of oral health reflects clinical status [4–6] and that tooth loss impairs oral health-related quality of life [45]. The magnitude of the per-tooth associations is comparable to that reported in other population-based studies, for example ORs of 1.05 per missing tooth and 1.28 per decayed tooth among rural Australian adults [6]. Cavitated lesions, as recorded in the ENS, are visible defects that may be accompanied by symptoms and can therefore be perceived by the individual, which plausibly explains why their association with SROH was consistent across educational groups.

The position of tooth loss matters. Maxillary anterior teeth are central to smile aesthetics and social interaction, and their loss carries emotional and social costs that go beyond masticatory function [46, 47]. Tooth loss that includes anterior teeth has a greater impact on oral health-related quality of life than the loss of posterior teeth only [48], and a previous analysis of the ENS 2016–2017 found that anterior tooth loss was linked to worse self-perceived oral health [29]. Because anterior tooth loss is widespread in Chile and strongly patterned by education and health insurance [26], its psychosocial consequences deserve attention in public programs, which have traditionally prioritized the restoration of masticatory function.

Removable denture use was associated with not-good SROH overall, in line with previous evidence that denture wearing is among the strongest correlates of poorer self-perceived oral health [17]. Denture use is both a marker of previous tooth loss and a treatment for it, and its impact on self-perceived oral health depends on the extent of tooth loss [49].

Educational attainment as an effect modifier

Several mechanisms, not mutually exclusive, may explain why clinical conditions were reflected less strongly in the self-ratings of less-educated participants. The first concerns expectations and social reference groups. Self-ratings of health are relative judgments, formed by comparison with what is considered normal for people like oneself [12]. In Chile, tooth loss, and consequently denture use, are far more prevalent among people with low educational attainment [22, 25, 26]; in that context they may be perceived as normative and accommodated through lowered expectations or response shift [13, 14]. Among more educated people, for whom a largely intact natural dentition is the norm, denture use and anterior tooth loss are more likely to be experienced as deviations from their reference group. This interpretation is consistent with Brazilian evidence that older adults frequently rate their oral health positively despite poor clinical conditions [19] and that more educated older adults report worse self-perceived oral health [20], and with the observation that education strengthens the link between SROH and oral health-related quality of life [21].

The second mechanism is oral health literacy. Recognizing oral conditions as health problems and interpreting their consequences require knowledge and skills that are socially patterned, and people with more schooling may be better equipped to identify a missing tooth, a cavity or a denture as markers of impaired oral health. Evidence linking oral health literacy with clinical outcomes in adults remains inconsistent, however [50], so this pathway should be regarded as a hypothesis.

Third, the meaning of a denture may differ between groups. In Chile, a substantial share of prosthetic rehabilitation among socioeconomically disadvantaged adults is delivered through targeted public programs, such as the Explicit Health Guarantees program of comprehensive oral care for 60-year-olds and the “More Smiles for Chile” program for women [51, 52], and participation in the latter has been associated with improvements in oral health-related quality of life [53]. For many less-educated participants, a denture may therefore represent a recent gain in appearance and function rather than a loss, which would attenuate its association with poor self-ratings.

Fourth, effect modification is scale dependent [54]. Not-good SROH was more frequent among less-educated participants regardless of clinical status, so heterogeneity of ORs across educational groups does not necessarily imply equivalent heterogeneity in absolute differences in prevalence, which are the more relevant measure for public health decisions [41]. For mandibular anterior tooth loss, the RERI was compatible with a modest positive additive interaction, but its CI included zero. Moreover, because high educational attainment was inversely associated with the outcome, the RERI is sensitive to the choice of reference category [55], and this estimate should be interpreted with caution. Estimating prevalence differences within educational strata would help to clarify the public health relevance of the modification observed.

Taken together, these findings mirror evidence from the general self-rated health literature that self-reports are less anchored to objective health among people with lower socioeconomic position [15, 16]. Notably, effect modification was absent for the two most visible or symptomatic conditions, maxillary anterior tooth loss and cavitated caries, and was most apparent for denture use and mandibular anterior tooth loss, whose appraisal arguably depends more on social norms and expectations. This pattern supports an interpretation centered on how conditions are appraised rather than on differences in their clinical severity.

Implications for public health

These results have implications for surveillance and service planning. If self-ratings are less sensitive to clinical disease among less-educated people, indicators based exclusively on SROH will underestimate the magnitude of educational inequalities in oral health, a bias already described for general self-rated health [16]. Population monitoring should therefore combine self-reported and clinical indicators, and comparisons of SROH across socioeconomic groups should be interpreted cautiously; approaches such as anchoring vignettes could help to correct for reporting heterogeneity [56]. Furthermore, because perceived need is a key driver of dental care seeking [7], people with low educational attainment and a high clinical burden may not seek care. Services that rely on spontaneous demand could thus perpetuate

inequalities, which supports proactive, community-based strategies such as those outlined in the Chilean National Oral Health Plan 2021–2030 [51]. Finally, evaluations of oral health programs based on self-reported outcomes should consider that the same clinical change may be appraised differently across socioeconomic groups.

Strengths and limitations

This study has several strengths: a nationally representative sampling frame, a standardized clinical examination performed by calibrated examiners, several complementary clinical indicators and an assessment of effect modification that combined stratified estimates, homogeneity tests, product terms and an additive measure, as currently recommended [41].

Several limitations should also be considered. First, the cross-sectional design precludes causal inference. Reverse causation is implausible for the clinical indicators themselves but cannot be excluded for covariates such as dental attendance, and adjustment for recent dental visits may have removed part of the pathway through which clinical conditions influence SROH. Second, the analyses were unweighted and did not account for stratification and clustering. The unweighted sample over-represented women and older adults; although these characteristics were included as covariates, which limits bias in conditional associations [43, 44], the estimates do not describe the Chilean population, and ignoring clustering may have yielded CIs that are too narrow. Findings with p-values close to 0.05, such as those for mandibular anterior tooth loss and missing teeth, should therefore be interpreted with caution. Third, the overall models were not adjusted for educational attainment. For maxillary anterior tooth loss, for example, all stratum-specific ORs (1.69–1.90) were smaller than the overall estimate (2.02), which suggests that the overall estimates are partly confounded by education; the stratum-specific estimates are therefore the more appropriate measures of association. In addition, smoking status was not included in two of the five models, so the adjustment sets were not fully comparable across indicators. Fourth, ORs overstate prevalence ratios when the outcome is common, as in this study, and should not be interpreted as relative risks [57, 58]; the OR-based RERI is likewise an approximation.

Fifth, oral examinations were performed by nurses rather than dentists, and periodontal status, restorative status and dental pain were not analysed, so the clinical picture is incomplete; misclassification of the clinical indicators is, however, unlikely to differ by educational attainment. Sixth, SROH was measured with a single item and dichotomized, which discards information. Seventh, the educational categories are broad, and for participants aged 15–24 years, many of whom were still studying, current attainment may not reflect final attainment; other dimensions of socioeconomic position, such as income, health insurance and rurality, which are also associated with oral health in Chile [26], were not examined. Eighth, several tests were performed, so some statistically significant results may have arisen by chance; conversely, tests for interaction have limited statistical power [59], so the absence of significant modification for some indicators does not rule it out. The consistency in the direction of modification across all five indicators may therefore be more informative than any single

test. Finally, the data were collected in 2016–2017, and the expansion of oral health programs since then may have modified the patterns observed.

Future studies should use survey-weighted analyses that account for the complex sampling design, estimate prevalence ratios and additive measures of effect modification for all indicators, and explore reporting heterogeneity directly through anchoring vignettes or qualitative research on how people with different educational backgrounds appraise tooth loss and dentures.

Conclusions

Clinically assessed tooth loss, cavitated caries and removable denture use were associated with not-good SROH among Chileans aged 15 years and older. The strength of these associations increased with educational attainment, most clearly for removable denture use, whereas the associations with the most visible or symptomatic conditions (maxillary anterior tooth loss and cavitated caries) were similar across educational groups. SROH appears to be less anchored to clinical status among people with fewer years of schooling; monitoring strategies that rely exclusively on self-reports may therefore underestimate educational inequalities in oral health.

Abbreviations

CI
Confidence interval
ENS
Encuesta Nacional de Salud (Chilean National Health Survey)
EQ-5D
EuroQol five-dimension questionnaire
IQR
Interquartile range
MH
Mantel–Haenszel
OR
Odds ratio
RERI
Relative excess risk due to interaction
SROH
Self-rated oral health
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
WHO
World Health Organization

Declarations

Ethics approval and consent to participate

The ENS 2016–2017 protocol and informed consent procedures were approved by the Scientific Ethics Committee of the Faculty of Medicine of the Pontificia Universidad Católica de Chile (project number 16-019). All participants provided written informed consent; for participants younger than 16 years, written informed consent was obtained from a parent or legal guardian. The present secondary analysis of anonymized data was submitted to the Scientific Ethics Committee of the Pontificia Universidad Católica de Chile (protocol code 230627005), which exempted it from review. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analysed during the current study are publicly available from the Department of Epidemiology of the Chilean Ministry of Health (http://epi.minsal.cl/encuestas-poblacionales/).

Competing interests

The authors declare no competing interests.

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Authors' contributions

IO: conceptualization, formal analysis, writing – original draft. CM: formal analysis, writing – original draft. JC: methodology, writing – review and editing. AC: conceptualization, supervision, writing – review and editing. MS: methodology, formal analysis, writing – review and editing. RM: investigation, writing – original draft. NP: investigation, writing – original draft. VA: investigation, writing – original draft. PM: data curation, resources, writing – review and editing. DO: conceptualization, methodology, supervision, writing – review and editing. All authors read and approved the final manuscript.

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Clinical trial number

Not applicable.

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Figures

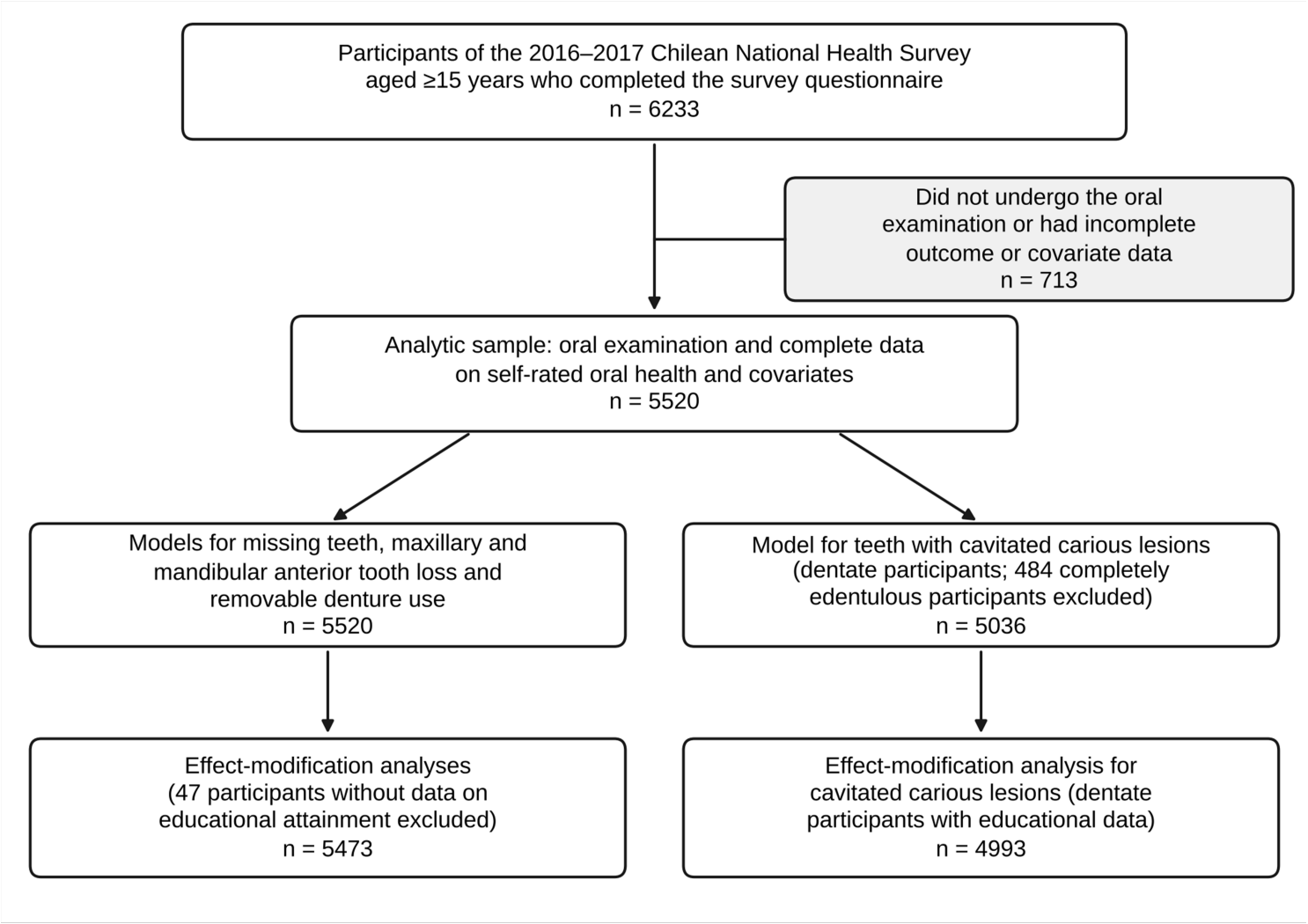


Figure 1

Flow diagram of participant selection, 2016–2017 Chilean National Health Survey

Numbers are unweighted participants. Effect-modification analyses excluded participants without data on educational attainment.

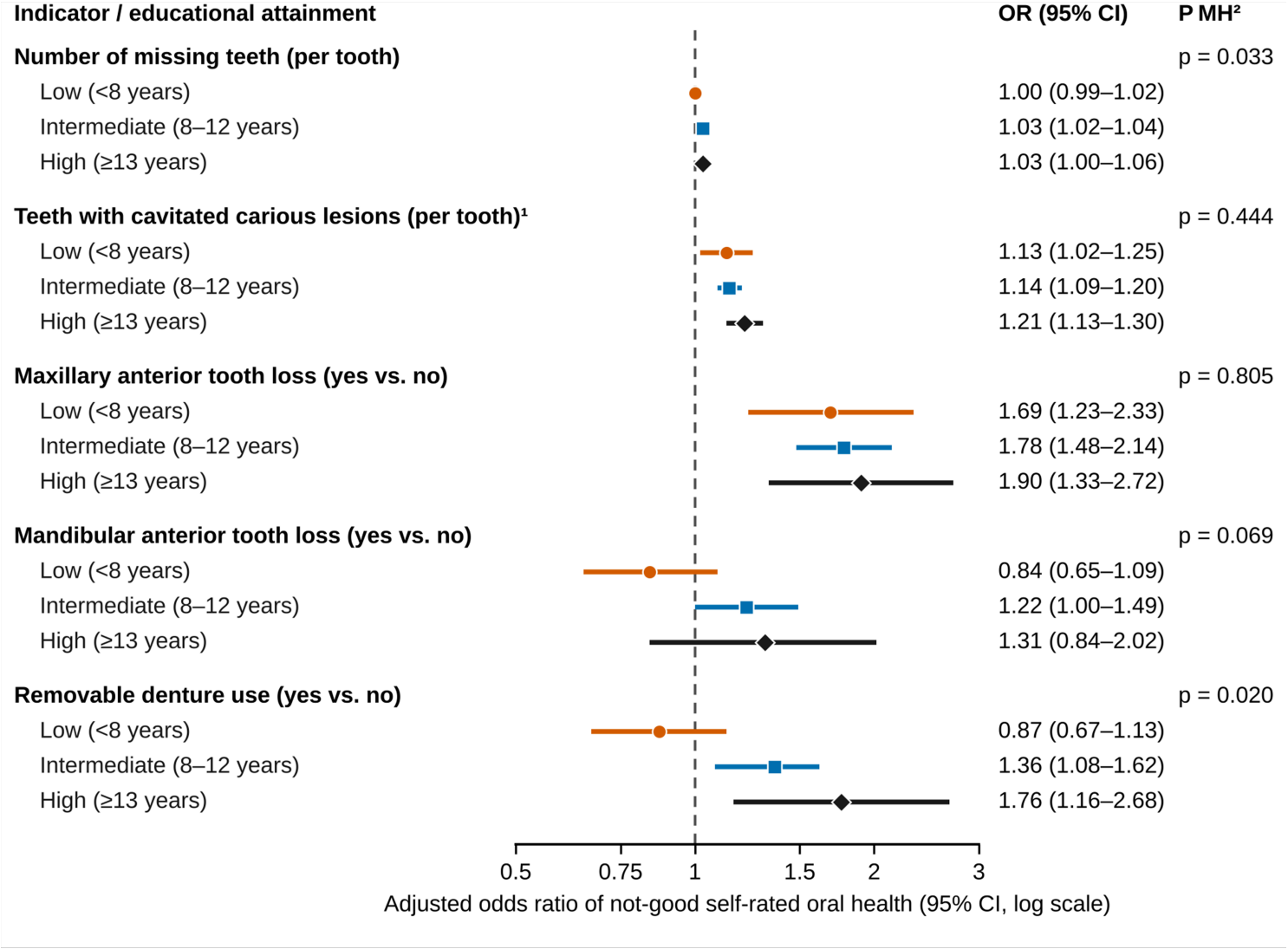


Figure 2

Adjusted odds ratios of not-good self-rated oral health by clinical indicator and educational attainment

Adjusted odds ratios (ORs) and 95% confidence intervals from logistic regression models fitted within strata of educational attainment (low, <8 years of schooling; intermediate, 8–12 years; high, ≥13 years), 2016–2017 Chilean National Health Survey. Models were adjusted for sex, age group, time since the last dental visit, anxiety/depression symptoms and, for missing teeth and anterior tooth loss, smoking status. The horizontal axis is on a logarithmic scale, and the dashed line marks an OR of 1. ORs for count indicators are per additional tooth. [1]Dentate participants only. [2]P MH, p-value of the Mantel–Haenszel test of homogeneity.

Supplementary Files

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- Additionalfile1STROBEchecklist.docx

- Additionalfile2TableS1.docx