Risk factors for impaired oral health among 18- to 34-year-old Australians

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impaired oral life; young adults; perceived oral health; dental service utilization; dental fear.

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Abstract

Objectives: The objective of this study was to determine risk factors for a summary measure of oral health impairment among 18- to 34-year-olds in Australia.
Methods: Data were from Australia's National Survey of Adult Oral Health, a representative survey that utilized a three-stage, stratified, clustered sampling design. Oral health impairment was defined as reported experience of toothache, poor dental appearance, or food avoidance in the last 12 months. Multivariate Poisson regression models were used to evaluate effects of sociodemographic characteristics, self-perceived oral health, dental service utilization, and clinical oral disease indicators on oral health impairments. Effects were quantified as prevalence ratios (PR).
Results: The estimated percent of 18- to 34-year-olds with oral health impairment was 42.4 [95 percent confidence interval (CI) 37.7-47.2]. In the multivariate model, oral health impairment was associated with untreated dental decay (PR 1.38, 95 percent CI 1.13-1.68) and presence of periodontal pockets 4 mm+ (PR 1.29, 95 percent CI 1.03-1.61). In addition to those clinical indicators, greater prevalence of oral health impairment was associated with trouble paying a $100 dental bill (PR 1.37, 95 percent CI 1.12-1.68), usually visiting a dentist because of a dental problem (PR 1.46, 95 percent CI 1.15-1.86), reported cost barriers to dental care (PR 1.46, 95 percent CI 1.16-1.85), and dental fear (PR 1.43, 95 percent CI 1.18-1.73).
Conclusions: Oral health impairment was highly prevalent in this population. The findings suggest that treatment of dental disease, reduction of financial barriers to dental care, and control of dental fear are needed to reduce oral health impairment among Australian young adults.

Introduction

In the past, measures in health epidemiology have been predominately clinical (1-3). This has also been a feature in oral epidemiology, where indices such as the Decayed, Missing, and Filled Teeth Index and the Community Periodontal Index of Treatment Needs have been used to measure objective signs such as dental caries and periodontal disease, thereby describing overall oral health status. However, the indices have been criticized as failing to consider functional and psychosocial aspects of health, and not adequately reflecting the health status, concerns, and perceived needs of individuals (4). This criticism led to the development of questionnaires measuring self-perceived impacts of oral health that enabled greater insight into the emerging domains of oral health-related quality of life and perceived need for oral health care (5). While those questionnaires vary considerably in their detail and design, all of them include assessments of three critical aspects of oral health-associated quality of life: pain, appearance, and function.

Toothache is a common cause of pain in the head and neck region, and it is often severe enough to affect quality of life. In turn, dental caries is the most common cause of toothache, although fractured teeth and exposed dentin because of wear (for example, toothbrush abrasion) may also cause pain (6). Disparities in self-reported experience of toothache are well recognized, with ethnic minority groups, the financially disadvantaged, and those with less formal education being disproportionately represented (7). Among irregular dental attenders – who constituted 43.8 percent of adults in

Australia's second National Survey of Adult Oral Health (NSAOH) (8) – toothache is the most commonly reported reason that dental care is sought (9).

The appearance of one's mouth is reportedly one of the most important features in regard to facial attractiveness (10), with associated consequences on self-image, social interaction, and psychological health (11). Dissatisfaction with dental appearance may have many causes, including concerns about the position, alignment, or spacing of teeth (12); color of teeth or oral soft tissues (13); scarring and trauma (14); presence of oral pathology (15); or presence of prosthodontic appliances (16). The perceived associations between dentofacial attractiveness and social traits, such as personality and social status, make dental appearance a substantial concern for many people (11,17).

Avoiding food because of dental problems is an example of an oral health impairment that may reflect functional difficulty, or which may be a consequence of discomfort or embarrassment. Food avoidance is likely to reduce enjoyment of eating and affect ability to maintain a healthy nutritional status (18). The avoidance of difficult-to-chew foods is associated with reduced body mass index and serum albumin levels (19). Re-establishment of masticatory function in such individuals is considered an integral component of their medical health care, with the aim of improving their nutritional status and quality of life (19).

The literature indicates that oral health impairment may have substantial economic and social capital impacts (20). These can be particularly debilitating among those aged 18-34 years who may be studying, in the early stages of a career, seeking a partner, beginning a family, or entering into substantial financial commitments such as house mortgages. Understanding risk factors for oral health impairment among this age group may lead to policies that reduce disparities in this phenomenon, thus improving both productivity and general life satisfaction. There is also the expectation that this age group of Australians should have few impairments because of the following: a) this generation has historically low rates of caries experience; b) they have grown up during an era when free school dental services were widespread; and c) arguably, they have enjoyed one of the healthiest and wealthiest childhoods in Australia's history.

The aims of this analysis are the following: a) to estimate the prevalence of oral health impairment as assessed by a summary oral health impairment measure (including aspects of dental pain, dissatisfaction with dental appearance, and difficulty eating) among a representative sample of 18- to 34-year-old Australians; b) to compare prevalence according to demographic, socioeconomic status, self-perceived oral health, dental service utilization, and oral health outcome risk indicators; and c) to ascertain the independent contribution of those risk factors to oral health impairment in this population.

Methods

Data were from NSAOH (8), a cross-sectional study of oral health among Australians aged 15 years or more living in all states and territories. For purposes of this analysis, only data for participants aged 18-34 years who partook in a telephone interview and received a dental examination were included.

Sampling

NSAOH utilized a three-stage, stratified, clustered sampling design, with the target population being the Australian adult population. The first stage selected postcodes, the second stage selected households within sampled postcodes, and the third stage selected one adult from each sampled household. Postcodes were stratified into two groups, metropolitan and non-metropolitan, and were selected with probability proportional to size. A systematic sample of households listed in the "electronic white pages" were selected for each sampled postcode. The third stage involved random selection of one person aged 15+ years from each household. In households with more than one person aged 15+ years, a computer algorithm selected either the person who most recently had had a birthday or the person who would next have a birthday. At completion of the telephone interview, participants were asked if they would be willing to take part in a clinical examination. Participants who failed to attend a scheduled clinical appointment were contacted up to six times. The response rate was 43.7 percent. The potential for response bias was assessed using six demographic indicators against population benchmarks.

Weighting

Because of the differences in the probability of participation, data were weighted to ensure estimates were representative of the Australian population from which survey participants were selected. Weights were calculated to reflect probabilities of selection and to adjust for different participation rates across postcodes, and among age and sex categories.

Ethical approval

Ethical approval was received by the University of Adelaide's Human Research Ethics Committee. Participants provided verbal consent prior to answering questions in the telephone interview and signed informed consent prior to the oral examination.

Computer-assisted telephone interview

Methods in the computer-assisted telephone interview (CATI) were based on the Dillman technique, such as the

mailing of a primary letter to households prior to telephoning, a protocol for contacting each household, and standardized procedures for asking questions and recording answers (21). The interview consisted of 79 questions based on those used in previous National Dental Telephone Interview Surveys conducted by the Australian Research Centre for Population Oral Health (22-24). The interview instrument was not validated.

Summary oral health impairment variable

The summary oral health impairment variable was created by combining three CATI items: experience of toothache, experience of discomfort because of mouth appearance, and food avoidance. Experience of toothache was assessed by asking dentate participants "During the last 12 months how often have you had toothache?" while experience of discomfort because of mouth appearance was assessed by asking "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?" Avoiding food because of oral health problems was assessed by asking participants "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?" For purposes of this analysis, those who answered "Very often," "Often," or "Sometimes" to any of the items were considered to have impaired oral health because of oral health-related factors. Other possible responses were "Hardly ever" or "Never."

Oral epidemiological examination

Information about clinical oral health status was collected during standardized clinical examinations conducted by 30 calibrated dentists. Calibration involved a 2-day training session at the University of Adelaide. The training involved a half-day didactic session followed by a day and a half of clinical training. Each volunteer was examined by two or three examiners, with the results of the examinations being compared by the trainers. At the conclusion of each half-day session, a tutorial was held to clarify any outstanding issues. Any examiners who differed markedly from the principal examiner were discontinued. Examining dentists followed a standardized protocol to record levels of tooth loss, dental decay experience, tooth wear, and periodontal disease (for those with no medical contraindications to periodontal probing). Oral mucosal lesions, tooth wear, dental plaque, calculus, and gingivitis were also assessed. For the caries assessment, all teeth present were divided into five tooth surfaces: occlusal/incisal, mesial, buccal, palatal/lingual, and distal. Each dental surface was assessed and categorized using visual criteria only. Untreated dental decay was defined as "cavitation of enamel or dentinal involvement or both being present" or "visible caries that is contiguous with a restoration." Calculus was the "presence of calculus at one or more of six tooth sites," plaque was considered as "visible soft deposits or an abundance of soft matter on one or more of six tooth sites," gingivitis was considered as "moderate inflammation and bleeding upon probing or severe inflammation with spontaneous bleeding on one or more of six tooth sites," and dental wear was considered as "completely exposed dentine on one or more of the four lower incisor teeth."

Replicate examinations were conducted, and moderate agreement was reached for measures of untreated dental decay (median intra-class correlation = 0.56). Any major discrepancies were discussed.

Statistical analyses

Statistical analyses took into account the clustered sampling design to yield unbiased standard error estimates and design effects for univariate, bivariate, and multivariate estimates using the complex module in SPSS 15.0 (SPSS Inc., Chicago, IL, USA) and Intercooled STATA 8 (StataCorp LP, College Station, TX, USA). Exposure variables were classified into demographic, socioeconomic status, self-perceived oral health, dental service utilization, or clinical oral health outcome groups. The univariate and bivariate distributions of the summary oral health impairment measure were determined, producing weighted population estimates.

Correlation tests confirmed the existence of weak associations between items in a given group (Pearson's correlation coefficient range 0.1-0.4), and one variable (average number of dental visits) was excluded in the final model because of colinearity with "last visited in last 12 months." The high prevalence of oral health impairment meant that odds ratios were poor indicators of relative frequency, so prevalence ratios (PR) were determined using Poisson regression modeling (25). To determine PR, the total number of individuals who have an attribute (oral health impairment) at a particular time is divided by the population at risk of having the attribute in the same given time (26). Three Poisson regression models were constructed; Model A included non-clinical risk factors, Model B included clinical risk factors, and Model C included both non-clinical and clinical risk factors. The final regression model for the summary oral health impairment measure was constructed by removing covariates one at a time according to *P*-value size.

An additional validation step was undertaken using an alternate definition to define oral health impairment as a positive report of all three impacts: toothache, impaired appearance, *and* food avoidance. This more stringent case definition necessarily created a lower prevalence of impairment, and the main objective in using this definition was to determine if similar risk factors emerged from a similar multivariate analysis.

Results

Some 984 participants aged 18-34 years completed a telephone interview and were dentally examined. Participants who took part in the dental examination were representative of those who took part in the telephone interview and the 18- to 34-year-old Australian population, based on overlapping 95 percent confidence intervals (CIs) between the 2001 census estimates and the examined sample on the demographic factors of a) occupation; b) birthplace; c) level of schooling; d) indigenous identity; e) employment category; and f) language spoken at home.

Just over 20 percent had experienced toothache; almost 26 percent reported having experienced dissatisfaction with appearance of their teeth, mouth, or gums; and almost 20 percent reported having avoided eating food because of oral problems (Table 1). Just over 40 percent had experienced toothache, impaired dentofacial appearance, or food avoidance in the last 12 months, while the prevalence of all three of the oral health impairment items was just over 6 percent. Demographic, socioeconomic status, and self-perceived oral health factors associated with toothache included being indigenous, not having a university degree, perceived difficulty in paying a $100 dental bill, cost having prevented recommended dental care in the last 2 years, and self-perceived need for fillings or extractions. Factors associated with impaired dentofacial appearance included not having a university degree, cost having prevented recommended dental care in the last 2 years, and self-perceived need for fillings or extractions. Factors associated with food avoidance included not having a university degree, being eligible for public dental care, being dentally uninsured, reporting difficulty paying a $100 dental bill, cost having prevented recommended dental care in the last 2 years, and self-perceived need for fillings or extractions. Indigenous persons had a higher prevalence of any oral health impairment, as did those without a university education, who reported that cost had prevented recommended dental care in the last 2 years or who perceived they had a need for an extraction or restoration. Factors associated with the composite measure of all three oral health impairments included living in a non-capital city, not having a university degree, being dentally uninsured, reporting difficulty paying a $100 dental bill, cost having prevented recommended dental care in the last 2 years, and self-perceived need for fillings or extractions.

Dental service utilization and oral health outcome factors associated with toothache included usually visiting a dentist because of a problem, having last visited a dentist in the last 12 months, last visiting a public dentist, avoiding dental care because of cost, having dental fear (answering "a little, moderately, very or extremely" to the question "Would you feel afraid or distressed when going to the dentist?"), having untreated teeth because of decay, having missing teeth because of decay, having restorations, and having periodontal pockets 4 mm+ (Table 2). Factors associated with impaired dentofacial appearance included usually visiting a dentist because of a problem, avoiding dental care because of cost, having dental fear, having untreated teeth because of decay, having missing teeth because of decay, having restorations, having periodontal pockets 4 mm+, and having calculus. Factors associated with food avoidance included usually visiting a dentist because of a problem, last visiting a private dentist, avoiding dental care because of cost, having dental fear, having untreated teeth because of decay, having missing teeth because of decay, having restorations, having periodontal pockets 4 mm+, and having incisal wear. Participants who had last visited a dentist because of a problem had a higher prevalence of any oral health impairment, as did those who reported avoiding dental care because of cost. Participants with untreated dental decay reported higher levels of oral health impairment, as did those with restorations, one or more periodontal pockets of 4 mm+, or with calculus. Factors associated with the composite measure of all three oral health impairments included usually visiting a dentist because of a problem, last visiting a public dentist, avoiding dental care because of cost, having dental fear, having untreated teeth because of decay, having missing teeth because of decay, having periodontal pockets 4 mm+, and having incisal wear.

In multivariate modeling, non-clinical risk factors significantly associated with any oral health impairment included not having a university qualification, difficulty paying for dental care, problem-based dental attendance, and dental fear (Table 3; Model A). Significant clinical risk factors in Model B included untreated dental decay, missing teeth because of decay, and presence of periodontal pockets. In Model C, non-clinical and clinical risk factors that remained significantly associated with any oral health impairment after adjusting for confounding included trouble paying for dental care, problem-based dental attendance, dental fear, untreated dental decay, and presence of periodontal pockets.

Three items remained significantly associated with oral health impairment when measured in the more stringent way (prevalence of all three oral health impairment items): reported difficulty in paying a $100 dental bill (PR 1.25, 95 percent CI 1.02-1.52), usually visiting a dentist because of a problem (PR 1.43, 95 percent CI 1.22-1.68), and untreated dental decay (PR 1.37, 95 percent CI 1.13-1.66) (results not tabled).

Discussion

In this representative sample of 18- to 34-year-old Australians, risk factors for one or more oral health impairments included socioeconomic factors such as difficulty paying a $100 dental bill and cost preventing recommended dental care, problem-based visiting behaviors, and dental

Table 1 Total Counts and Prevalences of 18- to 34-Year-Old National Survey of Adult Oral Health Participants with Experience of Toothache/Impaired Appearance/Food Avoidance by Demographic, Socioeconomic Status, and Self-Perceived Oral Health Variables (95% Confidence Interval in Brackets)

	Counts (unweighted)	Prevalence of toothache† (weighted)	Prevalence of dissatisfied appearance‡ (weighted)	Prevalence of avoiding eating food¶ (weighted)	Prevalence of impaired oral health summary measure§ (any weighted)	Prevalence of impaired oral health summary measure• (all weighted)
Total	984	21.4 (18.0-25.3)	25.9 (22.6-29.5)	18.7 (15.4-22.6)	42.4 (37.7-47.2)	6.4 (4.4-9.2)
Demographic						
Sex						
Male	325	18.2 (130-24.9)	23.7 (18.4-29.8)	15.7 (11.0-22.0)	38.5 (31.2-46.4)	5.9 (3.2-10.9)
Female	659	24.2 (20.1-28.9)	27.9 (23.8-32.3)	21.4 (17.3-26.0)	46.6 (41.1-52.1)	6.7 (4.6-9.8)
Age group						
18-24 years	291	22.9 (16.6-30.7)	23.0 (17.9-29.1)	17.0 (11.1-25.4)	40.7 (32.8-49.1)	6.0 (3.3-10.7)
25-34 years	693	20.5 (16.7-25.0)	27.8 (23.8-32.1)	19.8 (16.0-24.2)	43.5 (38.0-49.1)	6.6 (4.2-10.3)
Residential location						
Capital city	656	20.8 (17.0-25.2)	25.3 (21.3-29.6)	16.8 (13.3-21.0)	42.6 (36.8-48.7)	4.7 (3.1-7.0)*
Other	328	22.9 (16.2-31.4)	27.4 (21.5-34.3)	23.4 (16.3-32.3)	41.7 (34.4-49.4)	10.4 (5.6-18.6)
Indigenous status						
Indigenous	17	57.3 (23.5-85.4)*	32.4 (10.4-66.3)	9.1 (2.0-32.4)	82.3 (51.7-95.3)*	9.1 (2.0-32.4)
Non-indigenous	967	21.2 (17.7-25.1)	25.8 (22.5-29.5)	18.8 (15.4-22.7)	42.0 (37.4-46.9)	6.3 (4.4-9.2)
Socioeconomic status						
Highest qualification						
University degree	363	15.0 (10.9-20.2)*	19.3 (14.8-24.8)*	12.0 (8.5-16.8)*	31.4 (42.1-53.9)*	1.6 (0.7-3.8)*
Non-university degree	609	24.9 (20.7-29.7)	29.5 (25.0-34.4)	22.4 (18.2-27.2)	48.0 (24.3-39.4)	8.9 (6.1-12.8)
Eligibility for public dental care						
Eligible	203	27.3 (20.1-35.9)	29.6 (21.9-38.5)	28.5 (20.9-37.6)*	53.7 (43.5-63.7)	9.7 (5.5-16.4)
Ineligible	781	19.9 (16.2-24.1)	24.9 (21.2-29.1)	16.1 (12.8-20.2)	39.4 (34.3-44.7)	5.5 (3.4-8.8)
Dental insurance						
Insured	398	18.0 (13.4-23.8)	24.0 (18.8-30.2)	13.1 (9.1-18.5)*	39.9 (32.3-48.1)	2.1 (0.7-6.2)*
Uninsured	575	23.6 (19.1-28.8)	27.1 (23.2-31.4)	22.3 (18.0-27.3)	45.1 (39.5-50.9)	9.1 (6.3-12.9)
Trouble paying $100 dental bill						
Yes	212	33.6 (25.3-43.0)*	28.1 (21.4-35.9)	34.0 (25.8-43.3)*	53.6 (44.0-62.9)	12.9 (8.2-19.9)*
No	771	18.4 (15.0-22.3)	25.3 (21.4-29.7)	14.9 (11.7-18.7)	39.9 (34.6-45.4)	4.7 (2.7-8.2)
Cost prevented recommended dental care in last 2 years						
Yes	170	42.5 (32.8-52.9)*	49.8 (39.2-60.5)*	42.8 (32.4-53.8)*	68.8 (58.2-77.7)*	19.8 (11.3-32.3)*
No	493	16.6 (12.5-21.8)	20.5 (16.1-25.9)	13.9 (9.9-19.3)	37.6 (30.7-45.0)	2.1 (1.1-4.2)
Not visited in last 2 years	321	19.6 (14.8-25.5)	23.6 (18.6-29.6)	15.6 (11.1-21.5)	39.5 (32.1-47.5)	7.0 (4.1-11.7)
Self-perceived oral health						
Self-perceived need for extraction or fillings						
Yes	343	35.6 (29.1-42.7)*	40.2 (33.6-47.2)*	29.0 (22.7-36.2)*	61.7 (54.4-68.5)*	14.0 (9.2-20.8)*
No	614	14.0 (10.6-18.3)	18.3 (14.9-22.3)	13.3 (10.0-17.6)	31.9 (26.8-37.5)	2.4 (1.3-4.2)

* $P < 0.05$.

† A response of "Very often," "Often," or "Sometimes" to the item "During the last 12 months how often have you had toothache?"

‡ A response of "Very often," "Often," or "Sometimes" to the item "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?"

¶ A response of "Very often," "Often," or "Sometimes" to the item "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?"

§ A response of "Very often," "Often," or "Sometimes" to the items "During the last 12 months how often have you had toothache?" "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?" or "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?"

• A response of "Very often," "Often," or "Sometimes" to the items "During the last 12 months how often have you had toothache?" "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?" and "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?"

Table 2 Total Counts and Prevalences of 18- to 34-Year-Old National Survey of Adult Oral Health Participants with Experience of Toothache/Impaired Appearance/Food Avoidance by Dental Service Utilization and Oral Health Outcome Variables (95% Confidence Interval in Brackets)

	Counts (unweighted)	Prevalence of toothache† (weighted)	Prevalence of dissatisfied appearance‡ (weighted)	Prevalence of avoiding eating food¶ (weighted)	Prevalence of impaired oral health summary measure§ (any weighted)	Prevalence of impaired oral health summary measure• (all weighted)
Total	984	21.4 (18.0-25.3)	25.9 (22.6-29.5)	18.7 (15.4-22.6)	42.4 (37.7-47.2)	6.4 (4.4-9.2)
Dental service utilization						
Usually visit dentist						
Checkup	526	14.9 (11.2-19.5)*	18.2 (14.4-22.7)*	10.7 (7.6-14.7)*	30.6 (24.6-37.4)*	2.0 (1.0-3.9)*
Problem	457	29.6 (24.5-35.2)	35.4 (29.7-41.6)	28.7 (23.4-34.7)	56.6 (49.7-63.3)	11.8 (8.0-17.1)
Visit dentist in last 12 months						
Yes	459	26.2 (21.2-32.1)*	26.6 (21.3-32.6)	21.2 (16.1-27.4)	45.3 (38.0-52.8)	5.4 (2.8-10.3)
No	525	17.4 (13.8-21.9)	25.3 (21.1-30.0)	16.7 (13.0-21.2)	40.0 (34.0-46.3)	7.2 (4.7-10.7)
Last visit private dentist						
Yes	794	17.7 (14.5-21.3)*	24.6 (20.9-28.7)	15.0 (12.0-18.7)*	39.4 (34.1-44.9)	3.9 (2.4-6.2)*
No	185	35.8 (26.7-45.9)	30.8 (23.0-39.9)	32.7 (23.6-43.4)	54.6 (44.5-64.3)	15.9 (9.4-25.6)
Usually visit dentist once per year						
Yes	401	22.3 (17.2-28.5)	26.8 (21.2-33.1)	20.8 (15.7-27.1)	42.9 (35.5-50.7)	7.5 (3.9-13.8)
No	581	20.8 (16.7-25.7)	25.3 (21.3-29.7)	17.3 (13.4-22.0)	41.8 (35.8-48.1)	5.6 (3.8-8.3)
Avoid dental care because of cost						
Yes	442	31.4 (25.5-38.0)*	32.5 (27.1-38.6)*	25.9 (20.6-32.1)*	52.8 (46.0-59.4)*	12.1 (7.9-18.1)*
No	542	14.2 (10.8-18.5)	21.1 (17.1-25.8)	13.5 (10.1-17.9)	35.5 (29.3-42.1)	2.2 (1.2-4.1)
Dental fear						
Yes	408	30.8 (25.1-37.1)*	32.7 (27.0-39.0)*	23.1 (17.9-29.3)*	50.4 (43.5-57.3)*	9.7 (5.9-15.5)*
No	575	15.5 (11.5-20.5)	21.6 (17.6-26.1)	16.0 (12.1-20.8)	37.4 (31.5-43.7)	4.3 (2.6-6.9)
Clinical oral health outcomes						
Untreated dental decay						
Yes	269	34.9 (27.2-43.5)*	34.9 (27.4-43.2)*	32.0 (24.5-40.9)*	59.6 (51.2-67.4)*	13.4 (7.9-21.8)*
No	715	16.3 (13.0-20.3)	22.5 (18.9-26.4)	13.6 (10.6-17.4)	36.1 (31.0-41.6)	3.7 (2.4-5.7)
Missing teeth because of decay						
Yes	266	37.5 (29.5-46.2)*	32.8 (25.9-40.5)*	27.3 (20.4-35.6)*	51.4 (42.0-60.6)	14.5 (8.7-23.3)*
No	718	15.7 (12.8-19.2)	23.5 (19.8-27.6)	15.7 (12.4-19.6)	38.8 (33.7-44.2)	3.5 (2.2-5.3)
Restorations						
Yes	716	24.3 (20.3-28.9)*	28.5 (24.3-33.2)*	21.3 (17.2-26.0)*	47.7 (42.2-53.3)*	7.3 (4.6-11.2)
No	268	14.8 (10.1-21.2)	19.9 (14.6-26.5)	12.9 (8.6-18.9)	29.9 (22.3-38.9)	4.3 (2.2-8.3)
Periodontal pockets 4 mm+						
Yes	152	32.7 (23.0-44.2)*	35.6 (26.3-46.1)*	28.1 (20.6-37.1)*	58.1 (46.3-69.1)*	11.4 (6.5-19.1)*
No	786	19.3 (15.7-23.4)	24.2 (20.4-28.4)	16.8 (13.1-21.3)	39.6 (34.4-45.0)	5.4 (3.3-8.7)
Calculus						
Yes	633	22.8 (18.6-27.7)	29.8 (25.6-34.4)*	19.7 (15.5-24.7)	47.9 (42.3-53.5)*	7.2 (4.7-10.8)
No	349	18.8 (13.4-25.7)	18.4 (13.4-24.7)	16.9 (11.5-24.0)	31.2 (24.0-39.4)	4.8 (2.2-10.3)
Plaque						
Yes	197	25.7 (18.2-34.9)	31.5 (23.6-40.7)	24.6 (17.6-33.2)	51.3 (40.8-61.6)	10.8 (6.3-18.0)
No	784	20.3 (16.7-24.5)	24.4 (20.7-28.5)	17.2 (13.7-21.3)	39.7 (34.6-45.0)	5.2 (3.1-8.5)
Gingivitis						
Yes	167	24.6 (17.3-33.9)	29.4 (21.5-38.8)	23.2 (16.0-32.3)	50.0 (40.0-60.0)	8.4 (4.3-15.8)
No	772	20.2 (16.5-24.5)	24.8 (21.0-29.0)	17.2 (13.5-21.5)	40.4 (35.2-45.8)	5.6 (3.3-9.2)
Wear						
Yes	94	31.4 (21.1-43.9)	31.8 (21.5-44.2)	31.4 (21.2-43.9)*	50.2 (36.8-63.6)	15.2 (8.1-26.6)*
No	885	20.2 (16.6-24.3)	25.2 (21.7-29.0)	17.1 (13.5-21.6)	41.4 (36.4-46.6)	5.3 (3.3-8.4)

* $P < 0.05$.

† A response of "Very often," "Often," or "Sometimes" to the item "During the last 12 months how often have you had toothache?"

‡ A response of "Very often," "Often," or "Sometimes" to the item "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?"

¶ A response of "Very often," "Often," or "Sometimes" to the item "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?"

§ A response of "Very often," "Often," or "Sometimes" to the items "During the last 12 months how often have you had toothache?" "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?" or "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?"

• A response of "Very often," "Often," or "Sometimes" to the items "During the last 12 months how often have you had toothache?" "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?" and "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?"

Table 3 Poisson Regression Models of 18- to 34-Year-Old National Survey of Adult Oral Health Participants with Experience of Toothache/Impaired Appearance/Food Avoidance*

	Model A – non-clinical prevalence ratio (95% CI)	Model B – clinical prevalence ratio (95% CI)	Model C – non-clinical and clinical prevalence ratio (95% CI)
Highest qualification			
Non-university degree	1.25 (1.00-1.56)	–	–
University degree	ref	–	–
Trouble paying $100 dental bill			
Yes	1.30 (1.05-1.60)	–	1.37 (1.12-1.68)
No	ref	–	ref
Usually visit dentist			
Problem	1.58 (1.25-2.00)	–	1.46 (1.15-1.86)
Checkup	ref	–	ref
Cost prevented recommended dental care in last 2 years			
Yes	1.48 (1.17-1.88)	–	1.46 (1.16-1.85)
No	1.15 (0.90-1.48)	–	1.15 (0.90-1.48)
Not visited in last 2 years	ref	–	ref
Dental fear			
Yes	1.49 (1.21-1.84)	–	1.43 (1.18-1.73)
No	ref	–	ref
Untreated dental decay			
Yes	–	1.60 (1.29-1.99)	1.38 (1.13-1.68)
No	–	ref	ref
Missing teeth because of decay			
Yes	–	1.29 (1.03-1.62)	–
No	–	ref	–
Periodontal pockets 4 mm+			
Yes	–	1.34 (1.05-1.70)	1.29 (1.03-1.61)
No	–	ref	ref

* A response of "Very often," "Often," or "Sometimes" to the items "During the last 12 months how often have you had toothache?" "How often have you felt uncomfortable about the appearance of your teeth, mouth or dentures during the last 12 months?" or "How often have you had to avoid eating some foods because of problems with your teeth, mouth or dentures during the last 12 months?"
CI, confidence interval; ref = reference.

fear, as well as clinical outcomes such as untreated dental decay and presence of periodontal pockets. We acknowledge that the low threshold of one or more oral health impairments resulted in high prevalence (42.4 percent), although even when the more stringent definition of all three impairments was employed, it was notable that financial hardship, access to care, and dental disease were still associated with adverse impacts.

Regardless of the case definition used, it was striking that impairments were reported very frequently in this generation of young adult Australians who, in theory, have had the best opportunities for good oral health among generations born in the 20th century. In fact, population-wide studies in both Australia and the UK have noted that it is younger adults, rather than the elderly, who report more adverse impacts on quality of life (27). Possible explanations are that recent generations of younger adults have higher expectations than their parents' generations, or that the process of aging alters priorities as to the significance of oral health problems. However, these cross-sectional findings cannot distinguish among such explanations.

There is considerable utility in using a simple compositional measure of oral health impairment compared with lengthier questionnaires such as the Oral Health Impact Profile (28), General Oral Health Assessment Index (29), and the Oral Impacts on Daily Performance Scale (30). The measure of oral health impairment used here comprises arguably the three most important components of oral health-related quality of life: tooth pain, impaired appearance, and food avoidance. It is a simple and convenient way of conveying to policy-makers, who often have a general rather than specific knowledge of oral health, what factors are contributing to these oral health impacts, lending itself – in the policy context at least – to greater utility in a problem-solving capacity, and for monitoring and evaluation purposes.

It could be argued that it is important to explore the relative importance of each of the three components of the oral health impairment measure, as policy-makers might be more interested in finding solutions to one component, for example, toothache, than they would for another, for example, appearance. However, our findings indicate that there were many common associations in regard to the

three components of the oral health impairment measure (Table 1). This is perhaps unsurprising, given that the three components are not mutually exclusive. For example, the most common cause of toothache is untreated dental decay, which may cause both dental discoloration and contribute to difficulties with eating.

While our findings suggest that treatment of dental disease, reduction of financial barriers to dental care, and control of dental fear are needed to reduce oral health impairment among Australian young adults, the findings are only important to the extent that improvements in these areas are possible. One way in which to develop and implement effective interventions for improved oral health impairment is through Australia's dental sector. However, dental services for adults in Australia are generally provided through the private sector. Access to public dental services is available subject to ownership of a means-tested government health care, pension, or sickness beneficiary card. In 2004-2006, only 17.4 percent of 18- to 34-year-old Australians met the means-tested threshold for government-funded adult dental care (8). There is a chronic shortage of dental professionals in the public health sector, with 9.8 percent of dentists providing these services in 2000 despite 30 percent of the adult population being eligible for such care (31). Waiting lists for such services may be up to 4 years in some jurisdictions (32). As a consequence, most adults eligible for public dental care visit a private dentist and pay for their own treatment (18). Not all those remaining in the dental public health system receive free care, with a co-payment being necessary in the majority of cases. There are clear policy implications from this in regard to making dental services more financially accessible to 18- to 34-year-olds. Initiatives could perhaps include an introduction of dental insurance schemes that are affordable to those in the 18- to 34-year-old age group, basic dental care costs being covered by Medicare (Australia's universal health insurance scheme), lower dental care costs offered to students and those on low income, a reduction in the dental public health waiting lists by increased incentives to attract more dentists to work in this sector, and an increase in the role of dental auxiliaries.

It is important to detail the study's limitations. NSAOH was a cross-sectional investigation, meaning true causality cannot be determined. Also, while the sample population aimed to be representative of the adult Australian population, certain population subgroups, such as Aboriginal Australians, were underrepresented. In addition, the interview instrument was not validated.

In summary, our findings have shown that cost of dental care, dental attendance behaviors, oral health perceptions, and clinical outcomes are associated with impaired oral health, as measured by experience of toothache, impaired dentofacial appearance, or food avoidance in the last 12 months, among a representative sample of 18- to 34-year-old Australians. Our findings may be a useful guide for public health policy-makers in improving, promoting, and protecting the oral health status of Australian young adults, and have international relevance.

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References

1. Wilson IB, Cleary PD. Linking clinical variables with health-related quality of life: conceptual model of patient outcomes. *J Am Med Assoc*. 1995;**273**:59-65.
2. Mechanic D. Emerging trends in the application of the social sciences to health and medicine. *Soc Sci Med*. 1995;**40**:1491-6.
3. Reisine ST, Locker D. Social, psychological and economic impacts of oral conditions and treatments. In: Cohen LK, Gift HC, editors. *Disease prevention and oral health promotion. Socio-dental sciences in action*. Copenhagen, Denmark: Munksgaard; 1995. p. 33-71.
4. Locker D. Measuring oral health: a conceptual framework. *Community Dent Health*. 1988;**5**:3-18.
5. Slade GD. Assessment of oral health related quality of life. In: Inglehart M, Bagramian R, editors. *Oral health related quality of life*. Carol Stream, IL: Quintessence Publishing Co.; 2002. p. 29-46.
6. Sutton A. *Dental care and oral health sourcebook*. New York: Omnigraphics; 2003.
7. Alkhatib MN, Gilthorpe MS, McGrath C. Disparities in self reported oral health problems among a young Syrian adult population. *Int Dent J*. 2002;**52**:449-52.
8. Slade GD, Spencer AJ, Roberts-Thomson KF, editors. *Australia's dental generations; the national survey of adult oral health 2004-2006*. AIHW cat. no. DEN 165. Canberra, Australia: Australian Institute of Health and Welfare; 2007.
9. Duncan RP, Gilbert GH, Peek CW, Heft MW. The dynamics of toothache pain and dental services utilization: 24-month incidence. *J Public Health Dent*. 2003;**63**:227-34.
10. Baldwin DC. Appearance and aesthetics in oral health. *Community Dent Oral Epidemiol*. 1980;**8**:244-56.
11. Newton JT, Prabhu N, Robinson PG. The impact of dental appearance on the appraisal of personal characteristics. *Int J Prosthodont*. 2003;**16**:429-34.
12. de Oliveira CM, Sheiham A. The relationship between normative orthodontic treatment need and oral health-related quality of life. *Community Dent Oral Epidemiol*. 2003;**31**:426-36.
13. Wong AH, Cheung CS, McGrath C. Developing a short form of Oral Health Impact Profile (OHIP) for dental aesthetics: OHIP-aesthetic. *Community Dent Oral Epidemiol*. 2007;**35**: 64-72.

14. Lee S, McGrath C, Samman N. Quality of life in patients with dentofacial deformity: a comparison of measurement approaches. *Int J Oral Maxillofac Surg*. 2007;**36**:488-92.
15. Llewellyn CD, Warnakulasuriya S. The impact of stomatological disease on oral health-related quality of life. *Eur J Oral Sci*. 2003;**111**:297-304.
16. Pace-Balzan A, Butterworth CJ, Dawson LJ, Lowe D, Rogers SN. The further development and validation of the Liverpool Oral Rehabilitation Questionnaire (LORQ) version 3: a cross-sectional survey of patients referred to a dental hospital for removable prostheses replacement. *J Prosthet Dent*. 2008;**99**:233-42.
17. Gooch BF, Dolan TA, Bourque LB. Correlates of self-reported dental health status upon enrolment in the Rand Health Insurance Experiment. *J Dent Educ*. 1989;**53**:629-37.
18. Harford J, Spencer AJ. Oral health perceptions. In: Slade GD, Spencer AJ, Roberts-Thomson KF, editors. *Australia's dental generations; the national survey of adult oral health 2004-2006*. AIHW cat. no. DEN 165. Canberra, Australia: Australian Institute of Health and Welfare; 2007. pp. 173-86.
19. Budtz-Jorgensen E, Chung JP, Rapin CH. Nutrition and oral health. *Best Pract Res Clin Gastroenterol*. 2001;**15**:885-96.
20. Mehrstedt M, John MT, Tonnies S, Micheelis W. Oral health-related quality of life in patients with dental anxiety. *Community Dent Oral Epidemiol*. 2007;**35**:357-63.
21. Dillman DA. *Mail and internet surveys: the tailored design method*. 2nd ed. New York: John Wiley Company; 2000.
22. Carter KD, Stewart JF, Davies MJ, Szuster FS, Allister JH, Slade GD, Spencer AJ. *National telephone interview survey 1994*. Adelaide, South Australia, Australia: AIHW Dental Statistics Research Unit, 1994.
23. Carter KD, Stewart JF. *National telephone interview survey 1999*. Adelaide, South Australia, Australia: AIHW Dental Statistics Research Unit; 2002.
24. Carter KD, Stewart JF. *National telephone interview survey 2002*. Adelaide, South Australia, Australia: AIHW Dental Statistics Research Unit; 2003.
25. Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol*. 2003;**3**:21.
26. Last JM. *A dictionary of epidemiology*. *4th ed.* New York: Oxford University Press; 2001. p. 141.
27. Slade GD, Nuttall N, Sanders A, Steele J, Allen F, Lahti S. Impacts of oral disorders in Australia and the United Kingdom. *Br Dent J*. 2005;**198**:489-93.
28. Slade GD, Spencer AJ. Development and evaluation of the oral health impact profile. *Community Dent Health*. 1994;**11**: 3-11.
29. Atchison KA, Dolan TA. Development of the Geriatric Oral Health Assessment Index. *J Dent Educ*. 1990;**54**:680-7.
30. Adulyanon S, Vourapukjaru J, Sheiham A. Oral impacts affecting daily performance in a low dental disease Thai population. *Community Dent Oral Epidemiol*. 1996;**24**:385-9.
31. Teusner DN, Spencer AJ. *Dental labour force, Australia 2000*. AIHW cat. no. DEN 116. Canberra, Australia: Australian Institute of Health and Welfare (Dental Statistics and Research Series No. 28); 2003.
32. Davidson N, Skull S, Calache H, Chesters D, Chalmers J. Equitable access to dental care for an at-risk group: a review of services for Australian refugees. *Aust N Z J Public Health*. 2007;**31**:73-80.