LA Crocombe, DS Brennan and GD Slade

Does lower lifetime fluoridation exposure explain why people outside capital cities have poor clinical oral health?

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Does lower lifetime fluoridation exposure explain why people outside capital cities have poor clinical oral health?

Crocombe, LA[1, 2*]

Brennan, DS[1]

Slade GD[3]

1. Australian Research Centre for Population Oral Health, School of Dentistry, The University of Adelaide, Adelaide, Australia

2. Centre for Rural Health, School of Health Sciences, The University of Tasmania, Hobart, Tasmania, Australia

3. Department of Dental Ecology, UNC School of Dentistry, The University of North Carolina, Chapel Hill, North Carolina, United States of America

* Corresponding author, leonard.crocombe@adelaide.edu.au

Running title: Fluoridation exposure and rural clinical oral health

ABSTRACT

Background: Australians outside state capital cities have greater caries experience than their counterparts in capital cities. We hypothesized that differing water fluoridation exposures was associated with this disparity.

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Methods: Data were the 2004-06 Australian National Survey of Adult Oral Health. Examiners measured participant decayed, missing and filled teeth and DMFT Index and lifetime fluoridation exposure was quantified. Multivariable linear regression models estimated differences in caries experience between capital city residents and others, with and without adjustment for fluoridation exposure.

Results: There was greater mean lifetime fluoridation exposure in state capital cities (59.1%, 95% confidence interval=56.9,61.4) than outside capital cities (42.3, confidence interval=36.9,47.6). People located outside capital city areas had differing socio-demographic characteristics and dental visiting patterns, and a higher mean DMFT (Capital cities=12.9, Non-capital cities=14.3, p=0.02), than people from capital cities. After adjustment for socio-demographic characteristics and dental visits, DMFT of people living in capital cities was less than non-capital city residents (Regression coefficient=0.8, p=0.01). The disparity was no longer statistically significant (Regression coefficient=0.6, p=0.09) after additional adjustment for fluoridation exposure.

INTRODUCTION

Adults living outside Australian state capital cities have poorer oral health than their counterparts living in capital cities[1]. Non–capital-city residents are more likely to suffer complete tooth loss, to have an inadequate dentition (fewer than 21 teeth), and to wear dentures than capital-city residents, and they have more teeth affected by caries[2]. Avoiding difficult-to-eat foods is more common in people who reside outside capital cities than in capital–city-based people[3].

Proposed reasons for geographic variation in caries experience include lower socio-economic status of rural Australians[4], less availability of dental care outside of major cities[5], and provision of fewer preventive services and more dentures in rural areas[6, 7]. However, analysis of the 2004-06 Australian National Survey of Adult Oral Health[8] found that dental caries experience and the number of decayed and missing teeth were greater in non-capital city than capital city areas and that this was maintained after controlling for sociodemographic characteristics, preventive dental behaviours, and access to dental care. This indicates that there must be another factor, or factors, which explain why people residing outside capital cities have poorer clinical oral health than people living within capital city areas.

Slade et al.[9] found that the caries-preventive effects of water fluoridation were at least as great in adults born before the widespread implementation of fluoridation as after widespread implementation of fluoridation. More recently, Crocombe et al.[10] found that higher lifetime fluoridation exposure was associated with lower dental caries experience in younger adults in rural areas of Australia, largely reflected in a lower number of filled teeth.

Knowing whether differing levels of water fluoridation has a major association with capital and non-capital-city clinical oral health would give policy makers, administrators and dental practitioners further insight into oral health inequality. This study was designed to determine whether the greater dental caries experience of adults living outside Australian capital cities compared to adults in the capital cities was associated with lower exposure to fluoridated water among people living outside capital cities.

MATERIALS & METHODS

Data from the National Survey of Adult Oral Health 2004–06[11] (NSAOH) were used to compare the clinical oral health of Australian capital city and non–capital city residents. NSAOH used a clustered stratified random sampling design to select a representative sample of persons aged 15 years or more. Survey participants were interviewed by telephone and those who had one or more natural teeth were asked to attend a nearby dental clinic where standardised oral epidemiological examinations were conducted by one of 30 dentist–examiners trained in the survey methods. At the completion of the clinical examination, participants were given a pamphlet explaining that a questionnaire would be mailed to their homes. The 16-page questionnaire asked, among other things, about oral health behaviour. The Survey was reviewed and approved by The University of Adelaide's Human Research Ethics Committee. Full details of sampling, examination protocol and survey participation have been described in previous reports[12].

Australian postcodes were used to create two groups based on the Australian Bureau of Statistics postcode geographic classification: state capital city ('metropolitan' stratum) and remainder of state ('ex–metropolitan' stratum). The Australian Capital Territory was defined as a single metropolitan stratum. In the Northern Territory, ex–metropolitan postcodes were limited to the regional centres of Alice Springs, Katherine, Tennant Creek and Nhulunbuy.

The number of decayed, missing and filled permanent teeth (DMFT Index) was used to reflect a person's lifetime experience of dental caries. The number of decayed permanent teeth reflected the burden of untreated disease and the number of missing and filled permanent teeth indicated patterns of dental treatment.

Putative confounders were selected on the basis of having been shown in previous studies to be associated with clinical oral health: age[13], sex[14], country of birth[13], socioeconomic status[15,16], brushing with fluoride toothpaste[17], using sugar-free gum[18], smoking[19], diabetes[20], and access to dental care[21]. Although the current evidence is unable to answer the question of whether regular interdental cleaning provides a benefit above and beyond brushing with fluoride toothpaste[22], inter dental cleaning was included as a putative confounder because it is recommended by dental professionals to maintain good oral health[23].

Age was split into seven groups of 15-<25, 25-<35, 35-<45, 45-<55, 55-<65, 65-<75 and 75+ years. A continuous age variable was not selected because the association of DMFT with age displayed a different pattern for those aged 45 years and older. Seven age groups, rather than a lower number of age groups, were selected to decrease the possibility of residual confounding. Country of birth was dichotomised into Australia or overseas.

Socioeconomic status was measured by education and level of income. The highest level of education was trichotomised into Degree/Teacher/Nursing, Trade/Diploma/Certificate, and no Post-Secondary school education. Total household income was divided into low: less than $30,000, high: equal to or over $60,000, and middle: between these amounts.

Oral hygiene behaviours were the number of times brushed (Twice+/day, less than twice per day), used mouthrinse last week (Yes/no), used sugar-free gum last week (Yes/no) and regular interdental cleaning (At least daily, less than daily, not regularly). The tooth brushing dichotomy was used because people have been recommended to brush at least twice daily[24].

Two periodontal risk factors were included in the analysis because they may explain differences in numbers of missing teeth. These were the presence of diabetes (Yes/no) and smoking (Current/past/never smoked).

In Australia, socio-economically disadvantaged adults are eligible for public funded dental care, but the rationing of resources has led to disadvantaged adults being more likely to receive treatment for acute dental problems[21] than preventive/routine care. The number of locally-based dentists per head of population was included as an access to dental care variable because even though people may have the financial means and the incentive to access regular and preventive dental care, they may not be able to access dental care if there are not enough local dentists to provide that care. Difficulty paying a $100 dental bill or avoiding or delaying dental treatment because of cost is a barrier to receipt of dental care[25].

Access to dental care was measured using questions that assessed whether the participants were eligible for public dental care, the number of full-time equivalent (FTE) locally-based dentists (50+ per 100,00 people/under 50), whether they had a lot of difficulty in paying a $100 dental bill, the average time between dental visits (12 months or less, over 12 months), the usual reason for dental visits (Check-up/problem), and whether they had avoided or delayed dental treatment because of cost.

The lifetime fluoridation exposure was calculated using a fluoridation database maintained by the Australian Research Centre for Population Oral Health that recorded fluoride concentration of public water supplies, classified geographically by postcode[26]. It registered fluoride concentrations for 99.4% of the Australian population. They matched residential locations to water supplies in every year, coding fluoride concentrations as: (a) < 0.3 ppm F = 0; (b) 0.3 - < 0.7 ppm F = 0.5; and (c) ≥ 0.7 ppm F = 1.0 and assumed 0.5 ppm F for localities in New Zealand, Canada, or the United States and 0 ppm F for other foreign localities. The number of years at each concentration was multiplied by the concentration. The products were summed and divided by the person's age to yield the person's proportion of lifetime exposed to the equivalent of 1 ppm F in drinking water.

Data were weighted by age, sex and regional location to generate all statistics, thereby producing population estimates for the target population of dentate Australians aged 15 years or more. Categorical variables were summarised as percentages, while ordinal and continuous variables were summarised as means. A two-step analysis was undertaken: comparing the dependent variables by regional location, socio-demographic variables, preventive dental behaviours and access to dental care, and then including the lifetime fluoridation exposure variable. In each step, bivariate analysis was undertaken to identify and describe associations between the outcome variables and main explanatory variables and to find potential confounders. Variables that were statistically associated with both the explanatory (regional location) and at least one of the outcome variables were considered to be confounders. A multivariable analysis using linear regression analysis was then undertaken with the dental caries clinical measures as dependent variables. The regression coefficients generated from the regression models indicated the change in dental caries experience related to each explanatory variable. For continuous explanatory variables the regression coefficient indicated the expected change in dental caries experience for a one-unit change in the explanatory variable, such as percentage of exposure to water fluoridation. For indicator variables the regression coefficient indicated the expected change in caries experience relative to the reference category. Positive or negative regression coefficients indicate whether the expected change is higher or lower. SUDAAN (Research Triangle Institute, Research Triangle Park, NC) was used to adjust for complex analytical design, to weight for sampling probability and non-response.

RESULTS

Of the 14,123 persons interviewed, 5,505 (43.7%) were examined and 4,170 completed the questionnaire. Of those, lifetime fluoridation exposure was calculated for 3,770 people (Table 1). More people resided in capital city areas (2,514, 66.7%) than outside capital city areas (1,256, 33.3%). . Approximately half of the sample (52.8%) was less than 45 years of age, female (51.5%), or earned less than $60,000, while 36.5% had no secondary education and approximately one-fifth (20.5%) were born outside Australia. Over half (58.2%) the participants brushed their teeth more than twice a day, and over half (57.2%) had used a mouth rinse in the previous week. Most participants (28.0%) had not used gum in the previous week and only one fifth (20.5%) cleaned interdentally on a daily basis. Four percent of the respondents were diabetics and over half (58.0%) had never smoked. Over a quarter (27.1%) were eligible for public dental care, less than half (45.6%) had more than 50 full-time equivalent dentists per 100,000 population in their local area, 15.4% reported having a lot of trouble paying a $100 dental bill, over half (55.0%) had an average time of 12 months or less between dental visits, and over half (59.8%) usually visited a dentist for a check-up rather than a problem. Close to one-third (31.6%) of respondents reported avoiding or delaying dental treatment due to cost. The mean DMFT was 13.4, mean number of decayed teeth was 0.5, mean number of missing teeth was 4.5, and the mean number of filled teeth was 8.4.

Part 1 analysis: Socio-demographic variables, preventive dental behaviours, periodontal disease risk factors, and access to dental care variables.

People located outside state capital city areas had lower household incomes, were lesser qualified, were less likely to have been born outside Australia, less likely to brush twice or more per day, more likely to be eligible for public dental care, had a lower number of local dentists, visited a dentist less regularly, and were more likely to attend a dentist for a problem rather than a check-up, than people from capital cities (Table 1). People located outside state capital city areas had a higher caries experience (DMFT), and more decayed and missing teeth, but not more filled teeth, than people located within capital city areas.

Other than country of birth, all the putative confounders were significantly associated with at least one of the dental caries indicators (Table 2). Other than with the mean number of decayed teeth, the dental caries indicators were strongly associated with age. People on higher incomes had a lower mean DMFT Index, reflected in a lower mean number of decayed and missing teeth, than people on lower incomes. Males had more decayed, but fewer filled teeth, than females. People with a trade, diploma or certificate had a higher mean number of decayed, missing or filled teeth than people with degrees or without a post-secondary qualification. People who brushed twice or more a day had a higher DMFT Index, a lower mean number of decayed teeth and a higher mean number of filled teeth. Mouth rinsing in the previous week was associated with a lower DMFT Index and a lower mean number of filled teeth. Chewing of gum was significantly associated with dental caries experience. Regular interdental cleaning was associated with a higher DMFT Index and mean number of missing and filled teeth. Diabetics had a higher DMFT and a higher mean number of missing teeth than non-diabetics. People who never smoked had a lower DMFT and a lower mean number of decayed and missing teeth, than past or current smokers. Eligibility for public dental care was associated with poorer dental caries experience, other than with the mean number of filled teeth. A higher number of local dentists was associated with more dental caries and missing teeth. Having a lot of difficulty paying a $100 dental bill was associated with a higher DMFT Index and mean number of decayed teeth, but a lower mean number of filled teeth. People who visited the dentist more regularly had a higher DMFT Index with a lower mean number of decayed teeth, but a higher mean number of filled teeth. Usually visiting a dentist for a check-up was associated with better results in all the dental caries indicators than usually attending a dentist for a problem. People who avoided or delayed dental treatment due to cost had a higher mean number of decayed, but lower mean number of missing teeth than those who did not avoid or delay dental treatment due to cost. Household income, highest qualification, country of birth, times brushed per day in the last week, eligibility for public dental care, number of full-time equivalent local dentists, average time between dental visits, and usual reason for dental visiting were significantly associated with both regional location and at least one of the outcome variables of DMFT, decayed, missing or filled teeth. Though age was not significantly associated with regional location, it was decided to include age in the multivariable analysis because DMFT was strongly associated with age. Although the number of filled teeth was not significantly associated with regional location it was included in the multivariable analysis for completeness.

Following adjustments incurred through the multivariable modelling that included socio-demographic parameters, a preventive dental behaviour, and access to dental care in the regression model, people who lived outside state capital city areas still had a higher DMFT Index, largely reflected in a higher mean number of missing teeth than people living in capital cities (Table 3). Age was strongly associated with all the dental caries experience with the exception in the decayed teeth model. Higher income was associated with the mean number of missing teeth, and the highest income level had a lower mean DMFT Index. The level of qualification was also associated with the dental caries experience. More frequent toothbrushing was associated with fewer decayed teeth. More local dentists was associated with fewer decayed teeth and the usual reason for visiting was associated with lower mean DMFT, mean number of decayed and missing teeth.

Part 2 analysis: Lifetime fluoridation exposure

In bivariate analysis, there was a significantly greater mean lifetime fluoridation exposure in state capital city (59.1%, 95% confidence interval=56.9,61.4) than outside capital city areas (42.3%, 36.9,47.6). The mean percentage lifetime fluoridation exposure was significantly associated with age: (15-<25: 68.6%, 25-<35: 68.8%, 35-<45: 56.8%, 45-<55: 47.7%, 55-<65: 41.1%, 65-<75: 36.2%, 75+ years: 30.5%, $p<0.01$)

Following further multivariable modelling inclusive of lifetime fluoridation exposure, there was no longer a significant difference in the DMFT Index between the two regions, though there continued to be a significant difference in the mean number of missing teeth (Table 4). The DMFT estimate of -20.1 given in row 1 in the DMFT column indicated the negative change in dental caries experience in people aged 15-<25 years compared to the reference group, i.e. people aged 75+ years and the $p<0.05$ indicated the relationship was statistically significant. The DMFT estimate of -1.3 given in Proportion Lifetime Fluoridation Exposure row indicated the change in dental caries experience for a one-unit change in the percentage lifetime exposure to water fluoridation. There were not any changes in R^2 values for any of the regression models, nor were there any changes in statistical significance of any other variable between the two regression models.

DISCUSSION

The major finding was that with lifetime fluoridation exposure included in the regression model, there was no longer a significant difference in dental caries experience between people residing inside and outside Australian state capital cities. This study indicates that increasing lifetime fluoridation exposure for people living outside Australian capital cities would play a large role in removing the clinical oral health gap between people inside and outside capital cities. Fluoridation of drinking water remains the most effective and socially equitable means of achieving community-wide exposure to the caries prevention effects of fluoride[27]. Developed countries such as Australia should do more to provide access to fluoridated to water to all communities, including rural communities.

People living in non-metropolitan areas had a higher mean DMFT Index, largely reflected in a higher mean number of missing teeth than people living in metropolitan areas. People in rural areas commonly describe health as an absence of disease[28], and their money is spent on disease management rather than on primary care and health promotion[29]. This may explain why the difference in the mean number of missing teeth between capital and non-capital city areas persisted after controlling for socio-demographic parameters, preventive dental behaviour, access to dental care and lifetime fluoridation exposure in the regression model.

The limitations of the study should be noted. The use of a dichotomisation to define regional location may not be sensitive enough to capture differing levels of rural and remoteness. This study excluded people without a land-based phone from the study, and that will exclude some people from the study, for example, Aboriginals and Torres Strait islanders. Another criticism could be made of the dichotomising the number of dentists per 100,000 population at close to the mean number of fifty. However, the models were re-run using the number of dentists per 100,000 population as a continuous variable and it did not significantly affect the results. Missing teeth pose a threat to internal validity through misclassification of caries experience. However, dental caries is the main cause of tooth extraction in all ages[30] and periodontal disease did not vary between capital and non-capital city areas[2]. This study also found no significant variation between the regions for the periodontal risk factors for missing teeth of diabetes and smoking. A further criticism could be that the assumption of 0.5 ppm lifetime fluoridation exposure for the time people were outside of Australia may have resulted in a degree of misclassification. As a sensitivity analysis, the regression analysis was redone with only the Australian-born participants. The regression based on Australian-born participants indicated that there was not a significant difference in dental caries experience between capital city and non-capital city residents when lifetime fluoridation experience was in the regression (DMFT Est=0.36, p=0.36) or not (DMFT Est=0.74, p=0.06). However, the regression co-efficient was lower when lifetime fluoridation experience was in the regression indicating that lifetime fluoridation experience was a factor in the differing lifetime dental caries exposure between adults living inside and outside Australian capital city areas. The sample size of those born outside Australia was too small for a similar analysis.

An important consideration is whether the association is causal. As noted by Slade et al.[9], cross-sectional designs cannot establish a temporal ordering between exposure and disease and therefore cannot contribute to causal interpretation. However, cross-sectional studies are informative about temporality under two conditions: a) when studies compare lifetime exposure versus lifetime non-exposure; and b) when disease is quantified as lifetime, cumulative incidence. This study satisfies both these conditions, suggesting a causal relationship.

A major strength of this study was that NSAOH is only the second nationwide oral health survey held in Australia, had a large sample size, and the degree of non-participation bias was small[12]. The R^2 figures for DMFT (0.69), missing teeth (0.52) and filled teeth (0.41) models were higher than usually found in dental studies indicating that the data was close to the fitted regression line and the model explains much of the variability of the response data around its mean.

The results were consistent with previous research. That people from non–capital-city areas were more likely to have lower household incomes, lower educational qualification has been found by others[31], as has the relationship of age and country of birth[13], sex[14], socioeconomic status[15, 16] with the dental caries experience.

Further research needs to be undertaken to see whether the results change with differing levels of rural and remoteness. Future qualitative research should also be undertaken to assess collective rural/regional cultural (attitudinal) variations.

CONCLUSIONS

Dental caries experience and the number of decayed and missing teeth was greater in non-capital city than in state capital city areas. This was maintained for DMFT and number of missing teeth, but not for decayed teeth, after controlling for sociodemographic characteristics, a preventive dental behaviour, access to dental care, but not maintained for DMFT when also controlling for lifetime fluoridation exposure. Policies aimed at extending water fluoridation in rural areas. could play a role in removing the clinical oral health gap between people inside and outside Australian state capital cities.

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TABLES

Table 1: Relationship between socio-demographic characteristics, preventive dental behaviours, periodontal disease risk factors, access to dental care and regional location

		Descriptive analysis		Bivariate analysis		
		Total sample n=3,770		Capital city n=2,514	Non-Capital city n=1,256	
Parameters		**Col %**	**95% CI**	**Col %**	**Col %**	***p***
Socio-demographic characteristics						
Age	15-<25 years	15.1	12.6,17.6	15.5	14.3	0.36
	25-<35 years	17.1	14.6,19.5	18.2	14.8	
	35-<45 years	20.6	18.8,22.4	20.1	21.6	
	45-<55 years	19.5	17.7,21.3	19.0	20.5	
	55-<65 years	14.5	13.1,15.8	13.9	15.6	
	65-<75 years	7.6	6.7,8.5	7.3	8.2	
	75+ years	5.6	4.6,6.7	6.0	4.9	
Sex	Female	51.5	49.0,54.0	52.4	49.6	0.31
	Male	48.5	45.9,51.0	47.6	50.3	
Household Income	<$30,000	23.1	21.1,25.0	20.0	29.3	<0.01
	$30-<$60,000	30.5	28.2,32.9	29.3	33.1	
	$60,000+	46.4	43.5,49.3	50.6	37.7	
Highest Qualification	Deg/Teach/Nurs	35.2	32.5,37.9	40.5	24.4	
	Trade/Dip./Cert.	28.2	25.8,30.7	26.3	32.2	<0.01
	No Post Sec. Ed.	36.5	33.8,39.2	33.2	43.4	
Country of birth	Australia	79.5	77.5,81.5	76.1	86.4	<0.01
	Not Australia	20.5	18.5,22.5	23.9	13.6	
Preventive dental behaviours (%)						
Times brushed last week	Twice + per day	58.2	55.8,60.7	59.2	56.3	0.02
	<2 per day	41.8	39.3,44.2	40.8	43.7	
Used rinse in last week	Did rinse	57.2	54.8,59.6	58.1	55.3	0.39
	Did not rinse	42.8	40.4,45.2	41.9	44.7	
Used gum last week	Did	28.0	25.7,30.3	29.0	25.9	0.87
	Did not	72.0	69.7,74.3	71.0	74.1	
Regular interdental cleaning	At least daily	20.5	18.6,22.5	21.1	19.3	0.21
	Less than daily	39.4	37.0,41.8	41.9	38.2	
	Not regularly	40.0	37.5,42.6	38.8	42.4	
Periodontal disease risk factors (%)						
Diabetes	Yes	4.0	3.1,4.9	3.6	4.8	0.21
	No	96.0	95.1,96.9	96.4	95.2	
Smoking	Current Smoker	13.9	12.2,15.6	13.2	15.1	0.30
	Past Smoker	28.1	26.6,30.8	28.0	28.4	
	Never Smoked	58.0	55.7,60.3	58.8	56.5	
Access to dental care (%)						
Eligibility for public care	Eligible	27.1	24.9,29.2	25.1	30.9	0.02
	Not eligible	72.9	70.1,75.0	74.9	69.1	
FTE dentists per head	50+/100,000	45.6	43.1,48.2	66.6	3.6	<0.01
	>50/100,000	54.4	51.8,56.9	33.4	96.4	
Diff. pay $100 dental bill	A lot	15.4	13.7,17.0	14.7	16.7	0.94
	None - a little	84.6	83.0,86.3	85.3	83.2	
Av. time between visit	12 mth or less	55.0	52.4,57.7	58.5	48.2	<0.01
	> 12 months	45.0	42.3,47.6	41.5	51.8	
Usual reason dental visit	Check-up	59.8	57.2,62.4	64.1	51.3	<0.01
	Problem	40.2	37.6,42.8	35.9	48.7	
Avoided/delay due to cost	Yes	31.6	29.4,33.9	30.7	33.4	0.27
	No	68.4	66.1,70.6	69.2	66.6	
Dental caries indicators (mean)						
DMFT		13.4	12.8,13.9	12.9	14.3	0.02
Decayed teeth		0.5	0.4,0.5	0.4	0.6	<0.01
Missing teeth		4.5	4.2,4.7	4.1	5.3	<0.01
Filled teeth		8.4	8.1,8.8	8.5	8.4	0.85

Table 2: Relationship between socio-demographic characteristics, periodontal risk factors, preventive dental behaviours, access to dental care and DMFT (<45 excludes non-pathology), decayed, missing (<45 excludes non-pathology) and filled teeth

		Dental caries indicators							
		DMFT		Decayed teeth		Missing teeth		Filled teeth	
Putative confounders		mean	*p*	mean	*p*	mean	*p*	Mean	*p*
Socio-demographic characteristics									
Age	15-<25 years	3.0	<0.01	0.5	0.09	0.6	<0.01	1.9	<0.01
	25-<35 years	5.3		0.5		0.6		4.1	
	35-<45 years	10.3		0.5		1.7		8.1	
	45-<55 years	18.5		0.5		5.5		12.4	
	55-<65 years	21.8		0.4		8.4		13.0	
	65-<75 years	23.3		0.4		11.4		11.5	
	75+ years	24.5		0.4		13.5		10.7	
Sex	Male	12.9	0.10	0.5	0.02	4.4	0.63	8.0	0.01
	Female	13.8		0.4		4.5		8.9	
Household Income	<$30,000	18.3	<0.01	0.6	<0.01	8.7	<0.01	9.0	0.05
	$30-<$60,000	14.0		0.6		4.3		9.0	
	$60,000+	11.4		0.3		2.8		8.3	
Highest Qualification	Deg/Teach/Nurs	12.4	0.31	0.2	<0.01	3.1	<0.01	9.0	<0.01
	Trade/Dip./Cert.	15.3		0.5		5.3		9.4	
	No Post Sec. Ed.	12.5		0.6		4.9		6.9	
Country of birth	Australia	12.9	0.99	0.4	0.30	4.2	0.73	8.2	0.66
	Not Australia	15.3		0.6		5.5		9.2	
Preventive dental behaviours									
Times brushed	Twice + per day	14.1	<0.01	0.4	0.05	4.6	0.07	9.2	<0.01
	<2 per day	12.3		0.6		4.3		7.4	
Used rinse in last week	Did rinse	12.7	0.03	0.5	0.06	4.2	0.49	8.0	<0.01
	Did not rinse	14.2		0.4		4.8		9.0	
Used gum last week	Did	10.1	<0.01	0.6	<0.01	2.8	<0.01	6.7	<0.01
	Did not	14.6		0.4		5.1		9.1	
Regular interdental cleaning	At least daily	15.5	<0.01	0.4	0.03	5.8	<0.01	10.3	<0.01
	Less than daily	12.6		0.3		3.7		8.6	
	Not regularly	12.3		0.6		4.4		7.3	
Periodontal disease risk factors									
Diabetes	Yes	18.3	<0.01	0.6	0.14	8.5	<0.01	9.2	0.19
	No	13.2		0.5		4.3		8.4	
Smoking	Current Smoker	12.7	<0.01	1.1	<0.01	4.4	<0.01	7.3	0.81
	Past Smoker	16.0		0.4		6.0		9.7	
	Never Smoked	12.2		0.4		3.8		8.1	
Access to dental care									
Eligibility for public care	Eligible	17.0	<0.01	0.7	<0.01	7.7	<0.01	8.6	0.41
	Not eligible	12.0		0.4		3.3		8.4	
FTE dentists per head	50+/100,000	12.9	0.12	0.3	<0.01	4.1	<0.01	8.5	0.38
	>50/100,000	13.8		0.6		4.7		8.4	
Diff. pay $100 dental bill	A lot	12.2	<0.01	0.8	0.01	4.7	0.46	6.7	<0.01
	None - a little	13.5		0.5		4.5		8.5	
Av. time between visit	12 mth or less	14.6	<0.01	0.3	<0.01	4.5	0.62	9.8	<0.01
	> 12 months	11.9		0.6		4.4		6.8	
Usual reason dental visit	Check-up	13.0	0.03	0.3	<0.01	3.9	<0.01	8.8	<0.01
	Problem	14.0		0.8		5.4		7.9	
Avoided/delay due to cost	Yes	12.8	0.08	0.7	<0.01	4.1	0.03	8.0	0.06
	No	13.6		0.4		4.7		8.6	

Table 3: Multivariable models for dental caries indicators with socio-demographic characteristics, preventive dental behaviour, access to dental care parameters and regional location

	Dental caries indicators							
	DMFT		Decayed teeth		Missing teeth		Filled teeth	
Parameters	**Est.***	***p***	**Est.**	***p***	**Est.**	***p***	**Est.**	***p***
Socio-demographic characteristics								
Age (15-<25 years, ref: 75+ years)	-20.6	<0.01	0.2	0.20	-12.7	<0.01	-8.1	<0.01
Age (25-<35 years, ref: 75+ years)	-17.6	<0.01	0.4	0.01	-12.3	<0.01	-5.7	<0.01
Age (35-<45 years, ref: 75+ years)	-13.3	<0.01	0.2	0.12	-11.6	<0.01	-1.9	<0.01
Age (45-<55 years, ref: 75+ years)	-5.0	<0.01	0.3	0.04	-7.7	<0.01	2.4	<0.01
Age (55-<65 years, ref: 75+ years)	-2.1	<0.01	0.1	0.58	-5.1	<0.01	3.0	<0.01
Age (65-<75 years, ref: 75+ years)	-1.0	0.10	0.0	0.81	-2.7	<0.01	1.7	0.02
Income ($30,000-$59,999, ref:<$30,000)	-0.2	0.44	0.2	0.22	-1.2	<0.01	0.8	0.11
Income ($60,000+, ref: <$30,000)	-0.9	0.04	-0.0	0.76	-1.2	<0.01	0.4	0.46
Educ. (Trade/Dip/Cert, ref: No post-sec)	0.0	0.98	-0.2	0.02	-0.3	0.20	0.6	0.07
Educ. (Deg/Teach/Nur, ref: No post-sec)	-0.6	0.04	-0.3	<0.01	-1.1	<0.01	0.8	0.01
Preventive dental behaviour								
Times brushed (2+/day, ref: (<2/day)	-0.2	0.48	-0.1	<0.05	-0.3	0.10	0.3	0.31
Access to dental care								
Eligibility for public care (Yes, ref: No)	0.4	0.32	0.2	0.13	0.2	0.53	-0.0	0.98
FTE dentists (100,000 (<50, ref: ≥50)	-0.2	0.59	0.1	0.04	-0.2	0.33	-0.1	0.79
Av. time visits (>12 mths ref: ≤12 mths)	-1.9	<0.01	0.1	0.20	0.0	0.99	-2.0	<0.01
Usual reason visit (Chk-up, ref: Prob.)	-1.4	<0.01	-0.4	<0.01	-1.1	<0.01	-0.1	0.61
Region location (Non-metro, ref: Metro)	0.8	0.01	0.1	0.10	0.8	<0.01	-0.1	0.64
	R^2=0.69, Model p<0.01		R^2=0.09, Model p<0.01		R^2=0.52, Model p<0.01		R^2=0.41, Model p<0.01	

* The estimate is the regression coefficient, the size of which gives the magnitude of the effect that each independent variable is having on the dependent variable, and the sign on the coefficient gives the direction of the effect.

Table 4 Multivariable models for dental caries indicators with socio-demographic characteristics, access to dental care parameters, regional location, plus lifetime fluoride exposure

	Dental caries indicators							
	DMFT		Decayed teeth		Missing teeth		Filled teeth	
Parameters	**Est.***	***p***	**Est.**	***p***	**Est.**	***p***	**Est.**	***p***
Socio-demographic characteristics								
Age (15-<25 years, ref: 75+ years)	-20.1	<0.01	0.2	0.25	-12.8	<0.01	-7.5	<0.01
Age (25-<35 years, ref: 75+ years)	-17.2	<0.01	0.4	0.01	-12.4	<0.01	-5.1	<0.01
Age (35-<45 years, ref: 75+ years)	-13.0	<0.01	0.2	0.14	-11.7	<0.01	-1.5	0.04
Age (45-<55 years, ref: 75+ years)	-4.8	<0.01	0.3	<0.05	-7.7	<0.01	2.6	<0.01
Age (55-<65 years, ref: 75+ years)	-1.9	<0.01	0.1	0.59	-5.2	<0.01	3.8	<0.01
Age (65-<75 years, ref: 75+ years)	-0.9	0.14	0.0	0.82	-2.7	<0.01	1.8	0.01
Income ($30,000-$59,999, ref:<$30,000)	-0.3	0.55	0.2	0.22	-1.2	<0.01	0.8	0.13
Income ($60,000+, ref: <$30,000)	-0.9	<0.05	-0.0	0.76	-1.2	<0.01	0.4	0.40
Educ. (Trade/Dip/Cert, ref: No post-sec	0.0	0.95	-0.2	0.02	-0.3	0.20	0.6	0.06
Educ. (Deg/Teach/Nur, ref: No post-sec)	-0.6	<0.05	-0.3	<0.01	-1.1	<0.01	0.8	0.01
Preventive dental behaviour								
Times brushed (<2/day, ref: 2+/day)	-0.3	0.35	-0.1	<0.05	-0.3	0.11	0.2	0.47
Access to dental care parameters								
Eligibility for public care (Yes, ref: No)	0.4	0.30	0.2	0.14	0.2	0.54	0.0	0.99
FTE dentists (100,000 (<50, ref: ≥50)	-0.1	0.73	0.1	<0.05	-0.2	0.31	-0.0	0.97
Av. time visits (>12 mths ref: ≤12 mths)	-1.9	<0.01	0.1	0.21	-0.0	0.99	-1.9	<0.01
Usual reason visit (Chk-up, ref: Prob.)	-1.4	<0.01	-0.4	<0.01	-1.1	<0.01	0.1	0.65
Proportion Lifetime Fluoridation Exposure**	-1.3	<0.01	0.0	0.32	0.3	0.19	-1.6	<0.01
Region location (Non-metro, ref: Metro)	0.6	0.09	0.1	0.11	0.9	<0.01	-0.5	0.09
	R^2=0.69, Model p<0.01		R^2=0.09, Model p<0.01		R^2=0.52, Model p<0.01		R^2=0.42, Model p<0.01	

* The estimate is the regression coefficient, the size of which gives the magnitude of the effect that each independent variable is having on the dependent variable, and the sign on the coefficient gives the direction of the effect.
* Proportion Lifetime Fluoridation Exposure because this is a continuous variable.