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Access to dental care barriers and poor clinical oral health in Australian regional populations

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ABSTRACT

Background: This paper investigated the associations between oral health with behavioural, demographic, periodontitis risk, financial and access to dental care barriers and compared the results in three Australian regional areas.
Methods: Data were obtained from the Australian National Study of Adult Oral Health (2017–18). Oral health status was measured using DMFT-score, and mean numbers of decayed, missing or filled teeth and periodontitis prevalence using the Center for Disease Control and Prevention (CDC) and the American Academy of Periodontology (AAP) Periodontal Classification. The analysis included these dependent variables by three regional areas, seven socio-demographic variables, two periodontal disease risk factors, two preventive dental behaviours, two barriers to dental care and three access to dental care variables.
Results: Of the 15,731 people interviewed, 5,022 were examined. There was no significant difference in periodontitis prevalence between the regions. All the socio-demographic characteristics, periodontal disease risk factors and preventive dental behaviours were significantly associated with at least one of the dental caries indicators. In multivariable analysis, there was no significant association between regional location with any of the four clinical dental caries variables.
Conclusion: Poorer oral health outside major cities was associated with household income, education level, higher smoking, usual reason for and frequency of dental visiting.

Keywords: Access, dental services, oral health, regional, rural.

Abbreviations and acronyms: AAP = American Academy of Periodontology; CDC = Centre for Disease Control and Prevention; DMFT = Decyaed, Missing and Filled Teeth; NSAOH = National Survey of Adult Oral Health.

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INTRODUCTION

Untreated dental caries in permanent teeth is the most common untreated disease affecting the global population (34.1%).[1] Despite the use of oral health prevention strategies in both developed and developing nations, there has been less than a 4% reduction in the prevalence of untreated dental caries over nearly 30 years [1990: 31,407 cases per 100,000 people to 2017: 30,129 cases per 100,000 people].[1]

The proportion of Australians aged 15 years and over with complete tooth loss, an inadequate natural dentition or who have dentures decreased between 1987–88 and 2004–06 and again between 2004–06 and 2017–18.[2] The dental caries experience of adults (DMFT [Decayed, Missing and Filled Teeth] Score) similarly decreased over the same time period.[2]

Oral health is poorer in rural than in metropolitan areas of Australia.[3,4] Clinical oral health improved by a similar amount between 1987–88 and 2004–06 inside and outside Australia's capital cities resulting in the differential in oral health staying the same.[5] This suggested that the poorer rural oral health was not being adequately managed.[6]

A possible reason for poor oral health in rural areas might be poorer access to dental care. In both 2004–06[3] and 2017–2108[4], lower rates of visiting at least once a year and usually attending a check-up[7] were observed for those living outside of capital cities compared with those in capital cities, those with Year 10 or less schooling compared to Year 11 or more schooling, individuals with other or no qualifications than those with a degree or above, those eligible for public dental care compared to those ineligible and uninsured than insured persons. Other reasons for poor oral health in rural areas include reduced access to fluoridated drinking water, high-risk behaviours such as smoking and alcohol drinking, and usually

visiting a dentist for a problem rather than a check-up[3].

Major cities have the highest number per 100,000 population of practising dentists (64.6) and Remote/Very remote areas had the lowest (25.9) and this workforce imbalance has not improved since 2013.[8]

This paper aimed to find the associations in 2017-18 between oral health with behavioural, demographic, periodontal disease risk indicators, social demographic factors, financial and access barriers to dental care in three Australian regional areas in 2017-18. It wished to find if adult oral health was poorer than in Australia's major cities, and if not, what factors could be involved. It will inform policy makers, administrators and dental practitioners about which factors influence regional and remote oral health.

METHODOLOGY

Data from the latest National Study of Adult Oral Health (NSAOH 2017-18) were analysed. Study participants were selected using a multi-stage probability sampling design that began with the sampling of postcodes within states/territories in Australia. A sampling frame of postcodes was created that listed all postcodes designated as in-scope of the study. Through consultation with state and territory dental health services, some remote and very remote postcodes were excluded due to the costs and complexities involved in undertaking oral examinations in these postcodes. The postcode sampling frame was stratified by state and territory and further stratified into greater capital city and rest of state/territory regions. Individuals within selected postcodes were then selected by the Australian Government Department of Human Services from the Medicare database. Participants were given the option to either complete the questionnaire online or complete the questionnaire via a computer-assisted telephone interview. Participants were asked a series of questions about their oral health and dental service use. Participants who completed an interview and who reported having one or more of their own natural teeth were invited to undergo a standardised oral examination. Examinations were carried out by state/territory dental practitioners. Statistical analyses were carried out on the 5,022 adults who were examined. Information on the NSAOH 2017-18 study aims and methods[7] and study participation and weighting[9] can be found elsewhere. This study followed the STROBE Statement for reporting cross-sectional studies.

The NSAOH 2017-18 project was reviewed and approved by The University of Adelaide's Human Research Ethics Committee and ethical approval to conduct examinations in each jurisdiction was sought under the National Mutual Acceptance system.

Three regional levels (Major city, Inner regional, Outer regional & Remote/Very remote) were used for analysis rather than two (Inside and outside Major cities) because the proportion of dentists to population numbers in each region varied[8] and having three regions gives a greater gradient of rurality.[10]

Putative confounders were selected that have been shown in previous studies to be associated with oral health. These were subdivided into the categories of socio-demographic characteristics, periodontal disease risk factors and preventive dental behaviours. Periodontal disease risk factors were included because they might help explain the loss of teeth. Socio-demographic characteristics included age (15-<45, 45-<60, 60+ years), sex, annual household income (≤$AU30k, > $AU30k-<60k, $AU60k+), country of birth (Australia/Other), education level (≤Year 10, Year 11+), Aboriginal and/or Torres Strait Islander (Yes/No) and employment status (Employed/Not employed). Periodontal disease risk factors were smoking (Current/past/never smoked) and diabetes (Yes/No). Preventive dental behaviours were frequency of toothbrushing (2+, <2 day) and flossing (1+ per day, <1 per day) and the usual reason for dental visiting (Check-up, problem).

Barriers to dental care were financial: the difficulty in paying a $200 dental bill (none, hardly any, a little, a lot of difficulty) and avoided or delayed dental treatment because of cost (Yes, No). The access to dental care variables was the usual reason for dental visits (problem/check-up), the average time between dental visits (1+ times/year, ≤ once a year), and eligibility for public dental care (Yes, No).

Clinical oral health was measured by the prevalence of dental caries and periodontitis. The former by the mean number per participant of decayed teeth, missing teeth (under 45 years of age excluded non-pathology) and filled teeth due to pathology. The latter by the US Centers for Disease Control and Prevention (CDC) and the American Academy of Periodontology (AAP) Periodontal Classification and dichotomized into none/mild and moderate/severe.

Dental caries experience was indicated by the mean number of decayed, missing and filled teeth (DMFT score) per participant. To make an estimation of the mean number of teeth missing due to dental decay and periodontal (gum) disease, an assessment was made of the reason for missing teeth in people less than 45 years of age at the time of examination. This meant that teeth which were missing for reasons other than decay or gum disease could be excluded from the analysis. In older people, the assumption was made that missing teeth had been extracted for dental disease.

The dependent variables were compared by region, socio-demographic characteristics, periodontal disease risk factors, preventive dental behaviours, and the barriers and access to dental care variables. Data

analysis was performed with all data weighted to ensure the representativeness of the target population.[7] Bivariate analysis was undertaken to identify and describe associations between the outcome variables and main explanatory variables and to find confounders. For categorical variables, the bivariate variate analysis was done as a cross-tabulation with chi-square and t-tests for continuous variables. For collinearity, regression analysis for variance inflation factor calculation was used. Variables that were statistically associated with both the explanatory (regional location) and at least one of the outcome variables were defined as confounders. A multiple variable analysis with the dental clinical disease measures as dependent variables was then undertaken.

RESULTS

Of the 15,731 people interviewed, 5,022 were examined. Just over half the participants were aged between 15 and less than 45 years, there was an even split of the sexes, annual household income was approximately evenly split between the three categories, and just under 70% had a Year 11 education or higher. A third of the participants were born outside Australia, under 2% reported having Aboriginal or Torres Strait Islander ancestry and under 40% were unemployed (Table 1). With the periodontal disease risk factors, 6% reported a doctor saying they had diabetes and just under one-tenth were current smokers. Over two-thirds of participants brushed their teeth at least twice a day and just over a fifth flossed their teeth at least once a day and over 60% of the participants reported usually visiting a dentist for a check-up.

With the barriers and access to dental care variables, just under half visited a dentist once a year or less, over half had a little or a lot of difficulties paying a $200 dental bill, and under a half avoided or delayed dental treatment because of cost and just under a third were eligible for public dental care. The mean DMFT score was 11.20.

Inner regional areas had a higher proportion of people in both the oldest and youngest age groups than in the other two regions (Table 2). There were more people with the lowest household income level in inner regional than in major city areas. People in outer regional, remote and very remote areas had lower education levels and were less likely to be born outside Australia than people in major city areas. There was a higher proportion of Aboriginal or Torres Strait Islanders outside than inside major city areas.

People in inner regional areas were more likely to be previous smokers than people in major cities and people in outer regional, remote and very remote areas were less likely to usually visit a dentist for a

Table 1. Characteristics of participants

Characteristic	% (95% CI)
Social demographics	
Age	
15-<45 years	52.5 (49.9–55.2)
45-<60 years	23.7 (21.6–25.9)
60+ years	23.7 (21.9–25.7)
Sex	
Male	49.7 (47.1–52.4)
Female	50.2 (47.6–52.9)
Annual household income	
≤$AU30k	30.4 (27.9–33.0)
<$AU30k-<60k	32.5 (30.0–35.1)
$AU60k+	37.1 (34.5–39.8)
Education	
Year 11+	30.3 (27.8–32.9)
≤Year 10	69.7 (67.1–72.2)
Country of Birth	
Australia	67.5 (64.9–67.0)
Other	32.5 (30.0–35.1)
Aboriginal or Torres Strait Islander	
Yes	1.3 (0.9–2.0)
No	98.7 (98.0–99.1)
Employment Status	
Employed	61.1 (58.3–63.9)
Unemployed	38.9 (36.1–41.7)
Periodontal disease risk factors	
Diabetes	
Yes	6.0 (5.1–7.2)
No	94.0 (92.8–94.9)
Smoking	
Current	9.6 (8.2–11.2)
Previous	28.5 (26.2–31.0)
Never	61.9 (59.3–64.3)
Preventive dental behaviours	
Tooth Brushing	
2+ day	69.4 (67.2–71.5)
<2 day	30.6 (28.5–32.8)
Dental Flossing	
1+ per day	20.9 (19.0–23.0)
<1 per day	79.1 (77.0–81.0)
Barriers to dental care	
Difficulty paying a $200 dental bill	
None	26.3 (24.1–28.6)
Hardly any	17.0 (15.1–19.0)
A little	31.6 (29.2–34.2)
A lot of difficulty	25.1 (22.7–27.7)
Avoided or delayed dental treatment because of cost	
Yes	44.3 (41.6–47.0)
No	55.7 (53.0–58.4)
Access to dental care	
Usual Reason for Dental Visit	
Check up	62.7 (59.9–65.4)
Problem	37.3 (34.6–40.1)
Average time between dental visits	
1+ times/year	52.8 (50.0–55.7)
≤Once a year	47.2 (44.3–50.0)
Eligibility for public dental care	
Yes	29.5 (27.1–32.0)
No	70.5 (68.0–72.9)
Clinical Dental Diseases	
Dental caries	
DMFT: Mean (SD)	11.31 (10.85–11.77)
Decayed teeth: Mean (SD)	0.77 (0.67–0.87)
Missing teeth: Mean (SD)	4.40 (4.10–4.6.8)
Filled teeth: Mean (SD)	6.15 (5.86–6.45)

(continued)

Table 1 (continued)

Characteristic	% (95% CI)
CDC/APC Periodontal Classification	
None/Mild	70.8 (68.4–73.1)
Moderate/Severe	29.2 (26.9–31.6)
Regional Location	
Major city	72.4 (68.8–75.7)
Inner regional	16.1 (13.0–19.8)
Outer regional, remote & very remote	11.5 (8.7–14.9)

check-up or to visit a dentist two times or more a year than people in major city areas.

There was no significant difference in the proportion of people with respect to sex, diabetes, employment status, the frequency of toothbrushing or dental flossing, difficulty in paying a $200 dental bill or avoiding or delaying dental treatment because of cost between the three regions. Hence, these variables were not included in the multiple variable analyses.

A higher proportion of people in inner regional areas than in major city areas were eligible for public dental care and there were less dentists per 100,000 people in outer regional, remote and very remote areas than in the major cities. The DMFT score and the mean number of missing teeth were significantly higher outside than inside major city areas. However, there was no significant difference in the prevalence of periodontal disease between the three regional areas. For this reason, the influence of periodontal disease was not further reported in this paper. Even though there was also not a significant difference between the mean number of decayed or filled teeth between the regional areas, they were included in the multiple variable analysis to discover how they influenced the DMFT score.

Not surprisingly, as the variables were selected on whether they had been shown in previous studies to be associated with oral health, all the socio-demographic characteristics, periodontal disease risk factors, and preventive dental behaviours were significantly associated with at least one of the dental caries indicators (Table 3).

Age, annual household income, education, country of birth, being an Aboriginal or Torres Strait Islander, smoking, the usual reason for dental visiting, the average time between dental visits and eligibility for public dental care were significantly associated with both the regional location and at least one of the outcome variables and were included in the multivariable analysis.

In the multivariable analysis, there was no significant association between regional location with any of the four clinical dental caries variables (Table 4). Age was associated with all four clinical dental caries variables and annual household income with the decayed and missing teeth coefficients, but not with and filled teeth or the DMFT score. Education level was associated with the decayed and filled teeth coefficients. Country of birth or being an Aboriginal and/or Torres Strait islander was not associated with any of the dental caries indicators.

Current smoking was associated with more decayed and missing teeth which resulted in a higher DMFT score. With the access to dental care variables, usually visiting a dentist for a problem was associated with higher dental caries in all four multiple variable models than usually visiting for a dental check-up. Less frequent dental visiting was associated with lower DMFT score and less filled teeth. Eligibility for dental care was associated with a higher DMF and less filled teeth.

DISCUSSION

The results suggest that tackling differences between the three regions in social demographics such as income and education level as well as smoking behaviour will improve the oral health of people outside Australian major cities. Importantly they also indicate that an emphasis should be on encouraging people outside the major cities to visit their dentist for a check-up rather than waiting till they have a dental problem.

These results are important because they suggest that tackling social demographics and smoking prevalence might do more to lower the dental caries experience of people outside Australian major cities in the long term than the expensive option of increasing the number of dentists. This is a generational change. Improving access to education outside major city areas might flow onto improved incomes, reduced smoking rates, and more dental visits for check-ups rather than for a problem.

This does not mean that having more dentists outside major cities is not a good idea, particularly in the shorter term. The first reason is that more dentists will allow earlier detection of dental diseases and treatment can be provided when the disease is at an early stage. The second reason is that more dental practitioners will give those in rural areas time to provide more preventive practices such as fluoride applications and fissure sealants. Previous studies have found that rural dentists were less likely to supply preventive services than urban dentists[11] and this might be due to having a higher number of patients who need problem-based care resulting in having less available time to provide non-urgent dental care.[12,13]

This study found that being eligible for public dental care was associated with more missing teeth. This suggests that increasing the size of the public dental workforce outside Australia's major cities so that it can provide more preventive and conservative treatment rather than extractions as well as targeting high-risk groups might be a good strategy.

Table 2. Bivariate analysis of the association between regional location, oral health and putative confounders

Characteristic	Major city % (95% CIs)	Inner regional % (95% CIs)	Outer regional, remote & very remote % (95% CIs)	*P*
Social demographics				
Age				
15-<45 years	55.3 (52.2–58.4)	39.0 (32.6–45.8)	54.2 (48.3–59.9)	<0.01
45-<60 years	22.6 (20.0–25.4)	28.9 (24.7–33.4)	23.5 (18.8–28.9)	
60+ years	22.1 (20.0–24.4)	32.1 (27.5–37.0)	22.3 (18.5–26.6)	
Sex				
Male	49.8 (46.5–53.0)	48.2 (42.6–53.7)	51.9 (45.2–58.5)	0.72
Female	50.2 (46.9–53.5)	51.8 (46.3–57.4)	48.1 (41.5–54.8)	
Annual household income				
≤$AU30k	27.7 (24.6–30.9)	39.6 (34.0–45.5)	34.0 (28.5–40.0)	<0.01
>$AU30k-<60k	32.6 (29.5–35.8)	31.9 (26.7–37.6)	32.9 (27.0–39.4)	
$AU60k+	39.8 (36.5–43.1)	28.5 (23.7–33.8)	33.1 (26.5–40.4)	
Education				
Year 11+	34.0 (30.8–37.4)	21.4 (17.2–26.4)	19.0 (15.2–23.5)	<0.01
≤Year 10	66.0 (62.6–69.2)	78.5 (73.5–82.8)	81.0 (76.5–84.8)	
Country of Birth				
Australia	61.8 (58.3–65.1)	82.2 (78.2–85.7)	82.5 (76.2–87.5)	<0.01
Other	38.2 (34.9–41.6)	17.8 (14.3–21.8)	17.4 (12.5–2.38)	
Aboriginal or Torres Strait Islander				
No	99.6 (99.1–99.8)	96.8 (93.6–98.4)	95.7 (91.9–97.8)	<0.01
Yes	0.4 (0.2–0.9)	3.2 (1.6–6.3)	4.2 (21.8–8.1)	
Employment Status				
Employed	62.2 (58.7–65.5)	55.5 (49.3–61.5)	62.3 (56.3–67.9)	0.11
Unemployed	37.8 (34.4–41.2)	44.5 (38.5–50.7)	37.7 (32.1–43.7)	
Periodontal disease risk factors				
Diabetes				
Yes	5.8 (4.7–7.2)	6.5 (4.8–8.8)	6.8 (4.5–10.1)	0.71
No	94.2 (92.7–95.3)	93.5 (91.2–95.2)	93.2 (89.8–95.5)	
Smoking				
Current	9.7 (7.9–11.8)	9.4 (7.1–12.2)	9.6 (7.1–12.7)	<0.01
Previous	26.3 (23.5–29.2)	34.8 (29.8–40.2)	33.8 (28.0–40.0)	
Never	64.0 (60.9–67.0)	55.8 (50.3–61.1)	56.6 (50.6–62.5)	
Preventive dental behaviours				
Tooth Brushing				
2+ day	70.0 (67.4–72.6)	69.5 (64.3–74.2)	65.4 (59.3–70.9)	0.35
<2 day	30.0 (27.4–32.6)	30.5 (25.8–35.7)	34.6 (29.0–40.7)	
Dental Flossing				
1+ per day	20.8 (18.5–23.3)	22.6 (18.7–27.1)	19.1 (14.2–25.1)	0.60
<1 per day	79.2 (76.7–81.5)	77.4 (72.9–81.3)	80.9 (74.9–85.8)	
Barriers to dental care				
Difficulty in paying a $200 dental bill				
None	26.0 (23.3–28.9)	27.2 (23.4–31.4)	26.4 (21.1–32.4)	0.85
Hardly any	16.8 (14.5–19.4)	18.3 (13.9–23.8)	16.0 (12.7–20.0)	
A little	31.6 (28.5–34.8)	32.6 (27.9–37.8)	30.6 (24.4–37.6)	
A lot of difficulty	25.5 (22.5–28.8)	21.8 (17.6–26.6)	27.0 (21.7–33.0)	
Avoided or delayed dental treatment because of cost				
Yes	43.7 (40.3–47.1)	44.9 (39.8–50.0)	47.4 (41.0–54.0)	0.58
No	56.3 (52.9–59.7)	55.1 (50.0–60.2)	52.6 (46.0–59.0)	
Access to dental care				
Usual Reason for Dental Visit				
Check up	65.5 (62.0–68.9)	58.8 (53.8–63.7)	50.3 (44.1–56.5)	<0.01
Problem	34.5 (31.1–38.0)	41.2 (36.3–46.2)	49.7 (43.5–55.9)	
Average time between dental visits				
1+ times/year	55.8 (52.3–59.4)	49.2 (42.8–55.6)	39.2 (34.6–44.0)	<0.01
≤Once a year	44.2 (40.6–47.8)	50.8 (44.4–57.2)	60.8 (56.0–65.4)	
Eligibility for public dental care				
Eligible	26.0 (23.3–29.0)	40.8 (35.4–46.4)	35.2 (27.8–43.3)	<0.01
Not eligible	73.9 (71.0–76.7)	59.2 (53.6–64.6)	64.8 (56.7–72.2)	
Clinical Dental Diseases				
Dental caries (mean)				
DMFT	10.85 (10.32–11.38)	13.35 (12.16–14.54)	11.38 (10.17–12.59)	0.03
Decayed teeth	0.75 (0.62–0.87)	0.72 (0.53–0.91)	0.99 (0.79–1.20)	0.13
Missing teeth	4.00 (3.66–4.35)	5.86 (5.16–6.55)	4.74 (4.01–5.47)	<0.01
Filled teeth	6.10 (5.74–6.46)	6.77 (6.12–7.41)	5.65 (5.02–6.27)	0.84
CDC/APC Periodontal Classification				
None/Mild	71.5 (68.6–74.2)	69.5 (63.1–75.2)	68.2 (61.1–74.6)	0.61
Moderate/Severe	28.5 (25.8–31.3)	30.5 (24.8–36.8)	31.8 (25.4–38.9)	

Table 3. Bivariate analysis of the association between dental caries indicators, putative confounders and regional location

Characteristic	DMFT		Decayed teeth		Missing teeth		Filled teeth	
	Mean	*P*	Mean	*P*	Mean	*P*	Mean	*P*
Social demographics								
Age								
15-<45 years	5.26	<0.01	0.86	0.01	1.01	<0.01	3.38	<0.01
45-<60 years	14.13		0.75		5.75		7.63	
60+ years	21.91		0.58		10.51		10.81	
Sex								
Male	10.57	<0.01	0.88	0.02	4.26	0.39	5.43	<0.01
Female	12.05		0.67		4.51		6.87	
Annual household income								
≤$AU30k	15.52	<0.01	0.91	<0.01	7.38	<0.01	7.23	<0.01
>$AU30k-<60k	11.59		0.93		4.34		6.32	
$AU60k+	8.63		0.52		2.43		5.68	
Education								
Year 11+	8.57	<0.01	0.64	<0.05	2.28	<0.01	5.64	<0.01
≤Year 10	12.51		0.83		5.30		6.38	
Country of Birth								
Australia	10.86	<0.01	0.77	0.94	4.25	0.13	5.83	<0.01
Other	12.26		0.77		4.68		6.82	
Aboriginal or Torres Strait Islander								
No	11.35	0.07	0.76	0.34	4.40	0.22	6.19	0.01
Yes	8.31		1.31		3.35		3.64	
Employment Status								
Employed	8.76	<0.01	0.77	0.89	2.79	<0.01	5.21	<0.01
Unemployed	15.33		0.78		6.91		7.64	
Periodontal disease risk factors								
Diabetes								
Yes	18.01	<0.01	0.74	0.81	9.16	<0.01	8.11	<0.01
No	10.88		0.77		4.08		6.39	
Smoking								
Current	13.12	<0.01	1.61	<0.01	5.98	<0.01	5.53	0.09
Previous	14.27		0.69		6.47		7.11	
Never	9.67		0.68		3.18		5.81	
Preventive dental behaviours								
Tooth Brushing								
2+ day	11.30	0.94	0.65	<0.01	4.12	0.04	6.45	<0.01
<2 day	11.34		1.03		4.82		5.49	
Dental Flossing								
1+ per day	14.80	<0.01	0.58	<0.01	5.33	<0.01	8.88	<0.01
<1 per day	10.39		0.82		4.14		5.43	
Barriers to dental care								
Difficulty paying $200 dental bill								
None	11.88	0.27	0.53	<0.01	4.38	0.23	6.92	<0.01
Hardly any	10.86		0.69		3.80		6.37	
A little	11.36		0.76		4.45		6.15	
A lot of difficulty	11.01		1.08		4.72		5.21	
Avoided or delayed dental treatment because of cost								
Yes	10.99	0.19	1.13	<0.01	4.26	0.44	5.60	<0.01
No	11.58		0.82		4.49		6.59	
Access to dental care								
Usual Reason for Dental Visit								
Check up	10.21	<0.01	0.50	<0.01	3.51	<0.01	6.21	0.57
Problem	13.16		1.23		5.87		6.06	
Average time dental visits								
1+ times/year	12.52	<0.01	0.50	<0.01	4.42	0.78	7.58	<0.01
≤Once a year	9.98		1.07		4.35		4.56	
Eligibility for public dental care								
Eligible	15.88	<0.01	0.84	0.36	7.69	<0.01	7.38	<0.01
Not eligible	9.40		0.74		3.01		5.65	

Current smoking being associated with more missing teeth can be explained by the negative effect of smoking on periodontal health.

A factor that has not been examined in this paper is differing exposure to lifetime water fluoridation on dental caries nor the usage of professionally applied topical fluoride between people living inside and outside Australia's major cities. A previous paper using 2004–06 data found there was a greater mean lifetime fluoridation exposure in state capital cities than

Table 4. Multiple variable analysis models of DMFT, decayed, missing and filled teeth in relation to regional location, confounding variables and access to care variables

Characteristic	DMFT Coefficient	*P*	Decayed Coefficient	*P*	Missing Coefficient	*P*	Filled Coefficient	*P*
Social demographics								
Age (Ref: 15-44 years)								
45-<60 years	0.89	<0.01	−0.26	0.05	1.63	<0.01	0.73	<0.01
60+ years	1.30	<0.01	−0.49	<0.01	2.11	<0.01	1.11	<0.01
Annual household income (Ref $AU60k+)								
≤$AU30k	−0.04	0.33	0.44	<0.01	0.09	0.25	−0.19	<0.01
>$AU30k-<60k	0.02	0.54	0.50	<0.01	0.10	0.19	−0.07	0.20
Education (Ref: Year 11+)								
≤Year 10	0.03	0.35	0.14	0.35	0.20	<0.01	−0.06	0.18
Country of Birth (Ref: Australia)								
Other	0.04	0.15	0.13	0.32	−0.00	0.95	0.07	0.14
Aboriginal or Torres Strait Islander (Ref: Yes)								
No	0.11	0.53	0.50	0.28	0.38	0.05	−0.14	0.64
Preventive dental behaviours								
Smoking (Ref: Never)								
Previous	0.03	0.31	−0.17	0.16	0.18	<0.01	−0.06	0.18
Current	0.23	<0.01	0.40	<0.01	0.46	<0.01	0.00	0.99
Access to dental care								
Usual reason for dental visit (Ref: Check-up)								
Problem	0.25	<0.01	0.61	<0.01	0.24	<0.01	0.16	<0.01
Average time between visits (Ref: 1+ times/year)								
≤Once a year	−0.25	<0.01	0.39	<0.01	−0.04	0.42	−0.47	<0.01
Eligibility for public dental care (Ref: Eligible)								
Not eligible	−0.11	<0.01	0.01	0.57	−0.21	<0.01	−0.04	0.42
Regional location (Ref: Major City)								
Inner regional	0.04	0.24	−0.07	0.67	0.04	0.76	0.11	0.32
Outer regional, remote & very remote	0.02	0.61	0.08	0.60	0.06	0.95	−0.03	0.50

outside capital cities.[14,15] Fluoridation of drinking water remains the most effective and socially equitable means of achieving community-wide exposure to the caries prevention effects of fluoride.[16] Every effort should be made to increase access to water fluoridation for all Australians, not just for people living outside Australia's major cities.[17]

Another limitation was that the remoteness level might be too coarse a measure. Not all postcodes were sampled in NSAOH 2017-18 and so using anything below greater city/rest of state might have risks, for representativeness and small cell sizes. The number of dentists per 100,000 people was not available and it would have added strength to this paper to know its influence on oral health. Whenever using a cross-sectional survey, one must always be careful not to determine cause and effect. The number of Indigenous participants that had examinations was small limiting the conclusions that can be made about this variable. Less frequent dental visiting might not only be an indicator of access but also could be an indicator of utilisation which might influence the results. The strength of this study is the large sample size.

RECOMMENDATIONS FOR RESEARCH

Qualitative research should be undertaken to assess regional attitudinal variations in oral health and access to dental services. Research is required into the relative urban and rural changes in clinical and self-perceived oral health between the Australian National Adult Surveys of 2004–06 and 2017–18 as well as the effect of access to water fluoridation on the 2017–18 results. Research is also required into the factors determining poorer child oral health in rural compared to urban areas.

RECOMMENDATION FOR POLICY

The findings of this paper suggest that poorer oral health outside Australia's major cities was due to the social determinants of household income, education level and eligibility for public dental care and the behaviours of smoking, the usual reason for and the frequency of, dental visiting. To improve oral health outside Australia's major cities, governments and policymakers should focus on ways to improve rural household incomes and education levels, reduce the prevalence of smoking and encourage dental visits for check-ups rather than for problems.

RECOMMENDATION FOR PRACTICE

Continuing with campaigns and legislation aimed at reducing smoking rates as well as encouraging people to usually visit a dentist for a check-up as opposed to waiting until they have a problem, will improve clinical oral health in both urban and rural areas. Local action for

water fluoridation by rural dentists and community leaders will reduce dental caries significantly.

CONCLUSIONS

Poorer oral health outside major cities was associated with age and the social determinants of household income and education level. It was also associated with behaviours consisting of higher smoking, usual reason for and frequency of dental visiting.

AUTHORS CONTRIBUTIONS

Crocombe LA: Contributed to conception, design, data acquisition and interpretation, drafted and critically revised the manuscript. Chrisopoulos S: Contributed to critically revised the manuscript and supporting in the data acquisition process. Kapellas K: Contributed to critically review the manuscript. Brennan D: Contributed to critically review the manuscript. Luzzi L: Contributed to critically review the manuscript. Khan S: Contributed to conception, design, performed all the data analysis, data acquisition and interpretation and critically revised the manuscript.

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CONFLICT OF INTEREST

None.

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