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Associations between area-level disadvantage and DMFT among a birth cohort of Indigenous Australians

LM Jamieson,* LG Do,* RS Bailie,† SM Sayers,† G Turrell‡

*Australian Research Centre for Population Oral Health, School of Dentistry, The University of Adelaide, South Australia.
†Menzies School of Health Research, Charles Darwin University, Darwin, Northern Territory.
‡School of Public Health, Institute for Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Queensland.

ABSTRACT

Background: Individual-level factors influence DMFT, but little is known about the influence of community environment. This study examined associations between community-level influences and DMFT among a birth cohort of Indigenous Australians aged 16–20 years.
Methods: Data were collected as part of Wave 3 of the Aboriginal Birth Cohort study. Fifteen community areas were established and the sample comprised 442 individuals. The outcome variable was mean DMFT with explanatory variables including diet and community disadvantage (access to services, infrastructure and communications). Data were analysed using multilevel regression modelling.
Results: In a null model, 13.8% of the total variance in mean DMFT was between community areas, which increased to 14.3% after adjusting for gender, age and diet. Addition of the community disadvantage variable decreased the variance between areas by 4.8%, indicating that community disadvantage explained one-third of the area-level variance. Residents of under-resourced communities had significantly higher mean DMFT (β = 3.86, 95% CI 0.02, 7.70) after adjusting for gender, age and diet.
Conclusions: Living in under-resourced communities was associated with greater DMFT among this disadvantaged population, indicating that policies aiming to reduce oral health-related inequalities among vulnerable groups may benefit from taking into account factors external to individual-level influences.

Keywords: Indigenous Australians, DMFT, diet, area-level factors.

Abbreviations and acronyms: ABC study = Aboriginal Birth Cohort study; CHINS = Community Housing Infrastructure Needs Survey; DMFT = decayed, missing and filled teeth; NZDep 01 = New Zealand Deprivation Index; SEIFA = Socio-economic Indexes for Areas.

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INTRODUCTION

Indigenous Australians identify as being of Aboriginal or Torres Strait Islander descent, or both, and constitute 2.3% of the total population.[1] In Australia's Northern Territory, the Indigenous population comprises 27.8% of the total population. Indigenous Australians score worse on almost every health indicator than their non-Indigenous counterparts.[2] Recent evidence suggests that almost 60% of Indigenous Australians have untreated dental disease,[3] with substantial impacts on oral health-related pain and morbidity.[4]

Most attempts to explain the oral health status of disadvantaged groups, including Indigenous Australians, have focused on individual-level factors.[5–7] However, Turrell and colleagues recently reported that residents of disadvantaged neighbourhoods, as measured by the Australian Bureau of Statistics' Index of Relative Socio-economic Disadvantage, had poorer self-reported oral health after adjustment for individual-level factors.[8] Among adolescents in Brazil, Pattussi *et al.*[9] found that dental disease was higher in communities with lower levels of empowerment, independent of socio-economic variables at the individual- and area-levels and of individual risk factors including gender, fluoride, sugar consumption, toothbrushing and dental attendance. Jamieson and Thomson reported that edentulism, poor self-rated oral health and irregular dental visit behaviours were more prevalent among those from low socio-economic status households who were resident in high-deprivation areas.[10] Despite these studies, our understanding of how area-level factors influence oral health in the general population remains limited. Amongst Indigenous Australians, our knowledge of this issue is almost non-existent.

Access to dental health services is an area-level factor that may have a direct impact on oral health.[11]

Other influences include area-level conditions that lead to psychological stress and even clinical depression,[12] with the causal pathways between stress and some oral health outcomes being well documented.[13] Proxy markers of community dysfunction,[14] such as poorly operated public toilets, unsatisfactory sewerage systems, flooding risks and non-functioning public telephones[15] may also have some influence on oral health.

This study examined associations between area-level influences and DMFT among a birth cohort of young Indigenous Australian adults residing in Australia's Northern Territory.

METHODS

Data sources

Information was obtained from two sources: Wave 3 of the Aboriginal Birth Cohort (ABC) study for individual-level data, including experience of DMFT; and the Community Housing Infrastructure Needs Survey (CHINS) 2006 for area-level information.

ABC study

The ABC study is a prospective, longitudinal investigation involving a birth cohort of Indigenous Australians.[16,17] Babies were eligible for enrolment if they were live born singletons born at the Royal Darwin Hospital between January 1987 and March 1990 to an Aboriginal mother. The total number of mothers who agreed to participate was 686, accounting for 55% of potential recruits. Data in Wave 1 focused on gestational variables such as gestational age, birth weight, birth length, head circumference and placental weight. Wave 2, conducted between 1998 and 2001 when the mean age of participants was 11 years, included data from anthropometric and nutritional records, as well as physical examination, respiratory, renal, metabolic, cardiovascular, haematological, infection, social and community measures. Data for this study were derived from Wave 3 only (2006–2008). The Human Research Ethics Committee of the Northern Territory Department of Health and Community Services and Menzies School of Health Research (including an Aboriginal subcommittee with absolute right of veto) granted ethics approval for Wave 3 of the study. Study members gave informed consent before participating.

CHINS 2006

CHINS 2006 collected information from all Indigenous housing organizations in Australia and included information about housing, water, sewerage, power supply, education, health and other services.[18] CHINS 2006 was enumerated from 1 March to 30 June 2006. For the purposes of this study, data were requested from the Australian Bureau of Statistics for the 38 communities in which the Wave 3 ABC study participants who completed the dental component resided.

Sample

Method used to select individuals from the ABC study

Of the 468 ABC study participants in Wave 3 for whom vital status was obtained, 442 agreed to be dentally examined (age range 16–20 years) and provided complete information in a self-report dental questionnaire. This was 95% of the total number of participants examined at Wave 3 and 69% of those recruited at birth who were still alive. There were equal numbers of males and females.

Method used to select areas from CHINS 2006

Data from the 38 communities were grouped into 15 community areas based on geographic location so that sufficient numbers per community area were possible for analytical purposes. The numbers of participants per community area ranged from 11 to 81, with a mean of 29.

Measures

DMFT measures

Information about clinical oral health status was collected in Wave 3 of the ABC study during standardized examinations conducted by two calibrated dentists. The mean number of decayed, missing and filled teeth in the permanent dentition (DMFT) was used to assess dental caries outcomes. 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'. Filled due to decay was recorded when a tooth contained one or more permanent restorations placed to treat caries, while missing was recorded when a tooth had been extracted due to pathology.

Individual-level covariates

In addition to the dental examination, ABC study Wave 3 participants were asked to take part in face-to-face interviews that sought information on a range of items including age, gender and consumption of cariogenic diet. For the diet questions, participants were asked 'Can you tell me how often you eat/drink

the following': soft drink, fruit juice, cordial, milk, tea, fruit and sweets. Response options included 'every day', 'a few times a week', 'about once a week and less often' and were dichotomized into 'every day or a few times per week' and 'once a week or less often'. Participants were additionally asked if they took sugar with their tea.

There were significant associations between mean DMFT and three of the diet variables: consumption of soft drink, consumption of sweets and addition of sugar to tea. A combination diet variable was consequently created, with categories including 'good', 'moderate' and 'poor'. 'Good' was defined as consumption of soft drink consumed once a week or less often AND sweets consumed once a week or less often AND no sugar in tea. 'Moderate' was defined as consumption of soft drink every day or a few times weekly OR sweets every day or a few times weekly OR sugar in tea, while 'poor' was defined as consumption of soft drink every day or a few times weekly AND sweets every day or a few times weekly AND sugar in tea.

Area-level measures

The area-level measures from CHINS 2006 were based on their theoretical relevance to DMFT outcomes, based on the literature. The outcomes encapsulated the three domains of: (1) access to services; (2) infrastructure; and (3) communications. Specific 'access to services' items included distance to nearest hospital (less than 100 km or 100+ km) and distance to nearest dental service (less than 100 km or 100+ km). There were three 'infrastructure' items: community has operational toilets (yes or no), community experiences sewerage systems overflows and leaks (yes or no), community experienced flooding in last 12 months (yes or no). The item pertaining to 'communications' was 'all telephones in working order' (yes or no), referring to public pay phones in each of the communities.

There were significant associations between mean DMFT and all selected area-level variables. A combination area-level variable was consequently created and labelled 'access to services, infrastructure and communication'. Categories included 'good', 'moderate' and 'poor'. 'Good' was defined as 'distance to nearest hospital <100 km AND distance to nearest dental service <100 km AND operating public toilets AND did not experience sewerage systems overflows or leakages in last 12 months AND no flooding in last 12 months AND public telephone in working order'. 'Moderate' was defined as 'distance to nearest hospital <100 km OR distance to nearest dental service <100 km OR operating public toilets OR did not experience sewerage systems overflows or leakages in last 12 months OR no flooding in last 12 months OR public telephone in working order. 'Poor' was defined as 'distance to nearest hospital 100+ km AND distance to nearest dental service 100+ km AND no operating public toilets AND experienced sewerage systems overflows or leakages in last 12 months AND flooding in last 12 months AND no public telephone in working order.

Analysis

A series of two-level, random intercept models were fitted, with four models specified for the outcome. First, a fully unconditional (null) model was used to assess whether there was significant variance in DMFT among the community-area clusters. This model allowed partitioning the total variance of the outcome into within-group variance (individual-level) and between-group variance (community-area-level). Second, the unconditional model was extended to include individual-level fixed effects for behavioural factors (Model 2). In Model 3, community-area factors were included to assess whether they explained the variability of DMFT experience among the community-area clusters. Finally, the model was extended to include both individual- and community-area fixed effects (Model 4). Only individual and area-level variables that were significantly associated in bivariate analyses with the DMFT outcome were included. For the model building process, all categorical factors were dichotomized and the combination variables were grand mean centred. Grand mean centring standardizes a continuous variable by re-arranging its values around the variable's mean; hence making the model's intercept more interpretable. Analyses were performed using the SAS procedure PROC MIXED.

RESULTS

The mean DMFT of participants was 4.84. There was marked variation in DMFT by community area, with a range of 2.09 to 11.00. In bivariate analysis, mean DMFT was higher among females, those who consumed soft drink or sweets every day or a few times a week, or who added sugar to tea. Those ranking 'poor' on the diet combination variable had higher mean DMFT than their counterparts ranking 'good' (Table 1).

In bivariate analyses, DMFT was lower among participants who were located less than 100 km from hospital or dental services, who had operational public toilets, who did not experience sewerage overflows or leakages in the past year, who had not experienced flooding in the last 12 months or who lived in communities with all public telephones operating (Table 2). DMFT experience was higher among

Table 1. DMFT by individual factors

	N	Mean number of decayed, missing and filled teeth (SD)	95% CI
Demographic			
Gender			
Male	216	4.6 (4.9)*	3.4, 5.8
Female	226	5.7 (5.2)	4.5, 6.9
Age group			
16–18 years	301	4.9 (4.8)	3.7, 6.1
19–20 years	141	5.6 (5.6)	4.3, 6.9
Diet			
Soft drink consumption			
Every day or a few times a week	305	5.8 (5.1)*	4.6, 7.0
Once a week or less often	137	3.9 (5.0)	2.6, 5.2
Milk consumption			
Every day or a few times a week	306	5.2 (5.2)	4.0, 6.4
Once a week or less often	136	5.0 (4.7)	3.7, 6.4
Do take sugar with tea?			
Yes	366	5.4 (5.2)*	4.2, 6.5
No	76	4.1 (4.3)	2.6, 5.6
Fruit consumption			
Every day or a few times a week	288	4.9 (4.7)	3.7, 6.1
Once a week or less often	154	5.5 (5.7)	4.2, 6.8
Sweet consumption			
Every day or a few times a week	238	5.9 (5.3)*	4.7, 7.1
Once a week or less often	204	4.3 (4.7)	3.0, 5.5
Combination diet variable[a]			
Good	25	3.8 (3.7)*	1.7, 5.9
Moderate	258	4.3 (4.9)	3.1, 5.5
Poor	159	6.7 (5.3)	5.4, 7.9

*$p < 0.05$.
[a]Combination diet variable: 'Good' = soft drink consumed once a week or less often AND sweets consumed once a week or less often AND no sugar in tea. 'Moderate' = soft drink every day or a few times weekly OR sweets every day or a few times weekly OR sugar in tea. 'Poor' = soft drink every day or a few times weekly AND sweets every day or a few times weekly AND sugar in tea.

Table 2. DMFT by area-level factors

	N individual	Mean number of decayed, missing and filled teeth (SD)	95% CI
Access to services			
Distance to nearest hospital			
Less than 100 km	146	4.1 (4.3)*	1.7, 6.5
100+ km	296	5.4 (5.3)	4.2, 6.7
Distance to nearest dental service			
Less than 100 km	134	4.5 (5.2)*	2.5, 6.5
100+ km	308	5.4 (5.0)	4.1, 6.8
Infrastructure			
Community has operational public toilets			
Yes	235	4.9 (5.2)*	3.2, 6.6
No	207	5.3 (4.8)	3.8, 6.9
Community experiences sewerage systems overflows or leakages			
Yes	65	5.0 (5.3)*	3.8, 6.3
No	377	5.5 (5.0)	3.0, 8.1
Community experienced flooding in last 12 months			
Yes	43	5.4 (5.3)*	4.1, 6.6
No	399	3.8 (5.0)	0.6, 6.9
Communications			
All public telephones in working order			
Yes	366	4.7 (5.0)*	3.4, 6.0
No	76	6.5 (4.8)	4.2, 8.7
Combination access to services, infrastructure and communication variable[a]			
Good	77	2.4 (3.7)*	2.0, 6.9
Moderate	304	4.9 (5.2)	3.6, 6.1
Poor	61	6.9 (4.9)	4.5, 9.3

*$p < 0.05$.
[a]Combination access to services, infrastructure and communication variable: 'Good' = distance to nearest hospital <100 km AND distance to nearest dental service <100 km AND operating public toilets AND did not experience sewerage systems overflows or leakages in last 12 months AND no flooding in last 12 months AND public telephone in working order. 'Moderate' = distance to nearest hospital <100 km OR distance to nearest dental service <100 km OR operating public toilets OR did not experience sewerage systems overflows or leakages in last 12 months OR no flooding in last 12 months OR public telephone in working order. 'Poor' = distance to nearest hospital 100+ km AND distance to nearest dental service 100+ km AND no operating public toilets AND experienced sewerage systems overflows or leakages in last 12 months AND flooding in last 12 months AND no public telephone in working order.
1. Adjusted for between-community differences in DMFT (clustering)

individuals living in areas with 'poor' access to services, infrastructure and communication as defined by the categories used.

Results from the different multilevel models are presented in Table 3. Model 1 showed that the average community-area DMFT level was 5.14 and indicated that 13.8% of the variance in experience of DMFT was attributable to between community area differences. The design effect for the experience of DMFT variable was 4.07 (1 + [29.5 – 1] x 0.138), thus providing justification for our use of multilevel analyses.

When individual-level characteristics were added (Table 3, Model 2), it was observed that participants rating 'poor' on the combination diet variable had 2.72 more teeth that were decayed, missing or filled than their counterparts with more favourable diets. After adjusting for the individual effects of gender, age and the combination diet variable, the area-level variance was not markedly changed. Model 2 demonstrated that the between-area DMFT variance was still significant after accounting for individual-level factors. Addition of the combination community-area variable to the model decreased the variance between areas by 4.8% (Table 3, Model 3), indicating that the combination community variable explained one-third of the area-level variance. Poor access to services, infrastructure and communication was statistically associated with greater experience of DMFT. In Model 4 it was observed that the characteristics of the community-areas were associated with DMFT experience, even when individual characteristics were accounted for. Participants residing in community-areas rating 'poor'

Table 3. Individual-level and community effects on mean number of decayed, missing and filled teeth

Community areas = 15 Individuals = 442	Model 1 (null model)	Model 2 (plus age, gender and diet)		Model 3 (plus area-level factors)		Model 4 (plus age, gender, diet, and area-level factors)	
Intercept	5.14	4.05		4.85		3.75	
		B	95% CI	B	95% CI	B	95% CI
Individual level							
Gender (female)		0.58	−0.30, 1.46			0.59	−0.29, 1.47
Age-group (19–20 years)		0.54	−0.40, 1.48			0.50	−0.44, 1.44
Combination diet variable[a]							
Good		0	–			0	–
Moderate		0.61	−1.33, 2.55			0.59	−1.35, 2.53
Poor		2.72*	0.72, 4.72			2.70*	0.70, 4.70
Area-level							
Combination access to services, infrastructure and communication variable[b]							
Good				0	–	0	–
Moderate				1.98	−1.33, 5.29	1.80	−1.57, 5.17
Poor				3.94*	0.15, 7.72	3.86*	0.02, 7.70
Level 2 (community) variance[c]	3.61	3.57		2.25		2.33	
Intra-class correlation (%)	13.8	14.3		9.0		9.8	
P-value	<0.0001	<0.0001		0.0004		<0.0001	

[a]Combination diet variable: 'Good' = soft drink consumed once a week or less often AND sweets consumed once a week or less often AND no sugar in tea. 'Moderate' = soft drink every day or a few times weekly OR sweets every day or a few times weekly OR sugar in tea. 'Poor' = soft drink every day or a few times weekly AND sweets every day or a few times weekly AND sugar in tea.
[b]Combination access to services, infrastructure and communication variable: 'Good' = distance to nearest hospital <100 km AND distance to nearest dental service <100 km AND operating public toilets AND did not experience sewerage systems overflows or leakages in last 12 months AND no flooding in last 12 months AND public telephone in working order. 'Moderate' = distance to nearest hospital <100 km OR distance to nearest dental service <100 km OR operating public toilets OR did not experience sewerage systems overflows or leakages in last 12 months OR no flooding in last 12 months OR public telephone in working order. 'Poor' = distance to nearest hospital 100+ km AND distance to nearest dental service 100+km AND no operating public toilets AND experienced sewerage systems overflows or leakages in last 12 months AND flooding in last 12 months AND no public telephone in working order.
[c]Variance estimate.
*$p < 0.05$.

on the combination access to services, infrastructure and communication variable had 3.86 more teeth with experience of DMFT than the reference group, holding all else constant. Rating 'poor' on the combination diet variable was also statistically associated with increased DMFT experience.

DISCUSSION

This study set out to determine associations between area-level influences and DMFT among a birth cohort of Indigenous Australians aged 16–20 years. In bivariate analyses, dietary factors, access to services, infrastructure and communications were significantly associated with DMFT. In multilevel modelling, community disadvantage remained significantly associated after accounting for individual-level diet factors.

While our findings suggest that aspects of community well-being contribute to DMFT among Indigenous Australian young adults, the pertinent question is how? It is likely that our community disadvantage measure is a proxy marker of community dysfunction.[19] Community dysfunction has been reported to undermine social capital, which may in turn influence oral health.[9] One example of how undermined social capital might influence oral health is by shaping behaviours, such as accessing dental services, that affect dental caries.[9] Evidence also suggests that community dysfunction is associated with low self-esteem, which in turn may affect oral health-related behaviours, e.g. toothbrush ownership and use.[20] In addition, community values play a strong role in shaping health system change towards health promotion.[21] We could thus speculate that community dysfunction negatively influences oral health by impeding implementation of oral health promotion programmes.

Da Fonseca provided some insights on how poverty impacts on children's development and consequent oral health.[22] These included unstable housing, food insecurity, the direct effects of poverty such as diet quality and health, indirect effects of poverty such as stress and community dysfunction, and poor access to appropriate health services, including dental health services.

It is important to reflect on the study's limitations. Our findings are based on cross-sectional data, thus it is premature to conclude definitive causal effects. The grouping of community areas was also a limitation, with some areas being defined townships and others being sparsely settled regions. Our use of summary measures to assess diet and community disadvantaged may not allow a clear understanding of precisely what factors need to change in order to improve inequali-

ties in oral health among this vulnerable population. It is important to bear in mind that most other studies of area-level influences on health also use summary measures, such as the SEIFA (Socio-Economic Indexes for Areas) Index of disadvantage in Australia, the Scotland-based Carstairs score[23] and the New Zealand Deprivation Index for 2001 (NZDep01).[24] The creators of SEIFA (the Australian Government) conclude 'there are no perfect measures of disadvantage' and that 'the concept of relative socio-economic disadvantage is difficult to capture because it has many dimensions and because these dimensions are hard to measure'.[25] Krieger and colleagues conclude that a plurality of measures is useful for aetiological research,[26] i.e. to generate questions for further inquiry. This is perhaps where our findings are most helpful. The self-report nature of the dietary information may have led to an under-estimation of these items. However, under-reporting would have resulted in more conservative estimates of the diet-related associations with DMFT, meaning our findings are likely to be authentic.

Australia's National Oral Health Plan stipulates the need for research that increases understanding of Indigenous oral health issues at a community level.[27] Whilst this study goes some way towards this, it is clear that further information is required on the mechanisms by which area-level characteristics influence oral health outcomes. The findings have relevance for other marginalized populations throughout the world, as dental disease at a global level is recognized as being undisputedly related to social disadvantage.[28] Greater insight into whether it is social disadvantage at an individual- or area-level (or both) would be beneficial to both policy makers and researchers involved in interventions to reduce oral health inequalities in Australia and elsewhere.

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Address for correspondence:
Dr Lisa M Jamieson
Australian Research Centre for Population Oral Health
The University of Adelaide
Adelaide SA 5005
Email: lisa.jamieson@adelaide.edu.au