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Fluoridation and dental caries severity in young children treated under general anaesthesia: an analysis of treatment records in a 10-year case series

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Objective: To compare the severity of dental caries in the primary dentitions of children under 7 years (who received comprehensive restorative treatment under general anaesthesia, GA) from an optimally fluoridated area (0.85ppmF) and a low-fluoride area (~0.1ppmF). ***Research design:*** Consecutive clinical case series: clinical details (diagnoses and the treatments provided) were recorded for children who had received comprehensive dental care under GA between 2000 and 2009. Age, gender, ethnicity, socio-economic status and fluoridation status (determined from the residential address) were also recorded. ***Results:*** Of the 1396 treated children, 55.7% came from fluoridated areas and 52.5% were male. On average, children from low-fluoride areas were 2.4 months younger and presented with more decayed deciduous teeth than those from fluoridated areas (4.9 and 3.9 teeth respectively; p<0.0001). For each tooth type, the mean number of carious teeth at presentation was greater among the children from low-fluoride areas. In the multivariate model, the number of deciduous teeth affected by caries was lower among older children, those residing in a fluoridated area and among those seen after 2001. It was higher among those not living in high-SES areas. ***Conclusions:*** Children with severe dental caries had statistically significantly lower numbers of lesions if they lived in a fluoridated area. The lower treatment need in such high-risk children has important implications for publicly-funded dental care.

Key words: *Dental caries; Children; Fluoridation; Residence characteristics*

Introduction

A clear improvement in dental caries experience among New Zealand children has been observed over the last few decades, but a sizable proportion of children continue to experience the disease (Ministry of Health, 2010). Routine dental care for children in New Zealand is provided through school dental services provided by District Health Boards. Unacceptably high rates of extensive early childhood caries (ECC) mean that comprehensive dental treatment under general anaesthesia (GA) must be provided to approximately 5000 New Zealand children each year (Lingard *et al.*, 2008). Māori children are over-represented among GA patients (being about one-third but only 22% of the child population) as are children of low-socioeconomic status (SES; Lingard et al, 2008). The number of children requiring such treatment has been a problem in New Zealand since the 1980s and is a considerable drain on health resources because substantial resources and staff expertise are required to provide such treatment. ECC has been shown to have negative psychosocial effects on children, whereby they suffer from chronic pain, changed eating habits, sleep disturbance and altered growth (Davidson *et al.*, 2002); the wider effects on the household are also discernible (Malden *et al.*, 2008). Unnecessary time spent on waiting lists only serves to exacerbate these problems, and such treatment early in life may also predispose to future problems with dental anxiety and in using dental services (Karjalainen and Olak, 2003; Gazal and Mackie, 2007; Thomson *et al.*, 2009). However, treatment under GA improves quality of life for child and family alike (Anderson *et al.*, 2004; Malden *et al.*, 2008).

While community water fluoridation (CWF) has been shown to result in lower dental caries rates among both children and adults (Griffin *et al.*, 2007), it is unclear whether rates of treatment under GA for ECC are lower in populations residing in fluoridated areas. An unpublished analysis of referral rates for GA treatment in Dunedin (New Zealand) in 2006-2007 found that, while one in 88 children (under six years) from fluoridated Dunedin were treated under GA, approximately one in 24 children from nearby non-fluoridated Mosgiel and Outram required such treatment (unpublished data). Furthermore, the average age on referral was lower for non-fluoridated areas, suggesting that the burden of disease manifests at a younger age among the latter and may therefore have greater cumulative negative consequences. Only 39% of Otago child referrals come from the 56% of the population living in fluoridated areas whereas 61% come from the 44% in nonfluoridated areas (Davidson *et al.*, 2002). These data suggest that CWF may be associated with a lower proportion of ECC cases at the severe end of the caries distribution, and that, other factors being equal, the rate of referral of children from non-fluoridated areas (together with their associated caries burden) is likely to be higher than that from fluoridated areas.

Accordingly, this study aimed to conduct a retrospective clinical audit to enable comparisons of the presenting

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characteristics of child dental GA (for children aged between 12 months and seven years) and associated treatment from fluoridated and non-fluoridated areas of Otago for the 10-year period 2000 to 2009.

Methods

Child dental GA cases were identified among the Otago University School of Dentistry database of children treated under GA since 1989. Children referred for dental treatment come from the Otago region, and the School is the only centre in the region providing such care, so the sample comprises all known cases treated during the review period. According to the 2006 New Zealand Census, there were 193,803 Otago residents, of whom 21,879 (11%) were under 10 years of age. Māori and males comprised 12% and 51% of those, respectively.

Data for this review were collected for children aged between 12 months and 6 years, and excluded children whose GA treatment was not ECC-related (such as those with trauma-related problems or developmental anomalies requiring intervention). Information on age, gender, ethnicity, water fluoridation status, and socio-economic status (SES) of each child at the time of the GA treatment were extracted manually from the clinical records (which have exact details of the surfaces treated). With the ethnicity data, priority was given to NZ Māori ethnicity over any other if more than one affiliation had been recorded. Each child's street address was used in conjunction with Dunedin City Council maps to determine the water fluoridation status of the domicile. Each child was allocated an area-based SES score based on their nearest school's "decile rating" using the New Zealand Ministry of Education's targeted funding for educational achievement (TFEA) indicator for schools, whereby a lower score indicates poorer SES (Public Health Advisory Committee, 2003); if a child's domicile was equidistant from a number of schools, the highest score was recorded.

ECC disease severity on referral was determined from the number of extractions and restorations required for each case; thus, a single diagnosis was recorded for each tooth. If a tooth had more than one diagnosis, the highest priority diagnosis was recorded; in order of priority, those were abscess, pulpitis, caries, hypoplasia and erosion. A dmft index for each child was not recorded.

Anonymised data were analysed using SPSS v19. Following the computation of univariate descriptive statistics, differences among means were tested for significance using analysis of variance or appropriate nonparametric tests if data were not normally distributed (Mann-Whitney U-tests where two groups were compared, and Kruskal-Wallis tests where there were more than two). Differences among proportions were examined using Chi-square tests. The alpha level was set at 0.05. Linear regression was used to examine the association between CWF and the number of carious presenting teeth while controlling for confounding variables.

Results

Data on the 1396 one-to-six-year-old children who were treated under general anaesthesia over the 10-year period are presented in Table 1. The number of children treated ranged from 93 (in 2006 and 2008) to 225 (in 2002). Just over half were male, and just over half came from areas with community water fluoridation (hereafter referred to as 'fluoridated areas").

The mean age at presentation was 4.8 (sd 1.1) and 4.6 (sd 1.1) years among children from fluoridated and nonfluoridated areas, respectively ($p<0.001$), a difference of 2.4 months. About one in seven cases were of Māori ethnicity. Just over one-quarter were from areas with low-SES schools, and that proportion was higher among children from fluoridated areas.

The absolute number of children presenting over the observation period decreased for both groups of children, but it decreased more in nonfluoridated areas.

The great majority of the presenting caries was in deciduous teeth; 19 children (0.01%) presented with carious permanent teeth: 14 with one, and five with two. Data on

Table 1. Sociodemographic characteristics by year of procedure (brackets contain percentages)

Year of GA	*Females*	*Māori ethnicity*[a]	*School socio-economic status*[a]			*Fluoridated water supply*	*All combined*
			Low	*Medium*	*High*		
2000	81 (50.0)	17 (10.5)	42 (29.0)	60 (41.4)	43 (29.7)	70 (43.2)c	162 (11.6)
2001	73 (42.4)	24 (14.8)	46 (27.7)	52 (31.3)	68 (41.0)	94 (54.7)	172 (12.3)
2002	122 (54.2)	23 (11.8)	57 (26.0)	96 (43.8)	66 (30.1)	106 (47.1)	225 (16.1)
2003	78 (52.3)	19 (13.7)	41 (27.9)	49 (33.3)	57 (38.8)	94 (63.1)	149 (10.7)
2004	71 (46.1)	16 (11.1)	47 (31.5)	53 (35.6)	49 (32.9)	95 (61.7)	154 (11.0)
2005	57 (45.2)	14 (11.5)	32 (26.4)	48 (39.7)	41 (33.9)	84 (66.7)	126 (9.0)
2006	41 (44.1)	15 (16.5)	20 (21.5)	45 (48.4)	28 (30.1)	42 (45.2)	93 (6.7)
2007	50 (47.6)	18 (18.9)	27 (25.7)	40 (38.1)	28 (36.2)	68 (64.8)	105 (7.5)
2008	37 (39.8)	13 (15.7)	25 (27.8)	37 (41.1)	28 (31.1)	51 (54.8)	93 (6.7)
2009	53 (45.3)	18 (15.7)	33 (28.4)	32 (27.6)	51 (44.0)	74 (63.2)	117 (8.4)
Water supply							
Nonfluoridated	308 (49.8)	68 (11.7)	92 (15.8)	299 (51.4)	191 (32.8)c	—	618 (44.3)
Fluoridated	355 (45.6)	109 (15.0)	278 (36.2)	213 (27.7)	278 (36.2)	—	778 (55.7)
All combined	663 (47.5)	177 (13.5)	370 (27.4)	512 (37.9)	469 (34.7)	778 (55.7)	1396 (100.0)

[a] Based on referring clinic; data not recorded for 88 cases; cross-tabulation based on n = 1308

[b] Data not recorded for 45 cases; cross-tabulation based on n = 1351

[c] $p<0.05$ (χ^2 test)

patients' presenting deciduous caries status are given in Table 2. The children presented, on average, with more than 4.4 carious deciduous teeth (range 1-19). Children from nonfluoridated areas presented with more affected teeth than those from fluoridated areas, with the overall difference being 1.0 teeth, on average. Children in the medium-SES group presented with more carious teeth. Overall, the children presenting early in the decade had more affected teeth than those presenting at the end of the decade, but there was no clear trend (despite the differences being statistically significant).

Data on the distribution of dentinal caries in the deciduous dentition are presented by fluoridation status in Figure 1. For any given tooth, the proportion of affected teeth was greater among children residing in nonfluoridated areas (with only the differences for teeth 74, 81, 82, 83 and 84 not being statistically significant). The differences were particularly marked in the second molars and the upper incisors.

The number of deciduous teeth affected by caries was modelled (Table 3). On average, it was lower among older children, those residing in a fluoridated area and among those seen after 2001. It was higher among those who were not living in high-SES areas.

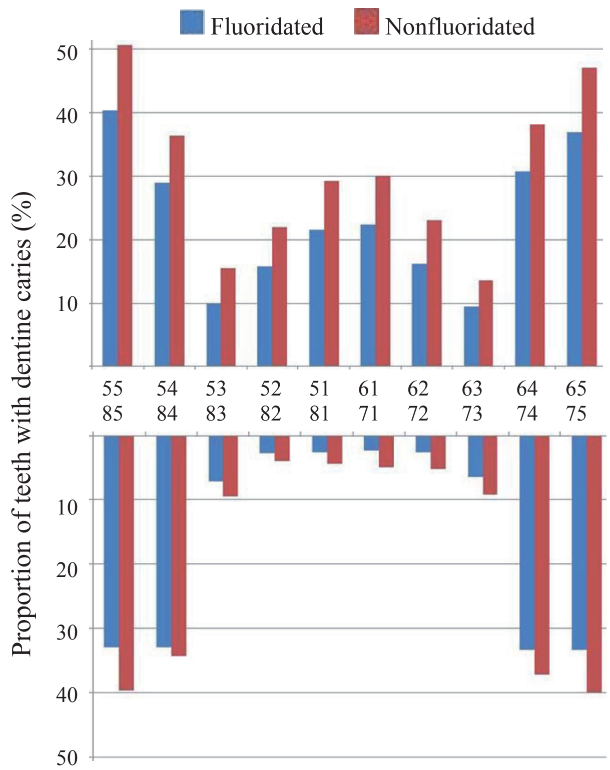

Figure 1. *Proportion of teeth with dentine caries, by residential fluoridation status and jaw (the FDI system of tooth notation is used)*

Table 2. Mean number of deciduous teeth with dentine caries upon presentation, by sociodemographic characteristics, fluoridation status and year of procedure

	Mean number of deciduous teeth with dentine caries upon presentation (sd)
Gender	
Male	4.5 (3.5)
Female	4.2 (3.4)
Water supply	
Nonfluoridated	4.9 (3.5)[a]
Fluoridated	3.9 (3.2)
School SES decile group[b]	
Low	4.3 (3.5)[a]
Medium	4.8 (3.5)
High	3.9 (3.2)
Ethnicity[c]	
Non-Maori	4.4 (3.4)
Maori	4.8 (3.8)
Year of GA	
2000	5.7 (3.7)[a]
2001	5.3 (3.6)
2002	4.0 (3.2)
2003	3.9 (3.2)
2004	3.9 (2.9)
2005	4.4 (3.4)
2006	5.3 (3.2)
2007	4.0 (3.2)
2008	4.0 (3.6)
2009	2.6 (3.0)
All combined	4.4 (3.4)

[a] $p<0.05$ (Mann-Whitney tests for all except the year of GA, which used the Kruskal-Wallis test)
[b] Data missing for 45 cases; SES, socioeconomic status
[c] Data missing for 88 cases

Table 3. Linear regression model for the number of carious deciduous teeth at presentation (n=1269)

	B coefficient (95% CI)[a]	*p value*
Male	0.29 (-0.08, 0.65)	0.123
Age (continuous variable)	-0.32 (-0.49, -0.16)	**<0.001**
Māori ethnicity	0.50 (-0.03, 1.03)	0.066
Low SES	0.64 (0.17, 1.11)	0.008
Medium SES	0.72 (0.29, 1.15)	**0.001**
Fluoridated area resident	-0.86 (-1.24, -0.47)	**<0.001**
Years 2002-2006	-0.45 (-0.87, -0.04)	**0.034**
Years 2007-2009	-1.20 (-1.69, -0.72)	**<0.001**

[a] Comparison groups: male - female; Māori - all other ethnic groups; low and medium SES - High SES; Fluoridated area resident - Nonfluoridated area resident; years 2002/2006 and 2007/2009 - years 2000/2001

Discussion

This retrospective clinical audit compared the presenting characteristics and associated treatment of 1396 child dental GA cases (aged 1-6 years) from fluoridated and non-fluoridated areas of the greater Dunedin area for the decade 2000 to 2009. Children from non-fluoridated areas were shown to be younger and have more teeth affected by caries, as did Māori children, those not living in high-SES areas, and those referred for treatment after 2001. For each tooth type, the mean number of carious teeth at presentation was greater among the children from low-fluoride areas than among those from areas with CWF.

Before discussing the findings, it is appropriate to consider the weaknesses and strengths of the study. The use of routinely collected data can be limiting because they have not been primarily recorded for the purposes of answering the research question, there has been no purposive calibration of the clinicians involved and it is difficult to assess how such inter-examiner variation might impact data quality. The study's underlying assumption was that the child's current residential address (and hence fluoridation status) reflects their lifetime exposure to fluoridated water, but this assumption does not necessarily hold; this may have led to an underestimation of the real differences in caries severity between the two groups. Turning to the study's strengths, the "real world" setting of the data can be a strength, and analyses of unit-record data pertaining to the effects of CWF on dental utilisation are scarce. In a notable recent example, Kumar *et al.* (2010) reported on Medicaid-reimbursed claims for New York State during 2006, characterising claims as caries-related (such as extraction, restoration or endodontic treatment) or non-caries-related, with the unit of analysis being the county, categorised by CWF status. After controlling for county characteristics, there was a clear gradient in caries-related claims (but not in the other claims) by county CWF status. The current study's use of data on referrals for ECC can be considered to augment those findings by examining another aspect of the differences associated with CWF.

Children requiring treatment under GA for ECC can be considered to be the most vulnerable and severely-affected victims of dental caries. They are not adequately portrayed in conventional analyses and representations of the effects of CWF, where the discourse tends to be limited to comparisons of rather more subtle differences in mean DMF scores or in the proportion without the disease. The tail-end of the caries distribution has received scant attention, yet that is exactly where the disease exerts its greatest effects on the day-to-day lives of children and their families (Anderson *et al.*, 2004; Jankauskiene and Narbutaite, 2010; Malden *et al.*, 2008). The current study's finding that children from nonfluoridated areas were younger and had more caries upon presentation for treatment of ECC under GA can be interpreted as an important difference from the public health perspective, suggesting that differences do indeed occur at the caries distribution's tail-end. It may be, of course, that there are alternative explanations for the observed dissimilarities. For example, if there was a higher proportion of non-European children living in the nonfluoridated areas, their greater caries experience would contribute to an apparent difference in caries presentation from those in fluoridated areas. To determine the likelihood of this, we obtained school dental service data on 5-year-olds from the New Zealand Ministry of Health (2011) and determined the proportion of non-European children in Otago in 2002, 2007 and 2009 (we were unable to do this for 2001 or 2000 because of differences in data presentation) to be 12.8%, 15.0% and 13.8% respectively in fluoridated areas, and 9.0%, 9.2% and 10.8% in nonfluoridated areas. These data do not support the alternative hypothesis.

Among the study's other findings, that a higher number of carious deciduous teeth upon presentation (albeit not statistically significant) was observed among Māori and those residing in more deprived areas is consistent with what is known of the occurrence of dental caries in New Zealand (Public Health Advisory Committee, 2003). The lower mean number of carious deciduous teeth among those presenting more recently is most likely because children are being referred earlier rather than waiting for marked infection and pain. This is moderately encouraging, and suggests some hope for the future.

In conclusion, children referred for treatment of severe dental caries under GA had fewer lesions if they lived in a fluoridated area. The lower treatment need in such high-risk children has important implications for publicly-funded dental care. The findings underline the continued importance of CWF as a public health measure for decreasing (but not eliminating) ECC in child populations. This study has expanded on earlier work and should be regarded as a surveillance study providing a critical piece of missing health services usage data for the ongoing fluoride debate; it is a novel way of evaluating the caries-preventive effects of water fluoridation.

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