Title: Effectiveness of water fluoridation in caries reduction in a remote Indigenous community in Far-North Queensland.

Abstract

Background:

Children in remote Indigenous communities in Australia have levels of dental caries much greater than the national average. One such, the Northern Peninsula Area of Far North Queensland (NPA), had an oral health survey conducted in 2004, shortly before the introduction of fluoridated, reticular water. Children were again surveyed in 2012, following 5 years exposure.

Methods:

An oral examination was conducted on all consenting children enrolled in schools across the community, using WHO Basic Oral Health Survey methodology.

Results:

Few teeth had restorations in both surveys. Age-weighted overall caries prevalence and severity declined from 2005 to 2012 by 37.3%. The effect was most marked in younger children, dmft decreasing by approximately 50% for ages 4 to 9 years; at age 6, mean decayed score decreased from 5.20 to 3.43. DMFT levels also decreased by almost half in 6-9 year olds. Significant unmet treatment needs exist, however, at all ages.

Conclusions:

There has been considerable improvement in child dental health in the NPA over the past 6-7 years. In light of continued poor diet and oral hygiene, water fluoridation is the most likely explanation. The cost-effectiveness for this small community remains an issue which, in the current climate of political antagonism to water fluoridation in many quarters, requires continued study.

Key words: Dental caries; oral health; water fluoridation; Indigenous health

Abbreviations and acronyms:

NPA National Peninsula Area [of Cape York Peninsula]

DMFT Decayed, Missing and Filled Teeth (permanent dentition)

dmft decayed, missing and filled teeth (deciduous dentition)

INTRODUCTION

Untreated dental caries in permanent teeth is the most prevalent condition evaluated in the recently published Global Burden of Disease study (1). Caries in permanent teeth is closely associated with caries experience of the deciduous dentition (2). Remote Indigenous communities in Australia are particularly at risk (3).

Prior to the assimilation of Indigenous communities into a westernised, "modern" Australian lifestyle, these communities enjoyed very good oral health (4). Since the 1970s however, dental caries in particular, has become a public health problem of an ever worsening nature. There is general consensus that the dental caries status of Indigenous children is especially poor, and substantially worse than their non-Indigenous Australian counterparts (3, 4, 5, 6). A common reason suggested for this worsened and worsening problem is related to the change from a traditional to a western diet. In rural and remote communities, such as in the Northern Peninsula Area (NPA) of Far North Queensland, the problem is substantially worse in that access to health promotive and preventive interventions, and access to dental services are severely limited (7, 8, 9). Proven interventions such as the artificial fluoridation of water supplies are often only implemented in large urban settings, mainly for reasons of cost-benefit and cost-effectiveness (10, 11, 12). A recent study comparing children's caries experience between areas with and without water fluoridation in Australia showed that, even after controlling for child age, residential location and socio-economic status (SES), caries experience in the deciduous and permanent dentitions was 28.7% and 31.6% higher, respectively, in low-fluoride areas compared with optimally fluoridated areas (13): The odds ratios for higher caries prevalence in areas with negligible fluoride compared with optimal fluoride were 1.34 and 1.24 in the deciduous and permanent dentitions, respectively.

In 2005, reticulated water was supplied to five small rural communities in the NPA and a fluoridation plant was installed. A dental survey conducted 1 year prior showed that dental caries was a significant problem in these remote communities (14). Caries experience for 6- and 12-year-old children was more than twice the average for the State of Queensland, and more than four times greater than the comparable average figures for Australian children overall. The tercile of children with highest caries experience had levels 7-8 times more than the national average, and the 10 per cent of children with the highest caries experience had mean dmft and DMFT scores more than 10 times that of the rest of Australia (14).

Assuming adequate performance of the fluoridation plant, by 2012, children 6-7 years old and younger will have enjoyed a life-time exposure to fluoride. Older children will have enjoyed partial exposure to fluoridated water. It is, therefore, important to measure the dental caries status of all these children in order to assess the effectiveness of this initiative. Such findings, especially if an economic analysis could be added, would provide valuable data in the planning of similar initiatives across Australia and in other countries with remote communities.

METHODS

We sought to examine all children on the rolls of the four campuses of the single State school in the NPA, covering pre-school, primary- and secondary-level classes. ~~Approval to conduct the survey was granted by the Chief Dental Officer for Queensland and the central office of Queensland Health as managers of oral health services throughout the State.~~ ~~Following a~~An exploratory visit was made to the community in March 2012 by the senior author, during which consultations were conducted with the Elders of the

NPA community, officers and staff of Queensland Health local services, staff of the NPA Family and Community Services agency, and the Principals of the schools involved. All expressed enthusiastic support. We then sought, and received, formal permission from ~~Approval to conduct the survey was granted by~~ the Chief Dental Officer for Queensland, ~~and~~ the central office of Queensland Health as managers of oral health services throughout the State, and~~was also granted by~~ the Torres Strait and NPA District Health Council ~~, the Elders of the NPA community, and the principals and teachers of the schools involved~~. Permission to access water records was given by Queensland Water and by Sun Water, the company contracted to manage the water supply.

Formal ethical approvals were obtained from Griffith University (DOH/21/12/HREC), James Cook University, and Education Queensland. The oral health examinations were conducted over 5 working days in October/ November 2012, integrated with the Queensland Government Well Persons Health Check 5-14 Years (Medicare Item No 715). These are Statutory periodic screenings of the whole community in particular age groups, conducted by nursing staff of the local health authority, to a defined protocol: any medical issues identified are referred to medical staff in the Community Hospital – that in the NPA being adequately staffed at the time. Information and parental consent forms were sent home from the schools approximately two weeks before the survey and returned to the school. In a number of cases the headmistress of the secondary school obtained verbal consent by telephoning families. All children with informed consent attending school on the day of examination were included.

The dental team established a station as children passed from registration and medical history taking through body measurements, recording of heart and breathing sounds, ear

and hearing tests, eye and vision tests, information and counselling on nutrition, physical activity, continence, alcohol/tobacco/drug use, social and emotional well-being and living environment. These stations were established in a class room within each school. Children answered a brief questionnaire concerning oral health knowledge, attitudes and practices. They then lay flat on a low table for head and neck, and for examinations of the mouth. These were conducted by two paediatric dentists, wearing gloves changed for each subject, with battery operated head lights and disposable mirrors and probes. Disposable gauze and paper towels were used for moisture control. Approximately 5% of cases were re-examined for intra-examiner, and 5% for inter-examiner calibration.

Counselling was given on diet and oral hygiene to all children and frequently to their families, when present. Those in need of dental treatment received letters to take to their parents/guardians advising them to seek an appointment with the community dental clinic. At the time of this survey the dental clinic was not staffed, but periodic visits were made by a dentist or dental therapist from Thursday Island, half a day's ferry journey away. The few children with active infections or who were in severe pain were notified directly to the Thursday Island clinic, who arranged to see and treat these cases on an upcoming visit.

Standard WHO Basic Oral Examination forms, 4th Edition, were used (15). DMFT and dmft data are reported, as is the Severe Caries Index as defined by Bratthal et al (16). The Fejerskov-Thylstrup Index was used to record the prevalence of dental fluorosis (17).

Data were transcribed to Excel and then analysed by SPSS.

RESULTS

Demographic characteristics

A total of 324 school-going children were examined, an overall "capture rate" of almost 60%. Those children nominally on school rolls who were not examined were not in school on the days of the survey: very few declined permission to participate. Most children examined attended the junior campuses (N=262). The distribution by sex was almost equal, 532.8% of the children being male. The age ranged from 4 to 15 years, with a mean age of 9 years (SD=3.2).

Kappa statistics for both within and between examiner variability were 0.8.

Because many of these children had a mixed dentition, data are presented as dmft and DMFT separately. The overall mean dmft was 2.76, with the decayed component being 2.48; few children had missing and/or filled deciduous teeth. The mean DMFT was 1.32, with the decayed component being 1.13. More than a third (36.2%) of the children were free of caries experience in the deciduous and more than half (55.3%) in the permanent dentition (dmft=0/DMFT=0). A fifth of children experienced a dmft more than 4 and DMFT more than 2.

Table 1 shows the mean dmft and its components by age, comparing pre- and post-water fluoridation findings. The mean decayed scores were significantly lower in children aged 4 to 6 and 8 to 9 in our study compared to the pre-water fluoridation period. For example in 6-year old children the mean decayed score was 3.43 compared to 5.20. In 7 year old children the mean decayed score was lower post-water fluoridation, however it was not statistically significant. The mean filled scores were

generally, and in some age groups statistically significantly, lower post-water fluoridation.

Table 2 shows the mean DMFT and its components by age, comparing pre- and post-water fluoridation findings. There were fewer statistically significant differences in the findings between the two studies in the permanent dentition. Older children, from 9 years upwards, did have fewer filled teeth however.

Table 3 shows the decayed component as a percentage of the dmft score and the percentage of children free of caries experience (dmft=0) in the deciduous dentition. The decayed component continues to comprise the major proportion of the dmft score, in excess of 80% across all age groups. The percentage of children free of caries experience was generally higher in the post-water fluoridation study. The Significant Caries Index data show a mean dmft of 7.80 and 5.90 respectively for the 10% and 30% of children with the worst caries scores (SiC_{10} and SiC_{30}). This represents respective reductions of 28.6% and 32.3% for the age-weighted SiC_{10} and SiC_{10} scores compared to pre-fluoridation. Table 4 shows the Decayed component as a percentage of the DMFT score and the percentage of children free of caries experience (DMFT=0) for the permanent dentition. These findings are similar to those seen in the deciduous dentition. SiC_{10} and SiC_{30} scores for the permanent dentition were 4.10 and 2.60 respectively: this represents reductions of 30.9% and 38.9% compared to pre-fluoridation.

Tables 3 and 4 show lower SiC30 and SiC10 scores post-water fluoridation compared to the pre-fluoridation survey for dmft and DMFT, across all ages.

Approximately 20% of children presented with dental fluorosis, none of which was more severe than TF score 2, (very mild/mild fluorosis), which is of no aesthetic concern. The majority of treatment required was limited to basic restorative care.

DISCUSSION

Our sample of consisted of approximately 60% of students nominally on school rolls. Those absent were predominantly truants, this being, unfortunately, a common problem in remote Indigenous communities in Australia.

Nevertheless, it is evident that t~~T~~here has been a significant, pleasing reduction in ~~the~~ caries experience amongst children of the NPA between 2004 and 2012. This is greatest in the 4- to 8-years-old cohort who, assuming adequate operation of the plant, have had an almost lifetime exposure to fluoride in the water. We regard it as unlikely that other factors such as diet and oral hygiene account for this significant difference. These factors were not measured in either study but, as far as is known, there have been no major differences in the range of foodstuffs available in the community stores. Basic groceries and perishable foodstuffs are imported by sea from Cairns in shipments approximately every two weeks. Whilst there are plenty of fresh tropical fruits, most [apart from the ubiquitous mangoes in season] are not grown in the community and, whilst these were reasonably priced, it is clear that most children prefer the widely available [and relatively expensive] carbonated drinks and convenience foods. Children were observed arriving for a school day already drawing on a can of “soda” and a packet of potato crisps. The “bush tucker” widely available is fish, caught off the only jetty in prodigious amounts by interested families, and other seafood, including dugong and turtle on special occasions. [There are special permissions for protected species to be hunted by some Indigenous communities in Australia]. Carbohydrates with high glycaemic indices, such as rice, yam and sweet potato are abundant.

Though superficial and possibly unreliable, over half of the children claimed to have and to use a toothbrush daily. Toothpaste was claimed to be used by most of these children and those brands available in the stores were~~as~~ fluoridated. Our observations on oral hygiene levels in the children do not indicate much effective tooth brushing.

Electronic records from Sun Water, dating back to 1 January 2009, were made available to us. Mean fluoride levels until 4 April 2011, when lightening damage to the control system shut down the fluoridation plant, was 0.68 ppm with a maximum of 0.89 ppm. However there were periods of occasional plant failure, mostly for a single day only. Repairs to the fluoridation plant were still awaited at the time of the survey.

It is also apparent that there is much consumption of imported bottled water in the community – in addition to the cariogenic drinks consumed. These two factors must have significantly reduced the potential benefits of the fluoridated water supply.

In spite of periods of irregular fluoride availability, it seems reasonable to conclude that the major cause of the improved oral health of this community is, indeed, the fluoridation of the public water supply. Whilst the economic viability of water fluoridation for a small community such as this might be questioned, we posit that the costs are outweighed by the significant caries reduction in both the deciduous and permanent dentitions as found in our study, seven years post-fluoridation. Considering that the next best alternatives to community water fluoridation all include interventionist, professionally applied, preventive measures, all of which require resources which are difficult and expensive to source in this remote area, the continuing availability of water fluoridation for this community is strongly recommended.In spite of the improvements we have shown, the level of untreated dental caries amongst children in the NPA is disturbingly high, affecting health and social function, and

imposing a considerable treatment burden on health resources. A significant minority of teenagers had very poor and unaesthetic dentitions. Our data do not permit us to partition the causes between lack of fluoridated water in the formative stages of their permanent teeth, poor diet and a lack of grooming behaviour in this rebellious age group.

Limitations of our study include our inability to access children absent from school, the unreliability of self-reported dietary and hygiene practices, and the incomplete records of the fluoridation plant. In spite of these, it is possible to conclude that the introduction of a fluoridated reticulated water supply in this rural, remote and Indigenous community has had a substantial health benefit. In light of the serious situation across Queensland, wherein we have shown that, across all care categories, almost 56 percent of those on the waiting list for public dental services were beyond the desirable waiting period (18), the present observations should inform policy for similar schemes in comparable communities not only in Queensland, but worldwide.

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Table 1. Deciduous dentition – decayed, missing and filled teeth (dmft) by age, pre- and post-water fluoridation

Age	Sample		decayed		missing		filled		dmft	
	Pre-fl	*Post-fl*	*Pre-mean*	*Post-mean*	*Pre-mean*	*Post-mean*	*Pre-mean*	*Post-mean*	*Pre-mean*	*Post-mean*
4	18	14	5.44	1.86*	0.67	0.21	0.39	0.00	6.50	2.07*
5	41	33	6.02	3.55*	0.27	0.15	0.34	0.12	6.63	3.82*
6	59	44	5.20	3.43*	0.41	0.59	0.76	0.05*	6.37	4.07*
7	37	33	4.70	3.79	0.24	0.15	0.62	0.03*	5.57	3.97*
8	53	39	4.60	2.64*	1.06	0.23*	0.79	0.05*	6.45	2.92*
9	54	33	3.63	2.33*	0.46	0.18*	1.31	0.18*	5.41	2.70*
10	48	20	1.83	1.60	0.42	0.05*	0.19	0.05*	2.44	1.70
11	45	22	0.27	0.82	0.00	0.00	0.09	0.05	0.36	0.86
12	38	25	0.05	0.16	0.00	0.00	0.11	0.00	0.16	0.16
Total	393	263								
Age weighted means			3.48	2.48	0.40	0.21	0.56	0.07	4.44	2.76
% difference				28.6%		48.1%		83.1%		37.9%

* p-value < 0.05

Table 2. Permanent dentition – Decayed, Missing and Filled teeth (DMFT) by age, pre- and post-water fluoridation

Age	Sample		Decayed		Missing		Filled		DMFT	
	Pre-fl	*Post-fl*	*Pre-mean*	*Post-mean*	*Pre-mean*	*Post-mean*	*Pre-mean*	*Post-mean*	*Pre-mean*	*Post-mean*
5	41	33	0.24	0.30	0.00	0.00	0.00	0.00	0.24	0.30
6	59	44	0.39	0.27*	0.08	0.02*	0.07	0.00	0.54	0.30*
7	37	33	0.22	0.48	0.00	0.00	0.16	0.00	0.38	0.48
8	53	39	0.79	0.56	0.09	0.05	0.30	0.00	1.19	0.62*
9	54	33	1.22	1.12	0.19	0.12	0.52	0.03*	1.93	1.27*
10	48	20	1.31	1.20	0.10	0.00	0.42	0.10*	1.83	1.30
11	45	22	1.71	1.59	0.18	0.14	0.56	0.05*	2.44	1.77
12	38	25	2.03	2.72	0.26	0.00	1.21	0.12*	3.50	2.80
13	34	26	2.29	2.46	0.21	0.12	1.24	0.23*	3.74	2.81
14	28	17	2.82	2.18	0.18	0.65*	1.57	0.35*	4.57	3.18
15	31	17	3.16	1.47*	0.23	0.29	1.87	0.59*	5.26	2.35*
Total	468	309								
Age weighted means			1.33	1.13	0.13	0.09	0.62	0.09	2.08	1.32
% difference				14.5%		28.9%		84.8%		36.4%

* p-value < 0.05

Table 3. Deciduous dentition – caries experience indices by age, pre- and post-water fluoridation

Age	Sample		Mean d/dmft (%)		dmft=0 (%)		SiC_{30}		SiC_{10}	
	Pre-fl	*Post-fl*	*Pre-fl*	*Post-fl*	*Pre-fl*	*Post-fl*	*Pre-fl*	*Post-fl*	*Pre-fl*	*Post-fl*
4	18	14	92.9	89.9	16.7	50.0	12.00	5.20	17.50	9.00
5	41	33	91.7	92.9	9.8	30.3	12.50	8.82	15.75	11.25
6	59	44	82.5	84.3	15.3	16.3	11.65	7.73	15.17	10.40
7	37	33	84.4	95.5	8.1	18.2	10.08	7.91	12.25	10.25
8	53	39	71.7	90.4	9.4	20.5	12.12	6.23	15.00	9.00
9	54	33	70.6	86.3	20.4	27.3	10.22	6.09	13.20	8.50
10	48	20	78.1	94.1	50.0	35.0	6.31	3.86	9.60	6.00
11	45	22	75.0	95.3	86.7	81.8	1.84	2.38		
12	38	25	33.3	100	97.4	92.0	1.35	0.44		
Age weighted means			74.9	91.4	34.6	36.2	8.7	5.9	10.9	7.80
% difference				22.1%		5.3%		32.3%		28.6%

Table 4. Permanent dentition – caries experience indices by age, pre- and post-water fluoridation

Age	Sample		Mean D/DMFT (%)		DMFT=0 (%)		SiC_{30}		SiC_{10}	
	Pre-fl	*Post-fl*	*Pre-fl*	*Post-fl*	*Pre-fl*	*Post-fl*	*Pre-fl*	*Post-fl*	*Pre-fl*	*Post-fl*
5	41	33	100	100	80.5	97.0				
6	59	44	71.9	90.0	72.9	76.7				
7	37	33	61.9	100	81.1	72.7				
8	53	39	56.7	90.3	60.4	71.8	3.33	1.84	5.60	3.25
9	54	33	60.5	88.2	33.3	39.4	4.28	2.64	6.60	3.25
10	48	20	69.4	92.3	31.3	45.0	3.94	3.14	5.40	6.00
11	45	22	70.1	89.8	33.3	40.9	5.53	3.88	7.25	5.67
12	38	25	56.0	97.1	28.9	24.0	7.08	5.89	9.50	9.00
13	34	26	66.0	87.5	20.6	26.9	8.36	6.33	12.00	9.33
14	28	17	62.3	68.6	21.4	17.6	10.11	5.13	14.33	9.50
15	31	17	63.0	62.6	3.2	35.3	9.90	5.50	12.33	9.50
Age weighted means			67.2	89.8	45.1	55.2	4.20	2.60	6.00	4.10
% difference				33.6%		22.4%		38.9%		30.9%