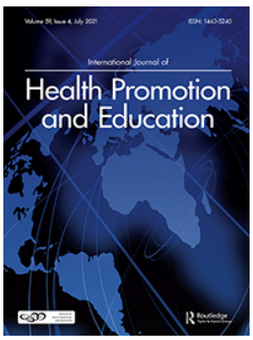

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Sugar in your diet: kino te pai! an evaluation of oral health science outreach and community impact

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ABSTRACT

This study evaluated the impact of a combined science outreach, oral health education and tooth brushing initiative introduced into a New Zealand Māori immersion primary school. Participants completed questionnaires on dental anxiety, oral health practices and dental knowledge before and after the intervention. Pre- and post-intervention responses were compared to determine if knowledge and outcomes had improved. Semi-structured interviews were conducted with six students 18 -months later to determine long term retention of information and subsequent oral health practices. Improvements in good oral hygiene habits and diet were observed in several areas. Interview participants comments showed that although students may be aware of recommended oral health practices, they will not necessarily implement them. A decline in the number of sugary drinks consumed daily was observed, alongside an increase in participants' understanding of the effect of fluoride on teeth. Not all dental terminology and scientific knowledge was retained long term because of this initiative; however, improvements were observed when reinforcement of messages was delivered regularly throughout the duration of the study. Scientific outreach and dental initiatives need to be ongoing to ensure long term retention of information provided, and to encourage regular oral health practices.

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Dental education; Māori; sugar; science education; tooth brushing

Introduction

High rates of sugar consumption are a global concern because of links with obesity, diabetes, cardiovascular disease, and dental caries (WHO 2015; von Philipsborn et al. 2019; Hu and Malik 2010). The WHO has recommended less than 5% of daily caloric intake as sugar (WHO 2015). In New Zealand (NZ), people consume more sugar per capita than any other Organisation for Economic Cooperation and Development (OECD) country (Sundborn et al. 2014). Sugary drinks are the primary means by which New Zealanders consume extra sugar (Utter et al. 2015). Māori and Pasifika children, and those living in high deprivation areas, are more likely to consume sugary drinks than New Zealand Europeans (NZE) (Utter et al. 2015;

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Adolescent Health Research Group, Youth'07 2008; MOH 2003). The links between high consumption of sugary foods and/or drinks, and the development of caries, have been well-established (Cheng et al. 2009; Johansson, Lingström, and Birkhed 2002).

Māori experience oral health inequalities in NZ. Māori children have higher rates of caries and are less likely to access dental care or brush their teeth than NZE children, despite publicly-funded dental care being available to all children until their 18th birthday. These inequalities are likely socially determined, being linked to low socioeconomic status and living in areas underserved by dental clinics (Clark and Slayton 2014; Rugg-Gunn 2013; Clark, Page, and Larkins 2019; MOH 2010).

Regular toothbrushing promotes remineralisation and inhibits demineralisation of enamel (Clark and Slayton 2014; Rugg-Gunn 2013; Clark, Page, and Larkins 2019). Supervised toothbrushing programmes have been implemented worldwide in schools attended by children at high risk of caries (Clark and Slayton 2014; Clark, Page, and Larkins 2019; Rong et al. 2003; Nomura et al. 2019; Macpherson et al. 2013). Caries rates have reduced significantly because of these initiatives and many children have made toothbrushing a habit. Some initiatives have been coupled with oral health education (OHE) focused on discussions of oral diseases, their causes, and prevention (Bhardwaj et al. 2013). A review of school and community OHE programmes concluded that these programmes, when combined with supervised toothbrushing, can improve children's oral hygiene practices and decrease caries rates (Silva et al. 2016). However, their sustainability is unknown, since only raising awareness might not change behaviour.

Financial constraints can also lead to the consumption of cheap non-nutritious foods and sugary drinks leading to obesity and dental caries (Bécares, Cormack, and Harris 2013; Durie 2003). Educational success can lead to better employment opportunities, higher incomes, improved health and quality of life. In NZ, Māori students are overrepresented in statistics for financial hardship, which creates barriers to educational success. They are also less likely than NZE students to engage with science and technology subjects (McKinley 2008; Houghton 2015).

Science education is important because children are immersed in a technologically and scientifically advanced world and being scientifically literate will help them succeed. An increased exposure to the scientific method will teach children to think critically, learn, solve problems and make informed decisions (UTA 2020). Science education is also a requirement to study health professions and there is a need build Māori health workforce in NZ. One important barrier to Māori students' engagement in sciences is that it is not typically taught in a culturally-relevant way.

Given many Māori students' disengagement with science, and the disparity in oral health care access, in 2017 a pilot OHE programme was co-developed by staff of the University of Otago Faculty of Dentistry and Department of Human Nutrition and Te Kura Kaupapa Māori o Ōtepoti (Kura). The Kura is a Māori immersion full primary school (years 1 to 8 of schooling or 5 to 12 years of age), located in the city of Dunedin (population 130,000), NZ. All teaching is delivered in Te Reo (Māori language) and embedded in tikanga (customary practices and beliefs). The initiative was a mutual exchange of knowledge and learning that incorporated Western science understandings and delivered through a tikanga Māori lens.

Kaupapa Māori education has principles focused on: Māori ways of knowing, doing and understanding the world; fostering the relationships of Māori to each other and to the world around them; and having a collective vision and aspiration for Māori communities (Smith 1990). Our outreach initiative promoted the notion that science is

inclusive of all cultures and fostered the connections of science to everyday life. The oral health and science outreach intervention aimed to promote science engagement amongst Māori learners, increase oral health knowledge, and improve oral hygiene habits in a school setting. This study evaluated whether the intervention improved oral health knowledge and oral hygiene practices among participants, and investigated whether those were retained 18-months after the cessation of the programme.

Methods

Ethical approval was obtained from the University of Otago Human Ethics Committee (17/068). Parental consent and child assent were obtained prior to commencing the intervention. Age at baseline and gender were recorded. The outreach intervention was delivered to 40 children aged 5–12 attending a Kura in Dunedin, NZ. Teaching and learning are conducted in the Māori language and follow the principles of Te Aho Matua Kura Kaupapa Māori. The concept of Whānau (family) includes the immediate whānau of the students and their wider connections, which extended to siblings who were at Kohanga (Māori language preschool). Classroom settings were arranged in multi-level learning which supported the tuakana/teina concept of older students supporting younger students.

The intervention took place during usual school hours. At baseline, participants completed three questionnaires (Supplementary material): two designed by the research team to identify the level oral health knowledge and current oral hygiene (OH) practices; and the third was the Modified Child Dental Anxiety Scale faces (MCDAS(f)). Young children received assistance to fill in the questionnaires.

Six interactive science activities were conducted at school over a six-month period, one activity per month. The topics and goals are presented in Table 1. Trained and calibrated students and staff from dentistry, oral health and human nutrition conducted and supervised the activities. The school principal, classroom teachers and support staff were also involved, translating concepts from English to Māori and vice-versa, and ensuring activities were delivered and undertaken in a manner consistent with the school's cultural values. Activities were delivered in English.

In parallel with science experiments, a supervised daily tooth brushing initiative was implemented. Tooth brushing was supervised after lunch once a week by final year oral health students, and daily by Kura teachers. Supervised tooth brushing lasted for six months, excluding school holidays. Key oral hygiene messages were reinforced daily, including brushing techniques (Modified Bass technique, see (Wainwright and Sheiham 2014)), frequency of brushing, and how much toothpaste to use.

At the end of the intervention, the three questionnaires were re-administered to test whether there had been changes in dental knowledge, OH and dietary habits, or dental-related anxiety. Data were analysed and descriptive statistics were produced using Stata Version 15.1.

Eighteen months after the programme had been implemented, six children were selected at random to participate in semi-structured interviews to investigate the medium to long-term impact of the initiative. The interview participants (three girls and three boys) were aged from 7 to 14 years (mean 9.5 years). Children were asked questions relating to their recollections of the programme, oral health knowledge, and current oral hygiene practices. All interviews were conducted at the Kura, lasted between eight and

Table 1. Summary of goals and description of science activities.

Activity	Goals/Description
Sugar and sugary drinks	Activity to discuss what children know about sugar; Investigate the types of foods Māori ate traditionally; to identify hidden sugars in sugary drinks and foods.
He Mahi tuatahi	An interactive competition-style activity where teams performed several tasks including creating a healthy breakfast; measuring how many teaspoons of sugar in various foods; preparing a poster about the effects of sugar in the body; a push-up competition to discuss the importance of physical activities.
Our oral environment	Activity on the various microorganisms present in our body and in the oral environment, and how they produce acids. Involved taking oral and skin swabs and growing microorganisms on agar plates.
From sugar to acids	Activity aimed at understanding the difference between acid, alkaline, and neutral substances, and the effect acid can have on teeth. Involved testing the pH of various household drinks and liquids using a neutral red cabbage solution and a pH meter.
How can we protect our teeth?	Activity to learn how fissure sealants and fluoride can protect our teeth. Involved applying fissure sealant on a plastic tooth under supervision, and comparing eggs soaked in vinegar and fluoride.
What do oral health professionals do?	Final activity, aimed to familiarise students with the dental environment, reduce anxiety relating to dental visits/treatment. Hands-on session at the Faculty of Dentistry, including activities at the simulation clinic and dental biomaterials laboratory.

15 minutes, and were transcribed verbatim. The interview data were analysed using thematic analysis, from which a semantic coding framework was used to identify key themes (Maykut and Morehouse 2002).

Results

All 40 Kura students were invited to participate. Parental consent and child assent were received for 26 participants. Five were lost to follow up for not attending the final assessment, and one was excluded due to having difficulty answering the questions. The remaining 20 participants were included in the study. There were more girls than boys (Table 2), and children were between five and twelve years-of-age, with half being under seven.

Oral hygiene (OH) and dietary habits

Responses to questions on OH and dietary habits before and after the intervention are presented in Table 3. Most children at baseline reported brushing two times per day (80%) for at least two minutes (75%). Half of the participants reported flossing at baseline, and this increased to 60% at the end of the study. An increase in water and reduction in sweet drink consumption was observed at the end of the intervention.

Oral hygiene (OH) and diet knowledge

Responses regarding OH and dietary knowledge before and after the intervention are presented in Table 4. At baseline, most children (75%) were aware of the recommended tooth-brushing frequency, and that water was the best choice of beverage (80%). Improvements were observed in all areas investigated. The number of participants responding that brushing should last for two minutes increased from less than half

(45%) at baseline, to nearly all (95%) post-intervention, with 30% responding that a soft toothbrush should be used. Most participants (84%) selected a 'smear' of toothpaste should be used, compared to only 15% pre-intervention.

General dental knowledge

Small increases in dental knowledge were observed between baseline and post-intervention responses regarding effect of acids on teeth, and what a fissure sealant is (Table 5). The number of participants who correctly identified oral 'bugs' increased (from 25% to 68%), and the largest difference was noted with fluoride knowledge, with an increase in children identifying that fluoride makes teeth stronger from 16% to 67%.

Eighteen participants completed all MCDAS(f) questions before and after the intervention (Table 6). There was a slight difference in scores post-intervention, and a small effect size (0.2) was observed. Dental anxiety scores pre- and post-intervention were low.

Table 2. Baseline demographic information on questionnaire participants.

Characteristics	Pre-intervention n (%)	Post-intervention n (%)
Total	20 (100)	20 (100)
Gender		
Girl	13 (65)	13 (65)
Boy	7 (35)	7 (35)
Age		
5 to 6 years	10 (50)	10 (50)
7 to 9 years	6 (30)	6 (30)
10 to 12 years	4 (20)	4 (20)

Table 3. Diet and oral hygiene habits before and after intervention.

Habits	Pre-intervention n (%)	Post-intervention n (%)
Total	20 (100)	20 (100)
Brushing Frequency		
2 or more times per day	17 (85)	16 (80)
Once a day	3 (15)	4 (20)
Less than once per day	0 (0)	0 (0)
Brushing time		
At least 2 minutes	15 (75)	17 (85)
One minute	4 (20)	2 (10)
Less than one minute	1 (5)	1 (5)
Flossing		
At least 1 time per day	2 (10)	6 (30)
At least 1 time per week	8 (40)	6 (30)
I don't floss	10 (50)	8 (40)
Water per day		
3 or more glasses	12 (63)	16 (80)
1 or 2 glasses	7 (37)	3 (15)
Not daily	0 (0)	1 (5)
Sweet drinks per day		
3 or more glasses	3 (11)	4 (20)
1 or 2 glasses	11 (55)	5 (25)
Not daily	6 (30)	11 (55)

Table 4. Participant oral hygiene and diet knowledge before and after intervention.

Question	Pre-intervention n (%)	Post-intervention n (%)
Total	20 (100)	20 (100)
How much toothpaste?		
A smear	3 (15)	16 (84)
A pea size	7 (35)	1 (5)
Cover half brush	4 (20)	2 (10)
Cover whole brush	4 (20)	0 (0)
A whole tube	2 (10)	0 (0)
How often should we brush?		
Once per day	4 (20)	0 (0)
Twice per day	15 (75)	18 (95)
Once per week	1 (5)	1 (5)
When dirty	0 (0)	0 (0)
When gums are red	0 (0)	0 (0)
How long should we brush?		
At least 2 minutes	15 (75)	17 (85)
One minute	4 (20)	2 (10)
Less than one minute	1 (5)	1 (5)
What type of toothbrush?		
Hard	4 (20)	0 (0)
Medium	4 (20)	2 (10)
Soft	12 (60)	17 (90)
A hairbrush	0 (0)	0 (0)
A finger	0 (0)	0 (0)
What drinks are best?		
Milo	3 (15)	1 (5)
Water	16 (80)	17 (95)
Coke	0 (0)	0 (0)
Sugar free fizzy	1 (5)	0 (0)
Orange juice	0 (0)	0 (0)

Interviews with participants

Recollections of the initiative

When participants were asked whether they liked tooth brushing at the Kura, five of the six said yes. Participant 3, however, said that he 'absolutely hated it [because it] was in the middle of lunchtime'. Participant 3 later said that he wanted the Dental School to return to the Kura because he was 'a science squirt [and wanted] more science'. Interview participants were also asked, without prompting, for their recollections of the initiative. Four participants mentioned specific aspects of tooth brushing, typified by the following:

> They told us to brush your teeth in circles like this (mimes tooth brushing) and every time you brush your teeth to put a little bit of toothpaste on your toothbrush, like this much (mimes a few millimetres with fingers). (P1)

Two participants also recalled science experiments, such as identifying how much sugar was present in common drinks and foods, and the effect that vinegar had on eggshells (simulating the acid effects on enamel):

> Once we did this science thing where we saw how much sugar was in the Coke, fizzy and all different things . . . and we had competitions [for] who could tell the most sugar. (P4)

Table 5. General dental knowledge before and after intervention.

Questions	Pre-intervention n (%)	Post-intervention n (%)
Total	20 (100)	20 (100)
What does acid do?		
Rots teeth	6 (30))	4 (22)
Causes bad breath	2 (10)	3 (17)
Can dissolve teeth	0 (0)	4 (22)
Heals teeth	2 (10)	2 (11)
Whitens teeth	10 (50)	5 (28)
What 'Bugs' live in our mouth?		
Bacteria	5 (25)	13 (68)
Lady bugs	5 (25)	2 (10)
Viruses	6 (30)	1 (5)
Fungi	3 (15)	1 (5)
Berty Germ	1 (5)	2 (11)
What does fluoride do?		
Causes holes	4 (21)	0 (0)
Makes teeth strong	3 (16)	12 (67)
Makes teeth white	1 (5)	6 (33)
Stains teeth	4 (21)	0 (0)
Makes breath fresh	7 (37)	0 (0)
What is a sealant?		
Type of toothpaste	5 (25)	8 (47)
Type of filling	2 (10)	3 (18)
Medicine	6 (30)	1 (6)
An animal in the water	4 (20)	1 (6)
A protective coating on teeth	3 (15)	4 (24)
What is plaque?		
A type of decay	2 (10)	0 (0)
Acid	3 (15)	4 (22)
Staining on teeth	2 (10)	3 (17)
The gum between teeth	7 (35)	11 (61)
Soft stuff on teeth	6 (30)	0 (0)

Table 6. Modified Child Dental Anxiety Scores pre- and post-intervention.

MCDAS(f) score	n	Mean (SD)
Pre-intervention	18	19.1 (7.4)
Post-intervention	18	17.3 (5.9)
Difference	18	1.8 (8.0)
Effect size	18	0.2

Oral hygiene and sugar

All interview participants reported that they did not consume sugary drinks and/or foods at the Kura, and four participants said they consumed sugary drinks sparingly. However, two stated that they often drank 'Mountain Dew' (P4) or 'Juice' (P5) at home despite being aware that it had a detrimental effect on teeth. When participant 4 was asked what happens to teeth if you drink sugary drinks, they said: 'They get fillings, and if they've already had a filling then you have to pull them out, which I'm getting done . . . either next week or the week after'. Other participants were also aware that consuming large amounts of sugar caused 'teeth rot' (P2) or caused teeth to 'fall out and you get plastic teeth also you get holes and you have to go to the dentist and they pull out your teeth' (P3).

Interview participants were asked how they looked after their teeth. All made comments that showed how they were aware that they should brush their teeth twice daily, but only four did. For example:

> I never really have time to brush them unless my Mum tells me too . . . Sometimes I end up skipping because I'm really tired . . . I try to do . . . at least once a day, but now it's been like once a week. (P4)

Dental anxiety

Two interview participants said they liked going to the dental clinic because they 'got to watch TV' (P6). Two participants described being fearful of going to the dental clinic because 'I never know what they're getting done because even if they say a check-up, sometimes they tell me the next time that I come I'm getting a filling . . . I hate it' (P4).

Oral health and wellbeing

The interview participants were asked if they considered their mouths were healthy, and four responded with similar comments that they knew they were healthy because they 'brushed [their] teeth' (P6). Participant 2 said her teeth were healthy 'because [she] eat[s] vegetables', while participant 5 said she knew they were healthy because she 'never had to do anything like fillings or have a crown or anything'. Only participant 4 considered her teeth were not healthy because: 'I don't like to brush my teeth'.

Oral health knowledge and terminology

When asked specific questions on correct toothbrushing techniques, most reported learning how they should brush for two minutes with a small amount of toothpaste. They were also asked questions on concepts such as bacteria, plaque and fluoride, and the impact these had on oral health. None of them could recall what bacteria or fluoride were or how fluoride affected their teeth. Only participant 4 could define plaque and described it as 'that furry stuff on your teeth [and you remove it] by brushing'.

Discussion

This research is the second national study exploring the effectiveness of toothbrushing initiatives implemented in primary schools (Clark, Page, and Larkins 2019), but the first to have combined an OHE and science programme and reported children's perspectives on the initiative. Children's perspectives are often absent in dental research, thus this is a strength of this study (Smith et al. 2018). The addition of children's recollections 18-months after the initiative has allowed its medium to longer-term effectiveness to be explored. Despite the small sample size and absence of a control group, this was the first study and intervention of its kind, in the only Māori immersion school in Dunedin city.

The involvement of Kura teaching staff and principal resulted in reinforcement of oral health messages daily, with Māori teachers supervising toothbrushing on most days, promoting the 'by Māori, for Māori' philosophy. Involving dental school staff and students weekly increased student contact with oral health workers, enabling positive, non-clinical interactions in a non-threatening environment that has Māori beliefs and ideologies at the forefront. This created a balance of power, whereby dental school staff

were visitors, and teachers and students were hosts. The initiative also involved developing a learning resource in Te Reo for teachers to use, addressing the lack of oral health resources in Māori language in NZ schools (UoO 2017).

At baseline, most children were already brushing twice a day for at least two minutes. Habits that showed a lower baseline score included flossing and water consumption, with approximately two thirds of participants reporting they consume three or more glasses of water per day. This is below the recommended amount (5 glasses for 5-9-year-olds; 7 glasses for 9 to 12-year-olds) (Sawka, Cheuvront, and Carter 2005). After the intervention, the number of children consuming three or more glasses of water/day rose significantly.

At baseline, 30% of children did not consume sweet drinks daily, and post-intervention, this rose to 55%. Since childhood oral hygiene can impact on adult oral health and quality of life, families need to play an active role enforcing toothbrushing and oral hygiene habits, and reducing sugary drink consumption (Heilmann, Tsakos, and Watt 2015). Children's non-compliance and parents acceding to nagging are common facilitators for children's lack of regular toothbrushing and sugar consumption (Duijster et al. 2015). Following the advice of the Ministries of Health (MoH) and Education, some NZ schools have banned sugar-added drinks and adopted a water-only policy (King 2016). The Kura had a healthy eating policy that encouraged whānau to provide healthy food, including water being the only drink available.

Most participants (80%) said water was the best drink for the body at baseline, yet only 63% reported consuming more than 3 glasses of water per day, which rose to 80% post-intervention. At baseline, 66% of children reported consuming one or more glasses of sugary drinks per day, and this reduced to 45% post-intervention. The NZ MoH has reported that 42% of Māori men and 29% of Māori women (aged 15+) consume sugary drinks three or more times per week (MOH 2021). If oral health initiatives are to be effective, then wider family consumption of these drinks needs to be addressed.

The NZ MoH recommends that fluoride toothpaste should be used for all ages, but just a smear should be used for children (MOH 2020). Only 15% of the participants selected a smear at baseline, with rose to 84% post-intervention. Knowing that a smear of toothpaste is the right amount is important: children would have learned about quantities, measurement, and safety, in addition to oral health. Over half of the children selected a soft toothbrush as best (60%), and most participants (75%) had good baseline knowledge that they should brush for two minutes. The number of children selecting the frequency as twice a day and a soft toothbrush as best also increased.

By 18 -months post-intervention, four out of six interview participants reported they brushed twice daily. This was consistent with other studies where around two thirds of children brushed twice daily following a toothbrushing intervention (Do and John Spencer 2016; White et al. 2006; MOH 2010). Other studies reported that children's oral health knowledge may increase after OHE initiatives, but this may not necessarily lead to long-term behaviour change (Watt et al. 2001; Cooper et al. 2013; Wind et al. 2005).

Monthly activities aimed to increase participants' dental science knowledge. None of the children knew that acid could dissolve teeth at baseline, and only 22% learned this post-intervention. The targeted activity on this topic involved pH testing of several solutions and monitoring the effect of soaking eggs in vinegar for a week. Children had difficulty making the connection that vinegar was an acid that dissolved the eggshell, having the same effect on a tooth. However, an important learning was that you can

change the state of a material by putting it in different solutions; thus, the activity had positive outcomes even though dental knowledge scores were low. The greatest improvement in dental knowledge was observed on what fluoride does, with an increase from 16% to 67% of students selecting 'fluoride makes teeth strong'.

An increase in science literacy in some areas is a positive result of this OHE programme. Nevertheless, 18-months post-initiative, most interview participants had difficulty recalling what bacteria or fluoride were. It was not possible to determine whether children interviewed had improved oral health literacy post-intervention; therefore, caution is required before concluding knowledge loss. Some participants might have engaged in surface-only learning and thus were unable to recall information after an extended period (Ross and Tuovinen 2001). Deep learning may have been achieved by ensuring children thoroughly understood the scientific processes involved in aspects such as demineralisation and remineralisation (Chin and Brown 2000).

In mainstream NZ schools, science is often taught from a NZE perspective, which ignores Māori worldviews and leads to Māori students disengaging with science (McKinley 2008). The comment made by one participant that he wished we would return to the Kura because he wanted more science was encouraging. Despite the uncertainties regarding long-term dental science literacy, the intervention has generated impact on science enjoyment among participants.

We hypothesised that continued interaction with dental staff and students in a safe environment, could help to reduce dental-related anxiety. Although already low, dental anxiety scores slightly reduced. Dental anxiety is common in children and adults and has roots in painful early dental experiences (Townend, Dimigen, and Fung 2000). Two interview participants reported they did not like going to the dental clinic because of previous pain. Although it cannot be ascertained if they experienced dental anxiety, their comments show earlier experiences resulted in reluctance to undergo further dental treatment (Shim et al. 2015).

Given the lower rates of dental attendance amongst Māori children (MOH 2010, 2012, 2018), initiatives aimed at addressing children's trepidation about dental care need to be implemented, in parallel with improving access issues. Future OHE and toothbrushing initiatives could include interactive activities so that children become familiar with the clinic environment, oral health practitioners, and supporting staff.

Conclusion

Dental science and oral health school-based initiatives can help address infrequent toothbrushing and high sugar ingestion among Māori children. This study focused on changes in dental knowledge and oral hygiene practices in a Māori Kura, which had been gained through participating in a combined science outreach, oral health education and toothbrushing initiative. Improvements in oral health knowledge and practices were observed across many areas. Continued reinforcement of key oral health messages is needed to ensure long-term information retention.

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