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A review of early childhood caries, risk factors and preventive strategies

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Abstract

Background: A recent review of New Zealand 5-year-old children's oral health data reveals that minimal improvements have been made over recent years, despite considerable investment. Furthermore, unacceptably wide inequalities among different ethnic and socioeconomically disadvantaged communities have remained largely unchanged.

Aims: To examine evidence-based risk factors that are associated with Early Childhood Caries (ECC) and current strategies to mitigate against them; identify preventive strategies that may further improve the overall oral health of New Zealand preschool children and reduce disparities; and make recommendations.

Methods: Articles and textbooks used in this review were identified primarily using electronic databases and from electronic and hand-searches of reference lists of articles and reports. Findings were collated and then organised into common themes.

Findings and Discussion: Ten themes were identified, namely: [1] high frequency of sugar consumption; [2] continuous breastfeeding at nights; [3] oral hygiene habits; [4] lack of exposure to fluoride; [5] socioeconomic, cultural and demographic background of parents/caregivers; [6] oral health literacy; [7] access to dental services; [8] oral health status of mothers and transmission of cariogenic bacteria; [9] teeth susceptible to caries due to developmental defects of enamel; and [10] role of genetics in dental caries. Based on these findings, it is recommended that prevention starts during pregnancy and continues through preschool years. Both population- and individual-based strategies aimed at modifying or eliminating aetiological factors causing caries and preventing initiation and progression of ECC appear warranted. Rather than developing oral health programmes in isolation, a common coherent risk approach integrated with other health initiatives is likely to be more efficacious. By addressing common risks and underlying social determinants, improvements in a range of chronic conditions are likely to be efficiently achieved.

Conclusions: To further improve the oral health of preschool children and to reduce inequalities, recommendations are described within 10 themes.

Introduction

Oral health is multi-faceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort and disease of the craniofacial complex (Glick et al, 2016). Failure to prevent childhood oral diseases has significant personal, societal, and economic costs. In New Zealand, direct expenditure for dental visits is estimated to be NZ$1.8 billion per annum (Munro, 2018). For the financial year 2017/2018, total expenditure on oral health by New Zealand's twenty District Health Boards (DHBs) was NZ$197.2 million; with Community Oral Health Services (COHS) accounting for NZ$98.42 million, adolescent dental services costing NZ$42.17 million, hospital dental services spending NZ$49.68 million, and emergency dental services for lower income adults costing NZ$7.45 million (National Clinical Director, Ministry of Health Riana Clarke, personal communication, May 2019).

Despite this ongoing substantial investment in oral health services, only modest improvements in young children's oral health profiles have been documented since 2000, and wide ethnic and socioeconomic inequalities remain largely unchanged (Ministry of Health, 2019b; Schluter and Lee, 2016).

Early Childhood Caries (ECC)

Dental caries that arises in early childhood and affects infants' or toddlers' primary teeth were formerly referred to as nursing or baby-bottle caries. However, to better reflect its multi-factorial aetiology, ECC was coined in 1999 by an expert panel and adopted as a standard nomenclature (Drury et al, 1999). ECC is defined as the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries) or filled tooth surfaces in any primary tooth of a child aged 71 months or younger (American Academy of Pediatric Dentistry and the American Academy of Pediatrics, 2016; Drury et al, 1999).

ECC is caused by the interaction over time between cariogenic bacteria, fermentable carbohydrates (mostly refined carbohydrate), and host factors (including teeth). While the development and progression of ECC are influenced by multiple risk factors, its pattern is generally similar - with variations due to age, eruption time, teeth and surface, and feeding practices. Notwithstanding these multiple variables, ECC invariably begins with white-spot lesions on the labial surfaces of the upper primary incisor teeth along the gingival margins. A Nigerian study of children aged between 6 and 71 months demonstrated that the most frequently affected teeth were primary mandibular molars, followed by maxillary incisors and molars (Sowole et al, 2007). The least affected teeth were maxillary primary canines and mandibular incisors and canines. A New Zealand study showed caries experience was greatest among the

primary second molars in either arch, and lowest among the mandibular incisors (Gowda et al, 2009). The risk for proximal caries in the posterior primary dentition is increased if contact points are closed compared to those that are open (Allison and Schwartz, 2003).

Prevalence and severity of ECC

An analysis of the Ministry of Health data on caries-free (Figure 1) and decayed, missing due to caries and filled primary teeth (dmft) (Figure 2) of 5-year-old children in New Zealand between 2010 and 2017 showed a sustained high rate of caries (Ministry of Health, 2019b). Moreover, important and sustained ethnic disparities in caries rates between Māori, Pacific, and non-Māori/non-Pacific (predominantly New Zealand European) children exists. In 2017, 62% of Pacific and 58% of Māori children had caries, compared to 30% of non-Māori/non-Pacific children. Compounding this, of those with caries, Pacific children had an average of 5.1 teeth affected, Māori children had 4.9 teeth affected, whereas non-Māori/non-Pacific children had an average of 4.1 teeth affected by caries. The 2017 data also revealed significant variation between DHBs: 65% of 5-year-old children in Northland and Lakes having caries, 33% of children in the Waitemata and Hutt Valley and 31% in Capital Coast experiencing dental caries. The variations likely reflect the differing socioeconomic and ethnic population compositions, and exposures to reticulated water fluoridation. These oral health data are based on cavitated carious lesions only. If non-cavitated lesions are also included, as stated in the definition of ECC (American Academy of Pediatric Dentistry and the American Academy of Pediatrics, 2016; Drury et

Figure 1: Percentage of examined 5-year-old children in New Zealand who had no obvious decay experience (caries-free) between 2010 and 2017, overall and partitioned by major ethnic groups (Ministry of Health, 2019b).

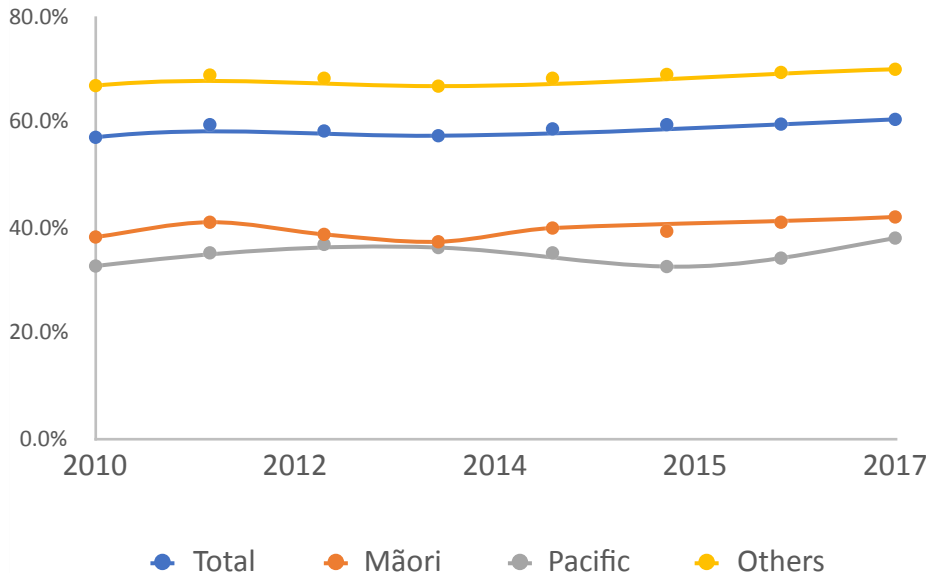
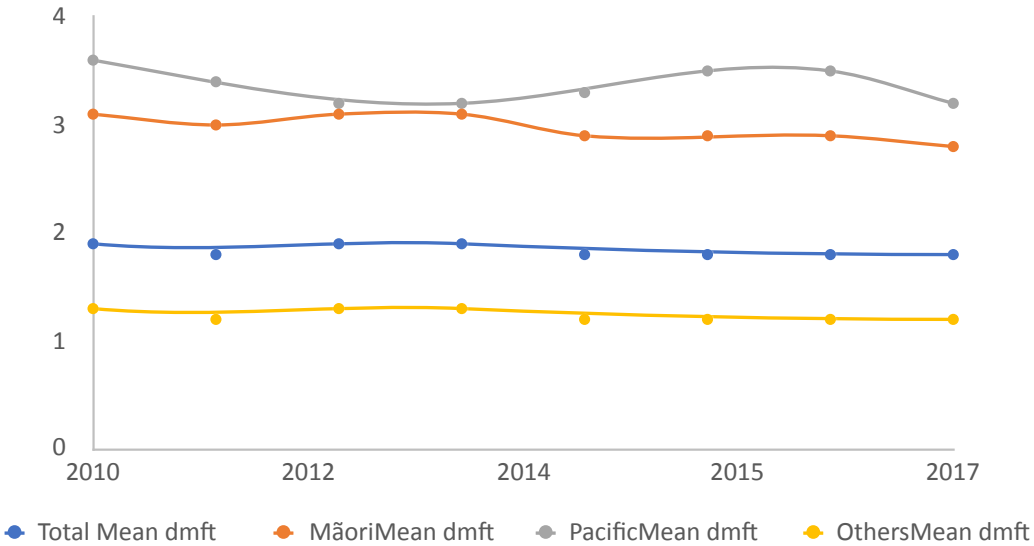


Figure 2: Mean dmft of examined 5-year-old children in New Zealand between 2010 and 2017, overall and partitioned by major ethnic groups (Ministry of Health, 2019b).



al, 1999), then the observed prevalence and severity rates would be even higher.

Recent national cross-sectional data on 318,321 4-year-olds attending the 'B4 School check' in New Zealand, reported experience of severe caries increased from 3.0% (95% confidence interval (CI): 3.0%, 3.1%) in 2010/2011 to 4.4% (95% CI: 4.3%, 4.5%) in 2015/2016 (Shackleton et al, 2018). These percentage increases also varied by ethnicity and deprivation with, for example, Pacific children's severe caries experience increasing from 7.1% (95% CI: 6.8%, 7.4%) to 14.1% (95% CI: 13.7%, 14.5%) over this time.

Similar patterns have been observed in other countries. In the 2012-2014 Australian National Child Oral Health Study, 34% of children aged 5-6 years had caries in primary teeth and 26% had untreated caries in these teeth; 44% of Aboriginal and Torres Strait Islander children compared to 25% of non-Indigenous children were found to have untreated caries (Do and Spencer, 2016). A 2017 English study of 5-year-old children reported an overall caries prevalence of 23%, a rate that varied by deprivation and ethnicity, with 34% in the most deprived areas having caries compared to 14% for those who were least deprived and the prevalence in Eastern European children was 49% (Dental Public Health Intelligence Team, 2018).

Importance of understanding ECC

The impact of ECC on young children can have significant short-term and long-term consequences. Pain and swelling can hinder a child's quality of life, limit the ability to eat, affect speech articulation/language development, distract from learning and playing, and increase the number of days with restricted activity or absence from school. Inability to eat normally has been shown to affect nutritional status, weight gain and growth, and may prevent young children from reaching normal height and weight (Casamassimo et al, 2009; Clarke et al, 2006; Sheiham, 2006). Learning, socialisation and self esteem are also affected by poor oral health. Each primary tooth extracted prematurely was shown to increase the need for later orthodontic treatment by 18% (Bhujel et al, 2016). If caries occurs in a primary tooth, then the successor tooth was found to be more than twice as likely to have a demarcated enamel defect (Broadbent et al, 2005). Additionally, children with caries in their primary teeth were three times more likely to develop caries in their permanent teeth (Li and Wang, 2002).

ECC has significant implications for the delivery of health care, including the increased likelihood of hospital admissions. During the 1990-2009 period, New Zealand dental admissions rates were found to be greatest among children aged 3-4 years compared to those in other age groups (Whyman et al, 2014). Moreover, during 2004-2005 and 2014 period, the number of children receiving dental treatment under general anaesthesia (GA) increased by 66.9% (Hunt et al, 2018). In New Zealand the cost of dental treatment under GA was estimated to be NZD$2,400 per child (personal communication, Robin Whyman and Hugh Trengrove), which poses increased resource and expertise burdens as volume of cases concurrently rises.

Aims

Set against New Zealand children's current backdrop of oral health, this review examines risk factors that are associated with ECC, and current strategies to reduce ECC and identifies strategies and makes recommendations for further improvement.

Methods

A previous literature review identified risk factors for ECC that include oral bacterial flora, dietary habits, oral hygiene practices, sociodemographic characteristics, ethnicity and enamel hypoplasia (Harris et al, 2004). That review's structure and content is updated here and contextualised within New Zealand.

The literature search used electronic databases, including PubMed, Google, Cochrane Library, World Health Organization (WHO), New Zealand Ministry of Health, New Zealand Dental Association and New Zealand Health Promotion websites, and selected textbooks. Articles and textbooks used in this review were primarily identified by using the following keywords: 'early childhood caries', 'definition of early childhood caries', 'oral health of preschool children', 'risk factors of early childhood caries', 'caries preventive strategies in preschool children', 'pattern and distribution of early childhood caries', 'maternal oral health', 'treatment under general anaesthetic', 'access to dental care', 'breastfeeding and dental caries', 'knowledge' and 'attitude' and 'role of genetics in dental caries'. Secondary electronic and hand-searches resulted from reference lists of articles and reports, and related sources. Findings were collated and then organised into common themes.

Findings

Building on the work of Harris et al. (2004), 10 themes were identified, namely: [1] high frequency of sugar consumption; [2] continuous breastfeeding at night; [3] oral hygiene habits; [4] lack of exposure to fluoride; [5] socioeconomic, cultural and demographic background of parents/caregivers; [6] oral health literacy; [7] access to dental services; [8] oral health status of mothers and transmission of cariogenic bacteria; [9] teeth susceptible to caries due to developmental defects of enamel; and, [10] role of genetics in dental caries. Each of these themes has been described in detail, separated into 'what is known' and 'strategies to mitigate the risk' subsections.

[1] High frequency of sugar consumption

What is known:

There is overwhelming and long-standing evidence on the unique role of free sugars and frequency of intake in causing dental caries (Gustaffson et al, 1954; Harris, 1963; Scientific Advisory Committee on Nutrition, 2015). Excessive amounts and frequent consumption of sugars are the main causes of dental caries (Moynihan and Petersen, 2004; World Health Organization, 2003). Sugary drinks are a major source of sugar, and their consumption is increasing in most countries, especially amongst children and adolescents (World Health Organization, 2017b).

Sugary drinks are defined as beverages containing free sugars. These include carbonated or non-carbonated soft

drinks, fruit/vegetable juices and drinks, water flavoured with liquid and powder concentrates, energy and sports drinks, ready-to-drink tea, ready-to-drink coffee, and flavoured milk drinks (World Health Organization, 2015). The New Zealand Childhood Obesity Programme Baseline Report showed that 10% of children aged 2-4 years consumed fizzy drinks three or more times a week. This increased to 15% in children aged 5-9 years (Ministry of Health, 2017b). Soft drinks containing acids and sugars have acidogenic and cariogenic potential. Studies have demonstrated a positive relationship between caries risk and dental erosion and the consumption of soft drinks (Harding et al, 2003; Sayegh et al, 2002). There is some evidence showing that caries risk is reduced when intake of free sugars is <10% of daily total energy intake (Moynihan and Kelly, 2014); a level recommended by WHO guidelines (American Academy of Pediatric Dentistry and the American Academy of Pediatrics, 2016), although the Scientific Advisory Committee on Nutrition in the UK argues for a 5% daily energy intake threshold (Scientific Advisory Committee on Nutrition, 2015). Cariogenesis is sensitive to even very low sugars intakes; a log-linear dose-response relationship between intake of sucrose or its monosaccharides and progressive lifelong caries development has been documented (Sheiham and James, 2015).

Frequent and long-term exposure of a child's teeth to liquids containing sugars is known to cause dental caries. When children are fed with a bottle containing milk, fruit juice, fizzy and other sweetened drinks, the sugars in these liquids pool around the infant's teeth and gums. During sleep the flow of saliva slows down and the baby swallows less often. Cariogenic bacteria have more time to utilise the sugars to produce the acid that causes caries. Thus, it is advised that children are not to be put to bed with a bottle and not to use a bottle as a pacifier. Children are also to be taught to drink from a regular cup as soon as possible, preferably by 12 to 15 months of age. Having cariogenic foods for snacks is also to be discouraged. Limiting cariogenic foods and drinks to meal times, and restricting sweets, candy, toffees, lollipops, is likely to reduce the prevalence and severity of ECC.

Recent studies have observed that milk and milk products were associated with lower caries experience (Johansson, 2002; Lempert et al, 2015; Tanaka et al, 2010). Milk, cheese and yoghurt contain minerals such as calcium, casein and phosphorus that help protect tooth enamel. Casein, a protein found in dairy foods, when combined with calcium and phosphorus, creates a protective protein film over the enamel surface of the tooth, reducing the risk of tooth decay. The bovine milk protein, lactoferrin, inhibits the aggregation and adherence of *Streptococcus mutans*. The tooth strengthening minerals, calcium and phosphorus, found in dairy foods, also help repair teeth after acid attacks (Olczak-Kowalczyk et al, 2017).

In New Zealand, COHSs provide oral health messages on diet and restriction on sugar intake, and anticipatory guidance to parents and caregivers whenever children are seen and treated. Well Child Tamariki Ora (a free service that is offered to all New Zealand children from birth to 5 years) promotes oral health messages on recommended diet during routine contacts with families. Schools and early childhood centres are encouraged to adopt 'water-only' policies and to ban sugary snacks and foods. A New Zealand group of researchers and public health specialists (FIZZ: Fighting Sugar in Soft Drinks) advocate: raising the price of sugary drinks through increased taxes; restricting sales and advertising; implementing sugary-drink-free policies in workplaces and public institutions; and the promotion of graphic warning labels on harmful products (see: https://www.fizz.org.nz/).

Strategies to mitigate the risk:

The WHO recommends avoidance of sugar before the age of 2 years (World Health Organization, 2017a). Thus, it is important to educate parents/caregivers on limiting sugar intake in foods and drinks and avoid free sugars for children under 2 years of age. Children requiring long-term medications for underlying medical conditions/diseases might be routinely offered alternative sugar-free medications by their medical practitioners, where available (Donaldson et al, 2015). National campaigns to switch to 'water-only' would benefit from strengthening, promotion and support. An effective lobbying on the introduction of mandatory regulation of marketing of sugary drinks to children, especially at times and places frequently visited by children such as children's sports and other events, would also be useful. It has been observed that Māori, Pacific and low-income New Zealanders rarely use nutrition labels to assist them with their food purchases for a number of reasons, including lack of time to read labels, lack of understanding, shopping habits and absence of simple nutrition labels on low-cost foods (Signal et al, 2008). Government and the beverage industry introducing a sugar icon on the packaging of all sugary drinks to indicate the amount of sugar in each product in teaspoons may thus have increased population utility. A joint nationwide advocacy campaign, targetting Government policy, is also urgently needed to introduce an excise tax on sugary drinks.

[2] Continuous breastfeeding at nights

What is known:

A systemic review and meta-analysis concluded that breastfeeding for up to 12 months is associated with a decreased risk of developing ECC (Tham et al, 2015). By contrast, the overall evidence on the effect of breastfeeding beyond 12 months appears to be correlated with an increased risk of ECC (Tham et al, 2015). Among children breastfed longer than 12 months, those fed nocturnally, or more frequently, had a further increased risk of dental caries. Beyond 12 months, confounding factors come into play as the most susceptible teeth have erupted and milk is no longer the main source of nutrition. A long duration of nocturnal breastfeeding causes the milk to pool around the teeth as there is less salivary flow, and the baby swallows less often. This causes cariogenic bacteria to initiate ECC. Although breastfeeding beyond 12 months appears to be a risk factor for ECC, further research is needed to understand its significance compared with other possible confounding factors as extended breastfeeding being associated with non-ECC benefits.

The WHO recommends mothers to breastfeed exclusively for 6 months (World Health Organization, 2019). Complementary feeding with continued breastfeeding is to be continued up to 2 years and beyond. WHO recommendations need be supported because of the proven health benefits associated with breastfeeding. Well Child Tamariki Ora providers and maternity services emphasise the importance of exclusively breastfeeding in infants for the first 6 months of life and for continued breastfeeding beyond 6 months complemented with appropriate types and amount of solid food.

Strategies to mitigate the risk:

Lead Maternity Carer (LMC), Plunket, and Well Child Tamariki Ora providers are supported and encouraged to advise parents/caregivers on the recommended complementary diet while breastfeeding. Complementary food and drinks given to babies with breastmilk are advised to be sugar-free and nutritious. Recommended diets include cereals, wheat biscuits, meat (chicken), fish, mashed cooked vegetables, fruits, cow's milk, water, cheese, yoghurt and fruits (Ministry of Health, 2012). Breastfeeding at night is not to be continuous and the baby needs to be removed from the breast when feeding is complete. COHSs across New Zealand are encouraged to have a uniform policy which promotes the benefits of breastfeeding in addition to other suitable sources of nutrition to mothers when they attend the dental clinics with their children. Providing information on potential caries risk due to long duration of nocturnal breastfeeding might also be part of this individual patient counselling. A consistent multi-agency approach is also likely to strengthen the message and reach the wider community.

[3] Oral hygiene habits

What is known:

The presence of cariogenic plaque on the teeth of preschool children can be used as an indicator of caries risk. Several studies showed correlation between visible plaque and ECC when controlling for background factors (Alaluusua and Malmivirta, 1994; Mohebbi et al, 2006). Ideally, infant's gums should be wiped with a clean gauze pad or washcloth after each feeding. Parents and caregivers are encouraged to brush their child's teeth as soon as the first tooth appears, using a soft toothbrush and a smear of fluoride toothpaste of at least 1000 ppm. Children's teeth must be brushed gently covering all teeth surfaces, ideally for 2 minutes twice every day in the morning and before going to bed at night. A rotating, battery-operated toothbrush is often convenient. Parents/caregivers of children under the age of 7 are encouraged to brush their children's teeth until they have the manual dexterity to do so effectively themselves. When teeth become in contact with each other, careful flossing between them once a day is important. The use of floss sticks or picks instead of regular string floss may be easier for parents and child.

A New Zealand study assessing the oral health practices of 4-year-old Pacific children and their mothers found that only 47% of the children usually brushed their teeth one or more times a day (Schluter et al, 2007). Mothers reported that 47% of children had no assistance with their brushing. The New Zealand Oral Health Survey in 2009 showed that 66% of children aged 2-4 years and 67% of those aged 5-11 years brushed at least twice daily (Ministry of Health, 2010b). Among children and adolescents aged 2–17 years, Māori were significantly less likely than non-Māori to brush at least twice daily with fluoride toothpaste. Findings from an on-line survey of preschool oral health initiatives showed that 77% of children under the age of 1 year had parents/caregivers who started brushing their teeth, with 58% brushing twice daily and 36% brushing once a day (Dallas et al, 2015).

The use of a fluoride toothpaste during toothbrushing has beneficial effect in the control of ECC. Programmes of daily teacher-supervised or mother-supervised toothbrushing with fluoride toothpaste can be effectively targetted into socially deprived communities and a significant reduction in dental caries can thereby be achieved, especially among caries-susceptible children (Curnow et al, 2002; Jackson et al, 2005). A bi-annual toothbrushing with fluoride toothpaste and oral health education programme is being delivered in preschool facilities in high-deprivation areas in Counties Manukau DHB. Preschool centre staff members are trained to implement a daily toothbrushing programme. An evaluation report of this programme demonstrated that children's involvement in the programme had positive impact on the frequency of toothbrushing with fluoride toothpaste, knowledge of reasons for visiting a dental clinic and about healthy foods and drinks (Litmus, 2016b). Findings from an in-school toothbrushing programme in Northland demonstrated that the children who completed the toothbrushing programme had better oral health, with more caries reversals, and a lower incidence of new carious lesions than those in the control group (Clark et al, 2019). Toothbrushing at school thus appears to reduce oral health inequalities. In New Zealand, Plunket provides support services for children under the age of 5 years. For more than 10 years Plunket, in liaison with a private company (Colgate), has provided families with free toothbrushes, toothpaste, and oral health messages when the child is around 6 months of age (Dallas et al, 2015). Toothbrushes are also provided to other children in families living in hardship. In some areas of New Zealand (e.g., Hawke's Bay, Nelson Marlborough) free toothpaste and toothbrushes and oral hygiene messages are given to children at immunisation times by the practice nurses (Dallas et al, 2015). An initiative of the New Zealand Ministry of Health is to promote and improve oral health preventive behaviours and practices, particularly toothbrushing, among preschool children (Allen and Clarke Policy and Regulatory Specialists Limited, 2015). The main component of the initiative is the targetted distribution of toothbrushes and fluoride toothpaste, together with clear and consistent oral health messages to preschool children and their families and whānau.

Strategies to mitigate the risk:

Targetted preschool toothbrushing programmes might be broadened to include all high-deprivation centres in Manukau. Other regions of New Zealand could be encouraged to initiate this brushing programme in early childhood centres in high-deprived areas. Children and pregnant women from deprived background of New

Zealand are to be provided with free toothbrushes and fluoride toothpaste, and either the Ministry of Health or the DHBs appropriately resourced to fund this programme.

[4] Lack of exposure to fluoride

Fluoride works mainly topically, by reducing demineralisation and enhancing remineralisation as a post-eruptive phenomenon, reducing the susceptibility of the teeth to caries progression.

(i) Community water fluoridation

What is known:

A 2004 study in Canterbury and Wellington showed that water fluoridation reduces oral health inequalities among New Zealand children of different ethnic and socioeconomic backgrounds (Lee and Dennison, 2004). This study demonstrated that caries prevalence and severity was consistently lower for children in the fluoridated area for 5-year-old and school Year 8 children compared with those in non-fluoridated areas.

With 9-year-old children a strong protective dose-response relationship between the proportion of children with caries in primary teeth and residential fluoridation status was seen in Auckland. Compared with children who lived continuously in non-fluoridated areas, children with intermittent non-fluoridation history were 0.78 times as likely to have caries, children with intermittent residential fluoridation history were 0.59 times as likely to have caries, and children with continuous fluoridation history were 0.42 times as likely to have caries (Kanagaratnam et al, 2009). Cost effectiveness of community water fluoridation as a public health measure in New Zealand has been well demonstrated (Fyfe et al, 2015; Moore et al, 2017; Wright et al, 2001). However, water fluoridation is expensive per person in smaller communities and is dependent on the population profile of the community. Adding fluoride to New Zealand's water treatment plants supplying populations under 500 is unlikely to be cost effective (Moore and Poynton, 2015).

New Zealand spring water normally has about 0.1 mg fluoride per litre and fluoridated tap water 0.6 to 1 mg per litre. Approximately 52% of the New Zealand population has access to a fluoridated water supply. Water fluoridation is a proven public health measure to reduce dental caries and efforts should be made to extend water fluoridation in all other areas in New Zealand where there is a reticulated water supply (Office of the Prime Minister's Chief Science Advisor and the Royal Society of New Zealand, 2014).

Strategies to mitigate the risk:

The decision whether or not to fluoridate reticulated water supplies currently sits with local authorities, who are responsible for providing local infrastructure and water supplies - but such bodies are not experts in health, and are often advised by the DHBs. Giving DHBs the power to direct which water supplies need to be fluoridated aligns with DHBs' responsibilities with respect to public health and with their expertise. Legislative changes regarding decision-making on the fluoridation of drinking-water supplies are currently before the New Zealand Parliament. If implemented, it will give DHBs the authority to fluoridate water supplies in their areas.

Fluoride tablets are considered for children aged 3 years and above living in non-fluoridated areas or on tank water. Their use is encouraged in children at risk of ECC. However, fluoride tablets are not recommended as a population measure in New Zealand (New Zealand Guidelines Group, 2009). High-deprived communities with no fluoridated water supply might be provided with free fluoride toothpaste and toothbrushes as a more reliable measure than provision of fluoride tablets.

(ii) Fluoride toothpaste

What is known:

The benefits of fluoride toothpastes are firmly established. A meta-analysis of 70 studies demonstrated that the effect of fluoride toothpaste on reducing caries levels increased with higher baseline levels of decayed, missing, and filled surfaces in permanent teeth (DMFS), higher fluoride concentration, higher frequency of use, and supervised brushing, regardless of whether their drinking water was fluoridated or not (Marinho et al, 2003). Children aged 2–4 years were significantly less likely to brush their teeth at least twice daily with fluoride toothpaste (15%) than those aged 5–11 years (40%) (Ministry of Health, 2010b). A sustained level of fluoride in plaque and on the enamel surface is desirable and one important source is fluoride toothpaste. Limited evidence showed that for children aged <6 years, fluoride toothpaste use is effective in caries control (Twetman and Dhar, 2015; Wright et al, 2014).

Twice daily brushing with fluoride toothpaste is recommended by the New Zealand Ministry of Health as a preventive method for ECC (Ministry of Health, 2008). A fluoride toothpaste of at least 1000 ppm is recommended. However, survey findings on preschool oral health initiatives found only 19% of responding children were using fluoridated toothpaste and nearly a quarter of children using baby toothpaste with less fluoride content, contrary to the Ministry of Health guidelines (Dallas et al, 2015). A smear of fluoride toothpaste is recommended until 5-years of age and a pea-sized amount used from the age of 6-years. Children are to be encouraged to spit the toothpaste foam and not to rinse in order to retain the topical effect. COHSs and Well Child Tamariki Ora providers advise preschool parents/caregivers on daily toothbrushing with 1000 ppm fluoride toothpaste as recommended by the Ministry (Ministry of Health, 2008).

Strategies to mitigate the risk:

All preschool children in New Zealand are encouraged to start brushing their teeth as soon as the first tooth erupts in the mouth with a 'smear' of 1000 ppm of fluoride toothpaste. Providing free toothpaste tubes and toothbrushes is effective in reducing caries in children living in deprived areas (Davies et al, 2002). The Scottish Child Smile programme reported reduction of treatment costs by £5 million pounds by offering free toothpaste and toothbrushes and twice a year fluoride varnish application to children in deprived areas (British Dental Association, 2018). Dental professionals and others are encouraged to lobby to stop the sale of children's toothpaste with low fluoride content (Twetman and Dhar,

2015; Wright et al, 2014). In the absence of legislation, toothpaste manufacturers are encouraged for using appropriate evidence in marketing these toothpastes within New Zealand. Evaluation of the oral health in preschool children participated in brushing programmes in Counties Manukau DHB area needs to be continued.

(iii) Fluoride varnishes

What is known:

Fluoride varnishes have been shown to be a safe and efficacious part of a caries prevention programme that included caries diagnosis, risk-assessment, and regular dental care (Marinho et al, 2013; Weyant et al, 2013). A New Zealand guideline published in 2009 recommends the use of high-concentration fluoride varnish in children over age 12 months who are at high risk of dental caries (New Zealand Guidelines Group, 2009). Fluoride varnish should be applied at 6-monthly intervals to all erupted teeth. Professionally applied high concentration fluoride gel and foam and fluoride mouth rinses are not recommended for children aged under age 6. Fluoride varnishes have been used at concentrations of 1% and 5% for the prevention of ECC. A systemic review demonstrated that preventive fraction for 1% fluoride varnish ranged from 6.4% to 30% and for 5% fluoride varnish it ranged from 5% to 63% (Mishra et al, 2017). Any protocol on the application of fluoride varnish needs to be based on caries risk assessment. COHSs apply fluoride varnish depending on the assessed caries risk status of children at clinic settings. A few COHSs around the country are also engaged in applying fluoride varnish in community settings such as at early childhood centres in targetted areas.

Strategies to mitigate the risk:

As part of the evidence-based approach to care these clinical recommendations are to be integrated with the practitioner's judgment and the patient's needs and preferences (Marinho et al, 2013; Weyant et al, 2013). All COHSs in New Zealand should be encouraged to implement community outreach fluoride varnish application programmes on preschool children living in high-deprived areas.

[5] Socioeconomic, cultural and demographic background of parents/caregivers

What is known:

ECC is associated with socioeconomic factors such as poverty, levels of parental education, ethnicity, number of children in the family and rural residence. Indigenous children, new immigrants, refugees and children from dysfunctional families are mostly affected by ECC (Psoter et al, 2006). A North American study showed that preschool children living in poverty are twice as likely to experience dental caries and twice as likely to have dental pain compared with preschool children living above the poverty level (Edelstein, 2002). The pattern is similar in New Zealand children. A few New Zealand studies including the Dunedin Multidisciplinary Health and Development study examining the socioeconomic patterns of dental caries experience at age 5 showed clear differentials in the prevalence and severity of dental caries (Evans et al, 1984; Treasure and Dever, 1992; Thomson et al, 2004). The prevalence of caries was lowest in the high socioeconomic group and severity of caries experience was highest in the low socioeconomic group. In 2017, it was estimated that 27% of New Zealand children aged 0-17 years were living with income poverty (Duncanson et al, 2017). In New Zealand, Māori and Pacific people are disproportionately affected by poverty and are over-represented in highly deprived communities (Shackleton et al, 2018). Many deprived parents with infants and preschoolers have limited oral health literacy, thus have difficulty prioritising or making appropriate toothbrush and paste choices, and struggle to afford or understand healthy diet options (Veerasamy, 2010).

Although there have been modest improvements made in ECC, persistent inequalities remain. Upstream actions relating to public policy have been successful in improving oral health, including: water fluoridation, better food labelling, regulations for advertisements and taxation on tobacco. Health promoting policies such as no-sugar policy in hospitals and workplaces have been implemented in some areas of New Zealand and there is a current public lobby in favour of introduction of a sugar tax. COHSs in many areas of New Zealand examine children from birth, and provide clinical preventive measures. Children are assessed for caries risk using a risk-assessment tool based on several factors including socioeconomic status of families; recall intervals for subsequent examination are decided based on their risk status. Children with high risk for caries are seen more often and provided with appropriate clinical care.

An oral health guide developed by the New Zealand Dental Association is being used by Well Child Tamariki Ora providers to raise awareness, educate, and promote oral health by providing clear and consistent messages to families of children at highest risk of developing dental caries (New Zealand Dental Association, 2008). The guide aims to reduce inequalities in oral health by offering providers information and guidance about the prevention of ECC. This guidance also includes effective strategies for identifying and preventing dental caries in children, including 'Lift the Lip' a quick and easy technique for screening the teeth of infants, toddlers and preschoolers for dental caries. The 'Lift the Lip' assessment, caries risk assessment and enrolment for dental services at the 9-to 12-month core contact was introduced within Well Child Tamariki Ora in 2010 (Ministry of Health, 2010a).

Strategies to mitigate the risk:

Disengagement with health behaviours and services because of socioeconomic, cultural and demographic reasons is often the result of a combination of complex circumstances and can have an intergenerational impact (Smith, 2016). The complex nature of inequalities implies that, in order to understand and address them, socioeconomic position markers and oral health outcomes should be carefully chosen so that they are appropriate for the specific age group. Increasing the focus on oral health of preschool children was a key objective in reorienting oral health services in New Zealand. Preschool programmes and services that target inequalities are to be considered the first priority

for funding (Ministry of Health, 2006). The Ministry of Health is urged to consider ways to include oral health in general health promotion strategies that address similar risk factors, and encourage DHBs to do the same. Since oral and general health gradients coexist and have similar characteristics, addressing oral health inequalities is likely to be an integral part of the policies on reducing overall health inequalities; oral health approaches need not continue to treat ECC in the dental silo alone. Clinical measures such as fluoride varnish is effective in reducing ECC but evidence regarding their effect on oral health inequalities is limited. Interventions based on oral health education have been shown to increase knowledge and change certain oral health behaviours, but these changes are not sustained over time. A study in Belgium showed a specific, multi-component, theory-based intervention at community level only had limited effect, and that this effect lasted only as long as the parents remained in contact with the preventive health services (Van den Branden et al, 2014). Dental personnel should be encouraged to broaden their perspective from merely exploring the relationship between exposures as specific risk factors and disease variables to the analysis of the broader environmental factors that shape individual as well as collective behaviours (da Fonseca and Avenetti, 2017). Actions are to be universal but with scale and intensity proportionate to the levels of disadvantage rather than focusing solely on the most disadvantaged.

In order to be beneficial, oral health initiatives need to be culturally appropriate and acceptable to New Zealand communities. Western health models at times are not perceived as adequate by indigenous communities (Jamieson et al, 2016). Oral health strategies and initiatives should be relevant to Māori cultural concepts, beliefs and practices as cultural competence and engagement are essential in a successful oral health workforce and service provision (Kilpatrick et al, 2008). Māori involvement in decisions affecting the determinants of oral health is continuing to be facilitated.

A study examining associations between maternal acculturation and selected infant and maternal health risk indicators revealed that those with strong alignment to Pacific culture had significantly better infant and maternal risk-factor outcomes than those with weak cultural alignment (Burrows et al, 2011; Schluter et al, 2017). These findings suggest that retaining strong cultural links for Pacific immigrants is likely to have positive health benefits. Thus, Pacific families should be empowered to pursue good oral health in ways that are culturally appropriate to them. However, further studies of the cultural/behavioural patterns that may be specific to various ethnic subgroups with the highest risk for ECC seems essential to the development of effective prevention strategies.

[6] Oral health literacy knowledge and attitudes of parents/primary caregivers towards oralcare

What is known:

Oral health literacy is 'the degree to which individuals can obtain, process and understand basic oral health information and services needed to make appropriate oral health decisions' (US Department of Health and Human Services, 2000). Lower literacy has been linked to problems with the use of preventive services, delayed diagnoses of oral diseases/conditions, poor adherence to oral health instructions, poor self-management skills, increased risks, poor health outcomes, and higher health care costs. Low parental oral health literacy was associated with dental caries among their children (Firmino et al, 2018). Good oral health literacy in parents/caregivers was associated with a lower rate of caries in children (Okada et al, 2002; Plutzer and Spencer, 2008).

However, a Christchurch study showed that 38% of parents had poor oral health literacy (Veerasamy, 2010). Many of these parents were not aware of the need for preschool dental visits, the importance of keeping baby teeth healthy, or the link between oral health and general health. Some Pacific, Asian and South Asian families have emigrated from environments where there was no free oral health service provision for children and adolescents, and were unlikely to be aware of available services in New Zealand. However, this knowledge gap is not restricted to immigrant populations; among Māori mothers, 10% believed that baby teeth do not matter as they fall out anyway, and 61% believed that all children eventually get holes in their teeth (Broughton et al, 2014).

In a survey commissioned by the New Zealand Government Health Promotion Agency, respondents and focus-group participants shared a common confusion over what age a child should start brushing (Roguski et al, 2015). There was also limited knowledge regarding what toothpaste to use. Oral hygiene of preschoolers was undervalued by some participants who believed the eruption of the adult teeth would remedy any dental issues experienced in early childhood, such as yellow staining and cavities. And some participants reported a belief that there is no need to engage in preschool oral health care when breastfeeding as the antibodies contained in the breastmilk provide a sufficient level of protection (Roguski et al, 2015).

Well Child Tamariki Ora providers continue to enrol infants in COHSs at 5-month immunisations contact, conduct the oral health risk assessment, and discuss oral health with parents. Education packs are distributed to early education centres in some parts of New Zealand, for example in Northland and Christchurch.

Strategies to mitigate the risk:

The COHSs would benefit from identifying parents/caregivers with low health literacy and tailor literacy-related interventions to the communication needs of these individual parents/caregivers, and assess parent recall and comprehension. Effective strategies to improve parent comprehension include conveying a few key points at each patient visit, jargon-free communication, use of pictures to clarify concepts, and confirmation of patient comprehension via the 'show-me' or 'teach-back' method. In addition to these advances, collaboration between multiple stakeholders in the health care system is likely necessary to overcome barriers to oral health literacy and enhance quality of care.

Key health-literacy approaches include professional development for the workforce, clarification of patient referral pathways and follow-up, and oral health messages for different audiences have been identified

(Counties Manukau Health, 2014). A health-literacy education package focused on babies and preschoolers' oral health might be developed at national level. Well Child Tamariki Ora providers and COHSs delivering education packages to parents and caregivers would increase understanding of the importance of oral health care for preschoolers. Education packs to preschool centres with translations in New Zealand's main languages could be provided. Midwives, LMCs and practice nurses might have additional training on oral health education for pregnant women. A study in Otago and Southland showed that some general practice nurses offer oral health advice to caregivers of young children. The majority would be willing to do so provided they had appropriate training and resources (Moffat et al, 2017).

It is important to provide regular 'Lift the Lip' training (every 2 years) for Well Child Tamariki Ora providers, LMCs/midwives, practice nurses and public health nurses. This would equip primary care teams with skills and resources to support the discussion of oral health in ways which build health literacy and to develop clear oral health messages. COHSs need to visit all preschools for education, enrolment and referrals to oral health clinics. Parents/caregivers need to have access to trained multilingual staff in COHSs, and have frequently asked questions and oral health messages translated in Te Reo, Pacific languages, and main Indian and Asian languages.

Increasing individual's knowledge by providing oral health messages via anticipatory guidance and motivational interviewing is one element of improving oral health. Motivational counselling is more beneficial than traditional health education (Weinstein et al, 2004). Motivational interviewing is a patient-centred communication style that uses techniques such as reflective listening and shared decision-making to elicit why and how patients might change their health behaviours. In order to achieve this patient-centred goal, directed communication should occur with patients expressing desire to reason, and the ability and the need to change. All oral health staff members could be trained on motivational interviewing by all DHBs. Culturally competent messages based on scientific evidence using the same language as the participants and based on their health literacy are important when communicating with parents/caregivers and children. Public education on the importance of early prevention needs to be an on-going part of early parenting education.

[7] Access to dental services

What is known:

Access to health services depends on financial, organisational and social or cultural barriers (Smith, 2016). Access measured in terms of utilisation is dependent on affordability, physical accessibility and acceptability of services, not merely adequacy of supply. In New Zealand, children are entitled to free regular oral health services from birth to their 18th birthday. These services include regular assessments and a range of preventive, restorative and surgical treatments. Access is reliant on ability to contact the COHS, transport and parental responsibility.

The New Zealand Health Survey 2016/2017 found that the dental utilisation was low (69.2%) for children aged 1-5 years (Ministry of Health, 2017a). Among children and adolescents aged 2-17 years, Māori and Pacific children and adolescents were significantly less likely to have visited a dental professional in the last 12 months than non-Māori/non-Pacific children and adolescents (Ministry of Health, 2010b). In a Christchurch study the odds of failing an appointment were significantly greater for preschoolers with a Māori or Pacific Islands ethnicity living in high-deprivation areas (Smith, 2016).

Consequences associated with patient disengagement can be unproductive staff, negative staff attitudes towards patients who disengage, ineffective use of resources and displacement of other patients waiting for an appointment (Mbada et al, 2013; Moore et al, 2001). Frequent disengagement with preventive care services can mean preventable issues remain undiagnosed. When the issue is identified, it is usually in an advanced stage, and secondary care is often required. Engaging with secondary-care services is invasive, often reinforcing the patient's anxiety or phobia. Focus-group participants in the Christchurch study identified four factors that influence appointment failure: waiting room and dental surgery ambience, staff attitude, physical resources that inhibit accessibility, and communicating with technology (Smith, 2016). Participants did not associate their childhood and current dental anxiety and fear with their preschooler's failed appointments. Recommendations by the focus groups involved enhancing the clinic environment, issuing parents with fridge magnets with the service's contact details, clinical staff communication, changing the clinic's hours to offer evening and weekend appointments, and changing the services' care-delivery model so preschoolers can be screened in COHS mobile dental vans instead of fixed clinics. The introduction of mobile dental services appears to have improved accessibility to preventive care offered by COHSs. However, ethnic minority children and those living in high-deprivation areas, remain a priority for improving accessibility to oral health service in New Zealand.

Since transformation of school dental services into COHSs in 2009, parents/ caregivers are now often required to attend the children's dental appointments, as dental clinics are no longer always attached to schools (Foote et al, 2014). Parents' attendance with their children enables them to be more involved in their children's oral health, but for many attendance at such appointments is difficult. Children with high oral health needs are more likely to be from families who are in low-paid jobs with little flexibility to take time off work, may have difficulty with transport, and may not give oral health a priority. When treatment clinics are far away or are not on public transport routes or the mobile or transportable dental units had moved from schools before treatment for all children has been completed, parents/caregivers need to take the children to the clinic at the next location, which may be at a considerable distance.

Other barriers to access the service include cultural acceptance, language difficulties, embarrassment of reaction by dental personnel, lack of oral health literacy and difficulty for the provider to contact some families to make dental appointments because of frequent change of addresses and telephone numbers. Māori and Pacific

families are more likely to be transient and therefore are more likely to miss appointments for on-going care and less likely to re-enrol (Young et al, 2016).

Engagement for Pacific Island families was linked to patient dignity and feeling welcomed, but also more importantly, how the service understood cultural competency (Ludeke et al, 2012). Understanding patient needs can increase engagement by using a language they are familiar with. Health practices using interpreter services have reduced patient disengagement with better attendances (Jacobs et al, 2004; Seers et al, 2013). Previous negative dental experiences learned by children or from others were found to be associated with children's dental fear (Ling et al, 2014). The receptionists' phoning the patient increased patient engagement better than posting appointment reminders, because patients felt more of a personal connection (Shmarak, 1971).

For children needing treatment under GA waiting times for both initial assessment and subsequent treatment varies across the country, with children in some DHBs waiting for many months (Lingard et al, 2008; Scotcher, 2018). Some DHBs are unable to manage to comply with the Ministry of Health's elective performance indicator of treatment within 4 months, and require more resources.

Strategies to mitigate the risk:

Access should be made easy with dental appointments at convenient times for the parents/caregiver to attend dental clinics with their children. Strategies to improve accessibility may include evening and weekend appointments, and screening preschool children on mobile dental vans (Smith, 2016). Running 'preschool days or weeks' during school holidays needs to be enhanced. Annual review of mobile/transportable dental units' schedules is important to ensure services are timely and accessible, especially for rural and high-risk populations (Foote et al, 2014). COHSs maintaining a strong relationship with Māori providers will enhance continuity of care when children move from Kohanga Reo and kura kaupapa schools to mainstream schools.

Equity in accessing oral health services by different communities must be addressed. Potentially vulnerable and 'hard to reach' families are to be identified and positive relationships fostered that enable health providers, including COHSs, and families to work together to address issues related to health and access to various services. Concerted efforts are to be made to contact families using multi-agencies such as Well Child Tamariki Ora providers and public health nurses, general medical practitioners, social workers, Māori providers, community health workers, early childhood centres and language nests. It is important to address the oral health of these whole families, not just children. Māori recommend embracing the 'Whānau Ora' and 'whānau-centred' approaches which advocates a culturally grounded, holistic approach focused on improving the wellbeing of whānau (family) and addressing individual needs within a whānau context (Te Puni Kōkiri - Ministry of Māori Development, 2015).

An integrated national information system developed and implemented nation-wide would ensure smooth transfer of detailed information across services and providers in relation to assessments, referrals and any areas of particular on-going concerns. All preschool children are not seen and treated within the appropriate dental recall intervals based on caries risk status because of the shortage of dental staff particularly dental and oral health therapists. Percentage of preschoolers who are overdue for their subsequent recall dental appointments are not within the national benchmark of 10% or less in all DHB areas (Ministry of Health, 2015b). Oral health therapists' work programme needs to be developed with Health Workforce New Zealand to address the numbers of therapists required to meet service demands. All COHSs would benefit from taking a consistent approach to addressing issues relating to therapist recruitment and retention. Training of oral health personnel on social awareness, cultural sensitivity and community-orientation could be strengthened (Davis et al, 2007). COHSs alone cannot deal with ECC; capacity of the medical workforce needs to be improved to address ECC by developing an oral health curriculum for medical students, and training general medical practitioners and other child health care professionals will aid identification of infants at risk of ECC.

Evidence has indicated that racial and ethnic diversity among oral health professionals is associated with improved access to care for minority patients (Smedley et al, 2004; Sullivan, 2004). The number of Māori and Pacific students entering the dental profession (oral health therapists and dentists) ideally should be increased to reflect New Zealand's cultural and ethnic diversity. It is also important to ensure that New Zealand's oral health workforce is culturally competent. To ensure that all oral health workers have the necessary cultural understanding, cultural competencies are to be developed to guide staff on these issues (Public Health Advisory Committee, 2003).

In order to ensure children, receive timely treatment outside the therapists' scope, it is time for COHSs to employ dentists and specialists; a few DHBs already employ community dentists. Regarding long wait-time for treatment under GA, COHSs and hospital dental services need to work together. COHSs are to work towards reducing the number of referrals by strengthening clinical preventive measures and provide regular oral health care to all preschool children within the appropriate recall intervals. COHSs need to continue engaging with all children who have received dental treatment under GA; need to review their oral health on a timely basis would avoid the need of repeat treatment under GA. A North American study showed that 40% of children experienced new caries within the first year after dental treatment under GA (Berkowitz, 2003). In New Zealand, the readmission rate for all dental reasons, within 4 years, for all ages was reported to be 5.6% between 1990 and 2004 (Whyman et al, 2012). Over this time, this figure has remained stable, and it was 5.8% for the latest period analysed (2000-2004) in this study. Repeat admissions were 8.4% for children aged 0-2 years.

Hospital dental services might work towards meeting the demand by increasing resources. More dental paediatric specialists are needed to work in hospital dental services. Present opportunities for these specialists

upon graduation are limited, and a different approach needs to be considered by the DHBs and the universities providing postgraduate training (Hunt et al, 2018). The training is expensive and not funded like medical paediatrics training is funded. Postgraduate training undertaken with the University of Otago and DHBs together would enable the clinicians to retain employment while training. Availability of a formal training programme for all dentists who intend to treat children under GA, is essential. National written treatment guidelines need to be formulated. Oral and inhalation sedation is an essential adjunct to the dental treatment of some young children.

[8] Oral health status of mothers and transmission of cariogenic bacteria

What is known:

Dental caries is a transmissible bacterial disease caused by two major groups of bacteria, namely the *Streptococcus mutans* (SM) and the *lactobacilli* species (Featherstone, 2008). Early acquisition of these bacteria may occur via vertical or horizontal transmission. Vertical transmission is the transmission of bacteria from caregiver to child. Several studies have showed that SM is transmitted mainly from mother to the infant (Damle et al, 2016; Li and Caufield, 1995). Although there is no strong evidence on the relationship between maternal oral health and that of the offspring, what evidence does exist is consistently supportive (Kilpatrick et al, 2008). The transmission of these cariogenic bacteria from mother to child depends on factors such as mother's cariogenic bacteria levels, dental caries status, oral hygiene, pre-tasting food and sharing utensils. A 2005 study demonstrated the possible perinatal influence on acquisition of SM bacteria by infants; babies delivered by caesarean section from a mother with low socioeconomic status, and who experienced dental caries acquire SM bacteria earlier than did a vaginally delivered infant (Li et al, 2005). In addition to vertical transmission from the mother, horizontal transmission can also occur among other family members and other children at day-care facilities (Alves et al, 2009; Mattos-Graner et al, 2001). Early colonisation of these bacteria is a major risk factor for ECC and for future dental caries. The timespan between bacterial colonisation and development of carious lesions is approximately 13 to 16 months; in children with hypomineralised teeth this duration is likely to be much shorter. More recent studies have demonstrated that SM can colonise the mouths of pre-dentate infants (Ramos-Gomez et al, 2002; Wan et al, 2001).

Informing pregnant women of the importance and safety of oral care during pregnancy and advice on receiving routine dental care would be a step forward in improving oral health during pregnancy. Oral health interventions for mothers may also have long-term benefits for children (Meyer et al, 2010). Interventions included examinations, oral health education and preventive treatment. In this study women were followed through pregnancy, then followed until their children were ages 13 to 14 years. They found that the intervention group had significantly higher rates of caries-free teeth (Meyer et al, 2010).

A trial on providing free dental services to pregnant women and those with babies up to 1 year of age, funded by the New Zealand Ministry of Health, ran for 3 years in the Waitemata and Counties Manukau DHB areas of the Auckland region (Litmus, 2016a). This trial targetted women in highly deprived areas has succeeded in addressing the needs of high-risk women. In the two areas that delivered services to the target group, the following outcomes were reported: increased child enrolment in the COHSs; addressed immediate dental needs resulting in improved quality of life; increased knowledge of oral health self-care and oral health literacy, which resulted in improved general health and improved healthy lifestyle choices. In these trials, breastfeeding was encouraged and smoking cessation advice was given to all participants. Free toothbrushes and paste were provided to all mothers and their children, and appropriate messages for both the mothers and babies and anticipatory guidance.

Strategies to mitigate the risk

Improving maternal oral health in disadvantaged areas leads to both improvement in the oral health of children and reduction in maternal cariogenic bacteria, thereby reducing the potential risk of transmission of these bacteria to their children (Feldens et al, 2007). Providing mothers with regular oral health information and free toothbrushes has been shown to lower the incidence of caries; 1.7% in the test group versus 9.6 % in the control group (Plutzer and Spencer, 2008). The Ministry of Health or the DHBs would benefit from funding the maternity oral programme similar to these trials. Either COHSs or private dental practitioners would be able to provide the needed care. In addition, updated oral health messages for both the mothers and babies could be developed in the main languages appropriate for different ethnic groups. It is important to carry out an evaluation on the influence on the oral health of children of the mothers who participated in this programme.

[9] Teeth susceptible to caries due to developmental defects of enamel

What is known:

Developmental defects of enamel (DDE) in primary teeth are often associated with hereditary, acquired, systemic and local aetiological factors (Salanitri et al, 2013). Systemic or local acquired conditions that occur during the antenatal, perinatal or postnatal periods of development can cause damage to developing enamel and result in enamel defects in the primary dentition. Children born prematurely and those with low or very low birth weight have a higher prevalence of enamel hypoplasia. The prevalence of enamel defects of primary teeth in New Zealand is not known, but prevalence in international series has shown rates in primary teeth as high as 25% (Elfrink et al, 2008; Li et al, 1995; Seow et al, 2011). Caufield and colleagues proposed the term HAS-ECC (hypoplasia associated with severe ECC) that emphasises the characteristics of hypoplasia as a risk factor for ECC (Caufield et al, 2012). DDE predisposes teeth to increased caries risk (Hong et al, 2009; Costa et al, 2017; Foulds, 2017). In most DHBs of New Zealand, children are examined by age 1 year and subsequent recall assessment examination is based on caries risk status. Enamel defects of primary teeth are detected at an early stage and children with enamel defects are seen regularly and appropriate treatment provided.

Strategies to mitigate the risk

DDEs of primary and permanent teeth should be detected early and long-term management of these teeth is to be instituted. Availability of dedicated referral pathways to paediatric specialists or to experienced dentists for any further needed treatments and adequate facilities to timely treat these children under sedation/GA are necessary. Studies on the prevalence and severity of DDEs of primary teeth are to be carried out among New Zealand preschool children of Māori, Pacific, Asian, European and other ethnic communities.

[10] Role of genetics in dental caries

What is known:

Although environmental factors clearly have greater influence, genetic factors also contribute to the causation of dental caries. These factors may influence aspects of oral development such as enamel structure, tooth and arch shape, and buffering power of saliva. Early twin studies support the heritability of dental caries (Bachrach and Young, 1927; Horowitz et al, 1958). Results of a study on 301 pairs of twins in 1927 demonstrated that monozygotic twins had similar caries incidence but the dizygotic twins did not (Bachrach and Young, 1927). Recent studies demonstrated that genetic variation in the host is associated with caries experience; these variations can play a role in caries aetiology as risk factors or as protective factors (Abbasoglu et al, 2015; Bretz et al, 2005; Shuler, 2001). The extent to which susceptibility to caries is under genetic control, and which genes may be involved, remain the subject of investigations. A study on the relative contribution of genetic and environmental stimuli on dental caries traits and microbial acid production in a twin model performed on 388 pairs of twins aged between 1.5 and 8 years suggests that variation in dental caries surface traits has a significant genetic contribution and that microbial acid production is modulated by the environment (Bretz et al, 2005). Some children appear to be more susceptible to ECC, others extremely resistant, regardless of the environmental risk factors to which they are exposed. Variations in genes involved in enamel formation and genes involved in immune response may contribute to ECC; susceptibility is the result of gene-environment interactions (Abbasoglu et al, 2015; Opal et al, 2015).

In New Zealand individualised or personalised caries risk is assessed at each child's examinations. Although genetic factors are not included in the assessment tool, caries experience of the child is included. This to some extent covers the genetic contribution.

Strategies to mitigate the risk

The multifactorial nature of dental caries has limited the opportunity to link patterns of inheritance with susceptibility to dental caries. Understanding of genetics and its role in caries have advanced tremendously in recent decades but still require more studies to understand its role fully. Identification of genetic risk factors will help screen and identify susceptible children to better understand the contribution of genes in caries pathogenesis.

Prevention

Two broad approaches are available to reduce risks: (i) the targetted approach - focusing the intervention on children likely to benefit; and (ii) the population approach to reduce risks in the entire population regardless of each individual's level of risk (Rose, 1985). Some interventions will reduce the burden associated with multiple risk factors, but notable sustained reductions in disparities in oral health will require more than just targetted individual changes (Lee and Divaris, 2014).

Prevention of ECC can be inexpensive but demands engagement with and partnership between child, family members, and services. Prevention is to start during pregnancy and continue with the mother and the child during preschool in collaboration with the Well Child Tamariki Ora providers (Ministry of Health, 2018b), general medical practitioner, and COHSs. Strategies need to include modifying or eliminating aetiological factors causing caries and increasing protection to prevent initiation and progression of ECC.

Modification of EEC risk factors is best performed in the first 1,000 days from pregnancy through to the child's second birthday (World Health Organization, 2017a). Infants ideally are to receive an oral examination within 6 months of the eruption of the first primary tooth, but by no later than 12 months of age (American Academy of Pediatric Dentistry, 2014). All COHSs need to enrol children from birth and assess oral health status by their first birthday. Each child is to be assessed for caries risk status at first examination either by the Plunket nurses, medical practice nurses or general medical practitioners. Children with high-risk status are to be referred to community oral health clinics for further examination and assessment. Dental and oral health therapists, and dentists at community oral health clinics are to assess the caries risk status at first visit and at each subsequent recall dental visit to tract changes in a child's level of risk at different ages (American Academy of Pediatric Dentistry, 2014; American Dental Association, 2009–2011).

Early detection of non-cavitated carious lesions and prompt intervention is important in order to reverse or arrest caries progression. Regular 'Lift the Lip' examinations of the upper incisor teeth for early signs of dental caries and existing cavities need to be considered (Ministry of Health, 2018b; New Zealand Dental Association, 2008b; Shackleton et al, 2018). Most advanced caries classification systems, such as the International Caries Detection and Assessment System (Pitts et al, 2014), require thorough tooth cleaning to detect non-cavitated lesions and the use of compressed air to detect early stages of caries.

Application of fluoride varnish and fissure sealant have been proven to be safe and efficacious part of a caries prevention programme. Fissure sealant is placed on pits and fissures of primary molar teeth when it is determined that the tooth, or the child, is at risk of experiencing caries (Beauchamp et al, 2008; American Academy of Pediatric Dentistry and American Dental Association, 2016). Preventively, the likelihood for treatment under GA can be reduced by the use of 38% silver diamine fluoride (American Academy of Pediatric Dentistry, 2017b;

Crystal et al, 2017; Ng and Sulyanto, 2018), atraumatic technique/interim restorative measure (American Academy of Pediatric Dentistry, 2017a) and stainless crowns using the Hall technique (Clark et al, 2017; Innes et al, 2007; Ludwig et al, 2014). Community outreach programmes on application of fluoride varnish on high-risk children and distribution of free toothpaste and brushes with appropriate oral health messages need to be strengthened.

Programmes of prevention in the United States resulted in fewer hospital-based restorative and surgical treatment visits and lower overall cost compared with baseline (Samnaliev et al, 2015). Another programme encouraging repeat oral health visits reduced hospitalisation and visits for caries-related treatment (Stearns et al, 2012). These evaluation programmes account only for the service provision costs associated with ECC and do not include pain, suffering, and psychological trauma for the child or indirect costs such as lost parental work time.

Common Risk Approach

Many of these underlying risk factors were also associated with other deleterious health outcomes. For example, there is a strong relationship between increased consumption of sugary drinks and obesity (Taylor et al, 2015; Vartanian et al, 2007). The New Zealand Health Survey 2016/2017 found that around 1 in 8 children aged 2-14 years were obese, and a further 21.5% were overweight (Ministry of Health, 2017a). Childhood obesity is associated with many negative immediate and long-term health effects. Exposure to tobacco smoke is another such factor; it has been associated with a dose-dependent influence on the development of caries of preschool children (Goto et al, 2019; Shenkin et al, 2004; Tanaka et al, 2009). Parental smoking also increases risks for serious respiratory infections, sudden unexpected death in infancy, ear diseases, and the child becoming a future smoker (Ministry of Health, 2019a). Associations between environmental exposure to tobacco smoke before and after gestation and oral health, including salivary changes in young children, have been shown (Hasmun et al, 2017). Moreover, there is an inverse relationship between breastfeeding and risk of overweight/obesity, and no association with the timing of the introduction of solid food (Bell et al, 2018). Adding messages on the importance of breastfeeding and smoking cessation with oral health messages would also be beneficial in reducing the risk for a number of important health outcomes, including ECC.

A key concept of the integrated common-risk approach is that by addressing common risks and underlying social determinants, improvements in a range of chronic conditions will be achieved more efficiently. Successful preventive approaches for ECC are unlikely to work in isolation (Lee and Divaris, 2014). These rely on inter-sectoral planning to include Ministries of Health, Education, Environment and Social Services and interdisciplinary planning to include local councils, teachers, primary health care workers, maternity services, oral health providers, COHSs, medical practitioners, practice nurses, public health nurses, hospitals, regional public health organisations and Well Child Tamariki Ora providers, and community pharmacists. An editorial in the New Zealand Dental Journal four decades back stated the same and emphasised the importance of contact and communication between dental profession and potential allies working with various groups of the population (Brown, 1977). Although contact between the dental profession and potential allies does exist in a limited way, efforts should be made to use them to their maximum potential. The Voluntary Schools Beverage Agreement between the New Zealand Government and beverage industry leaders, Coca-Cola Amatil New Zealand and Frucor Beverages, has resulted in both companies completely withdrawing the direct supply of full sugar carbonated soft drinks and full-sugar energy drinks from all New Zealand schools (Ministry of Health, 2015a). The Ministry of Education, in consultation with the Ministry of Health, has developed resources to assist schools and early-childhood education services, for example, Food and Nutrition for Healthy, Confident Kids - Guidelines to Support Healthy Eating Environments in New Zealand Early Childhood Education Services and Schools. Community festivals and events provide an opportunity to showcase healthier foods. There are a few local events featuring beverages that are free of sugar. Examples are Porirua's Creekfest, Auckland's Polyfest, and Hutt City's Pasifika Choice Festival Fun Family Touch Tournament. The Health Promotion Agency has developed a range of new resources promoting water and highlighting the amount of sugar in many beverages for use in workplaces and recreational settings. The Heart Foundation is re-introducing specific sugar-rules for Tick products. The new requirements will initially apply to high-sugar products such as breakfast cereals and muesli bars (Ministry of Health, 2015a). There is advice about healthy diets low in sugar to prevent dental caries and for general health in the Well Child Tamariki Ora Health Book, which was recently revised in New Zealand (Ministry of Health, 2018a).

Recommendations

Recommendations to further improve the oral health of preschool children, reduce inequalities in oral health, and decrease the individual and societal burden associated with ECC are described within 10 themes. Some of these recommendations are already employed in New Zealand.

- Sugar consumption:
  Educate parents and caregivers on the importance of avoiding exposing children to sugars before and beyond the age of 2 years.
  Introduce a sugar icon on the packaging and labels of all sugary drinks and food to indicate accurately the amount of sugar in each product.
  Strengthen the nationwide campaign to introduce excise tax on sugary drinks.
- Breastfeeding:
  Advise mothers on continued breastfeeding for up to 2 years of age and beyond and to feed infants with nutritionally adequate and safe complementary foods while breastfeeding.
  Night-time breastfeeding is not to be continuous and the baby needs to be removed from the breast on completion of feeding.

- Oral hygiene:
  Initiate supervised toothbrushing programmes in early childhood centres, particularly in highly deprived areas.
  Staff at early childhood centres supervise this DHBs-funded programme with facilitation by dental staff members at community oral health clinics.
- Fluoride exposure:
  Enact the Fluoride Bill currently stalled in Parliament.
  Provide fluoridated water to all communities in New Zealand with reticulated water, depending on their size.
  Provide fluoride toothpaste and toothbrushes at no cost to deprived families.
  Stop the sale of children's toothpaste with low-fluoride content in New Zealand.
  Apply fluoride varnish in high- and medium-risk children at community oral health clinics and community settings.
- Socioeconomic and cultural status:
  Instigate strategies targetting high-risk groups within the whole population.
  Develop oral health initiatives that are culturally appropriate and acceptable to New Zealand communities.
  Examine all babies by 1 year of age and assess the caries risk status at child's first dental examination.
  Well Child Tamariki Ora providers, general medical practitioners, medical practice nurses and public health nurses routinely 'Lift the Lip' and check for early carious lesions and refer identified children to COHSs for any needed care.
- Oral health literacy:
  Identify parents/caregivers with low oral health literacy and tailor literacy-related interventions to the communication needs of the individual parent using motivational counselling technique.
  Develop a national health literacy package with translations in New Zealand's main languages focused on babies' and preschoolers' oral health.
- Access:
  Make dental appointments convenient to parents and caregivers to improve access and regular attendances.
  Annually review the mobile and transportable dental units' schedule.
  Identify potentially vulnerable and 'hard-to-reach' families and maintain positive relationship that enable health providers and families to work together.
  Regularly review the numbers of therapists required to meet the service demand, by the COHSs.
  Improve the capacity of the medical workforce to address ECC.
  Increase the number of Māori and Pacific students entering the oral health professions to reflect the New Zealand's ethnic diversity.
  Shorten the wait time to receive treatment under GA to a few weeks.
- Oral health of mothers:
  Provide pregnant women and young mothers living in highly deprived communities with free oral health services.
  Review how the Ministry and DHBs use their oral health budgets.
- Developmental enamel defects:
  Detect developmental enamel defects of primary teeth early and institute long-term management of these teeth.
  Carry out periodic studies on the prevalence and severity of developmental defects of primary teeth among all New Zealand children.
- Common-risk approach:
  Integrate oral health into existing early childhood public health programme.
  Require collaboration between public health programmes that share common priorities such as nutrition and obesity.

Conclusions

Effective strategies are required to address risk factors for the improvement of overall prevalence and severity of EEC and to reduce inequalities among different communities. Rather than the oral health services handling EEC alone, a common risk-factor approach to combat multiple conditions – such as obesity – together with EEC would be more effective. Prevention of EEC, its detection at early stages before cavitation, and child-friendly treatment modalities should be adopted.

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