Evidence Brief: Dental caries prevention in school-aged children: effectiveness of dental/oral hygiene program delivery models

February 2016

Issue and Research Question

According to the Canadian Health Measures Survey conducted from 2007-2009, over half of Canadian children and adolescents aged 6 to 19 years old are affected by dental caries.[1] Dental caries are preventable and can theoretically be controlled by altering bacterial flora in the mouth, modifying diet, increasing acid resistance of teeth, or reversing demineralization.[2] However, in practice, only fluorides and sealants have been effective in reducing dental caries for populations.[2]

Fluorides can be delivered to individuals through tablets, toothpaste and mouthrinse, and in the community through fluoridated drinking water or milk. Fluoride can also be delivered professionally through varnishes and gels.[3] In terms of sealants, approximately one third of Canadian children and half of all adolescents have one or more sealants.[1]

In Canada, dental services are largely privatized where payments for dental care are usually out of pocket or through employer-sponsored private insurance.[1] Issues of equity exist for oral health outcomes for disadvantaged Canadians, and data consistently show unequal access to dental services.[1] In Canada, caries are extremely prevalent among Aboriginal children where over 90% are affected by dental caries. Thisranges between 1.6-2.9 times the prevalence and severity compared to non-Aboriginal children.[4] Children 6 to 11 years of age in families with public insurance, parents with less education than a degree or diploma, and families with middle income also have

relatively high prevalence rates of dental caries.[1] School-based programs that are available to all children or targeted to those at greatest need, may help to reduce inequities in oral health.

This Evidence Brief asks: *What dental/oral hygiene program delivery models are most effective at preventing dental caries in school-aged children?* Included are descriptions of different types of prevention activities, settings and service providers.

Methods

OVID Medline, Embase, CINAHL, Scopus and ERIC were searched on December 5th, 2014 by PHO Library Services for articles published from the databases' inception to present. Examples of key search terms include dental caries, oral hygiene, teeth, fluoride, mouthrinse, varnish, toothbrushing, sealant, and dental health education. Articles retrieved were assessed for eligibility by one reviewer. Reviews in the English language were eligible if they reported on interventions on dental/oral health programs in a school, community, or private practice setting, for school children aged 4-18 years. Titles and abstracts were screened for inclusion with all potentially-relevant articles retrieved in full text. Full text articles were retrieved and screened for inclusion by one PHO staff member, with 20% of those also screened by a second reviewer to establish agreement. Any disagreements on inclusion were resolved by discussion until consensus was reached. Relevant information was extracted from each full text article by one reviewer. Additional articles identified by external reviewers were included. The full search strategy can be obtained from PHO.

Main Findings

The electronic database search identified 586 articles, from which 16 reviews published 2007 to 2013 met inclusion criteria.

In addition to the 16 reviews from the electronic database search, one primary study was included for being set in the Ontario context and for an especially unique intervention. [5] In addition, 12 systematic reviews[6-17] and three reports[18-20] were included from external reviewers, bringing the total to 31 included articles.

Most studies in the review-level evidence focused on school-aged children within various age groups ranging from 1-19 years old. The age range is broader than the original inclusion criteria specifying ages 4-18 because reviews contained studies of varying age ranges, making it difficult to segregate results for 4-18 year olds only. Study duration ranged from 2 weeks to as long as 12 years. Studies incorporated into the included reviews were conducted in North America or Europe unless otherwise stated.

Outcomes of dental caries were commonly reported in permanent dentition as number of decayed, missing or filled teeth (DMFT) or number of decayed, missing or filled surfaces (DMFS). In primary dentition, outcomes included number of decayed, extracted or filled teeth (deft) or number of decayed, extracted or filled surfaces (defs), and prevented fraction (PF). PF is proportional to the reduction of dental caries between experimental and control group relative to the control.[21] It is expressed as a percentage that can be either negative or positive, where zero implies the same caries reduction in both experimental and control groups.

Interventions using Preventative Tools

Toothbrushing and toothpaste

Supervised toothbrushing with fluoride toothpaste in a classroom and community centre setting has been shown to reduce caries in children.[2] A Cochrane review by Walsh et al., (2010) studied the effectiveness of different concentrations of fluoride toothpaste on preventing dental caries in children and adolescents.[22] Results showed fluoride concentrations of 1000 ppm and higher had the greatest caries prevention.[22] For example, in permanent teeth using the DMFS index, brushing with 1000 ppm fluoride resulted in a 25% reduction in DMFS which rose to a 36%

reduction with 2400 ppm fluoride toothpaste compared to a placebo. Similar results were reported favouring brushing with high fluoride concentration toothpastes on permanent teeth using the DMFT index. For primary teeth, the relative risk of developing new caries was significantly lower in users of high fluoride concentration toothpaste compared to those who used low fluoride concentration toothpaste.[22]

A Cochrane review by Cooper et al. (2013) assessed the impact of primary school-based interventions aimed at changing toothbrushing behaviour.[23] All interventions included toothbrushing skill instructions and fluoride toothpaste information. Of the four included studies, only one 15-month study in 4-12 year olds measured defs/DMFS: It showed a non-significant reduction in caries.

Factors that could potentially influence fluoridated toothpaste effectiveness are the initial mean caries scores (higher scores increases PF), exposure to other fluorides (presence of any background fluoride such as in drinking water results in higher PF) and toothbrushing frequency (increasing from once to twice a day raises PF).[24]

Mouthrinses

School based fluoride mouthrinse programs usually involved children rinsing once or twice a day, or once a week or biweekly with a neutral sodium fluoride (NaF) solution packaged in 5 or 10 ml pouches.[2] Results from these mouthrinse programs showed a range of caries reductions from 20% to 50% in 5 to 10 year olds. These results are confirmed in a Cochrane review that examined 36 studies of supervised mouthrinse school programs.[8] Their meta-analysis showed significant pooled estimate of 26% PF reduction in DMFS.

Varnishes

A narrative review by Kumar and Moss (2008) and a systematic review by Azarpazhooh and Main (2009) found that fluoride varnish applied every 6 months was effective in preventing caries in the permanent teeth of children who are at high risk of developing dental caries.[2,25] Higher frequency of fluoride varnish application, such as three times in one or two weeks, did not significantly reduce caries prevalence.[25] However, a recent Cochrane Review by Marinho et al. (2013) indicated that the application of fluoride varnish on permanent teeth resulted in a 43% reduction in DMFS and on primary teeth a 37% reduction in defs compared to placebo or no treatment.[9]

A systematic review by James et al. (2010) investigated the effectiveness of chlorhexidine varnish compared to fluoride varnish.[26] Based on six parallel-group trials that ranged from two to three years in duration, chlorhexidine varnish did not significantly reduce caries compared to placebo, no treatment or fluoride varnish. This is the same result found in a more recent systematic review by Walsh, Oliveira-Neto and Moore (2015).[13]

Tablets

A systematic review by Espelid (2009) found that fluoride tablets (dissolved in the mouth) with doses of 0.25, 0.5 or 1 mg of fluoride may be able to prevent dental caries; however, a major disadvantage was that its effect was dependent on compliance.[27] A narrative review by Kumar and Moss (2008) found fluoride tablet programs in schools to be effective in preventing caries in permanent teeth when children were instructed to let the tablet dissolve slowly.[2] Taubert-Jeannin et al. (2011) reported that fluoride supplements (tablets, drops, lozenges or chewing gums) reduced DMFS by 24% in permanent teeth but in primary teeth the results were contradictory.[12]

Gels

A Cochrane review by Marinho et al. (2015) indicated that the use of fluoride gels resulted in a 28% reduction in DMFS in permanent teeth and 20% reduction in defs in primary teeth.[10] In terms of safety, the included studies had little comment on any possible adverse effects of using fluoride gels.

Sealants

Two systematic reviews by Gooch (2009 & 2011) on school-based sealant programs found that sealants are effective in: preventing the development of caries on sound pit and fissure surfaces 78% to 87% at one year and decreases from 33% to 69% at 2 or more years after placement; reducing the percentage of non-cavitated carious lesions that progress to cavitation by 71% up to 5 years; and reducing bacteria levels in carious lesions.[28,29] Four handed application in comparison to two handed increased the retention by 9%. In addition, teeth that have lost their sealants are not at a higher risk of developing caries than teeth that were never sealed. Two other systematic reviews found similar results.[6,7] One of these reviews reported that for resin based sealants, only 27% of sealed surfaces were decayed versus 77% of control surfaces after 9 years after placement.[6] Also, recommending proper isolation was important for sealant retention along with annual retention check-ups as the highest rate of sealant loss is reported within the first year after application.[7]

Dental sealants are recommended in permanent first and second molars for preventing pit and fissure caries. Sealants can be resin based or glass ionomer cement (GIC). According to a critical summary of a systematic review, no difference is reported between resin based and GIC sealants in the prevention of caries in permanent teeth.[15]

Comparison between sealants and varnishes have scarce evidence to support the superiority of sealants over varnish in the prevention of occlusal decay.[16,24]

Chewing gums

Two systematic reviews focused on the use of chewing gum as a dental-protective agent.[21,30] Ly et al. (2008) investigated chewing gum containing substances such as fluoride, minerals, alkalinizing agents, chlorhexidine and polyol (sugar-free) sweeteners on reducing dental caries in children aged 8-16 years.[30] Fluoride and minerals such as calcium and phosphate in chewing gum showed reduced demineralization and enhanced enamel remineralization. Alkalinizing agents such as bicarbonate in chewing gum showed increases in salivary pH and reduction of dental plaque and gingivitis. Chlorhexidine chewing gum also showed inhibiting plaque growth; however, studies on dental-protective chewing gum do not show a large enough difference to be clinically meaningful for preventing dental caries.[30]

In contrast, chewing gum that contains polyol (e.g., xylitol and sorbitol) have been more extensively studied. Studies (mostly randomized control trials or controlled clinical trials) ranging in duration from one to 40 months showed the greatest caries reduction with higher amounts of xylitol dose and frequency of use (three or five times per day) compared to no chewing gum.[30] Chewing gums with a mix of xylitol and sorbitol showed less but still significant caries reduction.[30] Deshpande and Jadad (2008) also found similar results - the highest dose of 10.67 g/day (lowest 2.9 g/day) of xylitol and sorbitol had the greatest PF.[21] Frequency of chewing gum was not analysed in this systematic review, but there were comparisons of xylitol and sorbitol mix where xylitol-containing chewing gum showed 58.66% PF, xylitol-sorbitol-containing chewing with 52.82% PF and sorbitol containing chewing gum with 20.01% PF.

A recent Cochrane Review by Riley et al. (2015) examined other xylitol-containing products such as fluoride toothpaste containing 10% xylitol, xylitol syrup, lozenges, sucking-tablets, tablets and wipes.[11] The authors found some low quality evidence that suggest fluoride toothpaste with xylitol may reduce caries by 13% compared to fluoride-only toothpaste in permanent teeth of children. However, evidence for the other types of xylitol products was mixed and was determined by the authors to be very low quality with high risk of bias. Some studies mentioned side effects such as sores in the mouth, cramps, bloating, constipation, flatulence, and loose stool or

diarrhoea but none were reported in children using fluoride toothpaste containing xylitol.

Comparisons between topical fluoride therapies

A review of Cochrane systematic reviews by Marinho (2009) assessed the effectiveness of fluoride-based interventions for preventing caries.[24] The authors found all topical fluorides on their own, which included gels, varnishes, rinses and toothpaste, had a significant impact on permanent teeth with pooled estimates of DMFS of 21% (CI = 14-28%), 40% (CI = 9-72%), 26% (CI = 22-29%) and 24% (CI = 21-28%) PF respectively in comparison to placebo. In primary teeth, varnishes made a significant reduction in caries with 20% PF compared to placebo, while gels had 26% PF but was not significant and for rinse and toothpaste there was no reported evidence.

Direct comparisons between topical fluoride therapies (TFT) such as varnish versus gel and toothpaste versus mouthrinse did not show a significant difference in pooled DMFS PF.[24] However, when toothpaste was combined with any other TFT, there was an additional 10% significant reduction in DMFS when compared to toothpaste alone.

Interventions in the Community

Fluoride in food and water

Milk fluoridation emerged in the 1950s (simultaneously in Japan, Switzerland and USA) with the first clinical results reported in 1959 (Japan). [3,31] Two narrative reviews by Banoczy (2007 & 2013) provide an overview of 50 plus years of fluoride research conducted around the world, supported by The Borrow Foundation in the UK (http://www.borrowfoundation.org/).The majority of studies showed significant caries reduction in both primary and permanent teeth. Across the studies, the target age ranged from under 1 year to 18 years. The fluoride content ranged between 0.5 to 1.0 mg per day with program duration 15 months to 10 years.[3,31] Overall, reduction in caries ranged from 16% to 75%, DMFT ranged from 31% to 89% and DMFS ranged from 37% to 67%. Supporting the narrative reviews, three other systematic reviews found similar results; the consumption of fluoridated milk significantly reduced DMFT in both primary and permanent teeth.[24,27,32] In addition, a Cochrane review and a report assessed some of the studies that were included in the reviews by Banoczy and found the evidence to be of low quality but still in support of milk fluoridation.[14,18]

Salt fluoridation community trials in Colombia and Hungary that began in the 1960s showed about 50% reduction in dental caries prevalence.[2] Espelid (2009) assessed studies identified in the 2007 Australian Health Technology Assessment report, where in Mexico, Jamaica and Costa Rica found DMFT data to have significant caries reduction; however, the evidence was rated low quality by the author because there was no assessment or adjustment for potential confounding variables.[27] In addition, a systematic review by Cagetti et al. (2012) examined salt fluoridation and reported no studies on salt fluoridation met their inclusion criteria.[32]

According to Gillespie et al (2007), fluoridating salt is advantageous as salt is an essential component of the diet and can reach large populations. Fluoridation is also compatible with iodisation.[17]

One study in Indonesia (from one review) on sugar fluoridation reported an 80% PF in the treatment group that used sugar containing 10 ppm fluoride compared to the control group. Review authors graded this study as low quality.[32]

Water fluoridation is well established, particularly in the United States. Based on 2012 data from the Centre of Disease Control and Prevention (CDC), 74.6 percent of US population on community water systems receive fluoridated water.[33] Kumar and Moss (2008) reviewed early studies that suggested caries reduction from water fluoridation initially ranged from 50% to 70% in children.[2] Even when there are other available sources of fluoride, such as in toothpaste and bottle

beverages, fluoridated water provides additional support on reducing dental caries prevalence.[2] On average, the mean DMFS of five to 17 year old children is 18% lower in children that live in fluoridated areas compared to those with no exposure. [2]

Unique Ontario community intervention

As noted earlier, one Ontario study was included in this Evidence Brief.[5] Muirhead and Lawrence (2011) reported outcomes for elementary schools participating in the "Healthy Schools" program in 2007-2008.[5] The program consisted of high quality instruction, healthy physical environments, supportive physical and social environments and access to resources through public health community partnerships. One hundred and six schools participated in the "Healthy Schools" program and were compared to 137 non-participating schools in York Region, Ontario. Oral health data was obtained from York Region Public Health Unit, which was conducted by nine annually calibrated dental hygienists who used a standardized dental screening protocol. Children were screened in junior and senior kindergarten (four to five year-olds), grade two (seven year-olds), four (nine year-olds), six (11 year-olds) and eight (13 year-olds). Data collected on oral health included percentage requiring preventive dental care (dental sealants, cleanings and topical fluoride treatments), percentage with urgent dental treatment needs and non-urgent dental treatment and percentage of who had ≥ two decayed teeth.

Schools participating in the "Healthy Schools" program had a significantly lower percentage of children with ≥ two decayed teeth and requiring urgent dental treatment, compared to non-participating schools.

Also, schools that participated in three or more health-related activities had a significantly lower percentage of children with ≥ two decayed teeth and requiring urgent dental treatment compared to schools with one, two or no health promotion initiatives.

Socio-economic status was also a factor taken into account in the effect of "Healthy Schools" interventions on oral health outcomes. Low-income "Healthy Schools" had a significantly lower percentage of children requiring preventive care, urgent dental treatment needs and children with ≥ two decayed teeth compared to low-income non-participating schools, whereas there were no significant differences between high income "healthy schools" and non-participating schools.[5]

Comparing Intervention Settings

A historical review by McCombs et al. (2007) examined a large community project that spanned the United States.[34] The project focused on school-based mouthrinse programs, which had a high participation rate of eligible children and overall was deemed a success by the National Institute of Dental Research.[34] The authors commented that it would be difficult to duplicate a similar participation rate in private practice. Another study in the same review compared the effects of delivering children's dental care by school-based programs and community-based private dentists.[34] The investigators concluded that children (n=1,859) participating in the school-based delivery model were more likely to utilize dental services, which could lead to improved oral health. However, based on the follow-up study in 406 children, findings suggested community delivery programs had a higher use of professional dental services.[34] Community delivered programs could develop better relationships with children and professional dental services [34] and possibly provide more flexible delivery mechanisms to suit local needs.[35] However, the majority of the studies in the other reviews were either school-based or community-based interventions, therefore intervention setting does not appear to have a strong influence on the effectiveness of preventing dental caries.

Comparing Intervention Administrators

Most reviews did not mention who administered the interventions. The studies that did specify who administered the interventions indicated they were usually conducted by

dentists, dental hygienists or whole teams such as teachers, school authorities, health counsellors, dentists, dental hygienists, nurse practitioners and physicians.[2,5,23,30,31,35]

None of the included reviews evaluated who was better at delivering oral health interventions for preventing dental caries. McCombs et al. (2007) did examine a study that evaluated diagnostic reliability among dental hygienist, dentist and non-dental personnel.[34] Results showed strong-to-good diagnostic correlation between dentist and dental hygienists, and good-to-fair agreement between dentists and non-dental personnel.[34] Most oral health programs therefore benefit from including trained personnel such as a supervising dentist or registered dental hygienist, physician or nurse practitioner.[2,5,23,30,31,35]

Cost-Effectiveness of Oral Health Services

Three reviews by Banoczy (2013), Kumar (2008) and McCombs (2007) included some form of analysis or mention of cost effectiveness.[2,31,34] An unpublished PHO report by Brandy Thompson, (2011; available upon request) specifically assessed the cost-effectiveness of common preventive oral health strategies, which included community water fluoridation, fluoride varnish, fluoride gels, fluoride mouthrinses, pit and fissure sealants, oral health education, combined therapies and dental examinations/check-ups.

The author determined community water fluoridation had the highest quality and greatest quantity of evidence supporting this intervention as a cost-effective preventive measure. Potential dental treatment cost savings were calculated in the millions. All the other intervention types had limited evidence or low quality (assessed by the author), therefore results in cost-effectiveness are inconclusive for the other oral health interventions.

Discussion and Conclusions

Fluorides remain an effective prevention strategy against dental caries.[35] Among the different methods of delivering fluoride, none showed greater efficacy on their own, however when multiple fluoride treatments were combined together, there was a significant increase in preventing dental caries.[24] Other treatments without fluoride such as resin based sealants were also found to be very effective.[24] There was some evidence to support xylitol and/or sorbitol containing chewing gum for preventing dental caries,[21,30] however the overall effectiveness was mixed.[11] In contrast, chlorhexidine varnish and behaviour change were not significantly effective in preventing dental caries.[23,26]

There is extensive evidence on water and milk fluoridation for effectively preventing dental caries, whereas there was a lack of quantity and quality of evidence on the effect of fluoridated salt and sugar on preventing caries.[2,3,27,31,32] Creating a healthy school environment improved oral health outcomes especially in low socioeconomic communities.[5] There is no conclusive evidence on the best setting or who administers oral health interventions. Most reviews contained studies that took place in schools or in the community that were conducted by individuals or teams where at least one was professionally trained. Fluoridated water was the only oral health strategy for which supportive cost-effectiveness evidence was located, however, we did no specifically search for cost effectiveness, therefore further investigation would be required.

Implications for Practice

Various preventative interventions have been identified in this evidence brief which can potentially address the burden of dental caries among school children. These interventions can be implemented based on the best available evidence and guidelines developed by Canadian associations. For example, fluoride mouthrinse is an effective strategy to reduce dental caries;

however, it should not be used for children less than 6 years old.[20] Also, it is important for administrators to know the fluoridation status of the community water as it helps in assessing caries risk level in children. For example, children living in a community with fluoride levels ≥ 0.3 ppm, do not require fluoride supplements.[19]

With the exception of water fluoridation, there is a scarcity of studies assessing the cost effectiveness of different oral health interventions. Considering that various delivery models are effective in preventing dental caries, oral health professionals should consider cost as a factor for deciding which treatment to administer. Another aspect that could be useful to explore is the best way to engage schools in oral health programs to maximize participation among school children.

Most studies on xylitol and sorbitol chewing gum in the included systematic reviews took place in the United States and have shown high efficacy in preventing dental caries.[21,30] However, for this evidence brief the search strategy did not specifically include chewing gum as a delivery method for preventing dental caries. Therefore, research on xylitol and sorbitol as a prevention strategy may require further exploration.

Combining multiple fluoride treatments has shown additive effects in preventing dental caries.[24] However, potential adverse effects of combining fluoride treatments, such as dental fluorosis, have not been assessed. That said, in Canada, moderate to severe fluorosis is very low with reports of less than 0.3% in children.[1] Oral health professionals should be mindful of interventions being conducted in their jurisdiction that have an impact on oral health, including healthy eating programs or school nutrition policies.[5] There could be possible additive effects of traditional dental treatments and broader health promotion activities.

Another aspect of combining treatments is taking note of the different types of cavities that each treatment focuses on. For example, sealants target caries in pit and fissures while mouthrinses target the whole tooth. Some combinations might be better than others in preventing dental caries in children. Therefore practitioners need to be aware of these differences when they are determining the most appropriate or most effective caries prevention option for their jurisdiction.

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Specifications and Limitations

This Evidence Brief presents key findings from the scientific literature. Its purpose is to investigate a research question in a timely manner in order to help inform decision making. This report is not a comprehensive systematic review of the literature, but rather a rapid assessment of the best available research evidence. There may be relevant pieces of evidence that are not included and these may alter the conclusions drawn from the document.

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