The Public Health Reach of High Fluoride Vehicles: Examples of Innovative Approaches

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Key Words

Fluoride · Public health · Toothpaste · Varnish

Abstract

Fluorides and sealants have been shown to reduce caries in populations, making fluoride interventions a large part of the dental public health effort. Although public health programs have traditionally focused on fluoride vehicles delivering less than 1,000 ppm of fluoride, more recent efforts have shifted toward the use of high fluoride vehicles such as varnishes and prescription toothpastes. In the USA, states are developing innovative strategies to increase access to dental services by using primary care medical providers to deliver early preventive services as part of well-child care visits. Currently, Medicaid programs in 43 states reimburse medical providers for preventive services including varnish application. Still, there is uncertainty about the cost-effectiveness of such interventions. In many resource-strained environments, with shortages of dental health care providers, lack of fluoridated water and lower dental awareness, it is necessary to develop sustainable programs utilizing already established programs, like primary school education, where caries prevention may be set as a priority. Dental caries among the elderly is an ongoing complex problem. The

5,000-ppm F toothpaste may be a reasonable approach for developing public health programs where root caries control is the main concern. Fluoride varnish and high concentration fluoride toothpaste are attractive because they can easily be incorporated into well-child visits and community-based geriatric programs. Additional research on the effectiveness and costs associated with population-based programs of this nature for high risk groups is needed, especially in areas where a community-based fluoride delivery program is not available.

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The importance of fluoride for the prevention of dental caries is well recognized, but finding the best mechanism for delivering the fluoride to the teeth remains a very difficult task. Factors such as baseline caries rates, social attitudes toward the disease, the availability of workforce, public water and financial resources for health care, not to mention dental care, all influence the ability to deliver fluoride.

Only fluorides and sealants have been shown to reduce caries in populations [United States Department of Health and Human Services, 2000], making fluoride interventions a large part of the dental public health effort.

Although public marketing of toothpaste traditionally focused on fluoride vehicles delivering less than 1,200 ppm of fluoride, and public health programs have focused on community water fluoridation, efforts are shifting toward the use of high fluoride vehicles such as varnishes and toothpaste in targeted high risk regions. Topical fluorides have been shown to be highly effective, and the use of fluoride-containing toothpastes is now almost universal.

Various systematic reviews, including meta-analyses, have been published in the last decade supporting the effectiveness of different topical fluoride vehicles as caries-preventive measures when used alone or in combination [Marinho et al., 2013c]. Concerning the uncertainty about the relative value of these interventions when used together, the authors concluded that topical fluorides (mouthrinses, gels, or varnishes) used in addition to fluoride toothpaste achieve a modest reduction in caries compared to toothpaste used alone. The D(M)FS pooled preventive fraction event was 10% (95% CI = 2–17%; $p = 0.01$) in favor of the combined regimens.

Fluoride toothpastes have been widely used for over 5 decades and remain a benchmark intervention for the prevention of dental caries. Existing evidence [Marinho et al., 2013a] on the effectiveness and safety of fluoride toothpastes in the prevention of caries in children is firmly established. It is well known that children who brush their teeth at least once a day with a toothpaste that contains fluoride will have less tooth decay (regardless of fluoridated drinking water consumption), and twice a day use increases the benefit [Marinho et al., 2013a]. It is also well established that the benefits of using fluoride toothpaste in preventing caries in children and adolescents are significant for fluoride concentrations of 1,000 ppm and above. The relative caries-preventive effects of fluoride toothpastes of different concentrations increase with higher fluoride concentration, with a D(M)FS preventive fraction versus placebo of 23% for 1,000/1,055/1,100/1,250 ppm concentrations, rising to 36% for toothpastes with a concentration of 2,400/2,500/2,800 ppm [Walsh et al., 2010]. However, this review was dominated by studies comparing fluoride concentrations of 1,000/1,055/1,100/1,250 ppm with placebo. Twetman et al. [2003] demonstrated significant differences in preventive fraction when comparing 1,000 ppm F with 1,500 ppm with higher reductions in caries in the young permanent dentition, and higher caries reductions were recorded with supervised brushing programs when compared to non-supervised ones. Hence, the forum for application of the toothpaste may be just as important as the toothpaste fluoride concentration.

Topically applied fluoride varnishes have been used extensively as an operator-applied caries-preventive intervention for over 5 decades. The evidence suggests a substantial caries-inhibiting effect of fluoride varnish in both the permanent and the deciduous dentitions based largely on trials with no treatment controls. Fluoride varnishes applied professionally 2–4 times a year substantially reduce tooth decay in children [Weintraub et al., 2006]. However, additional high quality research is required to determine the magnitude of the difference the fluoride varnish treatment makes, and to study acceptability and adverse effects [Marinho et al., 2013b]. Twice yearly applications of fluoride varnish have been shown to reduce DMFS increments by 46% for children and adolescents after a 1-year period [Marinho et al., 2013b], and the benefits are even greater for high risk children [Seppa, 1991]. Several clinical investigations have questioned the effectiveness of fluoride varnish programs as public health measures [Milsom et al., 2011; Agouropoulos et al., 2014]. The subject populations included in these studies had varied additional exposures to fluoride from sources including water and regular toothpaste programs. These studies were also conducted in subject populations with lower initial caries rates. The aim of this article is to review the public health value of high fluoride vehicles, as well as outcomes and challenges.

US Best Practices

In the USA, access to dental care is a significant problem for some young children, demonstrated by the fact that among low-income children, utilization of Medicaid and the Children's Health Insurance Program is low [CMMS, 2014]. Despite governmental economic difficulties, states are developing new and innovative strategies to increase access to dental services for their young and vulnerable populations. One such strategy is the utilization of primary care medical providers (PCPs) to deliver early preventive dental services as part of well-child care visits [Cantrell, 2009]. Young children tend to see PCPs far more frequently than dentists, a fact reflected in the recommendation of the American Academy of Pediatrics that a child see PCPs 11 times for a checkup by the age of 2 [Hagan et al., 2008]. The utilization of PCPs as a first line provider of preventive dental services in improving children's oral health is an innovative approach that facilitates the integration of the dental and medical communities, and oral health inclusion into primary health care. Since medical providers typically have higher rates

of participation in public-funded health care, Medicaid, than dentists, they can provide preventive oral health services to low-income children as part of well-child care while referring them to dentists for more complex restorative care.

A program called Into the Mouths of Babies (IMB) was initiated in North Carolina in 2000 in which physicians are reimbursed by Medicaid to conduct dental screenings of children 3 years of age or younger, apply fluoride varnish, and counsel parents. This program demonstrates the sustainable long-term success of this initiative [Rozier et al., 2010]. Varying by age, 18–39% of children in this program had fluoride varnish applications compared with a national estimate that only 2.5% of children younger than 4 years had fluoride treatments from dentists in 2006. In addition, children who had 4 or more preventive IMB visits in medical offices had a 17% reduction in dental caries-related treatments up to 6 years of age compared with children who did not receive an IMB visit. The economic impact of the program demonstrated that, assuming a payment of USD 54.81 for an IMB visit, the probability that the program reduced total Medicaid expenditures (i.e. was cost-saving) for hospital episodes was 32% [Stearns et al., 2012].

By 2013, Medicaid programs in 43 states had approved reimbursement of medical providers for preventive oral health services [American Academy of Pediatrics, 2015]. Currently, states are reimbursing PCPs for three separate services: (1) oral examination, screening and risk assessment, (2) anticipatory guidance and caregiver education, and (3) fluoride varnish application. For the latter, there is still uncertainty about its cost-effectiveness. Quinonez et al. [2006] demonstrated that fluoride varnish application in the medical setting was effective in reducing early childhood caries in low-income populations but was not cost-saving in the first 42 months of life, suggesting that long-term cost-effectiveness should be carefully evaluated in longitudinal cohorts.

Currently in the USA, there are several state initiatives that had resulted in extensive use of fluoride varnish in children. Iowa has had a fluoride varnish program since 1999 administered through Title V Maternal and Child Services and the Iowa Department of Public Health. In the first year of the fluoride varnish application program, Medicaid-enrolled children received 348 fluoride varnish applications. By the end of 2010, nearly 41,000 applications had been provided to uninsured and Medicaid-enrolled children [ASTDD (Iowa), 2015]. Another example is the 'Cavity Free Initiative' in Tennessee that targets Medicaid-enrolled children in the Early and Periodic

Screening, Diagnosis and Treatment Program. Training in early childhood caries and fluoride varnish application is provided to all public health nurses as part of their standardized orientation. From 2009 to 2012, more than 50,000 applications of varnish were made to teeth of at-risk children [ASTDD (Tennessee), 2015]. Finally, 'Maryland's Mouth Matters Program' was designed to reduce the incidence of tooth decay in children and contribute to the establishment of a dental home. Oral health trainings were provided to pediatricians, family physicians and nurse practitioners. As of June 2012, there were 686 providers who completed the training program, and 385 of these had enrolled with a dental benefits administrator as fluoride varnish providers, which improved utilization for children of 9–36 months. 58,770 fluoride varnish treatments have been provided since the start of the program, and it has become so successful that it is now serving as the StateStat measure for oral health, a performance measure and management tool that is being monitored by the Governor's office [ASTDD (Maryland), 2015].

Traditionally, most of the US states have led initiatives to deliver fluoride by implementing school-based mouthrinse programs. These programs were widely utilized as caries-preventive public health methods, other than water fluoridation, in the 1990s with as many as 4–12 million American children participating in school-based programs [Miller and Brunelle, 1983; Szpunar and Burt, 1990]. In 2009, 25 states had active fluoride varnish programs, 15 had fluoride mouthrinse programs and 11 had fluoride supplement/tablet and drop programs [CDC, 2009]. Recently, a few states have made decisions to eliminate rinse programs based on economics. For example, in North Dakota, a state that has had a fluoride program since 1976 ranging from tablets to mouthrinse recently decided to expand the 'Healthy Smiles Fluoride Varnish Program' into the school system, targeting 19 mouthrinse schools and 41 schools with a 50% or greater free and reduced-price meal rate [ASTDD (North Dakota), 2015].

Grenada: An Example of the Successful Use of High Fluoride Vehicle Programs in Worldwide School-Based Programs in Emerging Health Environments

In the USA and Europe, school-based high fluoride modality programs are functioning in the background of significant fluoride product usage and dental access/utilization even in the most underserved communities when compared to the oral health resource poor emerging health care systems. Throughout Europe, parts of

Asia and the USA/Canada, fluoride exposures may come from home toothpaste use, food consumption, professional application and from community water fluoridation [Perez-Perez et al., 2014]. For example in the USA, 67% of the population of all ages live in areas with fluoridated community water systems [CDC, 2012]. Much of the world, outside the USA and Europe, do not have large municipal/public water supplies. 89% of the world's population gets their water from 'improved' sources of drinking water, coming from a diverse system of small well systems, connections with lakes, streams and rivers [WHO, 2014]. The number and diversity of water supply systems makes the delivery of fluoride via water supply often the most cost-effective method of broadly achieving fluoridation, impractical based on cost and the logistics of actual supply. Attempts to introduce fluoride to the children through a fluoride salt program have met with mixed success and acceptance. The effectiveness of these programs have not been fully achieved though it is currently utilized by more than 100 million people and is by far the least expensive to deploy [Marthaler, 2013]. In many resource-strained environments, with shortages of dental health care providers, lack of fluoridated water and lower dental awareness, it is necessary to develop sustainable programs that are (1) affordable, (2) reach the susceptible populations and (3) cost-effective utilizing already established and successful programs, like primary school education. Primary school education is a national goal for all countries, and for those that have not reached minimal education programs for all children, caries prevention is probably not a priority.

When looking to develop a caries prevention strategy for regions with large underserved communities (or even small nations), it is important to build on the infrastructural strengths of the community, while understanding the current limitations of the health care/dental care systems. A recently completed 3-year pilot intervention, Smile Grenada, sought to capitalize on a strong primary and secondary school infrastructure and develop an evidence-based, cost-effective caries prevention program that results in a reduction in caries rates in the permanent dentition for large populations, while being manageable utilizing an expanded workforce (teachers and dental assistants) due to a stark shortage of dental professionals. This program was designed to be cost-effective and sustainable, and outcomes were measured and reported utilizing a cross-sectional epidemiologic study [Wolff et al., in press]. The school-based caries prevention intervention was three pronged: (1) teachers

were trained to conduct daily in-classroom 2-min brushing with 1,000 F ppm; (2) 3 applications each year of fluoride varnish Colgate® PreviDent® Varnish, with a single unit dose of 1 ml of this suspension containing 50 mg sodium fluoride, and (3) glass ionomer sealants applied to a subset of the population (6- to 7-year-olds); however, retention was poor [Wolff et al., in press]. The results of this school-based intervention were highly significant decreases in caries and demineralizations seen across all surveyed ages of 6, 7–8, and 14–15. The average number of decayed surfaces dropped from 9 at baseline to just over 6 ($p < 0.0001$), and the average number of demineralized surfaces dropped from 6 to less than 2 ($p < 0.0001$). When looking specifically at teeth that erupted during the high fluoride vehicle intervention in 6- to 8-year-olds, there were statistically significantly fewer decayed ($p < 0.0001$; baseline mean 0.93 ± 1.75 ; follow-up mean 0.23 ± 0.83) and demineralized surfaces ($p < 0.0001$; baseline mean 2.11 ± 2.74 ; follow-up mean 0.50 ± 0.97) on permanent first molars compared to the equivalently aged baseline cohort not having any fluoride exposure. This study demonstrated significant improvements in dental health by supplementing the existing schools and educators with training, preventive protocols and materials. This confirms the belief that, particularly in high caries risk environments, school-based lay public interventions can result in significant oral health improvements where infrastructure improvements such as public water supply may not be possible. Developing appropriate programs in caries prevention requires a thorough understanding of the existing assets in that location and capitalizing on the existing infrastructure strengths.

Community-Based Geriatric Programs

The global trend of control of periodontal tooth loss for many is accompanied by an increase in both the numbers of teeth present in aging and the burden of new caries and restored teeth present. Root caries is a major cause of tooth loss in older adults, and tooth loss is the most significant oral health-related negative variable of quality of life for the elderly [Gati and Vieira, 2011]. Population projections suggest that the proportion of the population aged 65 years and older will nearly double by 2030 and that the proportion of those aged 85 years and older will increase dramatically over the next 10–15 years [Gati and Vieira, 2011]. In addition, many fragile elderly people use medications and the standard of home-based oral hy-

giene is far from optimal [Holm-Pedersen et al., 2005; Petersen and Yamamoto, 2005; Ekstrand et al., 2008]. Consequently, new coronal caries, caries around existing restorations and initial root caries are an increasing health problem for the aging population. To complicate an already difficult caries situation, the living circumstances for an aging population vary worldwide. The aging population lives in a variety of living arrangements ranging from their original homes through living with children and in skilled nursing facilities. 'Naturally occurring retirement communities' or non-age-segregated buildings are neighborhoods or communities with high concentrations of older adults, many of whom had moved into their homes at a much younger age. For those people choosing to age in place, neither their families, their neighbors nor their communities have sufficiently planned for the oral health needs [Walker, 2005]. With changing living conditions, finances, and mobility, increasingly complicated dental care and increased numbers of teeth, elder patients face a growing challenge to maintain oral health [Wolff et al., 2014].

Although dental public health programs for older adults have received more attention in recent years, the breadth and variety of state dental health activities for older adults is unknown [Dolan et al., 2005], especially when high concentration fluorides are discussed. Fluoride varnish has been demonstrated to be beneficial for the primary and permanent dentitions of children (smaller caries increment or incidence with its use) and also for the permanent dentition in adults with root caries [American Dental Association Council on Scientific Affairs, 2013].

The use of 5,000-ppm F toothpaste is suggested to be one method to gain better control with root caries in frail elderly people [Baysan et al., 2001; Ekstrand et al., 2008]. A recent small scale public health program in Denmark, conducted on disabled elderly people with a mean age of >80 years and living in nursing homes, demonstrated that 5,000-ppm F toothpaste was significantly more effective for controlling root caries progression than 1,450-ppm F toothpaste, when teeth were brushed by nurses in a long-term care setting (8 months) [Ekstrand et al., 2013]. Preliminary studies indicate that, during the time when brushing takes place, a mean saliva concentration of 650 (± 270) ppm fluoride can be measured when tooth brushing is performed using 5,000-ppm F toothpaste [Ekstrand, 2006]. The corresponding figure when brushing with 1,450-ppm F toothpaste is 110 (± 45) ppm fluoride. Further, at least for a couple of hours, twice a day the fluoride concentration is 5 times higher in the saliva of those who

use 5,000-ppm versus those using 1,450-ppm F toothpaste [Ekstrand, 2006]. The 5,000-ppm F toothpaste provides a significant advantage over 1,450-ppm F toothpaste in this sense and may be a reasonable approach for developing public health programs where root caries control is the main concern.

Fluoride varnish has been utilized in the elderly population by anecdotal report, but a paucity of evidence-based clinical research remains about its efficacy for reducing root caries lesions [Wierichs and Meyer-Lueckel, 2015]. Based upon anecdotal information and extrapolation of fluoride caries reduction data in younger populations, expert opinions recommend that with seniors living in a variety of living circumstances, research utilizing PCPs may be a valuable resource for reaching the homebound and limited mobility elderly population [American Dental Association Council on Scientific Affairs, 2006].

Examples of New Public Health Programs in Development

Two major initiatives that incorporate significant fluoride varnish components within their programs are being implemented in Philadelphia and the Latin American Region. Temple University is conducting Project ENGAGE, which centers on a community-based team that includes community health workers and public health dental hygienists, to deliver tailored health education focusing on improving oral health behaviors, increasing nutritional and oral health literacy, decreasing dental anxiety and applying fluoride varnish at home, as well as care navigation to more than a thousand high risk/high cost children.

A second example of an international high fluoride vehicle initiative, the Pan American Health Organization in collaboration with Colgate Palmolive has been conducting 'Proyecto SOFAR, Salud Oral Factores de Riesgo' (Oral Health and Risk Factors) since summer 2013. The implementation activities have centered in Colombia, Guatemala, Honduras, Mexico, and Peru. Project SOFAR focuses on underserved, low-income, primarily rural and isolated communities. Dental and nondental providers are being trained to ensure they are capable of educating children and their caregivers in oral hygiene, common risk factors, and other preventive interventions including fluoride varnish applications. The aim is developing a community-based intervention that raises awareness about the importance of oral health and its relationship with general health.

Conclusion

Fluoride varnish and high concentration fluoride toothpaste are attractive in public health programs because they can easily be incorporated into well-child visits and community-based geriatric programs. Additional research on the effectiveness and costs associated with population-based programs of this nature for high risk groups is needed, especially in areas where a community-based fluoride delivery program is not available.

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This paper was conceived and written by M.T. and M.S.W.

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