

REVIEW ARTICLE

Evidence-based clinical recommendations for fluoride use: a review

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Abstract The use of fluoride as a preventive measure for dental caries has been established more than 50 years ago. The recommendations for fluoride use has been modified over the years due to factors like decreased prevalence of caries, increased prevalence of dental fluorosis and the widespread availability of fluoride in various forms to the community. In recent years, the role of evidence-based recommendations has come to the forefront, in an attempt to ensure the most favorable treatment for the individual. This review has attempted to appraise the most recent evidence-based recommendations for different fluoride modalities put forth by various organizations worldwide, in order to appreciate the current status of fluoride in the early 21st century.

Introduction

The use of fluoride as a preventive measure for dental caries over the latter half of the last century has clearly contributed to the overall reduction in prevalence of dental caries worldwide, the effect being predominantly on the smooth surfaces (Brambilla, 2001; Ellwood and Fejerskov, 2003). Various fluoride modalities have been tried and tested and many are in current use, ranging from public water fluoridation to professionally applied fluoride varnishes. Fluoride modalities can be classified broadly into systemically or topically administered. Topically applied modalities may be further classified into self applied or professionally applied methods. Regardless of the fluoride modality used, there is a clear consensus that the method of action of fluoride in preventing caries is primarily the topical effect of the fluoride ion on the enamel surface (Brambilla, 2001). In addition to enhancing remineralisation of the hard tissue surface, fluoride has an inhibitory effect on the enolase enzyme of oral bacteria found in dental plaque and improves the chemical structure of enamel, making it more resistant to dental caries (Jones *et al.*, 2005).

In spite of the success story of fluoride, controversies regarding the use of fluoride as a therapeutic measure in humans abound. Fluoride has been stated to cause dental and

skeletal fluorosis, cancer, and other health effects. Clearly, there is insufficient evidence to support the latter two claims (WHO, 1994). The indications for fluoride use as a preventive measure in dentistry has changed since it was first introduced largely due to reasons such as decreased prevalence of dental caries (Seppa, 2001), increased prevalence of mild fluorosis, increased awareness among the public of the multifactorial etiology of caries and that every individual is now exposed to varied and widely available sources of fluoride. With this changing scenario, it is appropriate to review the current recommendations of use for various fluoride modalities and the level of evidence if any, so that it can be prescribed appropriately by the dental professionals in the best interest of their patients. Hence, this review attempts to study the current evidence-based clinical recommendation for various fluoride modalities.

Evidenced-based dentistry - definitions and concepts

Evidence-based dentistry has been defined as an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences (American Dental Association Council on Scientific Affairs, 2006, 2007).

A systematic review contributes substantially to evidence-based dentistry, and is defined as a process of systematically locating, appraising and synthesizing evidence from

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scientific studies in order to obtain a reliable overview (Ismail and Bader, 2004).

Evidence-based clinical recommendations are developed on the basis of findings from systematic reviews of randomized clinical trials, or in the absence of such evidence, non-randomized intervention studies, follow-up (cohort) or case-control studies, or other study design (American Dental Association Council on Scientific Affairs, 2006).

In the process of developing evidence-based clinical recommendations, the relevant scientific literature is reviewed; evidence classified and graded depending on the strength of evidence. Recommendations, which are graded, are proposed depending on the level of associated evidence. Different systems of grading exist and the evidence-based clinical recommendations should be evaluated based on the grading system used. An example of the system used is shown in Table 1 and Table 2 (Centers for Disease Control and Prevention, 2001).

Table 1: Grading system used for determining the quality of evidence for a fluoride modality

Grade	Criteria
I	Evidence obtained from one or more properly conducted randomized clinical trials (i.e., one using concurrent controls, double-blind design, placebos, valid and reliable measurements, and well-controlled study protocols).
II-1	Evidence obtained from one or more controlled clinical trials without randomization (i.e., one using systematic subject selection, some type of concurrent controls, valid and reliable measurements, and well controlled study protocols).
II-2	Evidence obtained from one or more well-designed cohort or case-control analytic studies, preferably from more than one center or research group.
II-3	Evidence obtained from cross-sectional comparisons between times and places; studies with historical controls; or dramatic results in uncontrolled experiment (e.g., the results of the introduction of penicillin treatment in the 1940's).
III	Opinions of respected authorities on the basis of clinical experience, descriptive studies or case reports, or reports of expert committees.

Source: US Preventive Services Task Force. Guide to clinical preventive services. 2nd edn. Alexandria, VA: International Medical Publishing, 1996.

Most recommendations are based on critical evaluation of the collective body of evidence on a particular topic and provide dentists and other professionals with practical applications of scientific information to use in their clinical decision-making process. They are intended to provide guidance and not a standard

of care, requirement or regulation. The clinical recommendation must be balanced with the practitioner's professional opinion and the individual patient's preferences before it is put into practice (American Dental Association Council on Scientific Affairs, 2006).

Table 2: Coding system used to classify recommendations for use of specific fluoride modalities to control dental caries.

Code	Criteria
A	Good evidence to support the use of the modality
B	Fair evidence to support the use of the modality
C	Lack of evidence to develop a specific recommendation (i.e., the modality has not been adequately tested) or mixed evidence (i.e., some studies support the use of the modality and some oppose it).
D	Fair evidence to reject the use of the modality
E	Good evidence to reject the use of the modality

Source: US Preventive Services Task Force. Guide to clinical preventive services. 2nd edn. Alexandria, VA: International Medical Publishing, 1996.

Organizations with recommendations on fluoride use

Several organizations have put forward recommendations for fluoride use. Since it is not in the scope of this review to cover all organizations, a select few are taken into consideration, such that a world-wide overview can be achieved. Among the selected organizations whose recommendations will be mentioned in this review are the Centers for Disease Control and Prevention (CDC) in the USA (CDC, 2001), British Society of Pediatric Dentistry (BSPD) (Rayner *et al.*, 2003), European association of Pediatric Dentistry (EAPD) (Marks and Martens, 1998), Scottish Intercollegiate Guidelines Network (SIGN, 2000, 2005), Australian Research Centre for Population Oral Health (ARCPOH, 2006), and the World Health Organization (WHO, 1994). It is to be noted that only certain organizations such as CDC and SIGN that have graded their evidence and recommendations. The others are based on literature review and expert opinions.

Systemic fluoride

a) Water fluoridation

The role of fluoride in preventing caries was first identified in the mid 1930's through its presence in water consumed for drinking and hence water fluoridation is the foremost form of fluoride therapy in dentistry. Although initial studies revealed a 50 to 60% decrease in caries, more recent studies show a much lower effect of 18 to 40 % (CDC, 2001). A recent systematic review shows an even lower effect of 14% decrease in caries prevalence (McDonagh *et al.*, 2000).

However, there are numerous advantages of water fluoridation over other modalities which include low cost of implementation, reaching people of all ages and socioeconomic status (CDC, 2001). The main disadvantage remains the need for a good public water supply system. About 210 million people are said to receive water fluoridation worldwide (WHO, 2003). Water fluoridation still remains the cornerstone for caries prevention in the United States (US) and Australia after 50 years of existence, with continuous decline in caries levels evident even in the 21st century (AIHW DSRU, 2007; Williamson *et al.*, 2008). While the US aims to achieve fluoridation for 75% of the population by 2010 (CDC, 2008), UK and Europe rely less on water fluoridation, but more on milk and salt fluoridation methods; excluding Ireland, where water fluoridation is mandatory (Jones *et al.*, 2005).

The use of public water fluoridation is well supported. While the European organizations give no specific recommendation on fluoride concentration, probably due to lack of its use in the region, the CDC recommends a level of 0.7 - 1 parts per million (ppm) (CDC, 2001). Other organizations recommend a lower level of 0.5-1ppm or 1.1ppm (WHO, 1994; Marks and Martens, 1998; ARCPH, 2006). In the recent years, most organizations have expressed their concern regarding the amount of fluoride in bottled water, a more popular source of drinking water nowadays (CDC, 2001). For this reason, addition of fluoride where appropriate and fluoride labeling of bottled water is encouraged (CDC, 2001; ARCPH, 2006). Home filtration systems may also alter the fluoride level in water and need to be standardized (ARCPH, 2006). While the quality of studies supporting the evidence of the effect of water fluoridation has been low or moderate (Grade of Evidence II-1) due to technical difficulty in blinding the researchers, the recommendation is rated at grade 'A' (CDC, 2001).

The main concern and side effect of water fluoridation is dental fluorosis. Systematic reviews of water fluoridation clearly state that there is a dose dependent increase in fluorosis (McDonagh *et al.*, 2000); however countries with existent water fluoridation schemes maintain water fluoridation considering the benefit over the risk of dental fluorosis (AIHW DSRU, 2007). It is imperative that countries with public water fluoridation regularly monitor the F level, so that the optimum level is achieved to give maximum protection against caries and at the same time cause minimal dental fluorosis (CDC, 2001). In summary, water fluoridation is a very relevant public health measure till today. The WHO recommended that only one form of systemic fluoride measure should be used at any one time (Petersen and Lennon, 2004).

b) Fluoride supplements

Fluoride supplements (F supplements) were introduced in the 1940's in the US to compensate for areas with lack of fluoridated

water. They are manufactured as drops for infants, tablets to be chewed and swallowed or lozenges intended to be sucked slowly. A reported 60% caries reduction has been achieved in primary dentition and 39 to 80% in permanent dentition (WHO, 1994). However, the use of supplements are fraught with many disadvantages like high cost, poor compliance, improper use, increased risk for fluorosis and limited daily duration of exposure to teeth (CDC, 2001). Consequently, the role of supplements as a public health measure is limited (WHO, 1994; Rayner *et al.*, 2003; SIGN, 2000, 2005). Instead, they are recommended based on individual caries risk, mainly for high risk children and for those having less than optimal F in the water (WHO, 1994; Marks and Martens, 1998; CDC, 2001; Rayner *et al.*, 2003; SIGN, 2000, 2005).

The importance of eliciting the F history before prescription of F supplements has been stressed (WHO, 1994; Marks and Martens, 1998; CDC, 2001). However, the ARCPH (2006) does not recommend its use and WHO (1994) recommends a conservative prescribing policy, encouraging childproof containers not exceeding 120mg of supplements per container. The dosage schedule put forward by CDC (2001), BSPD (Rayner *et al.*, 2003) and EAPD (Marks and Martens, 1998) are essentially similar i.e., from 6 months to 3 years, 0.25mg; 3 to 6 years, 0.5mg; and 6 to 16 years, 1mg daily. Twice daily doses, different from time of tooth paste use are recommended to get the maximum effect, with slow sucking in the mouth for additional topical effect. Drops or soluble tablets are recommended for younger children. The quality of evidence for supplement use below 6 years of age is only grade II-3 with a recommendation of grade C, implying there is a lack of adequate evidence to develop a specific recommendation (CDC, 2001). However, in children above 6 years, evidence is Grade I, with Grade 'A' recommendation, showing there is good evidence to support the use of supplements in the older children (CDC, 2001). A similar recommendation was put forward by SIGN (2000, 2005).

Topical modalities of fluoride

a) Fluoridated toothpastes

Fluoridated toothpaste (F toothpaste) undoubtedly has been the cornerstone of caries prevention worldwide and accounts for the caries decline in the past few decades in the industrialized countries. In the developed countries, it occupied 90% of the market share in the 1990's (CDC, 2001). It is found to cause 15 to 30% decrease in caries experience (CDC, 2001); while a recent systematic review concluded that the caries reduction was 24% (Marinho *et al.*, 2003). The recommendations for use of F toothpaste are summarized based on age, as well as concentration and amount of

fluoride in the toothpaste. The quality of evidence for use of F toothpastes is I and the strength of recommendation is 'A' (CDC, 2001; SIGN, 2000, 2005)

(i) Recommendations on age to be used

Fluoridated toothpaste is generally recommended in all individuals regardless of caries risk, twice a day, with slight modifications for children. The CDC (2001) recommends that children below 2 years do not use fluoridated toothpastes. Similar recommendation is also stated by ARCPOH (2006), where children below 18 months are not recommended to use F toothpaste. For such children, consultation with a professional and assessment of risk is required prior to use. On the other hand, EAPD (Marks and Martens, 1998) and SIGN (2000) recommend its use in children as soon as primary teeth erupt, while WHO (1994) and BSPD (Rayner *et al.*, 2003) make no specific mention about its use in children less than 2 years.

(ii) Recommendations on concentration to be used

F toothpastes are available in regular concentrations of 1000 to 1500ppm for adults and in lower concentrations of 600ppm and below, primarily for children. Higher concentrations are available but WHO (1994) recommends that the limit be maintained at 1500ppm. The recommended use of low fluoride toothpaste varies, with EAPD (Marks and Martens, 1998) and ARCPOH (2006) recommending low fluoride toothpastes for all children less than 6 years. The BSPD (Rayner *et al.*, 2003) recommendation is similar, with the exception that children with high caries risk use regular concentration of 1000ppm. In contrast, SIGN (2005) clearly recommend that 1000ppm concentration be used for all children regardless of age and risk for caries once the primary tooth erupts. However, WHO (1994) and CDC (2001) are non-committal about low F toothpastes for children and encourage research and development in that aspect.

(iii) Recommendations on amount to be used

For children below 6 years, a general agreement between all organizations is that a pea sized amount should be used with parental supervision; the child being encouraged to spit with restricted use no more than 2 times a day. For children below 2 years, a smear is recommended by EAPD (Marks and Martens, 1998) and SIGN (2005). These instructions are encouraged to be labeled on the toothpaste tube along with the concentration of fluoride for the guidance of parents (CDC, 2001), a mandatory procedure in the US.

(iv) Other recommendations

SIGN (2000, 2005) and ARCPOH (2006) have additionally stated that the effects of F toothpaste are higher if there is no rinsing after its use and

have recommended that the toothpaste be spit out after use with no rinsing. The strength of this recommendation is "A". The WHO (1994) states that toothpastes are the most important delivery system of fluoride and encourage its use along with water fluoridation. In view of its accessibility in underdeveloped countries, it encourages "affordable" formulations and that toothpastes be exempt from duties and taxations. Additionally, candy flavoring is not encouraged in 1500ppm concentrations to avoid swallowing of the toothpaste. The importance of fluoride toothpastes as a cost-effective and feasible method of fluoride delivery is indisputable and will be so in all countries irrespective of the caries level and oral health care delivery systems (Seppa, 2001).

b) Fluoride mouth rinses

Fluoride mouth rinses (FMR) were part of the school mouth rinsing programmes in the 1970's and 1980's which was an alternative to water fluoridation in many countries (CDC, 2001). Overall, the caries reduction with use of mouth rinses in earlier studies has been reported to be 31% (CDC, 2001). Later studies have found reduced effectiveness of mouthrinses among school children (Holland *et al.*, 1995).

Currently, all organizations recommend that FMR be used only in high caries risk individuals above 6 years of age and contraindicate its use in children less than 6 years because of the high chances of swallowing in the younger age group. The evidence for this recommendation is Grade I and the strength of recommendation is 'A' (CDC, 2001). It is not cost effective as a public health measure (Marks and Martens, 1998), but WHO (1994) suggests that in low fluoride areas, FMR programmes in schools can be encouraged depending on the cost and caries status of the community. When used, mouth rinses should not replace toothpastes and should be used at a time different from toothpaste use for maximum effectiveness (ARCPOH, 2006). BSPD (Rayner *et al.*, 2003) and SIGN (2000, 2005) made no specific mention of mouth rinse in their recommendations.

c) Professionally applied topical fluoride

Professionally applied topical fluoride have been used since the past 50 years, initially as solution, currently as gel, foam and varnish preparations. Popular formulations with well established cariostatic efficacy include 2% Sodium fluoride (NaF), 1.23% Acidulated phosphate fluoride (APF) gel and 5% NaF varnish. Fluoride foam is a recent introduction with limited literature showing its efficacy (Evans, 2007).

(i) Gels: A clear evidence of caries inhibiting effect of fluoride gel in permanent dentition with 28% reduction in decayed, missing and filled tooth surfaces (DMFS) has been found (Marinho *et al.*, 2002). There is a general agreement among all organizations, that professional

application of fluoride be restricted to moderate to high risk groups, as there is no benefit in its use in low risk children. It is recommended that gels be applied for 4 min as against 1min, twice a year and only in older children (WHO, 1994; Marks and Martens, 1998; CDC, 2001; ARCPOH, 2006). While EAPD (Marks and Martens, 1998) states that it should be used in children above 4 years, ARCPOH (2006) recommends that it be used only in children older than 10 years. CDC (2001) suggests that the frequency of its use can be determined by the dentist on an individual basis. The quality of evidence is 'I' and strength of recommendation is 'A' (CDC, 2001).

ii) Varnishes: A substantial reduction of 46% in DMFS and 33% in decay, missing and filled tooth surfaces (dmfs) in primary teeth can be achieved with F varnishes applied 2 to 4 times per year (Marinho *et al.*, 2002). Like gels, varnishes are also recommended in individuals with high risk for caries only, however they have an advantage that they can be used in very young children, children with strong gag reflex and special needs children, where other forms of fluoride are impractical (Marks and Martens, 1998). There is no contraindication for its use (WHO, 1994). Both quality of evidence and strength of recommendation are similar to that of F gels.

The evidenced-based guidelines for the use of professionally applied topical fluoride (PATF) state that children of any age with *low risk for caries* may not receive additional protection with any form of PATF (American Dental Association Council on Scientific Affairs, 2007). The evidence for the above recommendation is 'Ia' and strength of recommendation 'B'. In children with *moderate risk for caries*; young children below 6 years are recommended a 6-monthly varnish application, while children 6 to 16 years may receive 6 monthly varnish or gel applications, the evidence being 'Ia' and strength of recommendation 'A'. In children with *high risk for caries*; young children below 6 years are recommended 3 to 6-monthly varnish application, while children 6 to 18 years may receive 3 to 6 monthly varnish or gel application. The evidence for this recommendation is 'Ia' and strength of recommendation 'A'. In individuals older than 18 years, although the recommendation remains similar to the younger age groups according to the category of risk, the evidence is not available and the strength of recommendation is 'D'. In conclusion, risk assessment is imperative prior to the selection of professionally applied topical fluoride in children.

Conclusions

It is strongly endorsed by most organizations that the daily use of fluoride should be a major part of any comprehensive preventive

programme for the control of dental caries in children (Marks and Martens, 1998). It is recommended that all persons should drink water with an optimal fluoride concentration and brush their teeth twice daily with fluoride toothpaste (CDC, 2001).

For persons at high risk for dental caries, additional fluoride measures might be needed and in prescribing fluoride it is the duty of the dentist to maximize beneficial effects of caries prevention and minimize harm from fluorosis. It is recommended that measured use of fluoride modalities is particularly appropriate during the time of anterior tooth development (<6 years). When used appropriately, fluoride is both safe and effective in preventing and controlling dental caries.

References

- AIHW DSRU: Armfield JM, Slade GD and Spencer AJ (2007). *Water fluoridation and children's dental health. The Child Dental Health Survey, Australia 2002. AIHW Cat. No. DEN 170. Dental Statistics and Research Series No. 36.* Canberra: Australian Institute of Health and Welfare.
- American Dental Association Council on Scientific Affairs (2006). Professionally applied topical fluoride: evidence-based clinical recommendations. *J Am Dent Assoc*, **137**(8): 1151-1159.
- American Dental Association Council on Scientific Affairs (2007). Professionally applied topical fluoride: evidence-based clinical recommendations. *J Dent Educ*, **71**(3): 393-402.
- Australian Research Centre for Population Oral Health (2006). The use of fluorides in Australia: guidelines. *Aust Dent J*, **51**(2): 195-199.
- Brambilla E (2001). Fluoride - is it capable of fighting old and new dental diseases? An overview of existing fluoride compounds and their clinical applications. *Caries Res*, **35** (Suppl 1): 6-9.
- Centers for Disease Control and Prevention (2001). Recommendations for using fluoride to prevent and control dental caries in the United States. *Morb Mortal Wkly Rep*, **50**(RR-14): 1-42.
- Centers for Disease Control and Prevention (2008). Populations receiving optimally fluoridated public drinking water- United States, 1992-2006. *Morb Mortal Wkly Rep*, **57**(27): 737-741.
- Ellwood R and Fejerskov O (2003). Clinical use of fluoride. In: Fejerskov O and Kidd EAM (eds.) *Dental Caries- The Disease and Its Clinical Management*. London: Blackwell Munksgaard, pp 189-222.
- Evans D (2007). APF foam does reduce caries in primary teeth. *Evid Based Dent*, **8**(1): 7.
- Holland TJ, Whelton H, O'Mullane DM and Creedon P (1995). Evaluation of a fortnightly school-based sodium fluoride mouthrinse 4 years following its cessation. *Caries Res*, **29**(6): 431-434.
- Ismail AI and Bader JD (2004). Evidence-based dentistry in clinical practice. *J Am Dent Assoc*, **135**(1): 78-83.
- Jones S, Burt BA, Petersen PE and Lennon MA (2005). The effective use of fluorides in public health. *Bull World Health Organ*, **83**(9): 670-676.
- Marinho VC, Higgins JP, Logan S and Sheiham A (2002). Fluoride gels for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev*, (2): CD002280.

- Marinho VC, Higgins JP, Logan S and Sheiham A (2003). Fluoride toothpastes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev*, (1): CD002278.
- Marks LA and Martens LC (1998). Use of fluorides in children: recommendations of the European Academy for Pediatric Dentistry. *Rev Belge Med Dent*, **53**(1): 318-324.
- McDonagh MS, Whiting PF, Wilson PM, Sutton AJ, Chesnutt I, Cooper J, Misso K, Bradley M, Treasure E and Kleijnen J (2000). Systematic review of water fluoridation. *BMJ*, **321**(7265): 855-859.
- Petersen PE and Lennon MA (2004). Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. *Community Dent Oral Epidemiol*, **32**(5): 319-321.
- Rayner J, Holt R, Blinkhorn F and Duncan K (2003). British Society of Paediatric Dentistry: a policy document on oral health care in preschool children. *Int J Paediatr Dent*, **13**(4): 279-285.
- Scottish Intercollegiate Guideline Network (2000). Preventing dental caries in children at high caries risk: Targeted prevention of dental caries in the permanent teeth of 6-16 year olds presenting for dental care. A National Clinical Guideline #47. Pg 1-42.
- Scottish Intercollegiate Guideline Network (2005). Prevention and management of dental decay in the pre-school child. A National Guideline #83. Pg 1-44.
- Seppa L (2001). The future of preventive programs in countries with different systems for dental care. *Caries Res*, **35** (Suppl 1): 26-29.
- Williamson DD, Narendran S and Gray WG (2008). Dental caries trends in primary teeth among third-grade children in Harris County, Texas. *Pediatr Dent*, **30** (2): 129-133.
- World Health Organisation (1994). *Fluorides and Oral Health*. WHO Technical Report Series 846. Geneva:WHO; 1-37.
- World Health Organisation (2003). *The World Oral Health Report 2003*. Geneva: WHO; 19.