Systemic fluoride supplementation in South Africa – updated guidelines for practitioners

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Abstract

The concentration of fluoride in potable water and the need for systemic fluoride supplementation has been debated for decades. The South African tap water supply was assessed in 1988 and 1992, and subsequently systemic fluoride supplementation recommendations were compiled. An updated supplementation table is required based on recent literature and current water fluoride concentrations in South Africa. The tap water fluoride values were obtained from the Department of Water and Sanitation of South Africa. This updated guideline for systemic fluoride supplementation is based on the 2016/2017 values.

Key words: Systemic fluoride; topical fluoride; tap water, ground water, surface water.

Introduction

Fluoride is present in most oral hygiene products and has been widely advocated by various dental associations across the world. In South Africa the debate has been intriguing dental researchers since 1935 (Louw & Chickte, 1997). The presence of fluoride in the oral cavity facilitates topical interaction with teeth to facilitate re-mineralization of the hydroxyapatite crystals (Hellwig et al, 2004). The biofilm (Pontius, 1993) and the saliva also interact with fluoride in the oral cavity, potentiating the bacterial inhibition and remineralisation effect of the fluoride. The enamel and dentine exposed to the oral environment are bound with fluoride from various topical sources which reduce the risk of demineralization (Walsh, 2009). The outer layer (10-20 µm) of the hydroxyapatite crystals in the enamel usually contains the highest concentration of fluoride.

The teeth are continuously exposed to various sources of food and beverages fuelling the oral bacteria. During the consumption of food, liquids and sugar, the pH in the oral cavity decreases below the critical pH value of 5.5 rendering the teeth vulnerable to demineralization. The saliva has a buffering capacity which facilitates an increase in the pH to a more neutral pH. The patient can use sugar free chewing gum to return the pH in the oral cavity to a neutral level if traditional oral hygiene methods (such as toothbrushes or oral rinses) are not available (Goldman et al, 2008; O'Mullane et al, 2016).

Fluoridated toothpaste is the most widely used dental caries prevention method. Featherstone (2000) cited that oral hygiene practices, which incorporate the regular use of a fluoride containing toothpaste, presents the most effective technique to prevent dental caries. Brushing with a fluoridated toothpaste is an effective method to retain a low and sustained fluoride concentration in the oral cavity. The effective removal of dental plaque by brushing twice daily is important to ensure that the bacteria adhered to the tooth structure is removed (Goldman et al, 2008; O'Mullane et al, 2016). However, the inter-proximal spaces between teeth require dental floss for effective plaque and biofilm removal.

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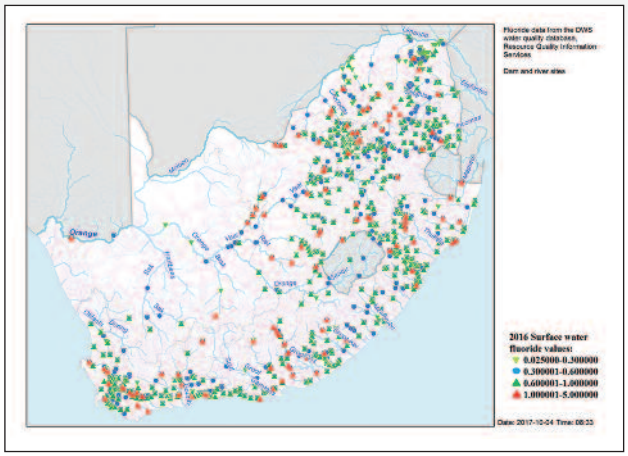

Figure 1: Surface water (rivers and dams) fluoride concentrations (Mulder, 2018)

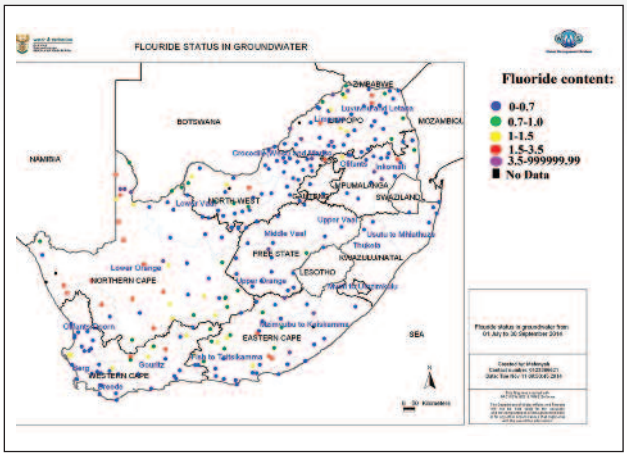

Figure 2: Groundwater fluoride concentrations of 2014 (Department of Water and Sanitation, 2014).

It is widely accepted that systemic fluoride is incorporated into teeth and bones during the development and mineralization process of these structures. The caries preventative effect of topical fluoride (i.e. such as toothpaste) is only relevant after the eruption of the teeth (Hellwig et al, 2004). The WHO recommended a fluoride concentration of 1000-1500 parts per million (ppm) in toothpaste (WHO, 1984). The effectiveness of fluoridated toothpaste above 1000 ppm was shown in the Cochrane systematic review, for use in patients with secondary teeth (Walsh et al, 2010). However, 400-550ppm is ideal for children below 7 years.

Fluoride sources

The three main delivery methods for caries prevention are namely: community based (fluoridated water, salt and milk), professionally administered (fluoride gels, varnishes) and self-administered (toothpaste and oral rinses) (O'Mullane et al, 2016). The main fluoride sources available to children in South Africa are various fluoridated products like toothpaste, systemic tablets/drops, oral rinses and tap water to a lesser degree in some provinces. Fluoridated toothpaste is a widely used and accessible source to many households in South Africa. A review of the literature concluded that toothpastes were effective in reducing and preventing caries up to 23% in the permanent dentition (Marinho et al, 2016). The Technical Report Series 846 (TRS846) on "Fluorides and Oral Health", is a publication regularly used for planning fluoridated oral health programs (WHO, 1994). The aforementioned WHO report can only be followed if the water fluoridation in the respective country is known. In order to reach and educate children, various school brushing and rinsing programmes can also play a role in the community.

Upon investigation of the various websites of the water boards, only a few provinces have the exact tap water fluoride concentration information freely available (eThekwini water board, 2018; Mohotsi, 2011, 2016).

Water fluoridation

Water fluoridation and de-fluoridation in certain parts of South Africa have been debated for decades. The water in many provinces of South Africa is not actively fluoridated by water boards. However, the elemental and bacterial composition of tap-, surface- and even ground-water are annually assessed by most districts in South African municipalities. Fluoridated water has a topical and systemic effect (Hardwick, 1982). For this reason the WHO indicated that the optimum target for water fluoridation is around 0.5-1 mg/L. The WHO (1984) recommended that if the ambient temperature is an average of 16ºC and a child consumes 2 L of water daily, at a fluoride concentration of 0.7-1.2 mg/L, no additional systemic fluoride is required. Rudolph et al (1995) concluded that tap water in South Africa containing 0.5 mg/L would be ideal, as this will allow for the use of fluoridated oral hygiene products as well. For South Africa the water fluoride level of 0.54 mg/L to a maximum of 0.7 mg/L fluoride was confirmed to be ideal, based on population based studies (du Plessis et al, 1995a; du Plessis, 1995b).

Groundwater and surface water generally have higher concentrations of fluoride than provincially supplied tap

water. The information for the fluoride concentrations of the surface water (dams and rivers) as well as groundwater is widely available from the various webpages of the Department of Water and Sanitation. The surface water contained in the rivers and dams have various fluoride values. The predominant ranges are 0.3-0.6; 0.6-1 and 1-5 mg/L (Figure 1). Groundwater predominately has fluoride values of 0-0.7 mg/L (Figure 2). The leaching of fluoride into groundwater from the rock formations located near the source play a role in the fluoride concentrations and can result in a range of 3-12 mg/L. Oceanic water fluoride concentrations are approximately 0.8-1.4 mg/L (Department of Water Affairs and Forestry, 1996). The water boards that offer desalination should consider the extent of the reverse osmosis process and the impact on the remaining ion concentrations. The process of reverse osmosis removes most to all of the ions including fluoride (under certain operating conditions) from the water (WHO, 2005).

The final tap water supply of various provinces constitutes water from rivers, dams, boreholes as well as desalination plants (WHO, 2005). When multiple sources of water are mixed together to constitute the tap water supply, there could be variations in yearly fluoride measurements. The variation in fluoride concentration is also influenced by the ambient temperature and rainfall patterns (Grobler et al 1988; Grobler, 1992).

The fluoride concentration in tap water consumed by many South Africans is probably the easiest to monitor due to the annual testing regulation based on the SABS standard (SABS, 2015). The SANS 241:2015 replaced the previous water quality guidelines that indicated the fluoride in tap water to be less than 4 mg/L (Department of Water Affairs and Forestry, 1996; Department of Water Affairs, 1995). Studies were conducted in 1988 and 1992 assessed the tap water fluoride concentrations from various cities in South Africa (Grobler et al 1988; Grobler, 1992).

Basic information on the tap water quality for various areas has been made available on the webpage of the Department of water and sanitation (Department of Water and Sanitation, 2018). The water quality as well as the dates and areas of tap water testing can be searched, but it still does not provide exact fluoride concentrations per area or district. The open access documents available are not of much value to the practitioners, since they generally provide the recommended fluoride value of <1.5 mg/L as regulated by the SANS 241:2015 (Ebrahim, 2016; eThekwini water board, 2018; Mohotsi, 2011, 2016).

In order for the oral health practitioner to make recommendations for the use of systemic fluoride supplementation, the exact fluoride concentration of tap water and oral health practices need to be considered. Personal communication with the Department of water and sanitation resulted in provision of the tap water fluoride concentration for 2016-2017 (Mulder, 2018). The averages of the two values were calculated and used to modify the map of South Africa (Figure 3 and Tables 1, 2) and the well established systemic fluoride recommendation table by Rozier et al 2010. A correlated and modified systemic fluoride supplementation table was constructed in order to serve as a systemic fluoride recommendation per province. It is based on the fluoride concentration in tap water and the use of appropriate toothpaste, twice daily (Table 2).

Fluoride exposure of the patient

In the event that the combined fluoride exposure (all sources combined) is less than 0.07 mg/kg of the body weight, the risk of dental fluorosis is minimal. It is important to remain cognisant that children under 6 years of age do not have an established swallowing reflex and therefore fluoridated oral rinses are not indicated for these children. When fluoride is ingested, children retain (55%) more fluoride than adults (36%). The major route of excretion is through the urine (Villa

Table 1. Average fluoride content of recorded 2016/2017 values as per Figure 3 (Mulder, 2018).

Fluoride content	< 0.3 mg/L (Low fluoride)	0.3-0.6 mg/L (Optimal fluoride)	0.6-0.99 mg/L (Optimal to high fluoride)	> 1mg/L (High fluoride)
Province	Western Cape	Limpopo Mpumalanga Free State	Gauteng North West	Eastern Cape Kwazulu-Natal Northern Cape

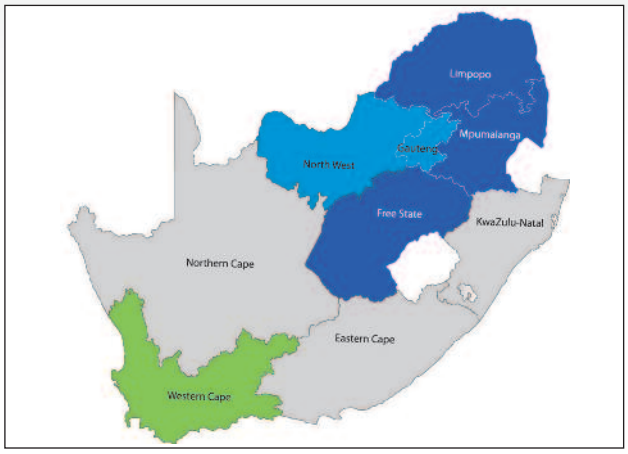

Figure 3: General provincial tap water fluoride concentration (Mulder, 2018).

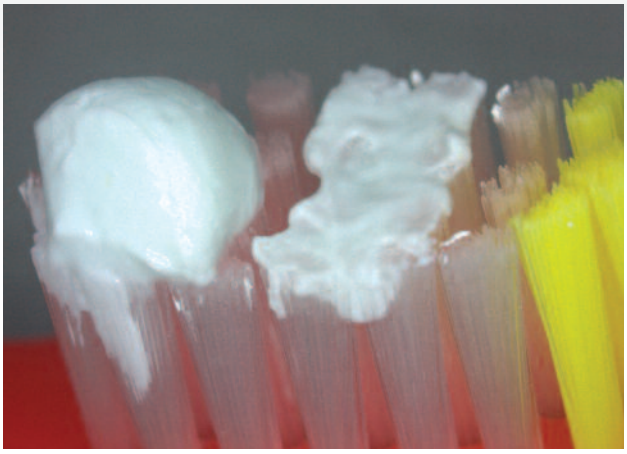

Figure 4: The toothpaste on the left shows a pea-sized amount (0.25 mg). The smear on the right a rice grain size (0.1 mg).

et al, 2010) and 10% through the faeces. Excessive fluoride exposure can result in various degrees of dental fluorosis, since children can swallow up to 80-100% of the dispensed toothpaste during brushing (Cochran et al, 2004). In order to prevent the occurrence of dental fluorosis when toothpaste and systemic fluoride are used, O'Mullane (2016) cited that an age appropriate toothpaste with no more than a smear layer or rice grain size (0.1 mg) of toothpaste should be recommended for children under 3 years. Children 3-6 years should use a pea size amount (0.25 mg) (Figure 4) (American Dental Association Council on Scientific Affairs, 2014; O'Mullane, 2016). Therefore the age appropriate toothpaste is used in conjunction with the systemic fluoride supplementation as per Table 2.

Systemic fluoride prescription schedule

Water fluoridation was cited by Muller et al (1998) to be an intervention that should be phased out as South Africans gain greater access to oral healthcare and the socio-economic status of the population improves. However, the WHO TRS846 report advocates that besides topical fluoride and water fluoridation, the use of systemic fluoride supplements in children 2 years and younger, resulted in a 60% dental caries development reduction for the primary dentition (WHO, 1994).

Systemic administration of fluoride (tablets/drops) requires the parent to strictly adhere to the regimen dose. Excessive fluoride between 18-36 months could result in dental fluorosis of the maxillary permanent central incisors.

Table 2. Modified fluoride supplementation in relation to age and water fluoridation for South Africa (Rozier et al, 2010; Mulder, 2018).

Age of child	< 0.3 mg/L (Low fluoride)	0.3-0.6 mg/L (Optimal fluoride)	0.6-0.99 mg/L (Optimal to high fluoride)	> 1mg/L (High fluoride)
0-6 months	Nil	Nil	Nil	Nil
6 months-3 years	1 tablet or 4 drops	Nil	Nil	Nil
3-6 years	2 tablet or 8 drops	1 tablet or 4 drops	Nil	Nil
6-16 years	4 tablet or 16 drops	2 tablet or 8 drops	Nil	Nil

Table 2 represents the updated recommended systemic fluoride supplementation according to the patient age and the fluoride in the tap water per province (Figure 3).

Conclusion

Consultation with a health care professional is advised when considering systemic fluoride supplements. The water fluoridation level and the sources of fluoride were considered to establish the appropriate systemic fluoride dose. One tablet or 4 drops equates to 0.25 mg/F. Based on the drinking water assessed by Grobler et al in 1988, 1992 and on the fluoride concentration of tap water for 2016/2017 (Figure 3. Table 1, 2) (Mulder, 2108), the recommendations can now be updated.

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Conflicts of interest

None.

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