

Guidelines for use of fluorides in Australia: update 2019

LG Do,*  Australian Research Centre for Population Oral Health

*National Oral Health Promotion Clearinghouse, Australian Research Centre for Population Oral Health, The University of Adelaide, Adelaide, South Australia, Australia.

ABSTRACT

Fluoride use is the cornerstone of dental caries prevention. There are numerous sources of fluoride which might have different balance of risks and benefits. The first National Guidelines for Use of Fluorides in Australia were developed at a national Workshop in 2005, and updated in 2012. Since then, more evidence on the balance of risks and benefits of fluoride has become available. A third national Workshop was convened in 2019 to update the Guidelines for Use of Fluorides in Australia.

Keywords: Australia, fluoride, guidelines.

(Accepted for publication 18 December 2019.)

INTRODUCTION

Poor oral health is a major health issue. Oral conditions affect 3.9 billion people worldwide, with untreated decay in permanent teeth the most prevalent condition globally.¹ Dental caries is the most prevalent oral disease in Australian children² and Australian adults.³ Dental caries has significant negative impact on health, development, behaviours and quality of life of the affected individuals and their surroundings, as well as economic cost on the society.⁴ Consistent with widespread dental problems, dental health expenditure in Australia is large, amounting to \$10.15 billion in 2016–17.⁵

While sugar consumption and dental plaque remain as key aetiological factors for dental caries, the use of fluorides has been the cornerstone of caries prevention. Research has led to the development of two central preventive programmes involving water fluoridation and use of fluoridated toothpaste.^{6,7} Water fluoridation (WF) is recognized as one of the most effective public health interventions.⁸ The efficacy of fluoridated toothpaste is well established, and while it is an individual behaviour, toothbrushing with a fluoridated toothpaste is widespread across the population.²

Development of the National Guidelines on fluoride use

In October 2005, ARCPOH hosted a workshop on the Use of Fluorides in Australia.⁹ The workshop aimed to update information on the nature and distribution of dental caries and fluorosis; to update information on the nature and use (or exposure) to fluorides; to consider the trade-off of the benefit of caries prevention versus the risk of dental fluorosis; to review the evidence of the efficacy/effectiveness of a range of individual fluorides in caries prevention and their risks for creation of dental fluorosis; and to develop guidelines for the use of fluorides in Australia. A second workshop was held in Adelaide in August 2012 to review those guidelines using critical reviews of the latest national and international evidence.¹⁰ In these 2012 fluoride guidelines for Australia, a total of 10 recommendations from the 2005 workshop remained unchanged as no new evidence was available to warrant amendment, and six recommendations were amended.

A third workshop on ‘The use of Fluorides in Australia’ was held in February 2019 in Adelaide, attended by 60 academic and dental health professional experts. The workshop was moderated by Professor Murray Thomson of the University of Otago. In this workshop, presentations were held on the themes of oral disease, effects of fluoridation on dental and human health, and the use of discretionary and professionally applied fluorides. This update of the fluoride guidelines reflects the presentations and consensus discussion from that workshop.

[Correction added on 4 January 2020, after first online publication: Australian Research Centre for Population Oral Health has been added in the author byline.]

Recent evidence: oral diseases in Australia: dental caries and dental fluorosis

Dental caries in children

Dental caries, the primary target condition of any dental programme using fluorides, is one of the most prevalent and important chronic conditions in children. Dental caries is a serious public health problem in both developing and industrialized countries.⁴

In the 2012–14 National Child Oral Health Survey, over 40% of children aged 5–10 years had caries in their primary teeth with a mean decayed, missing or filled teeth (dmft) of 1.5.¹¹ Over a quarter of 5- to 10-year-old children had untreated dental caries in their primary dentition. Just under one-quarter of children aged 6–14 years had experienced caries in their permanent teeth with a mean decayed, missing or filled permanent teeth (DMFT) of 0.5. Furthermore, over one in ten with untreated dental caries in their permanent teeth.

While there has been a substantial improvement in children caries experience across the years since World War II, changes in the last two decades have been more subtle. There have been small improvements in dental caries experience in the primary dentition of the children during the 1990s and 2000s. During the same period, dental caries experience in the permanent dentition has improved a little more (Do and Spencer 2016). Many children have no or minimal caries experience, but a small proportion still experience elevated levels of caries. Some 20% of children aged 5–10 years carried over 80% of the total population burden of dental caries in the primary dentition. Likewise, some 17% of children aged 11–14 years carried 80% of the total population burden of dental caries in the permanent dentition (Ha et al. 2016).

There are strong geographical variations in child dental caries experience in Australia. Children in Queensland, mostly non-fluoridated until the late 2000s, and in the Northern Territory, with a high proportion of Indigenous children, consistently had higher prevalence and severity of dental caries than the national averages.

Hence, there is a need to maintain the vastly lowered caries experience for most of the child population, and to intervene among individuals or groups of children with higher prevalence and severity of dental caries to further improve child dental health in Australia.

Dental caries in adults

Dental caries affects a large majority of Australian adults.³ Dental caries experience is strongly age-related. Some three quarters of young adults aged 15–34 years had caries, whereas almost all adults of older ages had

dental caries experience. People aged 15–34 years had on average 4.5 teeth affected by caries, but those 55+ years, born before the commencement of fluoride use in Australia had more than 20 teeth affected.

Dental fluorosis

Australia's approach to the use of fluorides has given primacy to achieve a near maximal reduction in dental caries without an unacceptable level of dental fluorosis. Nearly 90% of Australians live in areas with fluoridated drinking water. In addition, most Australian children and adults brush with a fluoridated toothpaste. Water fluoridation, toothpaste use and other fluoride sources are associated with an increase in the prevalence of any fluorosis.^{12–15} Measures aiming at reducing exposure to discretionary fluorides from the early 1990s have resulted in significant reduction in the prevalence and severity of dental fluorosis in both fluoridated and non-fluoridated areas in WA¹⁶ and SA.¹⁷ Very few children were found with mild or more severe fluorosis. Similar findings were reported in a large population-based survey in NSW in 2007.¹⁸

The National Child Oral Health Study 2012–14 provided the first ever national snapshot of the prevalence and severity of dental fluorosis in Australian children. Any level of fluorosis experience (a Thylstrup and Fejerskov (TF) score of 1+) was found in one in six Australian children. However, just under 1% of children had more definitive dental fluorosis (having a TF 3+ score). Very few children were observed with moderate to severe dental fluorosis (TF scores of 4 or 5).

Research on the natural history of dental fluorosis and its long-term impact has indicated that very mild to mild fluorosis as observed in Australian children diminished over time (Do et al 2016). Dental fluorosis was not found to have long-term negative impacts on oral health-related quality of life.

Recent evidence: update on nutrient reference values for fluorides

Nutrient reference values (NRVs) might be established to represent an estimated average requirement (EAR) or an adequate intake (AI) intended to cover average nutrient requirements and/or an upper level (UL) of intake, above which the risk of adverse effects increases. In 2007 an AI and UL were established for fluoride. In 2017, the National Health and Medical Research Council (NHMRC) revised the UL for fluoride for infants and young children up to 8 years of age.¹⁹

Two biomarkers were selected for the evidence review for infants and young children; dental caries and dental fluorosis, as measured by the dmf/DMF index and Dean's index respectively. Eight critical reports were identified (1997–2010); a database

search of 977 papers revealed further information from three studies that met the search criteria (GRADE assessment).²⁰ The critical reports all referred to the Dean studies in US cities during 1936–42 linking dental health and natural fluoride levels in water supplies. An Expert Working Group concluded there were no better data to use as a basis for establishing fluoride NRVs, as contemporary population studies were confounded by fluoridated toothpastes and/or products containing fluoride.

The AI is based on a mean fluoride intake from the diet (including drinking water with NHMRC Drinking Water Guideline of 1.0 mg F/L) that effectively minimizes dental caries. The previous AI (0.05 mg/kg body weight (bw)/day) for infants and children up to 8-year-old age group was maintained. A change was made in 2017 in that the AI is not considered applicable to infants aged 0–6 months, as breast feeding is assumed for most infants. A new UL of 0.2 mg/kg bw/day, which minimizes dental fluorosis of concern, was based on the 95th percentile of fluoride dietary intake assuming fluoridation of water at 1.9 mg/L. Estimated fluoride intakes from all sources (i.e. diet including water and other beverages, fluoridated toothpaste and/or supplements) in Australia and New Zealand for infants and children up to 8 years old were distributed around the AI but less than this new UL. This supports the continued use of fluorides in Australia including the fluoride level for drinking water and widespread use of low fluoride toothpaste from the age of 18 months and regular toothpaste from 6 years.

THE NATIONAL GUIDELINES ON FLUORIDE USE 2019

A. Community water fluoridation

Community water fluoridation has been the cornerstone of efforts to prevent caries in Australia since the 1970s. This position has been underpinned by population oral health research and reaffirmed across several generations of NHMRC reviews including reviews in 1991 and 2007. Previous iterations of these guidelines have had access to these reviews and contemporary research in arriving at its position on community water fluoridation.^{9,10} This iteration of the guidelines again had access to the most recent NHMRC review and even more recent contemporary research.

Effectiveness of water fluoridation

In 2017, the NHMRC carried out an extensive review of the evidence on the effectiveness and safety of community water fluoridation.¹⁵ In assessing the evidence on water fluoridation and caries, the York Review⁶ and an update carried out by NHMRC in 2007²¹

were used as a background. NHMRC then considered the Cochrane Review of the Effectiveness of Water Fluoridation.²² Some shortcomings of the Cochrane Review were noted.²³ Most prominent of these was the restriction of the included evidence to before and after non-randomized controlled studies. This had the effect of limiting the evidence to studies predominantly carried out prior to 1975.

NHMRC set about collecting further evidence. Evidence on water fluoridation and dental caries was collected through a review of reviews which included a wider range of study designs and the collection of primary studies published after those reviews across the period 2012–15, with an emphasis on Australian research. The 2017 NHMRC Review found consistent evidence that water fluoridation at current Australian levels is associated with decreased prevalence and severity of tooth decay in children and adults.

Research published post 2015 from Australia's National Child Oral Health Study (NCOHS)^{24,25} and the National Survey of Adult Oral Health (NSAOH)²⁶ extended evidence available on the effectiveness of water fluoridation in reducing dental caries.

Two recent studies among specific subpopulations also added support to the benefits of community water fluoridation. These were carried out in NSW and in a remote Indigenous community in far north Queensland.^{27,28}

Safety of water fluoridation

The NHMRC Review searched the post-2006 literature for evidence of possible harmful effects of water fluoridation on human health.¹⁵ The NHMRC Review concluded that water fluoridation at current Australian levels is not associated with cognitive dysfunction, lowered IQ, cancer, hip fracture and Down syndrome. There was no reliable evidence of an association between water fluoridation at current Australian levels and other human health outcomes.

The evidence reviewed by the UK York Review⁶ and the Cochrane Review²² confirmed the dose–response relationship between fluoride levels occurring naturally in drinking water and dental fluorosis. However, most of the studies behind this association were from countries where the levels of naturally occurring fluoride in water supplies are up to five times greater than levels used in Australia for water fluoridation. There have also been concerns over confounding by the exposure to other fluorides and the threshold for dental fluorosis of aesthetic concern. Therefore, other literature, predominantly from Australian studies were also considered by the NHMRC Review.¹⁵ In Australia, dental fluorosis has declined over a time when the extent of fluoridation in Australia has expanded. Most of the dental fluorosis in Australia is very mild

or mild. Research suggests that this level of dental fluorosis is not of aesthetic concern to affected children and adolescents or their parents. Moderate dental fluorosis is uncommon and severe dental fluorosis is rare in Australia.

The prevalence of fluorosis in Australia was well below that documented in the USA which led to the reduction in the US recommended level of fluoride in drinking water to 0.7 mg F/L in draft form in 2011²⁹ and formally in 2015.³⁰ Furthermore, the prevalence of fluorosis of concern in Australia, either from an aesthetic perspective alone or from a community perspective on the impact of both caries and fluorosis through ratings of oral health, was low.^{2,31} The US recommendation was considered for the revision of the Use of Fluorides in Australia guidelines in 2012 and no change was made in the fluoride level in drinking water for fluoridation as practised in Australia. This was rationalized on the basis of Australia's success in maintaining caries prevention in children while simultaneously reducing the prevalence and severity of dental fluorosis since the early 1990s through a range of measures targeting critical exposures in early childhood from the use of fluoridated toothpaste and other discretionary fluorides.^{16,17,32}

Impact on social and racial inequalities in childhood caries

The NHMRC Review 2007²¹ noted commentary evidence that water fluoridation reduces the inequalities between socioeconomic groups. However, a lack of high-quality, relevant evidence was also noted. The York review, in England, reported '*some evidence that water fluoridation reduces the inequalities in dental health across social classes in 5- to 12-year olds*'.⁶ A Cochrane review reported '*insufficient evidence to determine whether WF results in a change in disparities in caries across levels of SES*'.²² The recent NHMRC Review found additional evidence suggesting that WF reduces decay for lower socioeconomic groups and regional areas.¹⁵ However, evidence was limited, with studies of low quality.

Race- and income-related inequalities in oral health in Australian children by fluoridation were examined recently using national data.³³ Caries was socially patterned, both by race and income. Water fluoridation was associated with lower caries experience in nearly all race and income stratifications of this population-based study. Indexes of inequality indicated that caries experience was concentrated among lower income groups. Absolute inequalities were consistently lower in fluoridated than non-fluoridated areas. Income-related inequality in caries was also lower in fluoridated than in non-fluoridated areas for both Indigenous and non-Indigenous children.

A secondary analysis of a nation-wide longitudinal birth cohort study of Australian children also contributed evidence of impact of water fluoridation on socioeconomic inequalities in child oral health.³⁴

The 2019 Guidelines on water fluoridation

Therefore, the Workshop supported the continuation of water fluoridation at current Australian levels and recommended:

- (1) Water fluoridation should be continued as an effective, efficient, socially equitable and safe population approach to the prevention of caries in Australia.
- (2) Water fluoridation should be extended to as many non-fluoridated areas of Australia as possible, supported by all levels of Government.
- (3) The level of fluoride in the water supply should be within the range 0.6–1.1 mg/L.
- (4) For people who choose to consume bottled or filtered water containing fluoride, manufacturers should be encouraged to market bottled water containing approximately 1.0 mg/L fluoride and water filters that do not remove fluoride. All bottled water and water filters should be clearly labelled to indicate the concentration of fluoride in water consumed or resulting from the use of such products.
- (5) People in non-fluoridated areas should obtain the benefits of fluoride in drinking water using bottled water with fluoride at approximately 1 mg/L.

Note to Recommendation # 3: Individual states and territories have set targets and tolerances for fluoride in their water supplies with all being within the range 0.6–1.1 mg/L.

B. Self-use fluoride products – fluoridated toothpaste

Toothpaste for children and adults

The use of fluoridated toothpaste by children under the age of 6 years has been the focus of guidelines in Australia since 1993. Two strands of action have been pursued: changed practices by children and their parents in the use of fluoridated toothpaste (age of commencement, amount of toothpaste applied to a brush, the size of the working head of the brush, spitting out toothpaste foam and not rinsing, and not eating or licking toothpaste directly from the toothpaste tube)^{16,17}; and the availability and recommended use of a low fluoride children's toothpaste. The reported behaviour of children in toothbrushing indicates that most brush in line with guidelines, apart from about one-third of children commencing brushing with fluoridated

toothpaste before the recommended age of 18 months. Market leaders in toothpaste products have also supplied low fluoride children's toothpaste with appropriate labelling on use, something for which they are commended.

The topic of what the concentration of fluoride should be in children's toothpaste has been visited several times in Australia. In 2012 further consideration was stimulated by the availability of two Cochrane systematic reviews of the efficacy of fluoridated toothpaste of different fluoride concentrations.^{35,36} The reviews examined efficacy in caries prevention in children by fluoride dose in toothpaste. Most available evidence was on the immature permanent dentition which is erupting from age 6 years. Only four studies were available on the primary dentition. The effect of low fluoride toothpaste compared to a placebo³⁵ on the primary dentition was limited to one trial in children aged 6–9 years. This age range of participants raises the issue of relevancy. Head-to-head comparisons between active interventions were limited to three interventions in children with a primary dentition up to the age of 5 years old with mixed results.³⁶ Two of these studies reported non-significant differences in caries outcomes by fluoride concentration. This evidence was considered equivocal at the 2012 Workshop.¹⁰ Further evidence has become available after the Workshop³⁷ and is discussed in Appendix S2, Addendum # 1.

Evidence of clinical trials assessed in these Cochrane Reviews was therefore in line with the population level evidence, particularly that from Australian research. This includes the lack of significant change in caries in young children after the introduction of low fluoride children's toothpaste and other alterations to toothbrushing behaviour in Western Australia¹⁶ and in South Australia.^{12,17}

Toothpastes – older adults

As Australia's population ages, there is an increasing necessity to ensure that the prevention of the major oral diseases affecting older Australians is evidence-based, relevant and accessible to all. The home use of toothpastes by adult Australians is pervasive, with most older Australians using the standard products available which contain 1–1.45 mg/g fluoride (or 1000–1450 ppm). For older Australians with a high risk of root caries (as well as coronal caries) toothpastes containing up to 5 mg/g fluoride (or 5000 ppm) have been available for use.

The international evidence for adult use of 1.5 mg/g fluoride (or 1500 ppm) toothpaste is supportive of the benefits to adults and older persons, but care should be taken in the interpretation of the effectiveness and efficiency given the variability in populations and the

scarcity of dedicated, longitudinal clinical trials specifically controlling for enumerable confounding factors. Evidence for the use of 5 mg/g fluoride (5000 ppm) toothpaste, specifically in populations at high risk is more compelling and could guide good practice in most situations specific to older dentitions at elevated risk to caries.^{38,39} Allied health practitioners, registered or enrolled nurses and Indigenous health workers who have been trained and are competent might be engaged in the provision of toothbrushing and toothpaste advice to individuals and groups of older Australians.

The 2019 Guidelines on fluoridated toothpaste

- (6) From the time that teeth first erupt (about six months of age) to the age of 17 months, children's teeth should be cleaned by a responsible adult, but not with toothpaste.
- (7) For children aged from 18 months to five years (inclusive), the teeth should be cleaned twice a day with toothpaste containing 0.5–0.55 mg/g fluoride (500–550 ppm). Toothpaste should always be used under the supervision of a responsible adult. A small pea-sized amount should be applied to a child-sized soft toothbrush and children should spit out, not swallow, and not rinse. Young children should not be permitted to lick or eat toothpaste. Standard toothpaste is not recommended for children under 6 years of age unless on the advice of a dental professional or a trained health professional.
- (8) For people aged 6 years or more, the teeth should be cleaned twice a day or more frequently with standard fluoride toothpaste containing 1–1.5 mg/g fluoride (1000–1500 ppm). People aged 6 years or more should spit out, not swallow, and not rinse.
- (9) For people who do not consume fluoridated water or who are at elevated risk of developing caries for any other reason, guidelines about toothpaste usage should be varied, as needed, based on dental professional or trained health professional advice. Variations could include more frequent use of fluoridated toothpaste, commencement of toothpaste use at a younger age, or earlier commencement of the use of standard toothpaste. This guideline might be applied particularly to preschool children at elevated risk of caries.
- (10) For teenagers, adults and older adults who are at elevated risk of developing caries, dental professional or trained health professional advice should be sought to determine if they should use toothpaste containing a higher concentration (5 mg/g or 5000 ppm) of fluoride.

C. Self-use fluoride products – fluoride supplements

There has been no updated evidence on the effectiveness and safety of fluoride supplements since the last Workshop.

The 2019 Guidelines on fluoride supplements

- (11) Fluoride supplements in the form of drops or tablets to be chewed and/or swallowed, should not be used.

D. Self-use fluoride products – fluoride mouth rinses

A minority of mouth rinse products purchased by Australian consumers contain fluoride ion at the recommended concentration of 200–900 mg/L for daily and weekly use respectively. Some overseas research has examined daily or weekly supervised fluoride mouth rinse programmes as a strategy for subpopulations such as school children. However, no such programmes are being pursued in Australia. Instead, fluoride mouth rinses offer an additional fluoride vehicle for individuals with elevated risk of caries. Population data reveal that the use of fluoride mouth rinse increases among adolescents (Do and Spencer 2016). This suggests that it might represent an appealing additional source of fluoride among adolescents deemed to be at elevated risk of developing caries. However, it would be important to ensure that any such use of mouth rinse would not substitute for toothbrushing with fluoridated toothpaste. Children aged less than 6 years should not use fluoride mouth rinses because of the probability of its ingestion and risk of dental fluorosis.

The 2019 Guideline on fluoride mouth rinses

- (12) Children below the age of 6 years should not use fluoride mouth rinse.
- (13) Fluoride mouth rinse might be used by people aged 6 years or more who have an elevated risk of developing caries. Fluoride mouth rinse should be used at a time of day when toothpaste is not used, and it should not be a substitute for brushing with fluoridated toothpaste. After rinsing, mouth rinse should be spat out, not swallowed.

E. Professionally applied fluoride products

Fluoride varnishes

Fluoride varnish contains 22.6 mg/mL fluoride ion suspended in an alcohol and resin base. The most common product available in Australia is *Duraphat*. It is applied by dental and other health professionals directly to

dried teeth where it forms a waxy film that adheres to the teeth until it is worn off by chewing or brushing. There are other fluoride-containing varnish products on market today, with varying compositions and delivery systems. However, most are registered for use with dentine hypersensitivity not for the prevention of caries.

Fluoride varnish is effective in reducing caries in young children, adolescents and adults; for the prevention of coronal caries on all surfaces of the teeth; and for the prevention of root caries.⁴⁰ Their application up to four times a year has not been linked to an increased risk of dental fluorosis.⁴¹

There are provisions in place in most Australian jurisdictions for application of topical fluoride varnish by non-dental professionals.⁴² This broadens the opportunity for their use. Dental assistants with appropriate training might be involved in applying fluoride varnish. Other non-dental professionals who might be involved are usually registered or enrolled nurses, rural/remote health workers or Aboriginal health workers who have undergone specific training overseen by dental professionals. There is also scope for non-dental professionals' use of fluoride varnish to be included in the remit of residential-aged care workers and others who work with vulnerable populations.

The 2019 Guideline on fluoride varnishes

- (14) Fluoride varnish should be used for people who have an elevated risk of developing caries, including children under the age of 10 years.

Fluoride gel and foam

Fluoride gels contain a high concentration of fluoride, typically up to 12.3 mg/g fluoride. They are applied by dental professionals using trays that retain the material on the teeth for several minutes. After removal of trays, patients must spit out the residual gel. There is evidence of their effectiveness in children, however, they are contra-indicated for use in children under the age of 10 because large amounts of fluoride can be ingested. Furthermore, fluoride gels appear more efficacious in the permanent dentition.^{43,44} The reviews found no evidence that the effect was dependent on frequency of applications. Like all forms of professionally provided fluoride, gels offer an alternative vehicle for caries prevention for individuals deemed to be at an elevated risk and in whom other fluoride modalities are not available or suitable.

There is no evidence to support the use of foam.⁴⁵

The 2019 Guideline on fluoride gel

- (15) High concentration fluoride gels (those containing more than 1.5 mg/g fluoride ion) might be

used for people aged 10 years or more who are at an elevated risk of developing caries.

Silver diamine fluoride

Since its development in the late 1960s silver diamine fluoride (SDF) has been used widely in several countries. The US Food and Drug Administration (FDA) granted its breakthrough therapy designation to silver diamine fluoride 38% for the use in arresting dental caries in children and adults in 2016. In Australia, SDF is approved by the Therapeutics Goods Administration (TGA) to treat dentinal hypersensitivity.

Studies have tested SDF, using different concentrations and varying application regimes.^{46,47} There has been a resurgence of interest since its large-scale use, in the form of silver fluoride (SF), in public dental service for children in Australia in the 1980s. The findings to date suggest that the application of 38% SDF twice yearly is effective in arresting active carious lesions in primary teeth and root caries in permanent teeth among the elderly, and its major side effect is the black staining of the carious lesion. SF has been found comparable to atraumatic restorations with GIC in very remote Indigenous children.⁴⁸ Its use might be indicated in situations where traditional treatment approaches to caries management might not be possible due to behavioural or medical management challenges, or where access to care is difficult or not available.

The 2019 Guideline on silver diamine fluoride

(16) Silver diamine fluoride or silver fluoride might be used for people with caries in situations where traditional treatment approaches to caries management might not be possible.

F. Monitoring and developing caries prevention strategies in the population

The use of fluoride for promoting oral health has always involved a balance between the protective benefit against caries and the risk of developing fluorosis when used in young children. Monitoring fluoride exposure in childhood continues to be important in preserving the effectiveness of fluorides in caries prevention while limiting the risk of fluorosis. Appropriate guidelines that are based on evaluation of risk and benefit of each component of fluoride use can lead to a more beneficial outcome.

There will be a continuing need to review and revise guidelines for the best strategies to prevent dental caries. As noted earlier in the review of several fluoride vehicles, modifications of the existing guidelines become necessary for reasons including new evidence

from clinical trials, changing patterns of behaviour that alter the nature and amount of exposure to fluoride, and emergence of new evidence about the epidemiology of caries and fluorosis. In anticipation of the need for future revisions to these guidelines, it will be important, as in the present instance, to strengthen the evidence-base about individual fluoride vehicles, dental clinical practice, population exposures and the distribution of oral conditions, particularly the prevalence of caries and fluorosis and the psychosocial impact of both conditions.

Concurrently, it is important to identify and evaluate all preventive strategies, including caries-preventive agents that are not based on fluoride, such as calcium-phosphate caries preventive agents, xylitol and chlorhexidine. Dental professionals, their patients and the community need to be informed about the potential advantages and disadvantages of new interventions, and whether those new interventions should be used in addition to, or as a substitute for, existing preventive interventions. Interventions that appear promising need to be subjected to clinical trials among the target populations in whom they would be intended for use. Any new preventive agents should be adopted only if they are shown to be at least as effective as existing preventive strategies. It is not enough to adopt interventions merely because they appear promising, even if they are known to cause no harm, because their use might forego opportunities to provide other care that is effective. After the adoption of efficacious interventions in clinical practice or public health settings, their community effectiveness should be monitored through population-based studies.

Therefore,

- (17) There is a need to support further studies that examine the impact of fluoride vehicles in the Australian population including: studies of the epidemiology of dental caries and dental fluorosis; investigations of the impact of both conditions on people's well-being and quality of life; risk factors for dental caries and dental fluorosis; the use of fluoride vehicles in dental practice and the population; and the efficacy, effectiveness and cost effectiveness of fluoride vehicles.
- (18) Research is needed to develop new preventive interventions including new vehicles for fluoride delivery as well as other preventive strategies that are not based on fluoride. New interventions should be judged for their equivalency or superiority to existing preventive approaches that have documented efficacy.

Note to Recommendation # 18: Further discussion is provided in Appendix S2, Addendum # 2.

Note: All Recommendations are listed in Appendix S1.

ACKNOWLEDGEMENTS

The research was supported by National Oral Health Promotion Clearinghouse, Australian Research Centre for Population Oral Health, Australian Dental Association, Australian Dental and Oral Health Therapists' Association, Dental Hygienists Association of Australia (DHAA Ltd) and Colgate Oral Care. J Aldis, J Miller, AJ Spencer, LG Do and D Brennan organized the Workshop. Presenters reviewed and presented evidence of specific topics for discussion. WM Thomson moderated the discussion. LG Do and AJ Spencer prepared the Guidelines document. Attendees provided feedback and approved the final document.

DISCLAIMER

These guidelines reflect the consensus view of the 60 attendees at the workshop, drawn from all states and territories and representing academics from Australian dental schools, jurisdictional health authorities and peak organizations in dentistry. While the guidelines reflect the views of those attending the workshop, they might not reflect the views of the organizations with which those attendees are affiliated.

Moderator

W. Murray Thomson.

Presenters

Peter Arrow, Janis Baines, David Brennan, Susan Cartwright, Cathy Connor, Stuart Dashper, Loc G Do, Michael Foley, Diep H Ha, Jane Harford, Lisa Jamieson, Utz Mueller, Woosung Sohn, A. John Spencer, Kaye Roberts-Thomson, Frederick Wright.

Attendees

Jacqueline Aldis, Sandra Anderson, Derek Bazen, Linda Bertram-Takacs, Bijun Cai, Lyn Carman, Mikaela Chinotti, Sergio Chrisopoulos, Deborah Cole, Yvonne Dimitropoulos, Ian Epondulan, Catherine Feeney, Mario Ferrari, Ashlea Furlan, Martin Hall, Chris Handbury, Kelly Hennessy, Matthew Hopcraft, Eithne Irving, Kostas Kapellas, Jeroen Kroon, Yvonne Lai, Dianne Lantry, Adrienne Lewis, Liana Luzzi, Rahul Nair, Stuart Marshall, Angela Masoe, Jenny McKibben, Jennifer Miller, Paula Moynihan, Carol Nevin, Kristy Nixon, Peter Osborne, Mark Penrose, Melissa Plath, Anil Raichur, Sarah Raphael, Tanya Schinkevitch, Susanne Sofronoff, John Skinner, Youngha Song, Nicole Stormon, and Karen Smart.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. The 2019 National Guidelines for fluoride use.

Appendix S2. Addenda to the discussion.

REFERENCES

1. Marcenes W, Kassebaum NJ, Bernabe E, *et al.* Global burden of oral conditions in 1990–2010: a systematic analysis. *J Dent Res* 2013;92:592–597.
2. Do L, Spencer A. Oral health of Australian children. The National Child Oral Health Study 2012–14. Adelaide: University Press, 2016.
3. Slade G, Spencer A, Roberts-Thomson K. Australia's dental generations: the National Survey of Adult Oral Health 2004–06. Vol. AIHW cat. no. DEN 165. Canberra: Australian Institute of Health and Welfare, 2007.
4. Casamassimo PS, Thikkurissy S, Edelstein BL, Maiorini E. Beyond the DMFT: the human and economic cost of early childhood caries. *J Am Dent Assoc* 2009;140:650–657.
5. AIHW. Health expenditure Australia 2016–17. in Health and welfare expenditure series no. 64. Cat. no. HWE 74. Canberra: Australian Institute of Health and Welfare Canberra, 2018.
6. McDonagh MS, Whiting PF, Wilson PM, *et al.* Systematic review of water fluoridation. *BMJ* 2000;321:855–859.
7. NHMRC. Review of water fluoridation and fluoride intake from discretionary fluoride supplements. Melbourne: National Health and Research Council, 1999.
8. CDC. Recommendations for using fluoride to prevent and control dental caries in the United States. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2001.
9. ARCPOH. The use of fluorides in Australia: guidelines. *Aust Dent J* 2006;51:195–199.
10. ARCPOH. Fluoride Review Guidelines 2012. Adelaide: Australian Research Centre for Population Oral Health, 2012.
11. Ha DH, Roberts-Thomson KF, Peres KG, Arrow P, Do LG. Oral health status of Australian children. In: Do LG, Spencer AJ, eds. Oral health of Australian children: the National Child Oral Health Survey 2012–14. Adelaide: University Press, 2016;86–152.
12. Do LG, Spencer AJ. Risk-benefit balance in the use of fluoride among young children. *J Dent Res* 2007;86:723–728.
13. Fejerskov O, Manji F, Baelum V. Dental fluorosis: a handbook for health workers, Vol. 123. Copenhagen: Munksgaard, 1988.
14. Levy SM. An update on fluorides and fluorosis. *J Can Dent Assoc* 2003;69:286–91.
15. NHMRC. Information paper – water fluoridation: dental and other human health outcomes. Canberra: National Health and Medical Research Council, 2017.
16. Riordan PJ. Dental fluorosis decline after changes to supplement and toothpaste regimens. *Community Dent Oral Epidemiol* 2002;30:233–40.
17. Do LG, Spencer AJ. Decline in the prevalence of dental fluorosis among South Australian children. *Community Dent Oral Epidemiol* 2007;35:282–291.
18. Do LG, Miller J, Phelan C, Sivanewaran S, Spencer AJ, Wright C. Dental caries and fluorosis experience of 8–12-year-old children by early-life exposure to fluoride. *Community Dent Oral Epidemiol* 2014;42:553–562.

19. NRV. Australian and New Zealand Nutrient Reference Values for Fluoride. A report prepared for the Australian Government Department of Health and the New Zealand Ministry of Health. Canberra: The Australian Government Department of Health and the New Zealand Ministry of Health, 2017.
20. Spencer AJ, Do LG, Mueller U, Baines J, Foley M, Peres MA. Understanding optimum fluoride intake from population-level evidence. *Adv Dent Res* 2018;29:144–156.
21. NHMRC. A systematic review of the efficacy and safety of fluoridation. Canberra: National Health and Research Council, 2007.
22. Iheozor-Ejiogor Z, Worthington HV, Walsh T, *et al.* Water fluoridation for the prevention of dental caries. *Cochrane Database Syst Rev* 2015;(6):CD010856.
23. Rugg-Gunn AJ, Spencer AJ, Whelton HP, *et al.* Critique of the review of 'Water fluoridation for the prevention of dental caries' published by the Cochrane Collaboration in 2015. *Br Dent J* 2016;220:335–340.
24. Ha DH, Spencer AJ, Peres KG, Rugg-Gunn AJ, Scott JA, Do LG. Fluoridated water modifies the effect of breastfeeding on dental caries. *J Dent Res* 2019;98:755–762.
25. Spencer AJ, Do LG, Ha DH. Contemporary evidence on the effectiveness of water fluoridation in the prevention of childhood caries. *Community Dent Oral Epidemiol* 2018;46:407–415.
26. Do L, Ha D, Peres MA, Skinner J, Byun R, Spencer AJ. Effectiveness of water fluoridation in the prevention of dental caries across adult age groups. *Community Dent Oral Epidemiol* 2017;45:225–232.
27. Blinkhorn AS, Byun R, Mehta P, Kay M. A 4-year assessment of a new water-fluoridation scheme in New South Wales, Australia. *Int Dent J* 2015;65:156–63.
28. Kroon J, Laloo R, Tadakamadla SK, Johnson NW. Dental caries experience in children of a remote Australian Indigenous community following passive and active preventive interventions. *Community Dent Oral Epidemiol* 2019;47:470–476.
29. HHS. *Proposed HHS recommendation for fluoride concentration in drinking water for the prevention of dental caries. The Federal Register, 01/13/2011.* 2011, US Department of Health and Human Services. Available at: <https://www.federalregister.gov/articles/2011/01/13/2011-637>. Accessed 8 December 2013.
30. HHS. U.S. Public Health Service recommendation for fluoride concentration in drinking water for the prevention of dental caries. *Public Health Rep* 2015;130:318–331.
31. Do LG, Ha DH, Spencer AJ. Natural history and long-term impact of dental fluorosis: a prospective cohort study. *Med J Aust* 2016;204:25.
32. Spencer AJ, Do LG. Changing risk factors for fluorosis among South Australian children. *Community Dent Oral Epidemiol* 2008;36:210–8.
33. Do LG, Ha DH, Roberts-Thomson KF, Jamieson L, Peres MA, Spencer AJ. Race- and income-related inequalities in oral health in Australian children by fluoridation status. *JDR Clin Trans Res* 2018;3:170–179.
34. Goldfeld S, Francis KL, Hoq M, Do L, O'Connor E, Mensah F. The impact of policy modifiable factors on inequalities in rates of child dental caries in Australia. *Int J Environ Res Public Health* 2019;16:1970.
35. Marinho VC. Cochrane reviews of randomized trials of fluoride therapies for preventing dental caries. *Eur Arch Paediatr Dent* 2009;10:183–191.
36. Walsh T, Worthington HV, Glenny AM, Appelbe P, Marinho VC, Shi X. Fluoride toothpastes of different concentrations for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2010;(1):CD007868.
37. Walsh T, Worthington HV, Glenny AM, Marinho VC, Jeronic A. Fluoride toothpastes of different concentrations for preventing dental caries. *Cochrane Database Syst Rev* 2019;(3):CD007868.
38. Ekstrand KR. High fluoride dentifrices for elderly and vulnerable adults: does it work and if so, then why? *Caries Res* 2016;50(Suppl 1):15–21.
39. Ekstrand KR, Poulsen JE, Hede B, Twetman S, Qvist V, Ellwood RP. A randomized clinical trial of the anti-caries efficacy of 5,000 compared to 1,450 ppm fluoridated toothpaste on root caries lesions in elderly disabled nursing home residents. *Caries Res* 2013;47:391–398.
40. Marinho VC, Worthington HV, Walsh T, Clarkson JE. Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2013;(7):CD002279.
41. Garcia RI, Gregorich SE, Ramos-Gomez F, *et al.* Absence of fluoride varnish-related adverse events in caries prevention trials in young children, United States. *Prev Chronic Dis* 2017;14:E17.
42. Tellez M, Wolff MS. The public health reach of high fluoride vehicles: examples of innovative approaches. *Caries Res* 2016;50(Suppl 1):61–67.
43. Marinho VC, Worthington HV, Walsh T, Chong LY. Fluoride gels for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2015;(6):CD002280.
44. Twetman S, Keller MK. Fluoride rinses, gels and foams: an update of controlled clinical trials. *Caries Res* 2016;50(Suppl 1):38–44.
45. Weyant RJ, Tracy SL, Anselmo TT, *et al.* Topical fluoride for caries prevention: executive summary of the updated clinical recommendations and supporting systematic review. *J Am Dent Assoc* 2013;144:1279–91.
46. Rosenblatt A, Stamford TC, Niederman R. Silver diamine fluoride: a caries "silver-fluoride bullet". *J Dent Res* 2009;88:116–125.
47. Horst JA. Silver fluoride as a treatment for dental caries. *Adv Dent Res* 2018;29:135–140.
48. Roberts-Thomson KF, Ha DH, Wooley S, Meihubers S, Do LG. Community trial of silver fluoride treatment for deciduous dentition caries in remote Indigenous communities. *Aust Dent J* 2019;64:175–180.

Address for correspondence:

Professor Loc G. Do

ARCPOH, Adelaide Dental School, The University of

Adelaide, Adelaide, Australia

Email: loc.do@adelaide.edu.au