

Water fluoridation

Information for health professionals



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Fluoridation overview

- Water fluoridation reduces the prevalence of dental caries within the community. Six-year old children living in fluoridated areas of Victoria have up to 36 per cent less caries experience than those in non-fluoridated areas.
- By helping to prevent dental caries, water fluoridation limits associated pain, suffering and economic losses including costs of dental treatment.
- Water fluoridation benefits individuals of all ages, through its effect on developing and erupted teeth.
- Water fluoridation reduces the socioeconomic inequalities in caries experience.
- The beneficial effect of water fluoridation is additional to that of fluoridated toothpaste.
- With the exception of dental fluorosis, scientific studies have not found any links between water fluoridation and adverse effects.
- Maximal dental health benefits are obtained through a combination of water fluoridation, regular tooth brushing, appropriate use of fluoridated toothpaste, healthy diet and regular reviews by a dental professional.

Glossary¹

caries experience	The extent and severity of dental caries within a population. This is usually assessed using indices such as the DMFT (see below).
deciduous teeth	Primary ('first' or 'milk') teeth which begin to erupt at about six months of age and which are finally shed at about 12 years of age.
demineralisation	Reduction of the mineral content (principally calcium and phosphorous) of a tissue, notably the enamel, dentine or cementum of teeth.
dental caries	Disease of the teeth resulting in the demineralisation, cavitation and breakdown of calcified dental tissues (enamel, dentine or cementum) by microbial activity (see Figure 1).
dental decay	See dental caries.
dental fluorosis	A disturbance of tooth enamel formation caused by fluoride being present in the tissue fluids over a prolonged period during tooth development. The disturbance results in the development of porous enamel, which has an altered appearance ranging from the most mild forms, in which small flecks of white discolouration can be observed on the enamel surface, to the most severe forms, in which the enamel develops pitting and brown staining. Other disorders of enamel can be difficult to distinguish from dental fluorosis.

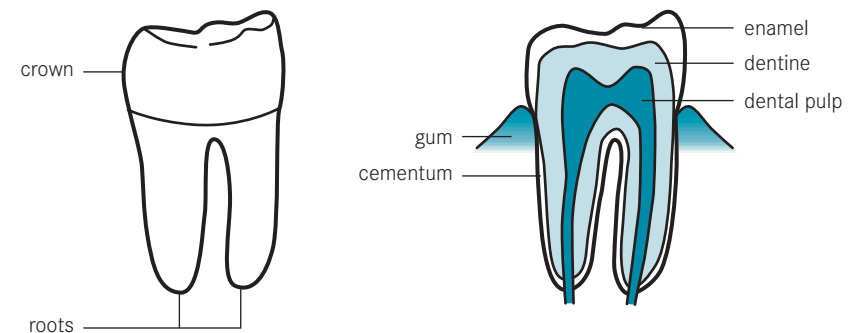


dentine	The calcified tissue surrounding the dental pulp and comprising the bulk of the tooth (see Figure 1).
DMFT, DMFS, dmft, dmfs	Indices describing the dental caries experience of individuals or populations. The DMFT index is calculated by summing the number of permanent teeth that are d ecayed, m issing or f illed. The index ranges from zero to 32, which is the maximum number of teeth that can be affected. The DMFS index is a count of the number of permanent tooth s urfaces that are d ecayed, m issing or f illed. The maximum number of surfaces that can be affected is 148. Upper-case lettering refers to permanent teeth, while lower-case lettering refers to the deciduous dentition.
enamel	The hard white calcified substance that covers the crown of each tooth (see Figure 1).
fluoride supplement	Any form of fluoride used to increase overall levels of fluoride exposure, such as fluoride tablets, drops or gels, fluoridated toothpastes and mouth rinses, and topical applications by a dental professional.
mg/L	Milligrams per litre. A measurement of the concentration of a substance. 1 mg/L = 1 ppm (part per million).
permanent teeth	The second set of teeth, which follows the deciduous teeth, and begins to erupt around six years of age.

prevalence	The number of individual cases of a given disease or other condition in a defined population at a specified point in time.
remineralisation	The process whereby a demineralised or hypomineralised tissue takes up minerals again.
water fluoridation	The adjustment of the natural amount of fluoride in water to a level recommended for optimal dental health benefits. In Victoria the optimal level is around 1 mg/L.

Figure 1: (A) Outside of a molar

(B) Cross-section of a molar



1. Introduction

Fluoride plays a crucial role in the prevention of dental caries. While some water supplies have adequate levels of natural fluoride to help protect against dental caries, most do not. The adjustment of fluoride in community water supplies has long been recognised as an effective method of preventing dental caries² and is a major factor responsible for the decline in the disease during the latter half of the 20th century.³

The overwhelming weight of scientific evidence supports the safety and effectiveness of water fluoridation, and it has been endorsed worldwide by numerous organisations, including the World Health Organization, World Dental Federation, National Health and Medical Research Council, Australian Dental Association, Australian Medical Association and the Public Health Association of Australia.

Within Australia, water fluoridation is the main public health strategy for caries prevention.⁴ More than 75 per cent of Victorians have access to fluoridated drinking water.⁵ Most of these people reside in Melbourne (which has been fluoridated for 30 years), and Bendigo, Shepparton, Echuca, Horsham, Sale, Traralgon, Morwell, Moe and Warragul. People in Wangaratta and Wodonga will have access to fluoridated drinking water supplies in 2007. People living in non-fluoridated rural and regional areas are disadvantaged with respect to their dental health compared with people living in fluoridated areas.⁶

This booklet has been prepared by the Department of Human Services Victoria and aims to present a broad overview of the value of water fluoridation, based on the overall weight of evidence. The information presented here is based largely on conclusions of major reviews commissioned by the National Health and Medical Research Council, and

supplemented by the United Kingdom Department of Health review (the York Review), World Health Organization findings and other sources as referenced. Individual studies are only presented in this booklet for issues not covered by the reviews mentioned above.

1.1 Background to the reviews

The National Health and Medical Research Council established a working group to conduct a review into the safety and effectiveness of water fluoridation, in response to concerns expressed by a small group of professional members of the community. The findings were published in 1991.¹

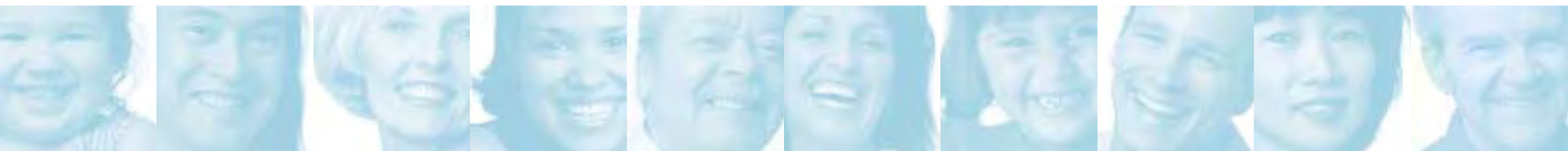
A subsequent review, dated 1999, was commissioned by the National Health and Medical Research Council to evaluate scientific evidence since 1990.⁷

A separate review, the York Review published in 2000, was commissioned by the Chief Medical Officer of the United Kingdom Department of Health, and involved a systematic review of the literature dating back to the 1930s.⁸

The weight of evidence examined in the reviews supports the safety and effectiveness of water fluoridation.

1.2 Interpretation of data

The National Health and Medical Research Council reviews and the York Review all acknowledge the difficulties of interpreting studies involving water fluoridation, including the ecological (population-based) nature of most studies.



2. Fluoride

2.1 Role of fluoride in oral health

- Fluoride helps prevent dental caries.

Fluoride plays a key role in the prevention of dental caries.

Dental caries develops when sugar-containing foods are metabolised by bacteria in the mouth, resulting in acid on the tooth surface. The acid removes calcium, phosphates and carbonates from the tooth enamel into the plaque and saliva surrounding the tooth (see Figure 2).

Figure 2: Comparison of normal teeth and those affected by dental caries



Healthy deciduous teeth



Deciduous teeth with significant caries



Healthy permanent teeth



Permanent anterior teeth with caries

The fluoride in saliva interacts with these minerals and salts at the tooth surface to remineralise the damaged enamel. A constant supply of a low level of fluoride within the saliva is most beneficial for replacement of lost minerals and therefore reduction of dental caries. Fluoride at an optimal level in the water supply provides the ideal, constant 'repair kit' for teeth.⁹

Fluoride helps protect both developing and erupted teeth against caries, and therefore benefits individuals of all ages. The presence of fluoride in the pre-eruptive phase leads to structural improvements that render the tooth more resistant to later acid attack.⁷

In the post-eruptive phase, fluoride⁷:

- promotes remineralisation of enamel lesions before cavities become permanent, through its presence in plaque and saliva
- reduces conversion of sugars into acids by bacteria
- is bacteriocidal in high concentrations, such as topical application by a dental professional.

2.2 Fluoride metabolism and excretion^{10, 11}

Most ingested fluoride is absorbed into the bloodstream, predominantly from the stomach and intestine. Minimal absorption occurs across the oral mucosa. Rapid distribution to the intracellular and extracellular fluid of tissues occurs, and 99 per cent of the total body fluoride content is retained in teeth and bones, where it becomes incorporated into the hydroxyapatite crystal lattice. Elimination from the body is primarily by urinary excretion.

3. Water fluoridation

- Water fluoridation is the adjustment of the natural amount of fluoride in the water supply to a level recommended for optimal dental health benefits.

Fluoride is present in water, plants and animals (and therefore in most foods). It is also present in rocks, soil and air, both naturally and as a result of human practices such as agriculture and industry.⁷

Natural levels of fluoride in water supplies in Australia tend to be lower than the optimal level recommended for the prevention of dental caries.¹² Water fluoridation programs therefore increase water fluoride levels to optimise dental health benefits.

3.1 Geographical overview of water fluoridation

- In Victoria, more than 75 per cent of the population receive fluoridated water.

The first water fluoridation scheme was implemented in the United States in 1945.¹³ Since then, water fluoridation has been endorsed by more than 150 scientific and health organisations worldwide,⁷ including the World Health Organization, World Dental Federation, National Health and Medical Research Council, Australian Dental Association, Australian Medical Association and the Public Health Association of Australia. Many people throughout the world benefit from naturally, or optimally adjusted, fluoridated drinking water supplies.

Australia has more than 50 years' experience with water fluoridation, following the introduction of the first program in 1953 in Beaconsfield, Tasmania.¹⁴ More than two-thirds of Australians have access to fluoridated drinking water,¹⁵ including residents of all capital cities except Brisbane.¹⁶ More than 75 per cent of Victorians receive fluoridated water, or will do so in 2007, with most of these people residing in Melbourne and Bendigo, Shepparton, Echuca, Horsham, Sale, Traralgon, Morwell, Moe and Warragul.⁵ People in Wangaratta and Wodonga will have access to fluoridated drinking water supplies in 2007. Figure 3 shows water fluoridation status within Victoria.

3.2 Benefits of water fluoridation

- By reducing the prevalence of dental caries, water fluoridation limits associated pain, suffering and economic losses including costs of dental treatment.
- Since the fluoridation of Melbourne's water supplies 30 years ago, the caries prevalence within Victoria has markedly decreased.
- Six-year old children living in fluoridated areas of Victoria have up to 36 per cent less caries experience than those in non-fluoridated areas.
- Water fluoridation benefits individuals regardless of age or education, and reduces the socioeconomic inequalities in caries experience.
- The beneficial effect of water fluoridation is additional to that of fluoridated toothpaste.
- Maximal dental health benefits are obtained through a combination of water fluoridation, regular tooth brushing, appropriate use of fluoridated toothpaste, healthy diet and regular reviews by a dental professional.

Dental caries can have an adverse impact on appearance, self-esteem, social interaction and the ability to speak and chew.^{17,18} Pain may result from dental caries, which if left untreated, may progress to a dental abscess and serious infection. Treating dental caries in children sometimes requires a general anaesthetic, with its attendant risks. In 2004–05 across Victoria there were almost 5,000 children under the age of 10, including 250 two-year olds, who required a general anaesthetic for treatment of their dental decay. In non-fluoridated areas of Victoria, three times as many people per capita required a general anaesthetic in hospital for treatment of dental decay than in fluoridated areas.¹⁹

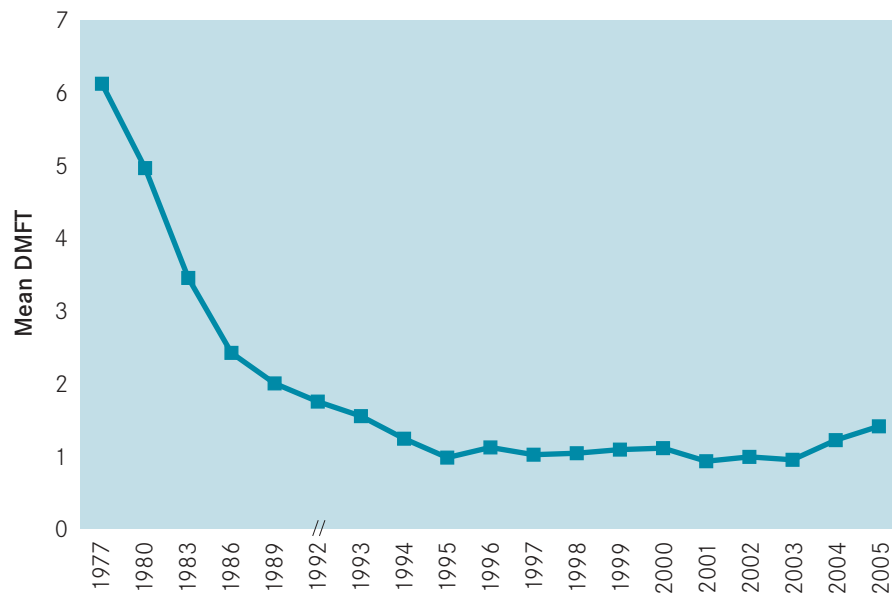
The consequences of dental caries are costly, in terms of both time and money. Water fluoridation reduces the prevalence of dental caries in children and adults, regardless of socioeconomic status or access to care, and has therefore been recognised as one of the top ten public health achievements of the 20th Century.³

3.2.1 Reduction of dental caries in children

Since the introduction of water fluoridation to Melbourne in 1977, the caries prevalence within Victoria has markedly decreased, as shown in Figure 4.

Figure 4: Caries experience in permanent teeth of 12-year olds in Victoria as measured by mean DMFT (decayed, missing and filled teeth)

(Data from Dental Health Services Victoria School Dental Service, 2006)



Numerous studies and subsequent reviews have confirmed the effectiveness of water fluoridation on caries reduction.^{7,8}

Six-year old children in fluoridated areas of Victoria have 36 per cent less caries experience in the deciduous dentition than those in non-fluoridated areas, and 12-year olds have 22 per cent less caries experience in the permanent dentition.⁶

The first edition of this booklet cited data from Dental Health Services Victoria School Dental Service, 2002. It showed the reduction in caries experience for six-year old children living in fluoridated areas of Victoria was 45 per cent when compared to children living in non-fluoridated areas, with a 38 per cent reduction for 12-year old children living in fluoridated areas.

This booklet (second edition, 2007) cites Dental Health Services Victoria School Dental Service 2006 data, covering the 2005–06 period.⁶ Since January 2005, the School Dental Service has increasingly targeted children who have higher dental needs.

The new data continue to show significant differences in dental caries experience between fluoridated and non-fluoridated populations, with six-year old children in fluoridated areas of Victoria having 36 per cent less caries experience in their deciduous teeth than those in non-fluoridated areas and 12-year old children from fluoridated areas having 22 per cent less caries experience.

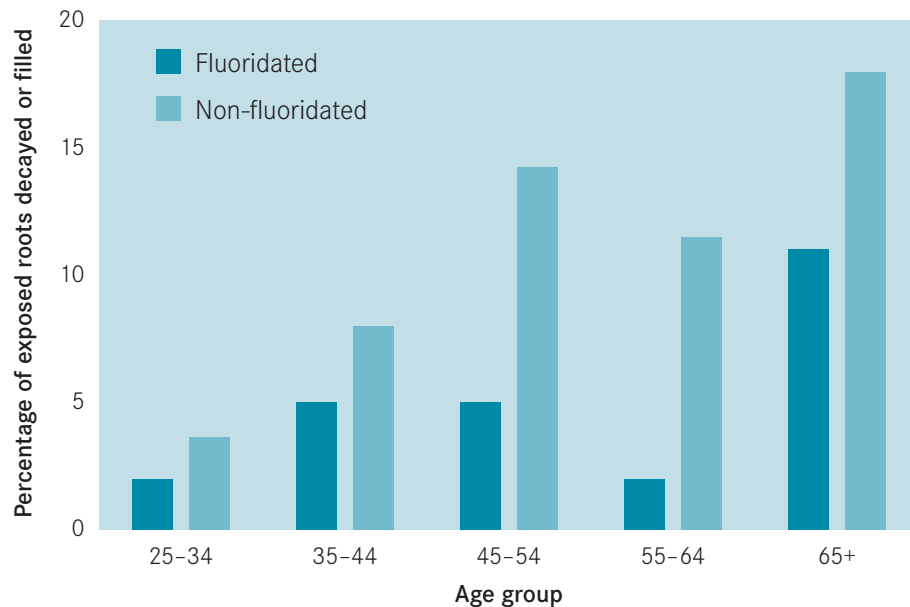
See also section 3.2.4 of this booklet, which discusses recent increases in dental caries experience in Australia.

3.2.2 Protective effects in adults

Water fluoridation helps protect against dental caries at all ages, with studies demonstrating beneficial effects in children as young as three and adults up to 75 years of age.²⁰ Adults are susceptible to decay in the root surfaces of their teeth (which can become exposed due to gum diseases). Adults living in fluoridated areas have considerably less root surface caries than those living in non-fluoridated areas, as shown in Figure 5.

Figure 5: Root-surface caries by age and fluoridation status: based on national survey of adult dental health in Ireland

(Reproduced with permission from the British Fluoridation Society, 1992)



3.2.3 Reduction of socioeconomic inequalities

Water fluoridation is of particular benefit to communities of low socioeconomic status, who tend to have higher rates of dental caries and less access to dental treatment and other forms of fluoride exposure.³ Water fluoridation reduces the socioeconomic inequalities in caries experience,⁷ and remains the most socially equitable means of achieving community-wide exposure to the caries-preventive effects of fluoride.⁴

3.2.4 Maximising dental health benefits

Maximal dental health benefits are obtained through a combination of water fluoridation, tooth brushing and appropriate use of fluoridated toothpaste, healthy diet and regular reviews by a dental professional. Until very recently, caries prevalence in children had decreased in both fluoridated and non-fluoridated areas. This decrease is thought to be due to wider exposure to other fluoride vehicles, such as fluoridated toothpaste, and a 'diffusion' effect with fluoridated foods and beverages being distributed to non-fluoridated areas.³ Very recent research has indicated that caries prevalence may be increasing in Australian children. This increase may result from the same factors associated with increasing obesity levels.²¹ This points to an even greater need for water fluoridation, which has been found to have an effect over and above that of other fluoride sources,⁹ providing additional topical fluoride to teeth throughout the day.

3.3 Risk of excess fluoride ingestion: dental fluorosis

- Dental fluorosis is mottling of tooth enamel which may result from excessive ingestion of fluoride while teeth are developing, and may be of aesthetic concern.
- If dental fluorosis does occur, it is generally of a mild, barely noticeable form.
- In areas with optimal water fluoridation, the risk of dental fluorosis can be minimised by limiting the exposure of young children to fluoride from other sources.

Dental fluorosis is defective formation of tooth enamel or dentine resulting from excessive fluoride ingestion during the period of tooth development, usually from birth to approximately six to eight years of age.¹¹ In its mildest (and most common)^{8,22} form it may manifest as barely noticeable whitish striations, while more severe forms involve confluent pitting and staining of the dental enamel.¹ Determining the exact level of dental fluorosis within a community is difficult, as there are numerous other causes of enamel defects that may resemble dental fluorosis.

Dental fluorosis can also occur in areas without water fluoridation programs. Since the mid 1990s, however, the prevalence of dental fluorosis in Australia has markedly reduced, mainly attributable to the use of low-fluoride toothpastes in young children, and awareness raising of correct toothpaste use by children (use under supervision, use of a pea-sized amount smeared over the brush, spitting out and not swallowing).²³

The risk of dental fluorosis occurring can be reduced by minimising exposure to fluoride in children with developing teeth, through measures such as⁴:

- discouraging ingestion of toothpaste by children
- cleaning children's teeth without toothpaste until the age of 18 months, unless otherwise recommended by a health professional

- using only a pea-size amount of low-fluoride toothpaste, smeared over the toothbrush, between 18 months and five years of age (inclusive), unless otherwise recommended by a health professional
- limiting the use of fluoride mouthrinses to children six years of age and older.

Dental professionals will determine suitability for additional fluoride therapies, assessing factors such as dental history, age, diet, oral hygiene, medical history and family history.

3.4 Safety of water fluoridation

- With the exception of dental fluorosis, scientific studies have not found any link between water fluoridation and adverse effects.

With the exception of dental fluorosis, scientific studies have not found any link between water fluoridation and adverse effects.^{7,8,11} The World Health Organization has concluded that 'water fluoridation is safe and cost effective'¹⁰ and in 2006, the World Health Organization, the World Dental Federation and the International Association for Dental Research urged governments to develop effective legislation and programs to ensure access to fluoride for dental health in all countries.²⁴

3.4.1 Bones

Research on the potential effects of fluoride on bone has focused on the areas of skeletal fluorosis, osteoporosis and fractures, and cancer.

Skeletal fluorosis

Skeletal fluorosis occurs only in individuals with excessively high levels of fluoride exposure, and is endemic in several parts of the world including India, China, parts of the Middle East and Africa, where water supplies have fluoride levels naturally higher than those recommended by the World Health Organization.²⁵ Skeletal fluorosis can also occur in workers with occupational exposure. It is a condition characterised by bone pain, joint stiffness and other arthritic symptoms, as a result of excessive incorporation of fluoride into bone.

While it is common in some developing countries, it is extremely rare in the developed world.²⁶

Osteoporosis and fractures

Fluoride has been used to treat osteoporosis. However, studies specifically examining the effectiveness of water fluoridation on increasing bone mineral density or decreasing fractures have yielded conflicting results.⁷

The National Health and Medical Research Council concluded that the stronger studies suggest a protective effect of water fluoridation on hip fractures.⁷ The York Review found no clear association between water fluoridation and prevention of hip fractures or all fractures.⁸

Since these reviews, a prospective study has been published examining the risk of specific fractures associated with fluoride on an individual rather than a community basis.²⁷ This study concludes that long-term exposure to fluoridated drinking water does not increase the overall risk of fracture in older women, and may reduce the risk of hip fracture and vertebral fracture.

Water fluoridation as a public health measure for the prevention of dental caries is safe in terms of any effect on bone mineral density.²⁷

Bone cancer

There is no established link between water fluoridation and the risk of bone cancer.^{7,8,20}

The 1999 National Health and Medical Research Council report⁷ reviewed five studies relating to bone cancer. One showed a weak protective trend against osteosarcoma; another showed a protective trend for males against osteosarcoma; and three found no significant overall association between bone cancer and water fluoridation.

In April 2006, a paper by Elise Bassin et al, 'Age-specific fluoride exposure in drinking water and osteosarcoma (United States)' was published in the journal *Cancer Causes Control*.²⁸ The paper presented partial findings of a 15-year study of fluoride and osteosarcoma. Bassin et al concluded that their exploratory analysis found an association between osteosarcoma and fluoride in drinking water in males, but not in females.

They also concluded that further studies were required to confirm or refute the findings. The supervisor of the study, Professor Chester Douglass, advised readers to be cautious when interpreting the findings, noting that the full findings of the study (yet to be published) did not show an association between osteosarcoma and fluoride in drinking water.²⁹ Other limitations of the study were also identified by the authors—these are summarised in the document 'Osteosarcoma and fluoride' published by the Department of Human Services and The Cancer Council Victoria, available from the Department of Human Services' water fluoridation website (details on page 30).

3.4.2 Other cancers

The published reviews have stated that there is also no consistent evidence of an association between water fluoridation and morbidity or mortality due to cancer in general.^{7,8,11} The York Review concluded this after considering ten studies including 27 separate analyses. The two studies of statistical significance suggested an association in different directions.

One study reviewed in the 1999 National Health and Medical Research Council report demonstrated a positive trend for uterine cancer and fluoridated water exposure, but time trends for five-year intervals suggested an association with risk factors other than water fluoridation.

After consideration of the York Review, the 1999 National Health and Medical Research Council review and other evidence, the United Kingdom Medical Research Council concluded that, based on current evidence, water fluoridation is not proven to cause cancer. Data after 35 years of exposure do not yet exist, however studies of lifetime exposure in naturally fluoridated areas provide a 'high level of reassurance concerning safety'.²⁰

3.4.3 Hypersensitivity/allergy

Concerns about hypersensitivity and allergic reactions to fluoride in community water supplies have been raised. Fluoride is an inevitable component of all diets, so those who complain that symptoms are related to fluoridated water are essentially claiming an effect from an incremental increase of fluoride, not its presence versus its absence.¹

In 1971, the Executive Committee of the American Academy of Allergy reviewed all clinical reports of alleged allergy to fluoride, and found no evidence that the wide range of non-specific symptoms were attributable to immunologically-mediated reactions. They also noted that there was insufficient clinical and laboratory evidence to state that true syndromes of fluoride allergy or intolerance exist, and unanimously declared that 'there is no evidence of allergy or intolerance to fluoride as used in fluoridation of community water supplies'.³⁰

More recently, the 1991 National Health and Medical Research Council review concluded that evidence of fluoride as an allergen remains unconvincing.¹ The weight of evidence indicates that fluoride is unlikely to produce hypersensitivity or other immunological effects.³¹

3.4.4 Reproduction

There is insufficient evidence to establish a link between water fluoridation and reproductive effects.^{8, 20, 31} Specifically, epidemiological studies show no evidence of an association between water fluoridation and risk of spontaneous abortion or congenital malformation.¹¹

3.4.5 Miscellaneous

Epidemiological studies of occupational exposure to fluoride (with higher exposure levels than obtained through optimally fluoridated drinking water) have provided no reasonable evidence of effects upon the respiratory, haematopoietic, hepatic or renal systems attributable to fluoride per se.¹¹

A small study of fluoride concentrations in pineal glands from cadavers with a mean age of 82 years found no association with long-term fluoride exposures.³²

3.5 Cost-effectiveness of water fluoridation

- Water fluoridation is a cost-effective means of reducing the prevalence of dental caries.

The World Health Organization concludes that water fluoridation is one of the most cost-effective means of delivering fluoride to a large number of individuals.¹¹ In a study assessing the cost savings resulting from water fluoridation, it was found that the reduction in costs of restorative treatment due to averted dental caries exceeded the cost of water fluoridation in communities of any size.³³ Likewise, a separate study concluded that fluoridation is very cost-effective, especially for communities with high proportions of children, indigenous people or people of low socioeconomic status.³⁴ In the 25-year period following its introduction, water fluoridation was estimated to have resulted in benefits to the Victorian community of around \$1 billion, through avoided dental costs and saved work and leisure time.³⁵

3.6 Ethics of water fluoridation

Most health professionals have regarded the benefits of water fluoridation in terms of beneficence (doing good) and justice (equity), as outweighing the relatively minor reduction in individual autonomy for some and the low risk of adverse effects.¹⁷

We should ask not are we entitled to impose fluoridation on unwilling people, but are the unwilling people entitled to impose the risks, damage and costs of failure to fluoridate on the community at large.

John Harris (Professor of Applied Philosophy at the Centre for Social Ethics and Policy of the University of Manchester), 1989.³⁶

In 2006, the World Health Organization, the World Dental Federation and the International Association for Dental Research confirmed that 'universal access to fluoride for dental health is a part of the basic human right to health.'²⁵

4. Summary

Fluoride plays a crucial role in the prevention of dental caries throughout life. Fluoridation of community water supplies is an effective way to deliver fluoride to all members of the community, regardless of age, individual motivation, socioeconomic status or the availability of dental care. The overwhelming weight of evidence supports water fluoridation as safe and effective in helping prevent dental caries.

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Further information

On the web

Department of Human Services:
www.health.vic.gov.au/environment/water/fluoridation
www.dhs.vic.gov.au/rrhacs/dentalhealth

Australian Dental Association:
www.ada.org.au

Better Health Channel:
www.betterhealth.vic.gov.au

British Fluoridation Society:
www.bfsweb.org

Dental Health Services Victoria:
www.dhsv.org.au

Telephone

Water fluoridation information line, Department of Human Services

Tel: 1800 651 723

Environmental Health Unit, Department of Human Services

Tel: 1300 761 874

