History of Water Fluoridation

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Introduction

Water fluoridation has been described by the Centre for Disease Control as one of the ten most important public health advances of the 20th Century[1]. In this brief paper, I will describe the history of water fluoridation and discuss the value of this policy in the early years of the 21st Century.

Natural Water Fluoridation

The story of fluoridation begins with a mystery staining of the teeth first described by dentist Dr. Frederick McKay in Colorado in 1901[2] and, independently in Naples in 1902 by Dr. J.M. Eager, an American dentist stationed in Italy. Over the following years, McKay became aware of several cases that suggested that the water supply might be responsible for the staining. He also noted that decay rates were much lower in areas with endemic dental staining than they were in other adjacent areas.

In the United Kingdom, an Essex dentist Mr. Norman Ainsworth had found dental staining similar to McKay's description of "Rocky Mountain Mottled Teeth". As part of a study for the Medical Research Council in 1925, Ainsworth examined over 4,000 children and, for the first time, produced a statistical comparison of decay rates between populations with the staining and those without. This study showed that those living in areas where mottled teeth were commonest tended to have much less dental decay.

A chemist with ALCOA (the Aluminium Company of America), H.V. Churchill, became involved in the story in 1931. ALCOA was concerned that there was a possibility that there was a link between this staining and the presence of aluminium in drinking water. The staining had appeared in the town of Bauxite, Arkansas, where ALCOA mined most of their aluminium. Churchill analysed water from several areas where the staining was endemic for unusual element concentrations and found the one common factor to all sites to be elevated levels of fluoride. The supply in Bauxite itself was measured at 13.7ppm (parts per million).

Ainsworth was aware of Churchill's research and decided to compare the water supplies from the endemic staining area around Maldon in Essex with that of the nearby town of Witham. The Witham water proved to have 0.5ppm fluoride, the samples from around Maldon ranged from 4.5 to 5.5ppm.

It seemed clear that fluoride levels in water were related to both the staining of the teeth and reduced decay levels. The US Public Health Service was anxious to investigate this relationship and appointed a dentist, Dr. H.T. Dean, to carry out the research. In a series of classic shoe-leather epidemiological investigations, culminating in his famous "21-City Study", Dean established that mottling of the teeth was extremely rare at fluoride levels of 1ppm or below, while the greater part of the caries preventive effect was to be seen at 1ppm. Dean published the results of his work in 1942.

During the Second World War, children from South Shields, an industrial town on the river Tyne in north eastern England, were evacuated to the Lake District. The Senior School Dentist for Westmoreland noted that the evacuees had far better teeth than local children. Robert Weaver, a dentist working for the Ministry for Education, was aware of the work being carried out in America and had the fluorine content of South Shields water analysed. It proved to be around 1.4ppm, much higher than is present in most water supplies. He had North Shields (on the other bank of the Tyne) water analysed; this proved to have a fluoride content of 0.25ppm. In 1944 Weaver examined 1,000 children on either side of the Tyne. This study demonstrated much lower decay rates in both permanent and deciduous teeth in South Shields. This study was the first to describe the effects on the primary dentition.

There are many areas in England which today have significant natural fluoride content in drinking water. These include Norwich, Ipswich, Cambridge, Hartlepool, Slough, Bath, Swindon, Colchester and other sites particularly in the counties of Essex, Norfolk, Suffolk, Durham, Shropshire, Wiltshire and in North East London.

The History of Artificial Water Fluoridation

Water naturally fluoridated at 1ppm clearly benefited dental health. Following Dean's studies, the health authorities in the United States sought to reproduce this effect in low-fluoride areas by adding fluoride. No obvious negative health effects had been noted in populations served by naturally fluoridated water.

A number of tests or pilot schemes were set up to see whether the idea could work in practice. On 25th January 1945, Grand Rapids, Michigan, became the first town in the world to be artificially fluoridated. The previous year, a baseline study comparing Grand Rapids with the neighbouring town of Muskegon had found similar decay levels in deciduous and permanent teeth in both areas. Six years later, surveys indicated that decay levels in 6 year-old children (i.e. those born since fluoridation commenced) in Grand Rapids was almost half of that of Muskegon. In July 1951, city officials in Muskegon decided to fluoridate that town's water supply.

Other pilot schemes in the USA were those in Newburgh, New York, which started fluoridating in May 1945, and Evanston, Illinois, which began fluoridating in January 1946. As with the Grand Rapids scheme, these towns were paired with nearby "control" towns (Kingston, New York and Oak Park, Illinois) in order to measure the effectiveness of the fluoridation scheme. In both cases, significant reduction in dental decay rates were described in the fluoridating towns, with little or no change in the controls.

Several important studies carried out outside of the USA in the early days include the Brantford-Sarnia-Stratford study in Canada (1945-1962), the Tiel-Culemborg study in the Netherlands (1953– 1969) and the Hastings study in New Zealand (1954 - 1970). As in the case of the American studies, significant reductions in decay experience were reported in artificially fluoridated areas.

The Department of Health in the United Kingdom became interested in this work. Three sites were selected for the initial fluoridation schemes in 1955; Watford, Kilmarnock and part of Anglesey. The areas selected as controls were Sutton, Ayr and

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the remaining part of Anglesey. Studies carried out after 5 years of fluoridation demonstrated much lower caries levels in the fluoridated areas in 5-year old children.

In the Republic of Ireland, the Fluoridation of Water Supplies Act 1960 allowed for the fluoridation of all public water supplies. The two major cities of Dublin and Cork eventually commenced fluoridation in 1964, following the rejection by the Supreme Court of a constitutional challenge to the 1960 Act. Local, regional and national studies carried out in the decades since have all confirmed that children and adults living in fluoridated areas in Ireland have significantly fewer decayed teeth.

Currently, some 40 countries have artificial water fluoridation schemes in existence. In some cases, only a small proportion of the population is covered by the schemes. Most recently published estimates of population coverage include[3]: USA (64%), Canada (43%), Panama (18%), Republic of Ireland (73%), Australia (61%), New Zealand (61%), Israel (75%), Malaysia (70%), United Kingdom (10%), Singapore (100%), Brazil (41%), Argentina (21%), Chile (40%), Spain (10%), Columbia (80%). Hong Kong is also fluoridated, with 100% population coverage. Recently there have been major extensions announced in the USA (particularly California) and Brazil.

Effectiveness of Water Fluoridation

The early studies reported reductions in decay experience of the order of 50% or more. That was at a time when fluoridated water offered the only significant source of fluoride.

The introduction of fluoridated toothpaste in the early 1970s has provided a very important source of fluoride and this is thought to have been a major contributor to the fall in decay rates experienced in OECD countries in the past decades. Thus the relative effectiveness of water fluoridation has fallen in recent years since the absolute decay values in non-fluoridated areas has fallen. While we still see relative disease reduction of 50%, the absolute value of this 50% has decreased. Nonetheless, in the opinion of the public health professionals involved, the value of the additional decay reduction brought about by fluoridation is more than significant enough to warrant the continuation of the policy.

An interesting recent study compared decay rates on both sides of the Irish border[4]. Northern Ireland provides an excellent control population for the Republic; caries risk is similar, it has no fluoridation schemes and the possibility of diffusion effects (the "Halo Effect") is likely to be low. The Halo Effect is a significant confounding factor; it occurs where there is a significant population movement between the two areas under study or where there is a significant movement of food or drink products manufactured in fluoridated areas into the control area. This effect can produce a serious underestimation of the true effectiveness of water fluoridation.

The aforementioned study showed that decay rates in Northern Ireland are of the order of 50% higher than in the Republic. Decay rates had been similar prior to the introduction of water fluoridation. This difference exists in spite of the fact that fluoride toothpaste usage appears to be higher in Northern Ireland.

Safety of Water Fluoridation

The question of the safety of water fluoridation has been investigated time and time again by a variety of national and international commissions, most notably in recent times by the NHS Centre for Reviews and Dissemination in 2000 (the York Review)[5]. This was a Systematic Review – which means that all relevant studies in all languages and in all publications were searched for and critically evaluated using validated guidelines. Over 3,000 studies relevant to dental and general effects of water fluoridation on humans were identified. York's main conclusion was that there was no clear evidence of any adverse effect from water fluoridation other than staining of enamel (dental fluorosis).

The York Review has been followed up in the United Kingdom by the Medical Research Council (MRC) in 2004[6]. The MRC's view is that there is very little cause for concern on any potential general health issue in relation to water fluoridation. In Ireland, the York Review was reviewed by the Forum on Fluoridation, which also interviewed some of the key personnel involved in the systematic review. The Forum drew similar conclusions to those of the York team.

Allegations have been made that water fluoridation is linked to almost every conceivable condition known to medicine – and some conditions beyond. The range of allegations covers such diverse items as cancer, Alzheimer's disease, effects on salmon spawning, and even increasing crime rates in American cities. The fact that none of these have so far been found to have any substance should not be surprising; there are populations that have been drinking naturally fluoridated water at around 1ppm for centuries for whom no obvious adverse effects have been demonstrated. Recent studies have supported the proposition that there is no chemical or biological difference between naturally and artificially fluoridated water[7,8].

Water fluoridation is supported by the World Health Organisation (WHO), which recommends water fluoridation where it is politically and technically feasible. Where water fluoridation is not possible, the WHO recommends salt fluoridation as a next-best option.

Dental Fluorosis

It has always been known that water fluoridation would be associated with low levels of enamel discolouration. Dean's studies predicted that very mild enamel fluorosis would affect a small proportion of a fluoridated population. The judgement call has always been that a low level of fluorosis is well worth the large reduction in dental decay brought about by fluoridation.

Dental fluorosis is still often measured on Dean's Index, which has six points corresponding to No, Questionable, Very Mild, Mild, Moderate and Severe Fluorosis. In Ireland, with over 70% of the population served by fluoridated water, 80% of the population has either No Fluorosis or Questionable Fluorosis, and perhaps 7% have fluorosis of aesthetic concern (i.e. Mild and higher).

The treatment of dental fluorosis is essentially very simple. Most of the staining is confined to the outer 50-100μm of enamel, and can actually be abraded away using pumice and acid-etch gel. The technique I have used is to etch the tooth surface using the gel

and then pumice for 5-10 seconds, repeating 10 times or so until the stain decreases. I find it is usually a good idea to start with the second premolar to see if the colour improves, as the staining may not actually be due to fluorosis, in which case the treatment may have little effect – remember that there are approximately 90 different known causes of enamel defects. A rubber dam should be used.

In contrast with tooth decay, fluorosis does not cause abscesses, does not cause pain and can be treated without use of any anaesthetics, either local or general.

There is no doubt that the level of fluorosis has increased in the Republic of Ireland over the past 20 years, even if the overall level of objectionable fluorosis is low. This increase has been thought to be due largely to the inappropriate swallowing of toothpaste by young children.

Other Forms of Community Fluoridation

Several other methods have been evaluated for providing community water fluoridation. Fluoridated salt is used quite successfully and widely in Europe and South America in particular. In situations where all salt in the economy is fluoridated, including that used in food production, its effectiveness comes close to that of water fluoridation. However, where fluoridated salt is simply provided on sale along with unfluoridated salt, its effectiveness on a population basis is quite limited.

Fluoridated rinses have been provided in many countries. The effectiveness during school years is almost as good as water fluoridation but the effect is a temporary one; once children leave the rinsing scheme, their decay rates tend to approximate to the general non-fluoridated population. In addition, there can be compliance problems within schools[9].

Milk fluoridation schemes have been pioneered most notably in the United Kingdom and in Chile. In the Manchester area, the Borrow scheme was set up to provide fluoridated milk to primary school children. In Chile, fluoridated milk is provided through the health service rather than through schools. This method of fluoridation is quite promising but, while beneficial, the effect does not yet appear to be as strong as for water fluoridation.

A major method of fluoridation is, of course, the use of fluoridated toothpastes. It is estimated that in excess of 95% of toothpaste sales in Western Europe are of the fluoridated products.

Recommended Use of Fluorides

Guidelines on the correct use of fluorides will need to vary not only between countries, but also between localities and even at the individual level. This is obvious since the decay risk will vary in this way too. For example, we can state that, based on diet and lifestyle surveys, inhabitants of Scotland and the entire island of Ireland have significantly higher decay risk than the inhabitants of the Nordic countries and England. Surveys have shown that persons on low income have substantially higher decay risk than others; and since there are regional variations in income within all countries, it is likely that these regional variations will show up as regions of higher decay risk too. Thus the relatively prosperous South of England tends to produce lower decay scores than the historically poorer North.

On the individual level, dental and medical considerations must be taken into account. An individual with a very high decay risk may require extra assistance from fluoride. Certain medical conditions can expose a person to unusually high risks of morbidity or mortality from dental infections or, more often, from the treatment of the dental problem; appropriate fluoride supplementation can have enormous immediate benefits for the general health of such individuals.

A number of bodies have published recommendations on the use of fluoride products and supplements. With the foregoing comments in mind, I wish to pay particular note to those of the European Association for Paediatric Dentistry (EAPD) of 2000[10], and the Forum on Fluoridation in Ireland (Forum) of 2002[11]. Both guidelines agree on certain basics, such as the value of water fluoridation, fluoride mouth rinses and professionally applied fluoride varnishes. Where there is significant variation between these recommendations concerns the appropriate use of fluoride supplements and fluoride toothpastes.

The Forum recommendations were specific to the situation in the Republic of Ireland only and were constructed mainly to provide broad information to the public. Thus the main messages were kept clear and simple. These are (a) do not use toothpaste for children under 2; (b) for children 2 to 7, tooth brushing should be supervised and that a pea-sized amount of adult-strength toothpaste is to be used. There was an important caveat – the above recommendations were general and could be set aside by the dentist if a high caries risk was detected.

Child dental health indicators in Ireland are among the best in Europe; for 5-year olds the decay index is the lowest in Europe while for 12-year olds, it is 4th lowest – in spite of the highly cariogenic dietary habits of Irish children. Since decay levels at 5 years of age are low, we can conclude that decay risk for those under 2 years of age is generally very low. The Forum recommends that children under 2 years of age have their teeth brushed with a toothbrush and tap water only – no toothpaste of any kind is advised. Paediatric low fluoride toothpastes (those at 500ppm or lower) were not recommended by the Forum as it considered that the current evidence base was insufficient at present to support their use.

Since most of Ireland is fluoridated and there is likely to be a significant Halo Effect, fluoride supplementation was not recommended by the Forum except in high risk individual cases.

The EAPD recommendations do include the use of supplementation as follows:

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"Recommended dosages of fluoride supplements

6 months to 3 years of age:
One 0.25 mg lozenge as a single dose per day (when water supplies have less than 0.3 ppmF). Lozenges are to be preferred, but drops or soluble tablets may be recommended for children unable to suck lozenges.

3 to 6 years of age:
One 0.25 mg lozenge twice a day (2x0.25 mg/day).

Over 6 years of age:
One 0.50 mg lozenge twice a day (2x0.50 mg/day).

In order to obtain a local effect of fluorides from fluoride lozenges and the use of fluoride dentifrice, the lozenges should be taken at different times of the day than when tooth brushing. Children should be encouraged to allow the lozenges to dissolve slowly in different sites in the mouth."

On the question of toothpastes, the EAPD recommendations differ from those of the Forum in the proposal that children under 2 have their teeth cleaned by smearing a very small amount of low fluoride (<500ppm) toothpaste on the teeth while those under 6 years of age brush using use low fluoride toothpastes.

As one can see, slightly different sets of reputable guidelines may exist. So which one should the dentist use? As a general principle, each dentist should seek to balance the relative risks of dental decay and enamel fluorosis when giving advice on the dental care of children under 7 years of age. While general guidelines are valuable in providing information to the dentist, I would recommend that, where possible, local expert advice be sought. The Community Dental Service in any country is likely to be a good source of information on factors such as local decay patterns and local water fluoride levels; it may be able to supply a set of guidelines suitable to that particular locality.

Conclusion: The Future of Water Fluoridation

Up to 1982, the only major cities to be fluoridated in the United Kingdom were Birmingham and Newcastle. In 1985, the government of the day passed a new fluoridation act which had the unforeseen effect of passing the right to fluoridate water supplies to the shareholders of the newly privatised water companies. Since 1985, in spite of requests from a number of health authorities, no new water fluoridation schemes came into existence. However, new legislation enacted at the end of 2003 has returned the decision-making function to the public authorities. Under the terms of that Act, a health authority wishing to fluoridate public water supplies must hold a public consultation exercise and take its outcome into consideration before proceeding with any new fluoridation scheme.

Fluoridation continues to provide a valuable public health benefit. However, like any preventive measure, it only makes sense where there exists a significant disease risk. The time may come in a particular society where the decay risk is too small to continue fluoridating or to consider starting. Such has been the case in Finland, where one town, Kuiopo, had been fluoridated for decades and has now terminated the scheme. In that situation, the caries risk was very low and the school dental service provided significant school-based fluoride programmes. Such was also the case in Basle, Switzerland, where water fluoridation was no longer deemed necessary due to the new availability of fluoridated salt.

Such will certainly be the case in the most of the South of England, where decay risk is now too low to gain any significant benefit from fluoridation.

There are areas where fluoridation could greatly benefit populations in Britain. In my view, fluoridation could be well worth considering at least in the North West of England and parts of Scotland. For example, Birmingham is fluoridated, Manchester is not. The dental health of Birmingham children is among the best in the United Kingdom while that of some Manchester children among the worst. This inevitably translates into greater misery, pain and increased recourse to general anaesthetic extractions in the high caries area.

Currently, it is estimated that 400 million people have access to fluoridated water worldwide and that this number is increasing. Fluoridation has been shown to be remarkably safe and effective means of reducing risk of the commonest disease in the western world. As long as the risk of dental caries remains significant, water fluoridation remains a public policy of great merit.

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