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# Fluoridation: A Review of the 1974 Literature

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## INTRODUCTION

Fluorides in dentistry are still receiving a great deal of attention from research workers, the dental profession and politicians. Faced with the vast literature on all aspects of this subject, it was decided to restrict the scope of this review to the publications concerning human studies on water fluoridation and dietary fluoride supplementation such as milk and salt fluoridation, which have been taken mostly from English language literature but include some readily accessible foreign language articles. These fields were felt to be of interest to the dental practitioner who is directly involved with the dental health and education of the community.

## FLUORIDATION STATISTICS

In 1974 over 160 million people throughout the world were drinking water containing 1 part per million (ppm) or more of fluoride (Zahnärztliche Mitteilungen, 1974). Of these over 100 million were living in the United States of America (Fluoridation Reporter, 1974b). Water fluoridation programmes were operating in more than 30 countries including the Netherlands, Canada, Australia, Brazil, Chile, New Zealand, Ireland and Czechoslovakia and other communist countries (Fluoridation Facts, 1974). In Canada at least 35,7 per cent and in Australia 41,4 per cent of the population were drinking fluoridated water (Zahnärztliche Mitteilungen, 1974). Four million people in Britain were exposed to fluoridated water, the largest cities which benefited being Birmingham and Newcastle (Burt, 1974a). Water fluoridation had been legally enforced in Ireland, Brazil and Greece (Zahnärztliche Mitteilungen, 1974). Africa was the only major part of the world where no water fluoridation was practiced (Ericsson, 1974).

## FLUORIDATION AND DENTAL HEALTH

Backer Dirks (1974) reviewed the many epidemiological surveys carried out in areas having naturally fluoridated water. These had led to the conclusion that a fluoride concentration of approximately 1 ppm under "Western living conditions" reduces dental caries by about half. In comparing studies of caries reduction in areas where water had been artificially fluoridated with those where the natural fluoride concentration was similar, the expected result that artificial fluoridation has the same effect as natural fluoridation, emerged.

Epidemiological studies concerning fluoridation reported in 1974 included the following.

After 10 years of water fluoridation in Basel the caries incidence of school children aged 7-15 years was compared with that before fluoridation (Gülzow *et al*, 1974). Reductions between 77,5 per cent and 44,6 per cent which depended on age and years of exposure to fluoride, were reported. The number of caries-free dentitions was also found to have increased.

In the ninth of a series of comprehensive studies regarding dental health after fluoridation in Karl-Marx-Stadt, Künzel (1974a) reported an average caries reduction of 48,5 per cent in 6-18 year old subjects after 12 years of fluoridation. In this period the control town, Plauen, experienced an 18,5 per cent caries increase. In the next article of the same series Blüthner *et al* (1974) reported that there was no difference between the occlusal conditions of 12-13 year old children living in Karl-Marx-Stadt and non-fluoridated Leipzig.

Jackson and co-workers were also engaged in extensive surveys comparing dental health in Hartlepool where the water was naturally fluoridated, with that in the fluoride deficient York. They reported that rampant dental caries in 5 year old children in Hartlepool was reduced by 60 per cent and attributed this to the fluoride content of their drinking water (Jackson, Murray and Fairpo, 1974). A further interesting statistic was reported by Freer (1974) regarding Hartlepool and York. The dentist : population ratio in the City of York was 1:2748 whereas in Hartlepool this ratio was 1:9716, indicative of better dental health in the high fluoride area.

Aasenden and Peebles (1974) examined several dental conditions in 3 groups of children aged 7-12 years; the first had had fluoride tablet supplementation from birth, the second were a control group while the third were resident from birth in a fluoridated area. They found the ratios of DFS scores for the three groups to be 1:5:2 and that the percentages of caries-free subjects were respectively 54,0, 5,4 and 23,9. Furthermore they examined the frequency of atypical pits and fissures and found this to be 47 per cent in the first, 4,3 per cent in the second and 23,9 per cent in the third group. This morphology, which is considered to be favourable since the pits and fissures are less retentive, was attributed to fluoride ingestion.

An article in the Fluoridation Reporter (1974a) cites 3 cases in which the effectiveness of fluoridation was proved "in reserve". In Antigo (Wisconsin), Austin (Minnesota) and Kilmarnock (Scotland) fluoridation

was discontinued for political reasons and a consequent increase in caries incidence was observed. As a result 2 of these places reinstated fluoridation.

Since the benefits of water fluoridation on the caries experience of younger children had been well documented, Keene and Catalanotto (1974) felt it would be valuable to examine this aspect in an older age group and selected 18-19 year old naval recruits as subjects. They observed that there was a greater prevalence of caries-free men from fluoridated cities and that those with histories of continuous residence in fluoridated communities, had a mean DMFT Index which was 43,4 per cent lower than that of men from non-fluoridated areas.

Pot, Purdell-Lewis and Groeneveld (1974) investigated the incidence of denture wearers in Tiel after 17 years of water fluoridation as well as in a control city, Culemborg. They found that there were a greater number of denture wearers in Culemborg than in Tiel and that a greater proportion of these were young denture wearers.

An argument used by antifluoridationists, is that fluoridation merely delays rather than prevents dental caries. Jackson (1974a) disputed this. Using available data from previous Hartlepool and York surveys and correcting DMFT values for teeth lost due to periodontal disease, he showed that although the effects of fluoride containing drinking water faded with age, the estimated prevention of caries in permanent teeth was about 30 per cent. When data from deciduous and permanent dentitions were combined, the overall level of true primary prevention was estimated as approximately 40 per cent.

In discussing his personal view on caries prevention, Waldman (1974) made the point that although fluoride was not the entire answer to caries prevention, in that dental hygiene and diet were important too, the "automatic" prophylaxis provided by fluoridated water would reach a large portion of the population who were never exposed to dental care or education.

## FLUORIDE CONCENTRATION IN ENAMEL

Rytömaa *et al* (1974) reported on an *in vitro* study of the enamel fluoride content in permanent and deciduous teeth from high and low fluoride areas. The mean fluoride content of surface enamel was 2,1 times higher in the fluoride rich than in the fluoride deficient area. This was a highly significant difference. Permanent teeth were found to contain 20 per cent more fluoride than primary teeth.

The article by Aasenden and Peebles (1974) also included an investigation of the enamel fluoride concentration of the 3 groups of subjects. *In vivo* enamel biopsies were taken which proved that the group who had received fluoride supplementation from birth had the highest enamel fluoride concentration, followed by the group living in the fluoridated area. The group from the fluoride deficient area had the lowest concentration.

In another *in vivo* study, Aasenden (1974) determined fluoride concentrations in the surface enamel of maxillary incisors and canines of male and female subjects resident in areas with varying amounts of fluoride in the drinking water. The mean enamel fluoride concentration from fluoride rich areas was consistently higher than that from the fluoride deficient area, and in all areas males generally had 10 per cent more than females. However, this latter difference was significant only in the higher fluoride areas. He attributed this sex difference in enamel fluoride to the longer pre-eruptive maturation period in males. This he felt, indicated that fluoride is incorporated into surface enamel during the pre-eruptive period and that the post-eruptive fluoride uptake occurs at a much slower rate

Charlton, Blainey and Schamschula (1974), in an *in vivo* study of 11 year old children living in high and low fluoride areas, also found a significantly higher fluoride concentration in enamel from children living in the fluoridated area. Furthermore, they established a positive relationship between fluoride content of enamel, plaque volume and the increase in hydrogen ion activity in plaque during sucrose fermentation. They proposed that the acidic fermentation products present in plaque effectively etch enamel and thereby assist fluoride uptake from the oral environment.

## FLUOROSIS

Since water fluoridation at a concentration of 1 ppm of fluoride, results only in the mildest forms of dental fluorosis occurring in not more than 10 per cent of the population, very little regarding fluorosis was reported in the literature on water fluoridation. In their previously mentioned paper Aasenden and Peebles (1974) showed that the prevalence of enamel fluorosis in the group who had received fluoride supplementation, was about twice as high as the group who had lived in the fluoridated area but that no discolouration or pitting of the enamel was observed in either group.

## TOXICOLOGY

Reviewing the safety of water fluoridation, Ericsson (1974) stated that "while nobody can guarantee the safety of any human measure under all circumstances, the safety of the adjustment of drinking water fluoride to about 1 ppm is supported by so large and so manifold scientific material and clinical data that any health hazard with this measure is extremely improbable. Specific claims of such hazards have been few and inadequately supported". In his opinion there was no proven health hazard from drinking fluoridated water. This view was also expressed by the National Association of German Dentists (Zahnärztliche Mitteilungen, 1974).

When the safety of water fluoridation is questioned, statistics on any disease incidence in areas of varying water fluoride concentration, are valuable. In a comprehensive study by Needleman, Pueschel and Rothman (1974), the frequency of Down's syndrome during a 17 year period was investigated in fluoridated and non-fluoridated communities in Massachusetts. They concluded that several years exposure to fluoridation does not cause an elevation in risk for Down's syndrome and that long term effects, if any, are likely to

be minimal. Strubelt (1974) in a letter concerning the mongolism controversy, referred to the work by Needleman *et al* (1974) and others and concluded that there was no scientific evidence on which to base any relationship between Down's syndrome and fluoridation

Kinlen (1974) examined data on the incidence of various types of cancer in areas of England and Wales, as well as cancer data from the United States, Holland and New Zealand. The data he examined were grouped into areas of different exposure to fluoride. He found no significant increase in prevalence of cancer of any type in fluoridated compared with nearby fluoride deficient areas.

The relationship between mortality rates and fluoride in drinking water was investigated by Nixon and Carpenter (1974). Mortality rates in 6 broad causes of death were analysed in 34 towns of different natural water fluoride content. Parameters such as water hardness, social factors, air pollution, latitude and rainfall were corrected for when correlation coefficients between standardised mortality rates and fluoride content of drinking water, were calculated. No significant correlation was found and all indications were that if naturally occurring fluoride had any effect, it was probably beneficial. The National Heart and Lung Institute of the National Institute of Health in America also refuted claims that increased heart deaths in Antigo, Wisconsin, were linked with fluoridated water (Fluoridation Reporter, 1974a).

Two case histories were presented (Greenberg, Nelsen and Kramer, 1974) which illustrated the possibility of ingesting an excess of fluoride from fluoridated drinking water (1 ppmF) due to an existing pathological condition. In both cases the patients were children with polydipsia resulting from nephrogenic diabetes insipidus. They exhibited dental fluorosis but no other abnormalities were detected. The point was made that patients suffering from conditions where water consumption is excessive, should be supplied in part with water from a non-fluoridated source.

There was some controversy as to whether or not fluoridated water is suitable for use in haemodialysis. Reed and Tolley (1974) felt that for use in dialysis, water of low fluoride concentration was preferable and descried the use of a semipermeable membrane to reduce the fluoride concentration in water from 1,05 ppm to 0,2 ppm. Parsons (1974) on the other hand, felt there was no conclusive evidence to suggest that dialysis against fluoridated water led to toxic or eventually damaging levels of fluoride in the bone and tissue of dialysis patients. He quoted previous work which showed no difference in the fluoride retention in bone from uraemic patients dialysed against fluoridated water when compared with patients dialysed against non fluoridated water. In the situation where deionised water is used for dialysis, the possible danger exists of the deionising resin becoming exhausted and eluting dialysate with fluoride concentrations in excess of that in the tap water. This was illustrated in a case history reported by Johnson and Taves (1974) where a patient suffered from elevated serum fluoride levels and severe bone mineralisation disturbances thought to be due to the introduction of excessive fluoride resulting from malfunction of the deionizer. He emphasised the necessity to guard against the use of a deionizer beyond its capacity.

Another example of a technical fault resulting in excessive fluoride ingestion is illustrated in a communication from Infante (1974). The malfunctioning of a school water fluoridating system resulted in the water fluoride concentration rising to 270 ppm. Nausea and vomiting were experienced by students and teachers but no one was hospitalised.

## TECHNOLOGICAL AND ECONOMIC CONSIDERATIONS

Künzel (1974b) broke down the costs involved in fluoridation into: the number of installations required; the building and maintenance of the plant; the technological demands and the volume of water requiring treatment. After determining these costs in the fluoridation of Basel, Karl-Marx-Stadt and Birmingham, he came to the conclusion that the annual cost per capita was about 1 DM which was in no way comparable with the high cost of dental treatment. He pointed out that direct savings would result from the 50-70 per cent reduction in dental caries and indirect savings from improved periodontal and orthodontic health. This in turn would lead to savings in dental manpower.

In a general review on the use of fluorides in caries prophylaxis, Thorpe (1974) presented the following cost benefit ratios (CBR) proving water fluoridation to be the most economical measure:

| | |
|---|---|
| 1. Water fluoridation | 1:65 |
| 2. Weekly mouthrinsing | 1:25 |
| 3. Daily tablets at school | 1:5 |
| 4. Daily tablets at home | 1:3,4 |

CBR was defined as the ratio of the cost of implementation to savings in cost of treatment.

Doherty and Powell (1974) developed a model for use in analysing the economic benefits of a preventive care programme such as fluoridation. Using available DMF survey data obtained before and then 10 years after the implementation of fluoridation, they established that dental care costs increased with age and found that this increase was greater before fluoridation than after. They proposed that this type of study would allow objective bases to be developed for use in policy recommendations and would be useful in estimating cost effectiveness in community health planning.

## SCHOOL WATER FLUORIDATION

A possible alternative to community water fluoridation which would reach people not served by central water supplies, is the fluoridation of school water (Heifetz, Horowitz and Driscoll, 1974). This would have the same advantages as community fluoridation in that it is safe and economical and requires no cooperation on the part of the children. A disadvantage is that the children are 5 or 6 years old before exposure, whereas the greatest benefit is derived when

fluoridated water is consumed from birth. Because children drink only part of their fluid intake at school, higher than optimal fluoride levels are recommended for school water in fluoride deficient areas. Heifetz, Horowitz and Driscoll (1974) found a measure of success with school water fluoridated at a concentration of 4,5 times that recommended for the community. In another publication Heifetz and Horowitz (1974) compared the caries reduction in populations where school water had been fluoridated to levels 4,5 times and 7 times higher than the optimum recommended for the area. Caries was reduced by 22,1 and 28,6 per cent respectively after 4 years but they felt that a longer follow-up period was required to decide on the optimum fluoride level for school water.

## FLUORIDE IN DIET

To overcome the ethical objection that water fluoridation threatens the freedom of choice, dietary fluoride supplementations (e.g. salt or milk fluoridation) have been proposed as alternatives. These measures would be economical, safe, easily controlled, available to a large segment of the population and yet optional (Beddows, 1974; Wix, 1974). Mackie (1974) made the point, however, that fluoridated milk would be used by the well informed section of the population who already had fair dental health, whereas the low socio-economic groups who would automatically benefit from water fluoridation, would not be reached. Burt (1974b) saw milk fluoridation as an additional therapy in caries prophylaxis but felt the expenses which would be incurred by the dairy industry would be an obstacle. The method should also be subjected to field trials.

Toth (1974) reported the results of a 5 year field trial of table salt fluoridation in Hungary. With a fluoride concentration of 250 mg per kg of salt a 34 per cent to 40 per cent caries reduction in children was reported. He determined optimum requirements of fluoride per kg body weight per day and by correlating this with average daily salt intake, established the necessary fluoride concentration in salt.

## POLITICAL AND ETHICAL ASPECTS OF FLUORIDATION ISSUE

Ericsson (1974) quoted 23 national and international reports which had all affirmed the safety of water fluoridation and recommended its implementation. He mentioned that no antifluoridationist literature of comparable thoroughness and authority had been published. Of the many scientific and health organisations which endorsed their support for water fluoridation, the World Health Organisation (Fluoridation Reporter, 1974a), the American Medical Association (Fluoridation Reporter, 1974b) and the National Association of German Dentists (Zahnärztliche Mitteilungen, 1974) reaffirmed their recommendation of this public health measure.

In a general review of the fluoridation question, its benefits and implementation, Burt (1974a) concluded that a legitimate ethical issue was involved. He pointed out however, that children, who derived most benefit from water fluoridation, in fact had no democratic rights and that therefore, the measure was a sound one.

The Assistant Surgeon General for Dental Services of the United States Army (Smith, 1974) reiterated the benefits of water fluoridation as the least expensive and one of the most effective public health measures. He felt the greatest obstacle in the implementation of fluoridation was the political action required. An example of this was the blocking of a bill to introduce fluoridation throughout New York State, by anti-fluoridationists in the Health Committee, although the bill had previously been carried unanimously by the senate (Sacks, 1974; Tillis, 1974).

Another instance where this political barrier was apparent was in the lack of clear support for water fluoridation by the Joint Working Party of the British Dental Association and the Health Departments of Great Britain (Williams, 1974). In his review of the report, Williams criticized the Working Party for assuming that the general introduction of fluoridation was not politically possible at that time and felt they should have recommended that mandatory powers be sought for the introduction of fluoridation. A fruther criticism of the report was made on the same grounds, by Winter and Murray (1974).

In order to overcome this political barrier to water fluoridation it is necessary not only to inform politicians of the safety and efficacy of the measure, but also to educate the public. This is the approach advocated by Bowen (1974) in a short article on how to gain community fluoridation. An interesting letter from a group of dental students (Wymans *et al*, 1974) questioned the knowledge of politicians on the benefits of fluoridation. During an exhibition held in the British Houses of Parliament, they learnt that the members of parliament, though well aware of the fluoridation question, were far more familiar with antifluoridationist opinions than they were with the positive and well documented advantages. They queried whether the dental profession was doing enough to supply politicians with the scientific basis for promoting fluoridation and opposing accusations and statements by antifluoridationists. Independently, Klieman (1974) appealed to the dental profession for increased membership of the Fluoridation Society, so that from a position of strength, the society could achieve its aim of presenting facts to politicians regarding fluoridation.

Hagen (1974) discussed another obstacle to be overcome for water fluoridation to be generally accepted. In this case it was that the medical and dental profession in Scandinavia regarded fluoridation as a pharmacological rather than a physiological and nutritional question. He emphasised the safety of fluoridation in terms of the regulatory mechanisms in fluoride metabolism and showed fluoride to be an essential nutrient.

The need to educate the public was stressed by both Smith (1974) and Bowen (1974). This was demonstrated by the drop in public support bwtween 1962, when 49 per cent of Norwegians supported fluoridation, and 1973 when only 34 per cent were in favour of it (Helöe and Birkeland, 1974). This difference of 15 per cent was attributed to lack of publicity and the attention given to air and water

pollution at that time. The American Dental Association (Fluoridation Facts, 1974) published a booklet reviewing all the pertinent facts, figures and findings relating to fluoridation. It was well documented, and examined and refuted many criticisms of water fluoridation. It could be a valuable asset in the education of the lay public.

In spite of allegations that scientific journals do not publish antifluoridationist literature (Mummery, 1974a; Bertrand, 1974; Gotzsche, 1974), several letters criticizing scientific methodology of studies carried out in high fluoride areas, appeared. Mummery (1974b) questioned the rationale behind the decision of Jackson *et al* (1974) to use a naturally fluoridated rather than an artificially fluoridated area in their epidemiological study of rampant caries on 5 year old children. He felt that other variables such as water hardness, were not controlled in this study. Jackson (1974b) however, justified his choice of naturally high fluoride areas in terms of the necessity of life-long exposure to fluoride in studies of this nature. He pointed out that water hardness had been shown to have no effect on caries prevalence. Furthermore, he quoted a number of studies in which caries reduction had been shown in artificially fluoridated areas. Cook (1974) criticised the paper on mortality rates in different areas by Nixon and Carpenter (1974), on the grounds that too many variables were introduced when data was taken from different communities. He maintained that the only valid comparison is within one community before and after the commencement of fluoridation. Carpenter and Nixon (1974) replied that it was a matter of opinion whether secular studies were more reliable than comparisons between similar, contemporary communities.

Some of the most valuable publications which appeared in 1974 were the European Organisation for Caries Research (ORCA) reports on water fluoridation (Backer Dirks, 1974; Ericsson, 1974; Künzel, 1974b). They have been referred to previously in this review and comprise 3 reports by international authorities. They cover all the essential facts regarding fluoridation in terms of its benefits, safety and cost and would be especially valuable to those who are in a position to influence its implementation.

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