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FLUORIDATION

by

K. E. Swann¹

¹Secretary, Fluoridation Committee of the New Zealand Board
of Health

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- "1. Drinking-water containing about 1 ppm fluoride has a marked caries-preventive action. Maximum benefits are conferred if such water is consumed throughout life.
- "2. There is no evidence that water containing this concentration of fluoride impairs the general health.
- "3. Controlled fluoridation of drinking-water is a practicable and effective public health measure."

First report of the WHO Expert Committee
on Water Fluoridation
Wld Hlth Org. techn. Rep. Ser., 1958, 146

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1. INTRODUCTION

The high prevalence of dental decay, its seriousness and the widespread nature of this disease have been described in other working papers prepared for these technical discussions. The problems of recruiting and training professional staff and dental auxiliaries in order to alleviate the effects of the disease have also been discussed.

It can be accepted therefore:

- (a) that dental disease is so prevalent and so widespread that it constitutes a serious public health problem;
- (b) that conventional means of protecting the teeth by controlling the diet, teeth brushing, etc. are not of themselves necessarily sufficient in inhibiting decay at a public health level;
- (c) that many countries are precluded from establishing a dental service capable of treating effectively all the teeth becoming decayed - even in the child population.

The discovery that the inclusion of an optimal amount of fluoride in the diet will substantially reduce the present rate of tooth decay introduces a new element into the sphere of dentistry. It removes the care of the teeth from the exclusive field of the dentist into the broad field of public health where the medical, engineering, chemical and other professions can join with the dentist to improve the dental health of nations.

The importance of water fluoridation lies in two unique characteristics:

- (1) it is the first and, so far, only effective means of inhibiting tooth decay by improving the structure of the tooth;
- (2) because it uses the communal water supply it can be used for the protection of the teeth of whole communities without involving any effort by the individual.

2. HISTORICAL BACKGROUND

- 1874 Erhardt¹ suggested a relationship between a low fluoride intake and a high incidence of dental decay.
- 1892 Crichton-Browne² implied that the amount of dental decay in England was in part due to a fluoride deficiency and recommended the addition of fluoride in some form to the diet.
- 1916 Black and McKay³ working in the United States of America published first major report describing the prevalence of "mottling of tooth enamel" in mouths significantly free from dental decay.
- 1931 A method of chemical analysis⁴ of sufficient sensitivity was developed to demonstrate that excessive amounts of fluoride in public water supplies caused "mottled enamel".

1930's - 1940's

Studies of Dean et al⁵ in the United States of America led to these prime conclusions -

- (a) where the fluoride level of a water supply was about 1.0 part per million there was approximately 60% fewer decayed teeth than in non-fluoride areas.
- (b) where the water supply contained less than 1.5 parts per million fluoride observable fluorosis of the teeth did not occur.

Similar results have since been demonstrated in many other countries.

1944/45 Controlled addition of fluoride salts to fluoride deficient water supplies began in Brantford (Canada) Newburgh (United States of America) and Grand Rapids (United States of America).

Controlled fluoridation has since spread widely throughout the United States of America and Canada while about twenty-five other countries now have one or more fluoridation plants operating.

3. SAFETY AND EFFICACY OF FLUORIDATION

The efficacy of controlled fluoridation in preventing tooth decay has been the subject of many studies⁶ and, despite criticisms⁷ of details of the organisation of some of these studies, each has produced results which in substance parallel each other. They reveal that tooth decay in children using from birth a fluoridated water supply is up to 60% less than in those children using a fluoride deficient water.

The theme of these technical discussions is to explore the inter-relationship of dental health with general health. Any improvement to the general standard of dental health by the use of fluoridated water must

contribute to an improvement in the standard of general health - provided the instrument used (i.e. the fluoride salt) does not itself impair in any way the proper functioning of the body.

It is not proposed to discuss the many studies undertaken to demonstrate the safety of controlled fluoridation⁸ but it is worth noting that a recent series of studies,⁹ co-ordinated so that each would supply a facet of information on the effects of the absorption of fluoride have recently been reported - and add yet more proof that fluoridation is harmless to general bodily health.

4. ALTERNATIVE FLUORIDE VEHICLES

In all countries a smaller or larger segment of the population will not have access to a piped water supply. Attempts have therefore been made, particularly in Switzerland, to supplement the amount of fluoride in the diet by using vehicles other than the water supply. These vehicles have included milk, salt and bread. None of these means has been demonstrated to produce results comparable with the ingestion of fluoridated water. The principal drawbacks to their use are:

- (a) difficulty of controlling accurately the dosage given.
- (b) save with milk, babies do not use sufficient quantities of the vehicle in the vital early years when the teeth are forming in the gums.

Tablets containing 1 mg of fluorine (usually in the form of 2.2 mg sodium fluoride in a saline or sugar excipient) are a better means of increasing the intake of dietary fluoride but their effectiveness depends on a regular daily intake and they are, therefore, by comparison with fluoridated water, an inconvenient agent.

The affinity of the fluoride ion for the apatite structure of tooth enamel has also led to studies on the effects of topical applications of fluoride to the surface of the teeth.

Topical treatment with fluoride solutions after cleaning and drying the tooth surfaces is a proven means of inhibiting dental decay but it is wasteful of skilled manpower and therefore has severe limitations as a public health measure. Fluoridated toothpastes and mouthwashes have not been demonstrated beyond doubt to prevent tooth decay to any great extent.

5. TECHNICAL FACTORS ASSOCIATED WITH FLUORIDATION

Fluoridation involves adding sufficient additional fluoride to the water supply to bring the total fluoride content up to 1 part per million. Two salts are commonly used - sodium silicofluoride (Na_2SiF_6) and sodium fluoride (NaF) although hydrofluosilicic acid (H_2SiF_6) is also added in some installations in the United States of America experimental work on

using the naturally occurring fluoride salt, fluorspar, is also being pursued.¹⁰ If these experiments are successful it should be possible to reduce substantially the cost of treating water supplies.

The addition of chemicals to water supplies for various purposes has long been a routine procedure. The only unusual features concerning the addition of fluorides are:

- (a) the extremely small amounts of chemical to be added,
- (b) the corrosive nature of the chemicals used,
- (c) the need to keep the dosage within narrow limits. (In New Zealand the National Fluoridation Committee has set the limits as 0.9 - 1.1 ppm fluoride).

Many types of suitable fluoridation equipment are readily available - the choice being dependent on the design of the water supply system. Most equipment is sufficiently accurate in operation to administer the small amounts of fluoride necessary without difficulty. It is desirable, however, to check daily the total fluoride content of the water. By testing water samples from widely separated points in the distribution system it is possible to ascertain that the fluoride is being uniformly spread throughout the water supply.

The analysis method used in New Zealand is that of S. Megregian (Anal. Chem. 26, 7, 1161). It is based on the reaction between fluoride and the coloured lake formed by the reaction of zirconium with solochrome cyanine. Zirconium and solochrome cyanine together form a red lake in acid solution, but when fluoride is present the zirconium reacts with the fluoride to form a complex, thereby reducing the intensity of the lake.

The procedure used is to add 5 m.l. of solochrome cyanine and 5 m.l. of acid zirconium chloride to a 50 m.l. sample of water to be tested and also to 50 m.l. standard solutions containing respectively 0.6, 0.8, and 1.0 p.p.m. fluoride. The samples are mixed and allowed to stand for 30 minutes while their temperature is brought to $20^{\circ}\text{C} \pm 2^{\circ}$. The amount of light of 527 m.u. wavelength absorbed by each sample and by the standard solutions is then found with a Bausch and Lomb colorimeter. By graphing the absorptions of the standard solutions against their known fluoride contents, a standard curve is obtained, and this is used to find the fluoride content of the water samples.¹¹

To protect workers handling the fluoride compounds suitable protective clothing and a face mask should be supplied. The fluoride compound needs to be housed so that it will be kept dry. Because of its toxic nature it should also be kept locked up to safeguard it from improper use.

The annual per capita cost of fluoridating a water supply is a few pence - between 6d and 1/- in New Zealand. By comparison with the cost of a dental treatment service, fluoridation is cheap. Apart from the initial cost of purchasing and installing the dosing equipment, the only significant item of recurring expenditure is for chemicals. This cost can vary widely - two significant features being:

- (1) the availability of the fluoride ion in the compound used. The percentage of fluoride by weight of sodium fluoride and sodium silico-fluoride is 44 and 60 respectively;
- (2) it may be necessary to use chemicals costing 2-3 times the cheapest available in order to obtain a chemical with the flow characteristics which make it suitable for use in dosing the water.

6. FLUORIDATION IN NEW ZEALAND

An attempt was made in 1953 to fluoridate the water supply of Hastings but the equipment employed proved unsuitable. This was replaced in 1954, since when the fluoride content of the water has been successfully kept at or about 1 ppm. The Hastings project was undertaken to demonstrate the effectiveness of water fluoridation under New Zealand conditions and to gain experience of the technical factors involved. For these reasons the central government is meeting the cost of the project for the first ten years.

In New Zealand, however, water supplies are controlled by local councils and the decision to fluoridate was that of the Hastings Borough Council. Nevertheless, there was some opposition to fluoridation and by 1956 the matter was threatening to become a local political issue. Fluoridation, however, was obviously of wider importance than the questions being raised in Hastings and the Governor-General in Council set up a Commission of Inquiry (with wide terms of reference) to investigate the whole subject.

The principal conclusions of the Commissioners were:

" ... It is our opinion that local authorities are established for the purpose of making community decisions and should be permitted to decide whether or not public water supplies should be fluoridated ...

" ... There is no practicable method of adjusting the intake of fluoride other than by addition of that substance to public water supplies.

"No alternative suggested would be effective as a public health measure.

" ... A national body should be established, charged with the duty of encouraging, advising, and assisting local authorities in regard to the installation and maintenance of fluoridation plants ...

" ... We are satisfied that widespread use should be made of the fluoridation process for the purpose of achieving an urgently needed improvement in the present serious state of dental health in New Zealand"12

This favourable report, together with the early results of fluoridation observed in Hastings,¹³ led the Department of Health to advocate the wide-spread fluoridation of New Zealand's water supplies. Each council was asked to consider the proposition and a health education programme was begun to bring to public attention the need for fluoridation. The anti-fluoridationists had not, however, been mollified by the report of the Commission of Inquiry. They continued to oppose by every possible means all attempts to persuade local councils to fluoridate. Many local Anti-fluoridation Societies were formed and later incorporated into a New Zealand Anti-fluoridation Association.

From developments which followed two main lessons emerged.

- (1) The importance of an effective health education campaign to convince the public at large of the need for fluoridation and the benefits which will ensue

The national health education programme which had been set in train was a long-term project. Health workers had been instructed to avoid controversy. It was hoped to spread the case for fluoridation by talks to civic groups, by the judicious distribution of health education material and generally to avoid being embroiled in arguments with anti-fluoridationists. During 1959, however, eight councils decided to hold a poll of their citizens (to coincide with the local body elections) on whether or not to fluoridate the water supply.

The Department of Health joined with the dentists and doctors and other interested citizens in forming local fluoridation committees in order to intensify health education activities in these towns. The post was used to send fluoridation information material to all households, paid advertisements were inserted in local newspapers, screen slides shown at cinemas, and the programme of talks to civic groups intensified and concentrated. The anti-fluoridationists were, however, intensely active and succeeded in sowing doubt in the minds of the public and in confusing the issue of improved dental health for children. In the event, the proposal to fluoridate was lost in every case.¹⁴

- (2) The importance of clear legal authority to fluoridate

In New Zealand there is no specific authority to fluoridate a water supply, but under Section 288 of the Municipal Corporation Act 1954, authority is given to councils to do things necessary for the preservation of the public health. It was thought sufficient for the Director-General of Health to formally issue a pronouncement that fluoridation was for the promotion of the public health for this section of the Act to cover the fluoridation of water supplies. Nevertheless two attempts have been made to test in the courts the validity of the action of local authorities in fluoridating the water. In the first,¹⁵ the plaintiff was non-suited and in the second¹⁶ the judge upheld the contention of the defendants that the action of the plaintiffs, under the Declaratory Judgments Act 1908, was misconceived. Thus, to date, the courts have not ruled on the legality of treating water supplies with fluoride. The Government has not thought it fit to promote legislation which would place the issue beyond doubt.

It is also conceivable in some countries that the provisions of the Poisons or Food and Drugs Legislation could be violated if the fluoridation of water supplies was introduced without adequate consideration being given to the legal basis of the procedure.

The experience of the Auckland City Council also illustrates a problem which may face communities in some countries. The Auckland Metropolitan water supply is controlled by the Auckland City Council and water is sold by contract to twenty boroughs within the metropolitan area.

The Auckland City Council decided, by majority vote, to fluoridate the water supply provided a majority of the boroughs purchasing the water agreed to the proposal. A majority did agree (or said they had no objection) but the City Council thought it prudent to seek from Parliament empowering legislation in case one or more of the dissenting boroughs disputed the validity of the City Council's proposal in the courts. The Empowering Bill was prepared and, in due course, considered by a Parliamentary Committee which recommended no action be taken until a greater degree of unanimity on the provision of the bill could be demonstrated. Thus fluoridation cannot be introduced into New Zealand's largest city.

7. FLUORIDATION IN HASTINGS

The Hastings fluoridation project is a government-sponsored scheme and the dental surveys associated with it have been undertaken by the Dental Research Officer of the Medical Research Council of New Zealand.^{13, 17.}

During September/November 1954, 1868 children were examined in order to establish a base-line against which to measure the effects of fluoridation.

In order to qualify for the dental examinations in this study, children must:

- (a) be of European extraction,
- (b) have lived in Hastings throughout life,
- (c) consumed only the city water,
- (d) be aged 5-16 inclusive,
- (e) be attending school on the day of the dental examiner's visit.

During March and April 1959, 1901 Hastings children were examined by the same Research Officer. After 4-1/2 years of fluoridation the following results, in summary, were observed:

- (1) the prevalence of dental decay in the permanent teeth of children aged six, seven and eight years had been reduced by 61%, 53% and 32% respectively;
- (2) reduction in the prevalence of caries in the deciduous teeth for children aged five, six and seven were 40%, 26% and 14% respectively;

- (3) the numbers of five-year old children immune to decay had risen from 4% in 1954 to 23%; in the case of six-year olds the proportion had increased from 3% in 1954 to 12% in 1959;
- (4) no cases resembling dental fluorosis were seen.

8. THE FUTURE OF FLUORIDATION IN NEW ZEALAND

To date only two cities are fluoridating - Hastings and Lower Hutt. During 1961 it is hoped that the cities of Wellington and Invercargill will commence fluoridating while one or two smaller communities are considering the matter.

The Department of Health, supported by the New Zealand Dental Association, has resumed a long-term health education programme to stimulate interest in fluoridation. This programme, together with the favourable results so far observed at Hastings,¹⁷ should eventually lead to the acceptance by the public and local councils of the need for fluoridating water supplies - especially since New Zealand has an enviable reputation for promoting the welfare of its children.

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