

In Colorado Springs, Colo., where the water supply naturally contains an excessive amount of fluoride, the recommendation to provide children with bottled water almost free of fluoride during development of the permanent teeth has produced measurable reduction of fluorosis, but few parents have followed the recommendation.

Experience in Preventing Dental Fluorosis By Using Low-Fluoride Bottled Water

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THE RELATIONSHIP between fluoride and dental health was first discovered in 1931. At that time it was learned that children with dental fluorosis had been born and reared in areas where excessive quantities of fluoride were present naturally in water supplies (1,2). Subsequent epidemiological studies (3-6) and animal investigations (7,8) have demonstrated an inverse relationship between the consumption of fluoride-bearing water and the prevalence of dental caries.

The optimal level of fluoride in drinking water is about 1.0 p.p.m. F, with a slight adjustment permitted above or below that point for temperature. This level is effective in preventing dental caries and, at the same time, constitutes the threshold for dental fluorosis (9). When the fluoride level of the drinking water exceeds the threshold, dental fluorosis makes its appearance, beginning with inconspicuous man-

ifestations. There is a proportionate increase in the percentage of the population affected by dental fluorosis and in the severity of the condition as the fluoride level increases beyond the threshold. In its milder forms, dental fluorosis is objectionable only because of the cosmetic effect, but when the fluoride level of a community water supply is high enough to produce the more severe forms, preventive measures are indicated.

The work of early investigators, in associating dental fluorosis with ingestion of high-fluoride water during the development of the permanent teeth, has shown that the disease can be prevented by consumption of water of low-fluoride content during the first 8 years of life (1,2). In an effort to apply this knowledge constructively, dentists and pediatricians of Colorado Springs, Colo., a community with a water supply high in fluoride and with a correspondingly high prevalence of dental fluorosis, have recommended since 1935 that parents provide their children with low-fluoride water during the development of the permanent teeth as a preventive measure against this disease. The local dairies have cooperated by supplying low-fluoride (0.2 p.p.m. F) bottled water from their private wells, delivering it to the homes

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with the milk. Many families have purchased this water.

To evaluate voluntary use of low-fluoride water as a measure to prevent dental fluorosis, a study of the city's 13- and 14-year-old children was conducted. First, we investigated the extent to which the bottled water had been used. Second, we compared the prevalence of fluorosis and of dental caries in children who had consumed the bottled water with the prevalence in children who had consumed only the city water.

Colorado Springs was the scene of previous studies by Dean (4,10) on the relationship of waterborne fluorides to dental fluorosis and dental caries, and by Russell (6) on the relationship to dental caries and periodontal disease. The city possesses the following requisites for quantitative evaluation (5) of the effects of ingestion of high-fluoride water:

1. The fluoride content (2.6 p.p.m. F) of the communal water supply is sufficient to cause dental fluorosis in a high percentage of continuous residents (4).

2. The history of the water supply discloses no relevant changes in its physical setup, source, or composition during the past 75 years. (Before initiating the study, a careful check was made of the water supply since 1935.)

Study Method and Procedures

The study information was collected during October 1953. The children selected for investigation included all available 13- and 14-year-old white children who were born in Colorado Springs, who had resided in areas served by the city water supply system, and who had not been away from the city for more than 30 days in any 1 year during the first 8 years of life.

The children were subjected to a strict screening procedure to exclude from the study any whose residence and water histories did not conform to the requirements. Four separate checks were made. First, a questionnaire was sent to the parents, requesting information on all absences of the children from the city during their first 8 years and on the source of water consumed by the family. Second, another questionnaire was sent to the parents of chil-

dren classified as eligible from answers to the first. This inquired into possible family residence in suburban areas not on the main city water system. Verification of the residence and water histories was obtained by oral questioning of the mothers during home interviews, and a final check was made at the time of the dental examination by oral questioning of the children.

During the home interviews, the mothers were questioned with respect to the early dietary of their children, particularly the use of bottled water and the period of its consumption. Information was secured on the water used in preparing formula and on the supplementary water customarily offered to the child between feedings, but not on the water used for cooking food eaten by the children.

Dental examinations were made by a dentist using mouth mirror, No. 5 double end explorer, and portable operating light. Data were recorded on degree of fluorosis and on dental caries in all permanent teeth except third molars. Fluorosis was classified as very mild, mild, moderate, or severe. Since it was anticipated that much of the caries would be located in pits and fissures, the criteria for diagnosis of beginning caries in those locations were established as (a) penetration of the pit or fissure by the explorer tip, (b) the explorer to remain in place without pressure, and (c) the explorer to resist withdrawal. No areas in which the explorer caught were counted as carious in the absence of the objective signs of opacity or penetration of softened tooth structure.

Subsequent to the dental examinations and the collection of data on residence and water consumption, the children were divided into a study group composed of children who had consumed bottled water and a control group composed of those who had used only the high-fluoride city water. The periods during which bottled water had been used ranged from as little as a week to as long as an entire lifetime. This presented a problem: The inclusion of children who had consumed the bottled water for only a few weeks would dilute the study group with virtual counterparts of the control group. The inclusion of only those children who had consumed the bottled water for the full 8 years of tooth development, which would

Table 1. Prevalence of fluorosis among 13- and 14-year-old children, according to source of water consumed, Colorado Springs, Colo.

Group and age	Number of children examined	Children with fluorosis	
		Number	Percent
Group I (bottled water) ¹	56	21	37.5
13.....	38	13	34.2
14.....	18	8	44.4
Group II (city water) ²	120	82	68.3
13.....	71	47	66.2
14.....	49	35	71.4

¹ All children received bottled water containing 0.2 p.p.m. F for a minimum period of the first year of life; some received it for longer periods of time, ranging up to 14 years. ² All children consumed city water containing 2.6 p.p.m. F throughout their lives.

be desirable from the standpoint of determining the effect of ingestion of low-fluoride water on fluorosis and dental caries prevalence, would not give a study group large enough to warrant serious conclusions. It was decided to set as the requirement for the study group the consistent use of bottled water (in formula and as supplementary water) during at least the first year of life. This requirement gave a study group of usable, although less than desirable, size. The first year of life was considered to be the most reliable continuous period during which bottled water was consumed.

Qualifying for admission to either the study group or the control group were 176 children. The study group (group I) was composed of 56 children who had consumed the bottled water for 1 year to 14 years. Twenty percent of these

children had consumed the bottled water for as long as 4 years. The control group (group II) was composed of 120 children who had consumed only city water.

Fluorosis and Dental Caries

Table 1 presents the findings with respect to prevalence of dental fluorosis in groups I and II. Of the 56 children who had received bottled water, 37.5 percent had fluorosis. Of 120 children who had ingested city water, some evidence of the condition was found in 68.3 percent. The findings were consistent for both 13- and 14-year-old children in both groups.

In addition to the percentage of children with fluorosis, the dental fluorosis index (5), which describes the degree of clinical severity of the disease, was computed for each group. The index employs a formula in which a weighted value is assigned to each degree of fluorosis. It therefore provides a more meaningful epidemiological picture of the relative intensity of fluorosis prevalence in a group than may be obtained by simple numerical count of those affected. The index range of 0.0 to 4.0 affords classification of the significance of fluorosis in a community from "negative" to "very marked," with intermediate degrees of "borderline" (0.4-0.6), "slight" (0.6-1.0), "medium" (1.0-2.0), and "marked" (2.0-3.0). An index of 0.6 or greater indicates a problem of public health concern.

The dental fluorosis index of group I was 0.75 as compared with an index of 1.17 for group II. In 1940, Dean (4) reported a dental fluorosis

Table 2. Prevalence of dental caries among 13- and 14-year-old children, according to source of water consumed, Colorado Springs, Colo.

Group and age	Number of children examined	Caries-free children		Number of DMF teeth	Number of DMF teeth per child
		Number	Percent		
Group I (bottled water) ¹	56	30	53.6	79	1.41
13.....	38	18	47.4	54	1.42
14.....	18	12	66.7	25	1.39
Group II (city water) ²	120	58	48.3	214	1.78
13.....	71	37	52.1	100	1.41
14.....	49	21	42.9	114	2.33

¹ All children received bottled water containing 0.2 p.p.m. F for a minimum period of the first year of life; some received it for longer periods of time, ranging up to 14 years.

² All children consumed city water containing 2.6 p.p.m. F throughout their lives.

index of 1.3 for 404 native white 12-, 13-, and 14-year-old children in Colorado Springs, an index slightly higher than the index of group II. Both 1.17 and 1.3 are classified as of "medium" significance.

The 11 children (20 percent) in group I who had consumed the bottled water for 4 years or more had a fluorosis index of 0.50. The remaining 45 children (80 percent) who had used this water for at least 1 year but for less than 4 years had a fluorosis index of 0.84.

The dental caries experience of the two groups is shown in table 2. About half the children in each group were caries free. The DMF rate for the group which had used bottled water was slightly lower than the DMF rate for the group which had used city water, 1.41 as compared with 1.78 DMF teeth per child. The difference, however, is not statistically significant.

Discussion

Although the mothers appeared to experience little difficulty in recalling, 13 to 14 years later, details of their children's dietaries, such as formula preparation, source of supplementary water, and length of time on bottled water, it is recognized that there is possibility of errors of memory. This was more probable when there were several children in the family. This circumstance must be kept in mind in evaluating the observations presented here.

It is possible that some, if not all, children in group I while on bottled water concurrently received variable amounts of city water through eating foods cooked in tap water or when the bottled supply was temporarily exhausted. It is likely, also, that as the children grew older, an increasing amount of city water was consumed from various sources outside the home, particularly after admission to school at age 6, and certainly by those for whom the provision of bottled water was discontinued. This would cause the fluoride intake of group I to approach that of group II, thus tending to obscure the effects of the variable under consideration. It is impossible to know with exactness the extent to which the city water was consumed by group I; however, these children revealed a fluorosis experience equivalent to that which is

known to result from consumption of water with an average fluoride content of about 1.5 p.p.m. during the development of the permanent teeth (11).

Among the children who consumed low-fluoride bottled water for periods ranging from 1 to 14 years, 37.5 percent developed fluorosis. In contrast, among the children who consumed high-fluoride city water throughout their lives, 68.3 percent developed fluorosis. If the percentage of fluorosis found in the latter group is considered to represent normal fluorosis expectancy in this city, and if the same proportion had prevailed in the group on bottled water, 38 children with fluorosis might have been expected instead of 21, a difference of 45 percent.

The recommendation by pediatricians and dentists in Colorado Springs that children receive low-fluoride water to prevent dental fluorosis has resulted in measurable benefit. The prevalence of fluorosis in children for whom this practice was followed for a year or longer was only half that observed in children who remained on the high-fluoride city water. The greater percentage of individuals without fluorosis among the children who had received the bottled water shows a definite correlation with ingestion of this water.

Nevertheless, the study indicates that this recommendation has not been practiced widely and consistently. Relatively few parents had ever provided bottled water for their children, and very few had provided it during the full 8 years essential for prevention of fluorosis. Of the 176 children studied, less than one-third (56) had received bottled water for as long as 1 year, and only 20 percent of these had consumed it for more than 4 years.

The fluorosis index of the children on bottled water (0.75) falls in the objectionable range; about one-third of them had an undesirable degree of fluorosis. It is possible that the recommendation might have been more successful in achieving its objective if it had been more strongly brought to the attention of parents through a variety of sustained educational measures. Of interest in this respect was the observation that several children were still consuming bottled water at 14 years of age, indi-

cating that their parents did not understand that it could be discontinued at age 8.

In view of the inadequate results obtained by voluntary use of low-fluoride bottled water, defluoridation of the city water supply to an optimal fluoride level might be considered as an alternative preventive measure. Defluoridation would benefit the total child population, in contrast to the existing practice which benefits only the few children who are given the bottled water consistently for the required number of years. Furthermore, defluoridation would obviate the possibility of children ingesting an excessive amount of fluoride from foods cooked in city water and from other sources. This is a likely circumstance as has been pointed out. The cost of defluoridation constitutes a deterring but not insuperable obstacle to employment of this measure.

The children on bottled water were not more susceptible to caries than the children on city water, an eventuality which might be expected to result from inadequate fluoride intake. On the contrary, the ingestion of bottled water apparently had no effect on the percentage of children immune to caries at the age levels studied. This suggests that the children on bottled water received, at a time critical to the development of caries-inhibiting factors, enough city water from various undetermined sources to produce the same degree of caries immunity as among the children on city water. Furthermore, they had a caries rate as low as that of the children who had ingested the city water. These observations indicate that the group I children had received an amount of fluoride of near-optimal level (11) with respect to caries prevention.

The caries rates of both groups were extremely low, even when compared with caries rates in other communities with high-fluoride water supplies. In part, this may be accounted for by the examination criteria employed, which described as carious only those pits and fissures which exhibited objective signs of caries.

Summary

In 1953, a study was undertaken in Colorado Springs, Colo., to learn what success in pre-

venting dental fluorosis had been achieved by the practice of recommending that children be given low-fluoride water during the development of their permanent teeth. For the past 75 years, the water supply of this city has contained about 2.6 p.p.m. F, and the prevalence of dental fluorosis in continuous residents has been high. Since 1935, bottled water containing 0.2 p.p.m. F has been available from the local dairies.

All available 13- and 14-year-old children who were lifetime residents of the city were the study subjects. From information obtained in home interviews with mothers of the children, it was learned that only 56 children had consumed bottled water for as long as the first year of life, as compared with 120 who had consumed only city water. The period of use of bottled water ranged up to 14 years, but only 20 percent of the 56 children had consumed the bottled water 4 years or longer. Several children were still on bottled water at the age of 14, indicating that their mothers did not understand that it could be discontinued at age 8.

Data from dental examinations provided the following observations:

1. Of the children on city water, 68.3 percent developed fluorosis. Of those using bottled water for varying periods of time, only 37.5 percent exhibited fluorosis. The lower percentage in the latter group may be attributed to the use of the bottled water.

2. Many of the children who used the bottled water still demonstrated objectional fluorosis, probably due to irregular use of this water. The fluorosis index for the group on bottled water was 0.75.

3. About 50 percent of each group of children were free of dental caries, and there was no substantial difference in the DMF rate between the two groups.

From these observations, it is concluded that the practice of recommending the use of low-fluoride water has resulted in a reduction in the prevalence of fluorosis and that it has not adversely affected the prevalence of caries. However, defluoridation of the city water supply to 1.0 p.p.m. F would seem to be a more effective means of preventing fluorosis. At the same time, it would assure consumption of water containing an optimum level of flu-

oride for prevention of dental caries by all children in the community.

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Trial Interviews for the National Health Survey

A pilot test study under the new National Health Survey program of the Public Health Service was initiated on January 28, 1957, in Charlotte, N. C. The action is designed to test several aspects of a questionnaire intended for nationwide use.

Basic data collected by interviewers from a sample of households in the metropolitan area of the city will include the number, age, sex, and other characteristics of persons with diseases, injuries, or handicapping conditions. Questions also concern medical care, the length of time afflicted persons are unable to pursue their normal activities, and the economic and other effects of their incapacity. The Charlotte study will also serve as a trial for field administration techniques.

Performance of this advance test and other field work on the survey has been assigned to the Bureau of the Census.

Legislation enacted by Congress last summer authorized the Surgeon General of the Public Health Service to set up continuing annual surveys and special studies on illness and disability in the Nation.