

Tenth Year of the Grand Rapids-Muskegon Study

Effect of Fluoridated Public Water Supplies on Dental Caries Prevalence

By FRANCIS A. ARNOLD, Jr., D.D.S., H. TRENDLEY DEAN, D.D.S.,
PHILIP JAY, D.D.S., and JOHN W. KNUTSON, D.D.S., Dr.P.H.

AS EARLY as 1942, it had been adequately demonstrated that the use of fluoride-bearing drinking waters produces a marked reduction in the incidence of dental caries. It was also known by that time that this beneficial effect occurs in populations using water supplies containing fluoride from natural sources in concentrations below the level established as the threshold for mottled enamel or endemic fluorosis (1).

These epidemiological studies suggested the hypothesis that the addition of fluorides to public water supplies would result in a substantial reduction in dental caries. To test this hypothesis and to evaluate the procedure as a method

of caries control, several studies were begun in 1944-45. One of these studies is the Grand Rapids-Muskegon study, conducted by the Public Health Service with the cooperation of the Michigan Department of Health, the University of Michigan, and the city officials of Grand Rapids and Muskegon, Mich. This paper summarizes some of the findings from 10 years of observation in that study.

General Procedure

As originally planned the Grand Rapids-Muskegon study was designed to continue for a period of 10 to 15 years. This period was selected so that observations would be comparable to those obtained in the basic epidemiological studies on children 12 through 14 years of age with a continuous history of using fluoridated water. The selection of the study areas, the methods and types of examinations, the selection of the annual study groups, and preliminary findings have been reported (2, 3).

Beginning in January 1945, sodium fluoride has been added to the water supply of Grand Rapids, the principal study area. Since that time the fluoride content of the water supply has been maintained at a concentration level of 1 p.p.m. (within the range 0.9 to 1.1 p.p.m.). The water supply at Muskegon, the control area, contained less than 0.2 p.p.m. of fluoride until July 1951. At that time Muskegon began adding fluoride to its water supply to maintain a level similar to that in Grand Rapids. (In this paper, parts per million of fluoride refers to the concentration of the fluoride ion.)

Dr. Arnold is director of the National Institute of Dental Research, National Institutes of Health, Public Health Service; Dr. Dean is secretary of the Council on Dental Research, American Dental Association; Dr. Jay is professor of dentistry at the University of Michigan School of Dentistry; and Dr. Knutson is chief dental officer of the Public Health Service.

The following dental officers of the Public Health Service conduct the annual dental examinations in the Grand Rapids-Muskegon study: Dr. Robert C. Likins, Dr. A. L. Russell, Dr. David B. Scott, Dr. D. E. Singleton, and Dr. Robert M. Stephan. The following dentists, formerly with the Public Health Service, also participated as examiners in the study: Dr. F. S. Loe, Los Angeles, Calif.; Dr. H. B. McCauley, Baltimore, Md.; Dr. S. J. Ruzicka, Cleveland, Ohio; and Dr. Edwin M. Short, Hyattsville, Md.

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To establish the caries status of the study population before fluoridation of the waters, complete oral examinations with a mouth mirror and explorer were made of virtually all children enrolled in elementary and secondary schools in Grand Rapids and Muskegon in 1944 and 1945. Each year thereafter, similar examinations have been made of selected samples of children in the two areas. (Bite-wing roentgenographic and bacteriological studies on selected samples of children will be reported in subsequent papers.) To provide an "expectancy curve," complete oral examinations were also made, in 1945 and 1946, of school children in Aurora, Ill., where it is known the water supply has contained 1.2 p.p.m. fluoride from natural sources for about 50 years.

The annual samples of the school population of Grand Rapids and Muskegon are taken from schools selected as representative of each city as a whole. The samples consist of all available children in certain grades (or in sections of the grades) in these schools. The grades are selected to yield certain age groups. The number of grades has been expanded each year so that for the 10th year of the study a representative sample of children at each age from 5 through 16 years was obtained. The grades selected for the annual examinations are as follows:

<i>Year</i>	<i>Grade</i>
1945.....	Kindergarten, 1, 8
1946.....	Kindergarten, 1, 4, 8
1947.....	Kindergarten, 1, 4, 8, 11
1948.....	Kindergarten, 1, 4, 8, 11
1949.....	Kindergarten, 1, 4, 6, 8, 11
1950.....	Kindergarten, 1, 2, 3, 4, 6, 8, 11
1951.....	Kindergarten, 1, 2, 3, 4, 6, 8, 11
1952.....	Kindergarten, 1, 2, 3, 4, 5, 6, 8, 11
1953.....	Kindergarten, 1, 2, 3, 4, 5, 6, 7, 8, 11
1954.....	Kindergarten through 11

Each year of the study, all available children in the selected grades (or section thereof) in each school in the study received dental examinations. Only the records of children aged 4-16 years who had used city water supplies continuously since birth are included in this report. Not included are records of children who lived outside their respective communities for more than 3 months in any one calendar year. The number of continuous resident chil-

dren and their distribution by age for each year of the study are shown in table 1.

Results

The amount of dental caries observed at each annual examination through 1954 in Grand Rapids and in Muskegon is shown in tables 2 and 3. There has been a striking reduction in the amount of dental caries in both the deciduous and permanent teeth. For example, in 1944 the average 6-year-old child had 6.43 def (decayed, extraction indicated, or filled) deciduous teeth; in 1954 the average child had only 2.95 def teeth. This represents a reduction of about 54 percent. Similar results were observed in the permanent teeth of children born since fluoridation started; that is those 6 to 10 years old. It should be noted also that some beneficial effect was obtained by the older children. For example, the 16-year-old children had an average of 13.50 DMF (decayed, missing, or filled) permanent teeth in 1944 and 9.95 in 1954. They were between 6 and 7 years of age when fluoridation started.

A breakdown of the dental caries experience rates for 1954 in the two cities is shown in table 4. For comparison with these results, table 5 offers the findings in 1945 among Aurora, Ill., children, who had used a naturally fluoridated water since birth. The caries experience observed among them is similar to that reported for other areas with fluorides of that concentration (1).

Prior to the decision to add fluoride to the water supply at Grand Rapids, it was concluded that the procedure would not produce an undesirable cosmetic effect, that is, mottled enamel. However, it was recognized that an increase in the milder, nonobjectionable forms of dental fluorosis was likely. In order to evaluate this factor fully, it is necessary to wait for observations on all permanent teeth (excluding third molars) which are calcified on fluoridated water. The observations to date give evidence of only a slight increase (0.24 percent in 1944; 0.36 percent in 1954) in the number of children with the milder forms of fluorosis, which are not objectionable from an esthetic or cosmetic standpoint.

[Tables 1,2,3 and 5 are included in the web version of this reproduction only. Available from : <http://www.who.int/bulletin>]

Table 1. Distribution of continuous resident children examined in Grand Rapids and Muskegon, Mich., according to age, by year of examination

Table 2. Average number of def¹ deciduous teeth per child² in Grand Rapids and Muskegon, Mich., by year of examination

Table 3. Average number of DMF¹ permanent teeth per child² in Grand Rapids and Muskegon, Mich., by year of examination

Table 5. Dental caries in deciduous and permanent teeth of continuous resident children of Aurora, Ill., as observed in the 1945-46 examination period

Table 4. Dental caries in deciduous and permanent teeth of continuous resident children of Grand Rapids and Muskegon, Mich., as observed in the 1954 examination

Age last birthday	Number of teeth per child						Percent of caries-free children ⁴
	Deciduous teeth		Permanent teeth				
	Filled	Total def ¹	Decayed	Missing ²	Filled	Total DMF ³	
Grand Rapids, Mich.							
4.....	0.68	2.12					
5.....	1.14	2.50	0.01		0.01	0.02	99.4
6.....	1.30	2.95	.11		.09	.19	89.3
7.....	1.45	3.26	.36		.35	.69	66.8
8.....	1.42	3.31	.52	0.02	.77	1.27	49.4
9.....	1.30	3.00	.74	.04	1.26	1.97	33.1
10.....	.98	2.35	.73	.07	1.63	2.34	26.6
11.....	.63	1.32	.78	.10	2.19	2.98	16.8
12.....	.12	.44	1.14	.26	2.55	3.87	13.5
13.....	.04	.18	1.56	.44	3.23	5.05	10.7
14.....			2.13	.52	4.36	6.78	5.6
15.....			2.08	1.02	5.23	8.07	1.2
16.....			1.96	1.35	6.90	9.95	2.0
Muskegon, Mich. ⁵							
4.....	1.18	3.03					
5.....	.98	3.98	0.03			0.03	98.4
6.....	1.64	4.85	.33	0.00	0.13	.45	79.8
7.....	1.96	5.35	.74	0	.41	1.14	49.7
8.....	2.03	4.98	1.23	.06	.95	2.18	27.5
9.....	1.60	3.81	1.29	.14	1.80	3.16	14.5
10.....	1.14	2.75	1.44	.23	2.20	3.72	5.7
11.....	.44	1.42	1.79	.32	2.67	4.58	4.3
12.....	.14	.61	2.05	.42	3.85	6.12	4.4
13.....	.06	.12	2.47	.72	4.97	7.98	1.6
14.....			4.31	1.39	5.31	10.74	0
15.....			3.55	1.42	6.51	11.19	1.4
16.....			2.78	1.42	8.77	12.55	1.1

¹ Decayed, extractions indicated, or filled deciduous teeth.

² Includes teeth listed as "remaining roots" and teeth destroyed beyond any possible repair.

³ Decayed, missing, or filled permanent teeth; each tooth is counted only once for this total. A tooth that has both a filled and a carious surface is included in both the "Decayed" and the "Filled" columns.

⁴ Permanent teeth only.

⁵ These children had already received the beneficial effects of 3 years of water fluoridation (see text).

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Discussion

From the results obtained in Grand Rapids after 10 years of water fluoridation, it is quite clear that this procedure is remarkably effective in reducing the incidence of dental caries. These observations are in accord with the results of similar studies conducted under separate auspices (4-6). The scientific evidence is conclusive, therefore, that water fluoridation is an effective public health procedure for producing a substantial reduction in the incidence of dental caries.

According to this study, the beneficial effects of fluoridated water are not confined to persons drinking the water since birth. The results suggest that some benefit was obtained by persons whose teeth had already formed or erupted when they started drinking fluoridated water. The effects on the teeth of adults in these cities have not as yet been ascertained. However, the fact that a reduction in caries was observed for teeth which had already been calcified when fluoridation was started indicates that some beneficial effect may be gained by older age groups.

The possibility of an increase in dental fluorosis in a community after fluoridation has received considerable discussion. After 10 years of fluoridation in Grand Rapids, the percentage of children classed as having fluorosis has increased, but, as anticipated, this increase is confined to the milder forms. As pointed out previously (7), the signs of the milder forms of fluorosis caused by ingestion of water containing 1 p.p.m. fluoride as a rule do not appear on the anterior teeth. It is the plan of this study to continue the observations to evaluate this factor fully. Thus far, however, the ingestion of the Grand Rapids water supply has not produced any undesirable cosmetic effect in the form of objectionable dental fluorosis on the anterior teeth.

Summary

The results of the Grand Rapids-Muskegon study after 10 years of observation indicate that the adjustment of the fluoride content of a communal water to an optimal level (approximately 1 p.p.m. fluoride) will produce the following effects:

1. A striking reduction in the prevalence of dental caries in the deciduous teeth. At the peak of prevalence, namely 6 years of age, the caries rate for the deciduous teeth was reduced by about 54 percent.

2. A marked reduction in the prevalence of dental caries in the permanent teeth. In children born since fluoridation was put into effect, the caries rate for the permanent teeth was reduced on the average by about 60 percent.

3. Some benefit among persons whose teeth having already formed or erupted when fluoridation is begun.

4. No undesirable cosmetic effect from dental fluorosis.

REFERENCES

- (1) American Association for the Advancement of Science: Dental caries and fluorine, edited by F. R. Moulton. Lancaster, Pa., Science Press, 1946.
- (2) Dean, H. T., Arnold, F. A., Jr., Jay, P., and Knutson, J. W.: Studies on mass control of dental caries through fluoridation of the public water supply. Pub. Health Rep. 65: 1403-1408, Oct. 27, 1950.
- (3) Arnold, F. A., Jr., Dean, H. T., and Knutson, J. W.: Effect of fluoridated public water supplies on dental caries prevalence. Seventh year of the Grand Rapids-Muskegon Study. Pub. Health Rep. 68: 141-148, February 1953.
- (4) Ast, D. B., Smith, D. J., Wachs, B., and Cantwell, K. T.: Newburgh-Kingston caries-fluorine study. XIV. Combined clinical and roentgenographic dental findings after ten years of fluoride experience. J. Am. Dent. A. 52: 314-325, March 1956.
- (5) Hutton, W. L., Linscott, B. W., and Williams, D. B.: Final report of local studies on water fluoridation in Brantford. Canadian J. Pub. Health 47: 89-92, March 1956.
- (6) Hill, I. N., Blayney, J. R., and Wolf, W.: The Evanston dental caries study. XI. The caries experience rates of 12-, 13-, and 14-year-old children after exposure to fluoridated water for fifty-nine to seventy months. J. Dent. Res. 34: 77-88, February 1955.
- (7) Dean, H. T., Jay, P., Arnold, F. A., Jr., and Elvove, E.: Domestic water and dental caries. II. A study of 2,832 white children, aged 12-14 years, of 8 suburban Chicago communities, including *Lactobacillus acidophilus* studies of 1,761 children. Pub. Health Rep. 56: 761-792, April 11, 1941.