

Grand Rapids Fluoridation Study—Results Pertaining to the Eleventh Year of Fluoridation

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As long as the adoption of water fluoridation is to be left to the vagaries of public or popular decision—and it is one of the few public health protective devices that is subject to such unpredictable action—every bit of scientific evidence of fluoridation's value should be readily at hand for persuasive use. This is the second of four important papers, "New Developments in Water Fluoridation." The remaining two will appear serially in succeeding issues.

✱ The control of dental caries by water fluoridation has been the subject of articles and reports for more than a decade. Relatively complete bibliographies on this subject are included in previous review dissertations.¹⁻⁴ It may be stated that all recognized scientific studies have demonstrated the certainty of this method as a public health procedure for securing better dental health for a community.

Although many of the studies on water fluoridation have been in progress long enough to evaluate the soundness of the procedure, much is to be learned concerning its various public health aspects. The purpose of the present paper is to review briefly the results of 10 years of one of these research projects; to summarize the findings of the eleventh year of the study, particularly those observations which pertain to dental health programs; and to evaluate the findings in respect to the results of other independent investigations of similar character. For this reason the

results of three of these studies covering the first 10 years of operation will be discussed.

Study Plan

Generally speaking, all of the studies referred to are designed to evaluate what, if any, effect fluoridation of a public water supply will have on the general health of the community using this supply. This public health responsibility has been foremost in the minds of all people concerned and has been recognized by everyone involved in initiating or endorsing such programs. The technical methods of evaluation used in these different research projects have been described previously.⁵⁻⁸

Particularly, the study plans were designed to determine the prevalence of dental caries in a community prior to fluoridation and to evaluate the effects by subsequent annual oral examinations. In each of these studies due attention has been paid to determining whether fluoridation has any effect upon the general health, in addition to the dental health, of the population using the fluoride water.

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Table 1—Distribution of Continuous Resident Children Examined in Grand Rapids, Muskegon, Mich., and Aurora, Ill., According to Age and Year of Examination

Age ¹	Aurora, Ill. 1945	Basic Examination 1944-1945	Grand Rapids, Mich.												1955
			1945	1946	1947	1948	1949	1950	1951	1952	1953	1954			
4	30	323	540	300	168	137	75	117	168	116	101	77	—		
5	407	1,633	1,714	831	886	842	777	720	853	1,087	715	529	—		
6	473	1,789	1,186	628	663	736	697	748	750	826	1,010	561	—		
7	516	1,806	149	82	69	55	54	438	423	422	410	751	—		
8	469	1,647	15	216	135	138	155	501	470	444	390	567	—		
9	368	1,639	—	525	465	484	519	520	582	720	623	477	—		
10	397	1,626	—	109	108	111	125	131	141	512	499	515	—		
11	383	1,556	—	17	18	22	140	130	151	246	291	499	27		
12	401	1,685	174	85	38	60	130	200	176	211	316	260	168		
13	401	1,668	953	547	625	600	574	530	497	497	557	224	254		
14	433	1,690	273	173	196	152	153	130	128	119	111	250	254		
15	467	1,511	80	53	80	64	64	58	53	80	99	240	307		
16	371	1,107	4	3	233	245	209	177	198	191	197	198	212		
	5,116	19,680	5,088	3,569	3,684	3,646	3,672	4,400	4,590	5,471	5,319	5,148	1,222		

Muskegon, Mich. ²															
4	20	43	18	26	51	41	63	52	43	40	—				
5	402	321	348	422	340	359	351	487	370	381	55				
6	462	339	312	305	393	310	294	353	397	386	72				
7	408	36	42	36	30	274	223	246	209	292	78				
8	376	18	13	10	12	190	275	205	212	244	75				
9	357	213	215	199	197	227	277	348	258	275	65				
10	359	62	57	52	52	51	62	287	311	226	63				
11	293	12	10	14	146	141	139	133	175	208	54				
12	328	21	19	11	28	43	48	46	163	183	93				
13	377	197	207	208	214	173	225	178	228	243	58				
14	369	77	50	79	66	63	59	54	51	121	—				
15	292	18	44	41	34	35	21	30	35	139	—				
16	248	1	199	205	132	146	155	132	161	185	—				
	4,291	1,358	1,534	1,608	1,695	2,053	2,192	2,551	2,613	2,923	613				

1. See reference 4 relative to effect of selection of sample by grades on specific age groups.

2. The basic examinations in Muskegon were not done until late spring of 1945; therefore, no examinations were made in the fall of 1945.

The Grand Rapids study, for example, was designed to continue 10–15 years. For base line data all children in attendance in schools were examined in 1944, prior to fluoridation. In each succeeding year, an increasing number of selected age group samples of school children were examined. In 1954, after

10 years of fluoridation in Grand Rapids, the age distribution of the examined sample was relatively complete for the ages five through 16.⁹ After the tenth year of observation, the study design called for a concentration of effort on a selected group of children more than 10 years of age (Table 1).

Table 2—Dental Caries Experience in Deciduous and Permanent Teeth of Continuous Resident Children of Grand Rapids and Muskegon, Mich., as Observed in 1954 Examination (From Pub. Health Rep. 71:652 (July), 1956)

Age Last Birthday	Deciduous Teeth		Permanent Teeth				Per cent of Caries-Free Children ⁴
	Number Filled	Total def ¹	Decayed	Missing ²	Filled	Total DMF ³	
Grand Rapids, Mich. Number of Teeth per Child							
4	0.68	2.12	—	—	—	—	—
5	1.14	2.50	0.01	—	0.01	0.02	99.4
6	1.30	2.95	0.11	—	0.09	0.19	89.3
7	1.45	3.26	0.36	—	0.35	0.69	66.8
8	1.42	3.31	0.52	0.02	0.77	1.27	49.4
9	1.30	3.00	0.74	0.04	1.26	1.97	33.1
10	0.98	2.35	0.73	0.07	1.63	2.34	26.6
11	0.63	1.32	0.78	0.10	2.19	2.98	16.8
12	0.12	0.44	1.14	0.26	2.55	3.87	13.5
13	0.04	0.18	1.56	0.44	3.23	5.05	10.7
14	—	—	2.13	0.52	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 Number of Teeth per Child							
4	1.18	3.03	—	—	—	—	—
5	0.98	3.98	0.03	—	—	0.03	98.4
6	1.64	4.85	0.33	0.00	0.13	0.45	79.8
7	1.96	5.35	0.74	—	0.41	1.14	49.7
8	2.03	4.98	1.23	0.06	0.95	2.18	27.5
9	1.60	3.81	1.29	0.14	1.80	3.16	14.5
10	1.14	2.75	1.44	0.23	2.20	3.72	5.7
11	0.44	1.42	1.79	0.32	2.67	4.58	4.3
12	0.14	0.61	2.05	0.42	3.85	6.12	4.4
13	0.06	0.12	2.47	0.72	4.97	7.98	1.6
14	—	—	4.31	1.39	5.31	10.74	—
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 which has both a filled and a carious surface will be included under both the "decayed" and the "filled" column.

4. Permanent teeth only.

5. It should be noted that these children had already received the beneficial effects of 3 years of water fluoridation (see text).

Table 3—General Comparison of Dental Caries Experience Rates for Deciduous (def) and Permanent (DMF) Teeth After 10 Years of Fluoridation in Grand Rapids, Mich., Brantford, Ont., and Newburgh, N. Y.

(Data from References 9-11)											
Age (Last Birthday)	Grand Rapids, Mich.				Brantford, Ont.				Newburgh, N. Y. ¹		
	No. Children Examined	Per cent Reduction Caries Rate			No. Children Examined	Per cent Reduction Caries Rate			No. Children Examined	Per cent Reduction Caries Rate	
	1944	1954	def	DMF	1944	1955	def	DMF	1954	1955	DMF
6	1,789	561	54	75	556	485	57	60			
7	1,806	751	48	63	616	448	52	67	708		58
8	1,647	567	43	57	614	483	43	54	(6-9 yrs.)		
9	1,639	477	35	50	608	423	34	46			
10	1,626	515	17	52	565	301	33	41			
11	1,556	499	2	54	604	280	— 2	39	521		53
12	1,685	260	—	52	658	336	—	48	(10-12 yrs.)		
13	1,668	224	—	48	531	247	—	42	263		48
14	1,690	250	—	38	307	93	—	36	(13-14)		
15	1,511	240	—	35	105	37	—	35	—	—	—
16	1,107	198	—	26							

1. Results based on difference between Newburgh and Kingston after 10 years fluoridation and include both clinical and roentgenographic findings.

Plans have been made to continue examinations for these age groups in Grand Rapids until the observations cover persons who have been continuously exposed to fluoride water throughout their elementary and secondary school lives.

The study design also was altered to take into account the fact that Muskegon, the original control city, had inaugurated fluoridation in July, 1951. For this reason observations are being continued on a sample (a single school group) of children from this city mainly for the purpose of evaluating periodontal conditions. The results of these observations constitute a portion of a later report by Dr. A. L. Russell.*

Results

In summary form the results of 10 years of fluoridation in Grand Rapids are shown in Table 2, both for deciduous and permanent teeth. In making comparisons on these data it should be remembered that Muskegon started fluoridation in July, 1951. A general comparison of the results in Grand Rapids with those of two other studies,^{10, 11} on the basis of 10 years' operation, is shown in Table 3.

From a public health program standpoint the success of the procedure may be evaluated in part by considering the unmet needs of the population observed. In this respect two major factors of the DMF rate can be utilized to measure the potentiality or effectiveness of fluoridation as a caries control method; namely,

* Russell, A. L. Effects of Fluorides on Periodontal Health. To be published in the June issue of the A.J.P.H.

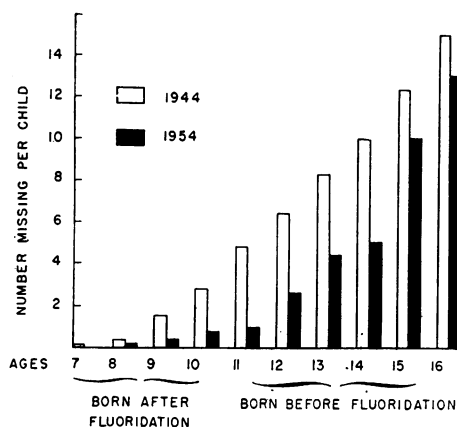


Figure 1—Missing Permanent Teeth per Child Before and After Ten Years of Fluoridation (Grand Rapids, Mich.).

the change in ratio of filled to unfilled teeth and the number of lost teeth. Using the data on the permanent teeth as presented in Table 2, the changes in ratios of these factors are presented graphically in Figures 1 and 2.

As stated earlier, the annual examinations in the Grand Rapids study have continued through the eleventh year. The results of these observations on the 11- to 16-year age groups are shown in

Table 4, and indicate that the beneficial effects of fluoridation have continued on through the eleventh year of research.

Prior to the inauguration of all of these studies the scientific evidence indicated that the fluoridation of water supplies would not produce a public health problem of dental fluorosis. It should be emphasized that full evaluation of the effects of fluoridated waters, as measured by dental fluorosis, are evaluated on the basis of erupted permanent teeth. The eleventh year of the Grand Rapids study gives a preliminary indication of the results to be expected. In Table 5 the results in respect to dental fluorosis on the 11- to 16-year-old children are shown.

Discussion

On the basis of these results and the data included in previous reports, one can conclude that fluoridation of public water supplies will effectively reduce the dental caries experience of those persons exposed to its effect continuously from birth onward. Also, sound scientific evidence shows that these beneficial re-

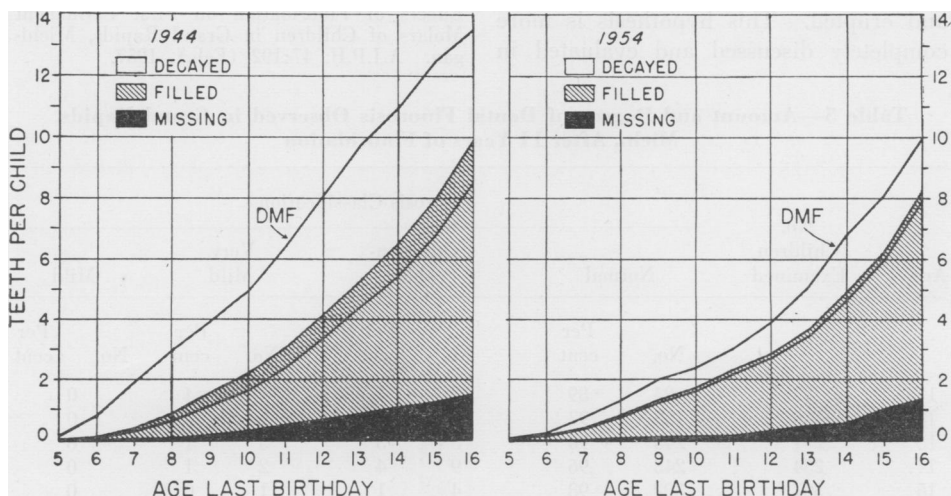


Figure 2—Dental Caries Prevalence in Permanent Teeth Examinations Made in 1944 and 1954 (Grand Rapids, Mich., Ages 5-16).

Table 4—Dental Caries Prevalence in Permanent Teeth of Continuous Resident Grand Rapids Children as Observed in 1955 (11 Years After Fluoridation)

Age	No. Examined	No. DMF Teeth per Child	Carious Teeth per Child	Filled Teeth per Child	Missing Teeth per Child	Per cent Reduction in DMF Teeth (1944–1955)
11	27	2.85	0.93	2.07	0.04	55.5
12	168	3.36	0.85	2.55	0.10	58.3
13	254	4.86	1.41	3.10	0.45	50.1
14	254	6.13	1.65	4.03	0.60	44.0
15	307	7.86	2.07	5.24	0.80	37.1
16	212	8.93	1.90	6.32	0.93	33.9

sults are not confined solely to those born subsequent to the inauguration of fluoridation. For example, the results shown for the 16-year age group in Table 2 indicate a reduction of 26 per cent in the expected amount of caries. The results of the two other studies referred to in Table 3 are similar to this observation.

A similar analysis of the data can be carried back into the results of previous reports on these studies, making comparisons on the basis of annual observations. Such an analysis suggests that the "caries susceptibility" of a tooth may be affected by water fluoridation even after the tooth has been formed and erupted. This hypothesis is more completely discussed and evaluated in

another report.* The evidence from the studies reviewed in this presentation indicates that fluoridation has a beneficial effect on teeth which are not fully formed, or are not fully matured in the oral environment.

From the public health standpoint there necessarily stems an interest in the practicability of the procedure. No attempt will be made to evaluate the economics of the technical aspects involved in water fluoridation other than to say that the process is comparatively inexpensive with only a rare exception. As far as dental health is concerned,

* See Hayes, R. L., et al. Posteruptive Effects of Fluoridation on First Permanent Molars of Children in Grand Rapids, Michigan. A.J.P.H. 47:192 (Feb.), 1957.

Table 5—Amount and Degree of Dental Fluorosis Observed in Grand Rapids, Mich., After 11 Years of Fluoridation

Age	No. Children Examined	Fluorosis Classification ¹							
		Normal		Questionable		Very Mild		Mild	
		No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
11	27	24	89	2	7	1	4	0	
12	168	155	92	8	5	5	3	0	
13	254	243	96	8	3	3	1	0	
14	254	243	96	9	4	2	1	0	
15	307	302	98	4	1	1	0.3	0	
16	212	209	99	2	1	1	0.5	0	

1. Classification according to Dean, reference 2.

there can be no doubt from the data shown in Figures 1 and 2 that the dental health problem in Grand Rapids, for example, has been brought under a better measure of control. If considered only in terms of dollars and cents, the savings to this community have been tremendous over the past 11 years. Economic considerations of this character, however, are usually misleading as far as evaluating public health procedures are concerned.

As stated earlier, the effects of water fluoridation on public health from aspects other than dental caries were fully considered before the inauguration of any of these programs. On the basis of previous scientific evidence investigators anticipated that water fluoridation would produce a slight increase in the prevalence of the mildest forms of dental fluorosis. Although sufficient time has not elapsed to evaluate this factor fully, the results to date (Table 5) show that the degree of fluorosis produced by fluoridation at levels recommended for caries control is of no public health significance.

In all these studies particular attention and interest has been paid to any effects fluoridation might have on other biologic systems of the body. In none of the studies has there been any scientific evidence to suggest an adverse effect on any segment of a rather large population living under divergent environmental conditions. These observations, in conjunction with the fact that millions of people have used naturally fluoridated waters for generations, attest to the complete safety of the procedure.

Summary

The observations of the Grand Rapids study for the past 11 years of water

fluoridation have been summarized. The results of this study, together with others which have been conducted for similar periods, indicate the feasibility of this procedure for the control of dental caries. In all studies the findings show a reduction of 60-65 per cent in the prevalence of caries in the permanent teeth of children born subsequent to the change in water supply. Furthermore, the evidence strongly suggests beneficial effects on teeth which were formed, or erupted, prior to the initiation of water fluoridation.

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