An 11-year follow-up study of dental caries after discontinuation of school-based fluoride programs

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Haugejorden O, Lervik T, Birkeland JM, Jorkjend L. An 11-year follow-up study of dental caries after discontinuation of school-based fluoride programs. Acta Odontol Scand 1990;48:257–263. Oslo. ISSN 0001–6357.

The purpose of the present study was to determine whether the caries-preventive effect of school-based programs with fluoride (F) mouthrinsing or toothbrushing was evident at the end of a post-treatment follow-up period of 11 years. Two groups of subjects examined at 14 years of age (born in 1960), who had participated in fortnightly F rinsing ($n = 52$) or in F brushing 4–5 times a year at school ($n = 50$), were re-examined radiographically and completed a questionnaire at age 25 years. A comparison group of 25-year-olds ($n = 51$) was also included. Analyses of variance showed that the benefits of participation in school-based F programs seem to have been lost. It appears that these caries-preventive programs have delayed rather than prevented caries and that F toothpaste and other caries-preventive efforts have been insufficient to avert a substantial caries activity during the follow-up period. □ *Dental epidemiology; preventive dentistry; questionnaire; radiography*

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Follow-up studies of caries development 1 to 7 years after discontinuation of school-based fluoride mouthrinsing or toothbrushing programs have given conflicting conclusions (1–6). Several studies have had relatively short follow-up periods (0.5–2.5 years) (4–6) or methodologic limitations such as retrospective controls (3, 5, 6). Some long-term benefits have been reported, but the evidence with regard to caries prevalence at the age when the subjects left the programs has been only indirect (1, 2). Interpretation of existing evidence of post-treatment benefits from participation in school-based fluoride rinsing programs is also confounded by lack of information on the individual level about caries-preventive activities and dental attendance during the follow-up period (3–6). For these reasons it was decided to attempt to extend the post-treatment follow-up period beyond 7 years for groups whose caries prevalence was known when they left a fluoride mouthrinsing or toothbrushing program and to include a comparison group without exposure to this type of school-based caries preventive program.

The purpose of the present study was to determine whether supervised school-based fluoride programs have had any long-term effect on caries prevalence and incidence during an 11-year post-treatment follow-up period.

Materials and methods

Study sites

Porsgrunn, Skien, and Sarpsborg are Norwegian towns with 31,300, 47,300, and 11,900 inhabitants, respectively. Socioeconomic conditions are comparable, and domestic water supplies contain less than 0.13 mg fluoride per liter.

Study participants

We attempted to locate for this study Porsgrunn and Skien residents born in 1960 who had been examined by Birkeland & Jorkjend (7) at 14 years of age in 1974. Supervised mouthrinsing with a 0.2% NaF solution once a fortnight (20 times a year)

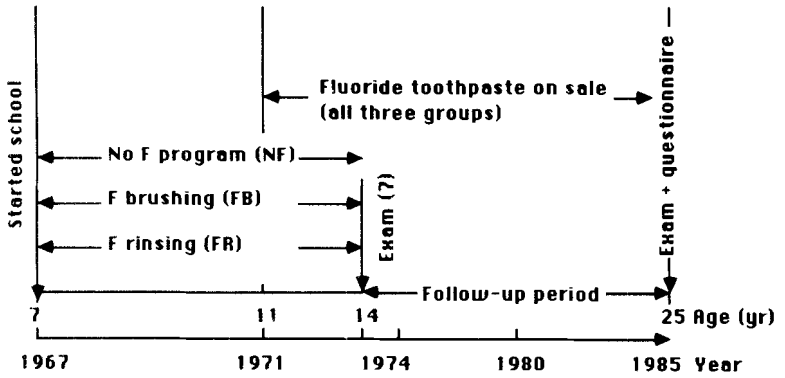

Fig. 1. Study design and fluoride (F) exposure in accordance with type and duration.

had started in Porsgrunn (FR) in 1964, and supervised toothbrushing with 0.5% NaF solution 4–5 times per year in Skien (FB) in 1965. Residents of Sarpsborg born in 1960 were chosen as a comparison group because they had not been exposed to a school-based fluoride program (NF) during the relevant period (1967–1974) (Fig. 1).

The subjects were invited by letter and through local newspapers and radio to receive radiographic examination between June 1985 and March 1986. To exclude subjects who had not attended school in Sarpsborg, they were asked to return an answer slip, and 62 persons did so.

Eligible subjects who did not turn up at a designated local public dental clinic after one reminder were offered free consultation plus radiographic examination by a dental practitioner of their own choice. Ten to 15% of the participants took advantage of this offer.

The number of participants and the non-response by group is shown in Table 1. The mean age of the subjects in the FR group was 25.34 years (±0.30 years), in the FB group 25.33 years (±0.32 years), and in the NF group 25.66 years (±0.27 years); these differences between the groups were not statistically significant ($P > 0.10$).

Table 1. Number of subjects and non-response, by group

Description	Group		
	FR*	FB†	NF‡
Target group	88	90	181
Address unknown	2	—	3
Not Sarpsborg, 7–15 years	—	—	69
Away from home, etc.	2	4	5
No radiographs	—	—	1
No contact	32	36	52
Participants	52	50	51

* FR = fluoride rinsing at school, Porsgrunn.
† FB = fluoride brushing at school, Skien.
‡ NF = no fluoride program at school, Sarpsborg.

Questionnaire

All subjects were asked to complete a questionnaire containing precoded questions. The answers with regard to participation in school-based F programs were in agreement with information about the NF subjects given by the Public Dental Service in Sarpsborg and about the FR and FB subjects by Birkeland & Jorkjend (7). Other questions pertained to dental visiting habits while at and after leaving school; use of flouride-containing toothpaste; exposure to fluoride rinsing at home; professional topical application of fluorides; frequency of intake of cariogenic snacks or beverages between meals; and their own occupation, to determine social class (class 1: with higher education or in top administrative positions; class 2: white-collar workers, foremen, and farmers; class 3: blue-collar workers, etc.). The percentage distribution of subjects by group and by the most important independent variables of the study is given in Table 2. Chi-square analyses on 2 degrees of freedom showed no statistically significant differences in distribution of subjects among

Table 2. Percentage distribution of subjects by group*, gender, social class, dental visiting habits, type of dentifrice used, and frequency of snacks between meals

Characteristics	FR ($n = 52$), %	FB ($n = 50$), %	NF ($n = 51$), %
Sex			
Women	63.5	48.0	51.0
Social class			
1 + 2	26.0†	28.3‡	32.0†
Dental visit			
Yearly while at school	94.2	78.0	84.3
Last visit <12 months ago	75.0	70.0	74.5
Regularly at least once a year	75.0	61.2§	74.5
Fluoride dentifrice	92.3	88.0	92.2
Cariogenic snack			
Every day or every second day	40.4	32.0	47.1

* Abbreviations as in Table 1.
† $n = 50$.
‡ $n = 46$.
§ $n = 49$.

groups ($P > 0.05$). Although not statistically significant, there were some notable differences with regard to gender, dental visits while at school, and regularity of dental visiting habits after leaving school.

Radiographic examination

One pair of posterior bitewing and three upper anterior periapical radiographs were taken of each subject, using Kodak DF57 ultra-speed films and Twix filmholders. Exposure time and processing were in accordance with the manufacturer's recommendations. The radiographs taken at 25 years of age were assessed under standardized conditions by one examiner, who was unaware of the subjects' group identity. The criteria and definitions used were those described by Haugejorden (8). This entailed the recording of the earliest detectable approximal radiographic carious lesion, as did Birkeland & Jorkjend (7). Approximal surfaces from mesial on second molars to mesial on first premolars and on maxillary incisors were assessed (36 surfaces). Fillings on occlusal (16 surfaces) and buccal or lingual (20 surfaces) surfaces on molars, premolars, and maxillary incisors were also recorded (totally, 72 surfaces).

Teeth presumed to have been extracted because of caries were assigned 2 surfaces in DMFS scores for approximal surfaces and 4 surfaces in DMFS scores for all 72 surfaces considered (no maxillary incisors were missing because of caries).

The radiographs from the examination of the FR and FB subjects at 14 years of age (7) were not available for re-assessment in 1987, when the most recent radiographs were examined. Consequently, prevalence estimates at age 14 years are based on the records of Birkeland & Jorkjend (7). Estimates of caries increment on 68 surfaces (excluding buccal or lingual surfaces of 4 maxillary incisors) between 14 and 25 years of age are based on examinations by different examiners. This is not a serious problem because the filled component dominated the DFS scores at both ages, and it is known that inter-examiner variability is negligible for the recording of restored surfaces.

The subjects of the NF group had not been radiographically examined for survey purposes at 14 years of age. Consequently, the caries incidence from age 14 to 25 years could not be determined.

Statistical analyses

Two-tailed Student's t tests were used to compare independent samples and paired observations. Three-way analysis of variance (ANOVA) was applied to compare caries

Table 3. Mean (±SD) radiographic caries prevalence (DMFS) at age 25 years on the basis of all 72 surfaces by gender and group

	Men		Women	
Group*	$\bar{x}$	SD	$\bar{x}$	SD
FR	32.3	10.27	27.0	13.38
FB	36.0	10.72	33.7	11.69
NF	34.6	12.17	33.6	9.84

* Number of subjects in subgroups may be calculated from Table 2.

scores among groups by means of StatView 512+ (9).

Examiner error

Eighteen sets of radiographs taken at 25 years of age were reassessed independently and unknown to the examiner. There were no statistically significant differences between duplicate component or DFS or DMFS scores ($P > 0.10$).

Results

Caries prevalence at age 25 years

Mean DMFS scores by gender and groups are given in Table 3. It will be seen that men consistently had a somewhat higher mean DMFS score than women, especially in the FR group. This is the reason why gender was included as one of the variables in the three-way analysis of variance of the results.

Mean radiographic caries prevalence scores at 25 years of age are shown by group for various numbers and combinations of surfaces in Table 4. The subjects of the FR group on the whole had somewhat lower DS, MS, FS, and DMFS scores than those in the other two groups. One notable exception was the mean number of surfaces presumed missing for reasons other than caries, for which the scores were 3.7 (FR), 1.9 (FB), and 1.6 (NF), or 4.4, 2.9, and 4.1 regardless of reason for extraction.

The subjects had high caries prevalence scores, ranging from 28.9 DMFS in the FR group to 34.9 DMFS in the FB group when including 72 surfaces. The corresponding scores for 36 approximal surfaces were 15.6 and 18.7, respectively. DFS scores for 12 maxillary incisor surfaces ranged from 3.0 to 3.5. Furthermore, decayed surfaces constituted from 1.8% to 3.7% of the total DMFS scores, and filled surfaces from 89% to 96% of the scores. The NF group had the lowest proportion of filled surfaces (89%) and DS score, which accounted for 3.4% of the total DMFS (Table 4).

Table 4. Mean (±SD) radiographic caries prevalence (DMFS) at age 25 years on the basis of all 72 surfaces, 36 approximal and 12 maxillary incisor surfaces, by group

	FR ($n = 52$)		FB ($n = 50$)		NF ($n = 51$)	
Index	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
All 72 surfaces						
DS	1.1	1.46	0.6	1.11	1.2	1.58
MS	0.8	2.32	1.0	3.08	2.5	4.04
FS	27.1	12.07	33.3	11.64	30.5	11.33
DFS	28.2	12.07	33.9	11.55	31.6	11.24
DMFS	28.9	12.49	34.9	11.14	34.1	10.94
36 approximal surfaces						
DS	1.0	1.47	0.6	1.11	1.1	1.51
MS	0.3	1.01	0.5	1.49	1.2	1.94
FS	14.2	8.62	17.6	8.61	16.2	8.42
DFS	15.2	8.60	18.2	8.57	17.4	8.33
DMFS	15.6	8.71	18.7	8.38	18.6	8.05
12 maxillary incisor surfaces						
DS	0.2	0.46	0.1	0.45	0.3	0.58
FS	2.9	2.93	3.4	2.86	3.1	3.38
DFS	3.0	3.03	3.5	2.93	3.4	3.45

Table 5. Mean (±SD) caries prevalence (DFS) at 14 and 25 years of age and caries incidence (ΔDFS) between 14 and 25 years, by group (68 surfaces)

	FR ($n = 50$)		FB ($n = 49$)		
Index	$\bar{x}$	SD	$\bar{x}$	SD	P^*
DFS14	19.2	9.50	25.2	10.37	0.05
DFS25	27.3	11.79	32.8	11.15	0.16
ΔDFS14–25	8.2	7.63	7.6	7.48	0.45

* Probabilities based on three-way ANOVA.

Some mean differences in crude caries prevalence scores were statistically significant at the 5% level, using Student's two-sample tests (Table 4). A 3-way ANOVA, taking gender, regularity of dental visits after leaving school, and group into account, showed that observed differences in DMFS score (72 surfaces) at 25 years of age were not statistically significant ($F = 2.345$, $P > 0.10$). Comparisons among the three groups by means of other combinations of surfaces and indices of caries prevalence concurred with this finding.

Caries incidence at 14–25 years of age

The caries prevalence scores at 14 years of age were based on 68 surfaces (7). The DFS scores for groups FR and FB at this age and at 25 years for subjects present on both occasions showed 11-year caries increments of 8.2 DFS and 7.6 DFS, respectively, a difference that was not statistically significant (Table 5).

An estimate of the number of surfaces at risk of primary caries attack during the follow-up period was obtained by subtracting from 68 surfaces the DFS score at 14 years of age and the number of surfaces lost for reasons other than caries. This approach gave caries attack rates of 18.1% for the FR group and 18.7% for the FB group.

Discussion

The present results are important for three reasons. First, supervised fluoride mouth-rinsing or brushing programs and use of fluoride toothpaste are providing a limited caries reduction from about 32 to about 20 DMFS in 14-year-olds (10). Our present low caries prevalence in these age groups is about 8 DFMS (11), an improvement that may be related to long-term preventive efforts. Secondly, it was disappointing to observe a caries increment of 8 DFS (mainly FS) in spite of fluoride toothpaste and other caries-preventive efforts. Thirdly, benefits and attitudes gained through participation in the supervised fluoride programs have a small effect on the caries prevalence at the age of 25. On the other hand, only every fifth person of the former participants of school-based F programs had lost a tooth because of caries, compared with every second person in the NF group.

Birkeland & Jorkjend (7) found a mean difference between the FR and FB group of 8.6 DFS at 14 years of age; the corresponding difference for the participants in the present investigation was 6.0 DFS. At age 25 it was 5.5 DFS, a difference that was non-significant at the 5% level according to the 3-way ANOVA. Relatively small study groups and an exceptionally large difference in DMFS score between men and women in the FR group (Table 3) have clearly affected this outcome.

The results of this study may have been influenced by the fact that caries experience was determined by partial recording in groups showing relatively high caries prevalence. Thus there was a danger of saturation ('ceiling effect'). Logically, this would be most critical in the posterior region of the mouth, but ANOVA limited to 12 maxillary incisor surfaces confirmed the results for 72 surfaces. Still, it cannot be precluded that saturation, especially in the FB and NF groups, may have reduced the possibility of detecting long-term benefits of school-based F programs which may have persisted.

A study of the annual reports of the School Dental Services of Sarpsborg (NF) showed that members of the 1960 cohort, although they had not participated in a school-based F program, on the average had received 0.4 professional topical F applications (2% NaF) per year in the course of 9 years and 0.4 F rinses per year in the dental clinics during their last 7 years at school. Use of F tooth-

paste may be assumed to have been reasonably comparable in all three groups after 11 years of age (Fig. 1, Table 2). Thus another explanation is that the differences in F exposure among groups may have been too small to affect DMF scores at 25 years of age.

The more favorable results shown by group FR may partly be due to a relatively high proportion of women in the group. It is known that women in Norway brush their teeth more often than men and consequently use a F toothpaste more often (12, 13). The fact that the women in the present study consistently had slightly lower caries prevalence score than their male counterparts (Table 3) tends to support this view. The percentage distribution of study participants by group on some independent variables other than school-based F program tends to favor a lower caries prevalence score in group FR than in the other two groups, especially group FB (Tables 2 and 3).

Dental visiting habits while at and after leaving school favor the FR group, but neither self-care nor professional services would appear to have been sufficient to control caries activity during the follow-up period (Table 5). The finding that caries-preventive knowledge among dentists and dental hygienists in Norway (14) and the caries preventive services they provided (15) were in need of updating in relation to the current state of the art may partly explain this observation.

In the present material there was a positive correlation between the number of dentists subjects had been treated by and their caries prevalence scores (results not presented). After leaving school the subjects of the FR, FB, and NF groups had on the average been treated by 2.0, 2.2, and 1.7 dentists, respectively—a finding that tends to favor a lower DMF score in the NF group than in the other two groups.

Collectively, the evidence presented here supports the contention that the benefits of school-based F programs decrease as the length of the follow-up period after discontinuation increases (2, 4, 5). Thus the caries prevalence in the FB group was marginally higher than in the NF group; that is, the long-term benefits of limited practical importance observed after 7 years (1) was not found after 11 years. The statistically non-significant lower caries prevalence score of the FR group compared with the other two study groups cannot reasonably be ascribed wholly to participation in the school-based F mouthrinsing program, as other independent variables tended to favor lower caries scores in this group. The presence of interaction approaching significance at the 5% level in the ANOVA supports this conclusion. Thus it seems that these school-based caries preventive programs have delayed rather than prevented caries and that fluoride toothpaste and other caries-preventive efforts have been insufficient to avert caries activity.

Acknowledgements.—We would like to thank the Norwegian Research Council for Science and the Humanities for financial support (grant 13.51.80.001); DE-NO-FA and Lilleborg Fabrikker for providing participants with aids to oral hygiene; colleagues for their assistance; and the Public Dental Services in the three towns for the loan of clinical facilities.

References

1. Haugejorden O, Rise J. Caries prevalence in Norwegian recruits 5–7 years after discontinuation of supervised fluoride toothbrushing programmes. Caries Res 1981;15:308–17.
2. Haugejorden O, Lervik T, Riordan PJ. Comparison of caries prevalence 7 years after discontinuation of school-based fluoride rinsing or toothbrushing in Norway. Community Dent Oral Epidemiol 1985; 13:2–6.
3. Horowitz HS, Heifetz SB, Meyers RJ, Driscoll WS, Li S-H. A program of self-administered fluorides in a rural school system. Community Dent Oral Epidemiol 1980;8:177–83.
4. Koch G. Caries increment in schoolchildren during and two years after end of supervised rinsing of the mouth with sodium fluoride solution. Odont Rev 1969;20:323–30.
5. Leske GS, Ripa LW, Green E. Posttreatment benefits in a school-based fluoride mouthrinsing program. Final results after 7 years of rinsing by all participants. Clin Prev Dent 1986;8:21–3.
6. Leverett DH, Sveen OB, Jensen ØE. Weekly rinsing with a fluoride mouthrinse in an unfluoridated community: Results after seven years. J Publ Health Dent 1985;45:95–100.
7. Birkeland JM, Jorkjend L. Effect of mouthrinsing and toothbrushing with fluoride solutions on caries among Norwegian schoolchildren. Community Dent Oral Epidemiol 1975;3:201–7.

8. Haugejorden O. A study of the methods of radiographic diagnosis of dental caries in epidemiological investigations. Acta Odontol Scand 1974;32(suppl 65):64–76.
9. Brain Power Inc. StatView 512+. Calabasas, Calif.: Brain Power Inc., 1986.
10. Birkeland JM, Broch L, Jorkjend L. Benefits and prognoses following 10 years of a fluoride mouthrinsing program. Scan J Dent Res 1977;85:31–7.
11. Birkeland JM, Bragelien J. Continual highly significant decrease in caries prevalence among 14-year-old Norwegians. Acta Odontol Scand 1987; 45:135–40.
12. Schwarz E, Heløe LA. Hygiejnevaner og opfattelse af egen tandsundhed. In: Heløe LA, ed. Tannhelsen i Norden. Holdninger, interesse, kunnskap. Oslo: Aasen, 1979:56–74.
13. Heløe LA, Aarø LE, Søgaard AJ. Dental health practices in Norwegian adults. Community Dent Oral Epidemiol 1982;10:308–12.
14. Augustson L, Rølla G. Kariesprofylakse. Nor Tannlegeforen Tid 1986;96:7–10.
15. Nielsen WA, Haugejorden O. Kariesprofylaktiske tiltak for voksne pasienter i Norge i 1985. Nor Tannlegeforen Tid 1987;97:1–6.

Received for publication 19 June 1989