Continual highly significant decrease in caries prevalence among 14-year-old Norwegians

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The MFS of 14-year-old children in Lillehammer, Norway, were recorded in 1959, 1969, 1979, and 1984. The data were extracted from dental records of random samples of 76 children. The mean MFS was 34.1 in 1959 and 28.0, 13.8, and 7.5 the following years. The caries prevalence was reduced by 78% from 1959 to 1984. In 1959, 16.6 approximal surfaces were filled, but in 1984 only 1.3. Significantly fewer radiographically initial lesions were observed in 1984 than in 1979. The continual decrease in caries prevalence is related to various fluoride programs, fluoride dentifrices, decreased caries prevalence among preschool children, and an assumed decreased challenge. □ *Dental caries; evaluation; fluoride; preventive care*

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Decreasing caries prevalence has been reported among Scandinavian children and adolescents in recent years (1–6). From Norway only limited information is available (4–6). Although our School Dental Service and the Public Dental Service have been offering schoolchildren free, comprehensive dental care for much of this century, no adequate system for monitoring dental health over time has been introduced.

The MFT and MFS have been recorded for several years in some areas. These data are based on the number of filled surfaces and extracted teeth at the end of the dental treatment carried out every school year. Such data may be used to demonstrate changes in caries prevalence with time. The aim of this study was therefore to use information from dental records to analyze changes in caries prevalence from 1959 to 1984 in a town with a prophylactically oriented Public Dental Service.

Materials and methods

Data were collected from the Public Dental Service in the town of Lillehammer (22,000 inhabitants), in the eastern part of Norway, where there has been a high degree of stability among the dentists. The material was extracted from the dental records of 14-year-olds born in 1945, 1955, 1965, or 1970. Each population of children comprised 300–350. From each of these cohorts 76 records were randomly selected.

The caries experience of each child was based on the recordings of filled and missing tooth surfaces at the end of the dental treatments in 1958/59, 1968/69, 1978/79, and 1983/84. Fillings in pits and fissures on the buccal and lingual surfaces of the molars were recorded on these surfaces. Fissure sealants had not been used. Very few teeth had been extracted because of caries and only in the 1945 and 1955 cohorts. Since the proportion of missing teeth was minimal, they were counted as filled. Teeth extracted for orthodontic reasons were excluded. MFS values were calculated for each child, each tooth, and for each tooth surface. To assess this underestimation of the DMFS, the number of untreated, radiographic approximal lesions (enamel + dentin) was evaluated by comparing bitewings and the dental treatments carried out in 1968/69, 1978/79, and 1983/84.

The children had been given yearly check-ups and dental treatment from the age of 6 years. Bitewing radiographs had been

included in the examinations from the age of 12 years in the 1955, 1965, and 1970 cohorts. The Service has been prophylactically oriented for many years. The children's fluoride exposure is summarized in Table 1. Fluoride tooth-brushing (0.5% NaF), five times yearly, was introduced in 1965 but was replaced by fortnightly mouth-rinsing (10 ml of 0.2% NaF) for children in the last school year in 1972. These fluoride programs were offered to all children, and more than 95% participated. Chewable fluoride tablets were offered to preschool and school children up to age 9 from 1975. On the basis of recordings, about 50% of the preschool children regularly took the tablets. At the end of the yearly treatment, the children of the 1965 and 1970 cohorts either carried out a mouth-rinsing (10 ml of 0.2% NaF), or fluoride varnish (Duraphat®) was applied.

The drinking water in Lillehammer contains 0.1 ppm fluoride. Fluoride dentifrices were released on the Norwegian market in 1971, and they were reported to be used by 82% of 7- to 15-year-old children in 1975 (7). Fluoride dentifrices were not recommended for children younger than 4 years of age.

Student's *t* test was used to evaluate differences between mean values.

Results

The mean number of MFS for the 14-year-old children showed a substantial decrease, especially between 1969 and 1984 (Table 2). On the basis of the MFS values from 1959, the compared caries prevalences were significantly reduced, by 18% in 1969 ($t = 2.64$) and by 60% and 78% in 1979 and 1984, respectively. The frequency distributions of the MFS changed from approximately normal in 1959 and 1969 to positively skewed, especially in 1984, when 36% of the children had MFS values of 0–4 (Fig. 1). This change in distribution and a tendency towards polarization of the MFS values are also indicated by increasing coefficient of variation (0.46 in 1959, 0.44 in 1969, 0.69 in 1979, and 0.76 in 1984 (Table 2). In 1984, 9% of the children were caries-free.

The distribution of the MFS values within the dentitions indicated that caries prevalence decreased gradually over time and that the greatest decrease took place between 1969 and 1979 (Fig. 2). On the basis of the 1959 data, the reduction was 45% in the molars in 1979, 74% in the premolars, and 85% in the incisors. Finally, the reduction amounted to 12.8 surfaces in the molars (65%) and 94% in the premolars and the incisors.

As would be expected, the mesial surface of first molars was the most frequently filled approximal surface in this age group (Fig. 3). Moreover, a similar and approximately parallel distribution of disease within the dentition was evident, although the prevalences were very different. Thus, surfaces

Table 2. Mean number of MFS ($\pm$SD; $n = 76$) among 14-year-old children in Lillehammer, by year of examination

	Year of examination			
	1959	1969	1979	1984
Mean	34.1	28.0	13.8	7.5
SD	15.79	12.36	9.53	5.71

Table 1. Cohorts of 14-year-old children in Lillehammer and their age at the start of exposure to various fluoride sources

Cohort, year of birth	F-brushing	F-rinsing	F-dentifrice	F-tablet
1945	—	—	—	—
1955	10 years	—	—	—
1965	7 years	13 years	6 years	—
1970	7 years	13 years	4 years	5 years

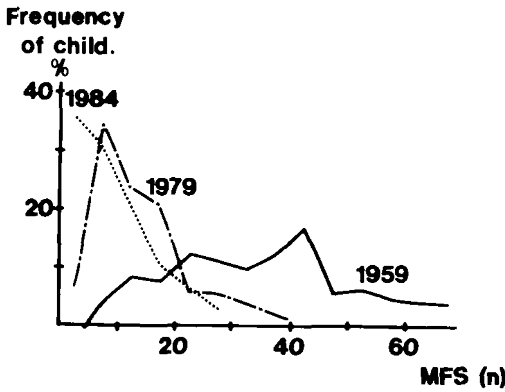

Fig. 1. Distribution of 14-year-olds in Lillehammer, Norway, by MFS in 1959, 1979, and 1984.

with a low caries prevalence in 1959 were nearly caries-free in 1984. To judge from the 1959 data, when 16.6 of the approximal surfaces were filled, the reduction amounted to 25%, 81%, and 92% (12.4, 3.1, and 1.3 filled surfaces) for the following cohorts.

The decreasing caries prevalence on the approximal surfaces was only partly reflected in a reduced number of filled occlusal surfaces of first molars (Table 3). Most of these surfaces were filled until 1979, and even in 1984 62.5% were filled. One-third of the decrease from 13.8 to 7.5 MFS between 1979 and 1984 was accounted for by less fillings in pits and fissures.

An average of 2.41 (SD, 3.09; $n = 53$) initial radiographic caries lesions were unfilled when the restorative treatment was completed in 1979. The corresponding data were 1.0 (SD, 1.52; $n = 55$) in 1984—that is,

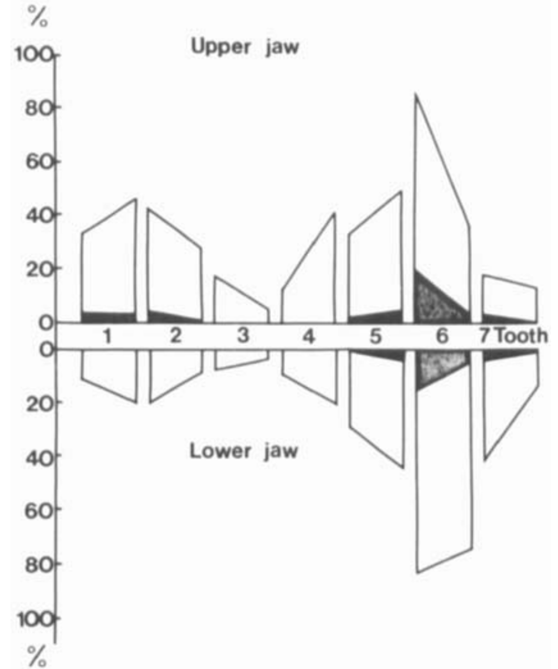

Fig. 3. Percentage of decayed (MFS) approximal tooth surfaces in 14-year-old children in 1959 (open bars) and 1984 (shaded bars).

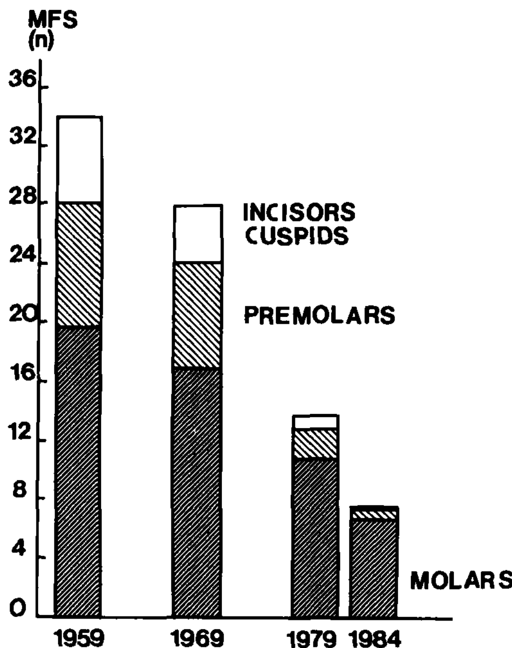

Fig. 2. The mean number of MFS of different teeth among 14-year-old children, by year of examination.

Table 3. Mean number of filled occlusal and mesial surfaces of the first molars and the ratio between filled occlusal and mesial surfaces among 14-year-old children, by year of examination

	Year of examination			
	1959	1969	1979	1984
Occlusal	3.9	3.9	3.7	2.5
Mesial	3.3	3.0	1.4	0.7
Ratio occl. to mes.	1.2	1.3	2.6	3.6

significantly ($t = 3.08$) fewer initial lesions. Moreover, very few lesions in the outer half of dentin remained unfilled: 2% of the unfilled radiographic lesions in 1979 and 4% in 1984. In 1969 a mean of 2.0 (SD, 2.18; $n = 40$) radiographic lesions remained unfilled. The unfilled initial lesions constituted 47% of the total DMFS (DS + MFS) on the approximal surfaces in 1984 and 1979 but only 17% in 1969.

Discussion

Methodologic comments

This retrospective study is based on the hypothesis that information accumulated in the dental record reflects the real caries experience of a child. Because only filled surfaces and teeth extracted because of caries were recorded, the DMFS is underestimated. The degree of underestimation is affected by the number of caries lesions and by the criteria for filling lesions and for extracting teeth.

In this material radiographic initial lesions that remained unfilled resulted in an underestimation of the DMFS of 13% in 1984, 17% in 1979, and 7% in 1969. During the past 5–10 years the criteria for class II fillings seem to have changed among some Norwegian dentists, since a smaller proportion of radiographic enamel lesions are filled (8). The occurrence of significantly fewer initial caries lesions in 1984 than in 1979 does not support a marked change in criteria for class II fillings between these years. Whether the criteria for class I fillings have changed during the period of observation is difficult to assess. Table 3 indicates a high proportion of filled occlusal surfaces, even in 1984.

Exclusion of the D-lesions on the approximal surfaces causes a considerable underestimation of the DMFS on these surfaces. If the comparison between 1969 and 1984 is based on filled approximal surfaces or on filled and decayed lesions, the caries reduction is 89% or 82%, respectively. Thus, exclusion of the D-lesions does not invalidate the conclusions based on the data presented. On the contrary, the evaluation of the underestimation confirms that the information from these dental records provides a reliable assessment of trends in caries prevalence. In conclusion, these considerations and the sampling procedure indicate that the present MFS recordings reflect the actual caries prevalence in Lillehammer over a period of 25 years.

Comments on the findings

Before strong emphasis was placed on caries preventive programs, a DMFS score of about 30 in this age group was recorded in several Norwegian areas (1, 9, 10) (Fig. 4). The average MFS of 7.5 in 1984 is at the national DMFS level in Denmark (11) and the level of some Swedish areas (12, 13) but lower than recently reported (FS = 11.9) in a cross-sectional study in Trøndelag, Norway (6). The start of the decrease in Norway was linked to fluoride supply.

Two findings were striking and unexpected in this study: 1) the magnitude of the decrease and the continuance of the decreasing caries prevalence; and 2) the caries activity of the 1970 cohort seems to have been significantly lower than that of the 1965

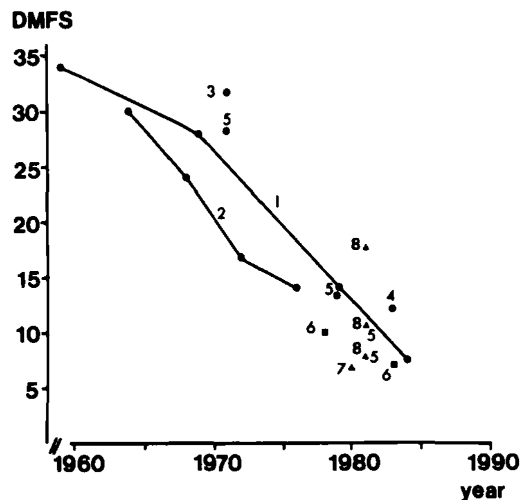

Fig. 4. Mean DMFS in 14-year-old children in Norway, 1) present study; 2) Ref. 10; 3) Ref. 9; 4) Ref. 6; 5) Ref. 1, in Denmark; 6) Ref. 11, in Sweden; 7) Ref. 12; and 8) Ref. 13, by year of examination.

cohort. This conclusion is based on a lower number of filled approximal surfaces and fewer unfilled initial caries lesions.

The magnitude of the decrease and the continuance of the decrease in caries prevalence are difficult to explain. The distribution of disease of the approximal surfaces (Fig. 3), related to the overall prevalences, indicates the effect of factors affecting the caries activity. Moreover, the parallel distribution within the dentition is typical for areas with different amounts of fluoride in the drinking water (14). Factors related to the continual decrease may be 1) fluoride exposure, 2) caries prevalence of preschool children, 3) less challenge owing to changes in sugar consumption, composition of plaque, and amount of plaque, and 4) changed criteria for fillings. The latter factor has been discussed and may only have a modest effect.

The length of exposure to fluoride and the sources were different for the different cohorts (Table 1). In the early seventies fluoride tablets were prescribed for very few Norwegian children (5), but children in Lillehammer were given tablets from 1975. The chewable tablets and some dentifrice are swallowed and hence could give a pre-eruptive fluoride exposure, especially in the 1970 cohort. By combining different fluoride vehicles, a modest additive effect is expected (15). Moreover, the cariostatic effect increases with prolonged exposure to fluoride. The decreased caries prevalence between 1959 and 1969 may be ascribed to the fluoride brushing program. Most of the decrease between 1969 and 1979 may be related to the use of different fluoride vehicles from the age of 6 years. The low disease level in 1984 may partly be related to a more intensified fluoride supply when the teeth erupt and to a longer fluoride exposure.

In this town the mfs for 6-year-old children decreased from 14.2 in 1974 (10.4 for the 1970 cohort) to 4.5 in 1983. The low caries prevalence of the 1970 cohort may therefore partly be explained by the preschool caries prevalence, since the disease at the age of 7 years is associated with the prevalence at the age of 14 (16–18).

In Norway the amount of sugar consumed between meals has increased rather than decreased during the past decades (19). Emphasis has been placed on oral hygiene in this community. However, no data are available indicating improved oral hygiene or changes in plaque microflora or sugar consumption among these children. Thus, the reduced caries prevalence may partly be related to the length and intensity of the fluoride exposure, to improved dental care for preschool children, and to changed challenge.

The decreasing caries prevalence is in agreement with findings in many Western countries (1–6, 20–24). The low caries prevalence recorded in many communities today is an indication for authorities responsible for dental health to increase the period between check-ups to save resources. Moreover, the distribution of the DMFS values and the low disease level indicate the need for individual diagnosis and treatment planning, especially with long intervals between check-ups. The sensitivity of the methods used today to identify caries-risk children, however, is not acceptable (16–18, 25). Intensified research on proper assessment of caries activity and identification of caries-risk children is needed, as this may further decrease the caries prevalence, prevent overtreatment and undertreatment, and save resources.

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