

ORIGINAL ARTICLE

Analysis of the ups and downs of caries experience among Norwegian children aged five years between 1997 and 2003

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Abstract

Objective. To study caries trends and investigate the possible reasons for changes among 5-year-old Norwegian children in the period 1997–2003. In this cross-sectional analytical time trend study at district, county, and national levels, aggregated data from the Public Dental Services (PDS) and official statistics were used, i.e. number of children and percentage receiving treatment, sale of fluoride tablets, socio-economic background, caries prevalence, and d_3mft scores. **Results.** Caries prevalence increased from 30% in 1997 to just over 40% in 2001, but by 2003 it had dropped to 36%. The corresponding mean number of d_3mft were 1.1, 1.6, and 1.4 at national level. Caries prevalence and experience varied considerably between counties and between dental districts throughout the observation period. Multivariate analyses at county level indicated a significant negative association ($p < 0.05$) between caries prevalence, the sale of fluoride tablets, and net mobility. The impacts of the predictor variables education, income, infant mortality, proportion of immigrants, and the percentage of children treated varied but were rarely significant. **Conclusions.** The increasing trend in the prevalence of caries among 5-year-old Norwegian children in the period 1997 to 2001 has reversed. The deterioration in dental health of 5-year-olds after 1997 was associated with a reduction in the sale of fluoride tablets, whereas increased sales of fluoride tablets after 1998 reflect improved caries prevention among preschool children and may explain the improved caries status of these children in 2003.

Key Words: Dental caries, deciduous teeth, epidemiology, fluoride tablets, predictors, trend

Introduction

A 1996 review of pre-1995 caries prevalence data from European countries concluded that there had been no further decrease in countries where caries prevalence in primary teeth was already low [1]. When recent studies are considered, however, findings pertaining to the deciduous dentition of children 5 to 7 years of age are inconsistent. Caries declined among Belgian children 6 years of age from 1983 to 1998 [2], and reports from The Netherlands suggest a halt in the decline among children 5–7 years of age after 1982 [3–5]. Following a period of stability from 1987 to 1995 [6], a modest decline was observed in England and Wales from 1995 to 2001/2002 [7]. While the prevalence of caries was stable or showed only a modest decline among children 5 years of age between 1988/89 and 1996/97 in England, a marked decrease occurred in four Dudley towns after the implementation of water fluoridation in 1987 [8]. Reports from North America also conflict,

in that both a decline [9] and an increase in caries have been reported [10]. Most data from the Nordic countries covering the period 1973–1998 show improvement [11–13], but there are some indications of a leveling out or even a reversal of the trend [14–16], i.e. 5-year-olds in Norway experienced a 9% points increase in prevalence of caries in the period 1997 to 2000 [17]. If this annual growth rate (7.9%) had persisted, the prevalence of caries in 2005 would be back at the 1985 level.

The purpose of the present paper was to study trends in caries status from 2001 to 2003 and to investigate possible reasons for the observed changes in caries experience among 5-year-old Norwegian children from 1997 to 2003.

Material and methods

The Dental Health Service Act of 1983 obliged Norwegian counties to provide incremental dental care

Table I. Number and percentage of children 5 years of age treated in the Public Dental Services according to administrative level—Norway 1997–2003

Administrative level	Total number of children		Percent treated	
	Minimum	Maximum	Minimum	Maximum
National	59,667	62,202	76.6	89.1
County	999	7,172	38.9	98.8
District	110	2,262	40.2	100.0

free of charge to persons 0 to 18 years of age. The act assigned priority to prevention over restorative treatment. The services have almost exclusively been provided by salaried dental staff in publicly owned and financed dental clinics.

The 19 counties each have between 3 and 9 dental health districts ($n=103$) in which there are a varying number of clinics. Dental health data are aggregated from clinic to district, from district to county and then reported to the national level. The number and proportion of 5-year-old children examined and treated from 1997 to 2003 are given in Table I.

Dental data

The oral examinations of 5-year-old children are not routinely supplemented with bitewing radiographs. The components of the dmft (decayed, missing, filled teeth) index are defined as follows: d = tooth requiring restorative treatment because of caries, lost or fractured filling; m = tooth missing because of caries, and f = filled tooth without need for treatment. In practice, these criteria reflect the prevailing restorative treatment intervention level, i.e. cavitation or lesion into dentine (i.e. d_3). Information was not available at individual level. The percentage caries prevalence (d_3 threshold) and the d_3mft counts for 5-year-olds were used to study caries trends from 1997 to 2003.

Background information

Sales of fluoride tablets per county were expressed as the defined daily dose (DDD) per 1,000 inhabitants

younger than 15 years of age. The data were available for the years 1995 to 2003 at county level [18] (Table II). This information was used to compute a lifetime fluoride tablet exposure variable for each birth cohort. In 1997, the sales figures for 5-year-olds in each county were weighted for population size (< 15 years) and averaged for the years 1995, 1996, and 1997. For children aged 5 in 1998, the sales figures for 1995, 1996, 1997, and 1998 were used; for 1999 the sales from 1996 to 1999, and for 2003 the sales figures for the years 2000–2003. The average sales figures given in Table II were lower than the 367 DDD per 1,000 for the years 1992–1996. With the exception of the sale of fluoride tablets, no variable given in Table II is reported at county or district level.

Fluoride-containing toothpaste has more or less taken over the Norwegian market and the sales figures are stable (Table II).

Several variables were used to reflect the socio-economic circumstances at county level: the proportion of the population that had completed a college or university degree, income, infant mortality, net mobility of the population between counties and the proportion of the population 0–17 years of age classified as first or second generation immigrants [19]: [<http://www.ssb.no>, read 9 August 2004]. The variable immigrants was included because it has been reported that immigrant children may be more affected by caries than native-born children [16,20–21]. Other predictor variables used were: The proportion of eligible children treated per year and the combined percentage of vacant positions for dentists and dental hygienists at county level.

Statistical analysis

The data were analyzed using SPSS[®] for PC (version 11.0). Since the data were aggregated for each administrative level, the findings for 5-year-olds are presented as percentage caries prevalence and mean d_3mft , d_3t , and ft scores with range for counties. Relative change in caries prevalence and experience are expressed in terms of compound annual growth/reduction rates because of the non-linearity of the

Table II. Sugar consumption (kg/person/year); consumption of soft drinks (liters/person/year) (Norwegian Brewers and Soft Drink Producers, www.brom.no 2004); sale of fluoride tablets (DDD = defined daily doses/1,000 persons younger than 15 years of age/day) [18] and sale of toothpaste (g/person/year) (Denofa Lilleborg plc, personal communication 2004)

Year	Sugar consumption (kg)		Soft drinks (liters)		Fluoride tablets (DDD)	Toothpaste sales [†]
	Total	Chocolates/sweets	Sugar sweetened	Light		
1997	47.8	13.1	92.6	26.4	175	319.4
1998	45.6	13.2	92.0	22.0	174	309.2
1999	43.2	13.4	92.1	24.9	177	314.7
2000	42.1	12.7	92.5	22.5	219	284.6
2001	44.6	13.5	91.4	23.6	261	319.0
2002	42.5	12.9	93.2	23.8	288	311.1
2003	41.4	13.2	86.9	26.1	314	308.2

[†] Non-fluoride toothpastes represented about 0.5% of sales 1997–2003.

caries trend [22]. Frequency distributions were compared using chi-square tests and Student's *t*-test for paired observations to test the null hypothesis that there was no difference from one year to the next in caries prevalence or d_3mft score.

Bivariate and multivariate analyses were carried out at county and national level. Bivariate associations were assessed using Spearman's rank correlation coefficient (r_s) and the distribution on $n - 2$ degrees of freedom to test the null hypothesis that $\rho = 0$. The four predictors found to be most strongly associated with the dependent variables (caries prevalence or d_3mft score) were included in multiple linear regression analyses (enter or stepwise). Multiple linear regression analyses were used because the dependent variables exhibited neither significant skew nor kurtosis. A maximum of four predictors were allowed in the regression analyses as there are only 19 counties [23]. Collinearity was controlled by keeping the variance inflation factor (VIF) below 10 [24]. Model fit was assessed by ANOVA and expressed in terms of adjusted R^2 . The significance level was 5%.

As Public Dental Service dentists have been encouraged to vary the length of recall intervals according to individual caries activity, all multiple regression analyses were repeated with the percentage of children treated as a control variable even though its bivariate correlation with the percent caries prevalence was weak and statistically not significant (strongest $r_s = -0.258$). In addition, the three predictor variables most strongly associated with caries prevalence were included in these analyses.

Results

Descriptive findings

The prevalence of caries (d_3mft threshold) increased from about 30% in 1997 and 1998 to just over 40% in 2001, but fell to 36% in 2003 (Figure 1). These changes represent an annual growth rate of 6.6% from 1997 to 2001 and an annual reduction rate of 5.5% from 2001 to 2003. The difference in caries prevalence between the best and the worst county varied between

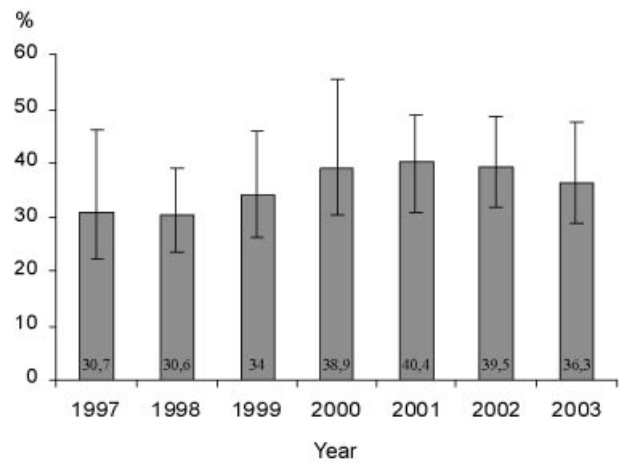


Figure 1. Percentage caries prevalence (d_3 threshold) among 5-year-old children in Norway according to year. The vertical line (I) indicates the range in prevalence between counties.

17 and 25 percentage points (Figure 1). The greatest inter-county difference was recorded in the year 2000.

The prevalence rate of caries increased in all counties from 1998 to 1999 and from 1999 to 2000, and in 76% to 80% of the dental districts (Table III). Although the prevalence was significantly higher in 2003 than in 1997 (one sample *t*-test: $t = 4.93$, 18 d.f., $p < 0.01$), it declined significantly from 2001 to 2003 (one sample *t*-test: $t = 8.01$, 18 d.f., $p < 0.01$) (Figure 1). As expected, the variation was greater at district level than at county level.

The mean number of d_3mft per child increased from 1.1 in 1997 to 1.6 in 2001, but by 2003 had fallen to 1.4. The number of decayed teeth varied between 0.71 (1997) and 1.14 (2001), the *ft* component between 0.24 (1999) and 0.38 (2000). The mean number of missing teeth was less than 0.11 throughout the observation period (Figure 2). The difference in mean d_3mft score between the worst and the best county varied from 0.8 in 1998 to 1.2 in 2000. The lowest mean d_3mft score of a county was 0.7 in 1997, the highest 2.3 in 2000 (Figure 2).

The pattern of change in prevalence and experience of caries was unaffected when the analyses were limited

Table III. The number of Norwegian counties and dental districts reporting a reversal of caries trend and the magnitude of change from one year to the next from 1997 to 2003 for children 5 years of age (percentage caries prevalence)

Time interval	Counties		Dental districts†	
	No. of counties with reversal	Difference in percentage points	No. of districts with reversal	Difference in percentage points
1997–1998	10/19	–4.7 to 12.0	57/102	–15.0 to 14.2
1998–1999	19/19	–6.5 to –1.4	79/103	–17.3 to 15.0
1999–2000	19/19	–9.6 to –1.4	74/92	–14.5 to 5.3
2000–2001	13/19	–12.9 to 6.5	55/92	–15.5 to 10.1
2001–2002	5/19	–1.6 to 6.2	39/87	–7.6 to 11.2
2002–2003	1/19	–0.5 to 6.8	23/98	–10.7 to 15.6
1997–2003	19/19	–3.1 to 16.4	88/101	–26.2 to 10.1

† Results based on the same dental districts throughout did not change the observed pattern.

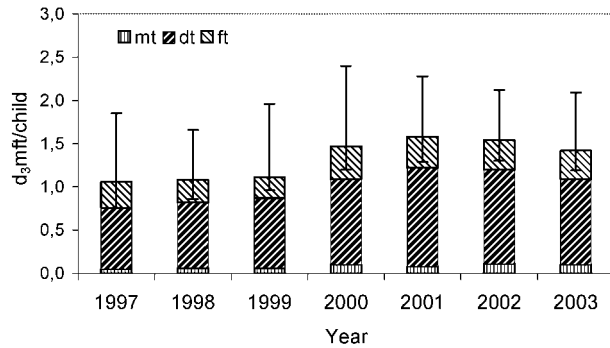


Figure 2. Mean d_{3mft} and component scores for children 5 years of age in Norway according to year. The vertical line (I) shows the range in county mean d_{3mft} .

to districts and counties that had provided a complete set of data throughout the period of observation.

Bivariate and multivariate analyses

Table IV gives the correlation between selected predictor variables, percentage caries prevalence, and d_{3mft} according to year. Significant negative relationships were observed between sale of fluoride tablets, percentage immigrants 0–17 years old, net mobility between counties, infant mortality, and caries prevalence ($p < 0.05$). All the significant associations were recorded for the years 1997–2001. Some associations changed from negative to positive and vice versa during the observation period, e.g. education, income, and infant mortality (Table IV). The d_{3mft} scores at county level confirmed most of the associations between predictors and caries prevalence, e.g. the effect of fluoride, immigration, and mobility. In addition, income became significant in 1998 and 2000 (Table IV).

There was a significant inverse relationship between caries prevalence and the sale of fluoride tablets when the four predictor variables with the highest absolute value of Spearman's correlation coefficient were employed in multiple linear regression analyses (Table V). The same applied to net mobility, except for the year 2002. A significant effect (inverse) of the percentage treated was found in 2001 and a direct effect of education in 2003. All seven regression models were significant ($p < 0.05$) and explained variance (adjusted R^2) ranged from 34.3% (2002) to 78.5% (1998) (Table V).

Multiple regression analyses controlling for level of education and infant mortality did not change the results in Table V appreciably, nor did inclusion of an interaction variable to allow for a strong positive association ($r_s \geq 0.82$) between education and income. In analyses controlling for the percentage treated, the effect of fluoride tablets became non-significant in 2002 and did not fulfill the inclusion criterion (2003). Net mobility remained not significant in 2002 and was not in the model in 2000. Education entered the analysis only in 2002, but was not significant when controlling for the percentage treated. No significant effect of the proportion of immigrants 0–17 years old was recorded by either method of analysis.

In order to make maximum use of the variability in caries prevalence between counties and between the years of observation in trend analyses, a data matrix was constructed for the 7 years (1997–2003) and 19 counties to give $n = 133$. In both bivariate and multivariate linear regression analysis, significant associations ($p < 0.01$) were found between percentage caries prevalence and year, percentage of children treated, sale of fluoride tablets, and net mobility. The predictor variables explained a significant proportion of the

Table IV. Bivariate associations (Spearman's rho) between selected predictors, caries prevalence (%) and d_{3mft} for children aged 5 years in Norway 1997 to 2003

Year of study	Covariates						
	Percent exam./treated	Fluoride tablets	Education	Income	Immigrants 0–17 years	Net mobility	Infant mortality
Caries prevalence ($d_{3mft} > 0$) ($n = 19$ counties)							
1997	-0.26	-0.56*	-0.06	-0.42	-0.52*	-0.65**	0.10
1998	-0.03	-0.74**	-0.06	-0.26	-0.51*	-0.46*	0.01
1999	-0.19	-0.61**	-0.14	-0.30	-0.57**	-0.64**	-0.50*
2000	-0.07	-0.66**	-0.19	-0.44	-0.64**	-0.38	0.06
2001	-0.26	-0.53*	0.08	-0.12	-0.42	-0.44	0.12
2002	-0.09	-0.31	0.14	-0.17	-0.38	-0.30	0.23
2003	-0.01	-0.16	0.25	-0.09	-0.24	-0.31	0.12
Decayed, missing, and filled teeth (d_{3mft})							
1997 ¹	-0.22	-0.53	-0.08	-0.44	-0.53	-0.79**	0.33
1998 ²	-0.04	-0.60*	-0.20	-0.58*	-0.55	-0.84**	0.09
1999 ³	0.04	-0.55*	-0.10	-0.33	-0.53	-0.87**	-0.40
2000 ³	0.14	-0.62*	-0.33	-0.65**	-0.67**	-0.52	0.42
2001 ⁴	-0.17	-0.35	0.18	-0.15	-0.31	-0.46	0.39
2002 ⁵	-0.07	-0.14	-0.13	-0.37	-0.30	-0.46	0.24
2003 ⁶	-0.13	-0.19	0.15	0.18	-0.26	-0.43	0.29

¹ $n = 12$; ² $n = 13$; ³ $n = 14$; ⁴ $n = 15$; ⁵ $n = 17$; ⁶ $n = 18$; * $p < 0.05$; ** $p < 0.01$.

Table V. Summary of multiple regression analyses with percentage caries prevalence as dependent variable (county level) for the years 1997–2003 (*n* = 19 counties)*

Year	Predictor variables							ANOVA		
	Exam/ treated	Fluoride tablets	Education	Income	Immigrants	Net mobility	Infant mortality	Explained variance %	F	<i>p</i> -value
1997	na	S	na	NS	NS	S	na	54.4	6.36	<0.005
1998	na	S	na	S	NS	S	na	78.5	17.47	<0.001
1999	na	S	na	na	NS	S	NS	71.1	12.09	<0.001
2000	na	S	na	NS	NS	S	na	65.9	9.71	<0.001
2001	S	S	na	na	NS	S	na	71.8	12.45	<0.001
2002	na	S	na	na	NS	NS	NS	34.3	3.35	<0.05
2003	na	S	S	na	NS	S	na	38.7	3.85	<0.03

* S = significant association (*p* ≤ 0.05); NS = non-significant association (*p* > 0.05), na = not applicable.

variance in percentage caries prevalence (*R*² = 0.679; *F* = 70.77, d.f. 4/128, *p* < 0.01).

As the time trend in caries prevalence appeared to be curvilinear (Figure 1), separate multivariate analyses were carried out for the years 1997 to 2001 and 2001 to 2003. The final models for the whole period and for the years 1997 to 2001 contained the same predictor variables, i.e. fluoride tablets, year of observation, mobility, and percentage examined. In the final model for the period 2001 to 2003, fluoride tablets, mobility, and immigrants entered the equation, while year and percentage examined did not. When the stepwise option was employed in the analyses, *F* tablets entered in the first step and accounted for 49% to 68% of total adjusted *R*² in the three models.

The multivariate regression analyses with the mean *d*_{3mft} as dependent variable were limited to the years 2001–2003, as fewer than 15 counties reported *dmft* scores before 2001. These analyses confirmed to some extent the findings when caries prevalence was the dependent variable, except that the percentage of immigrants 0–17 years had a significant impact on *d*_{3mft} in all three models (Table VI). Explained variance (adjusted *R*²) ranged from 30.3% (2003; model *p* = 0.07) to 44.4% in 2001. The regression models explained a significant proportion of total variance in *d*_{3mft} score in 2002 and 2003 (Table VI).

Discussion

The prevalence rate of caries in Norwegian children 5 years of age decreased from 50% in 1985 to 30% in 1997 [17]; it increased to 40% in 2001, but by 2003 had

fallen to about 36% (Figure 1). The mean *d*_{3mft} and component scores followed a similar pattern between 1997 and 2003 (Figure 2). These findings show that the caries situation of the deciduous dentition of Norwegian children aged 5 years first deteriorated and then improved during a relatively short period of time. Reports from other countries have found continuing decline [2,11–13] or a variable pattern [1,3–10, 14–17].

Three observations make the present Norwegian findings special. First, the annual rate of growth of caries prevalence from 1997 to 2001 (6.6%) exceeded the annual reduction rate between 1985 and 1997 (4.3%) [17]. Second, the deterioration in dental health involved all counties and most dental districts (Table III) and, third, the increase in the cumulated *mft* component of the *d*_{3mft} score (Figure 2) indicates also an increased caries experience before 5 years of age.

At county level, multivariate analyses provided some evidence in favor of predictors of the observed trend in caries experience. Net mobility remained significantly associated with caries prevalence in all except one analysis (2002) (Table V). When controlling for the socio-economic variables, the sale of fluoride tablets had a significant impact on variation in caries prevalence between counties throughout the 7-year period. The multivariate time trend analysis (*n* = 133) confirmed the impact of fluoride tablets and mobility and provided support for controlling for the percentage of children treated (dental service variables).

The multivariate analyses revealed a significant negative association between fluoride tablet sales and caries prevalence in the counties (Tables IV and V).

Table VI. Summary of multiple linear regression analyses with mean *d*_{3mft} as dependent variable (county level) for the years 2001–2003 (*n* = 19 counties). S* = a significant association (*p* ≤ 0.05); NS = a non-significant association (*p* > 0.05), and na = not applicable

Year	Predictors					Explained variance %	ANOVA	
	Fluoride tablets	Net mobility	Immigrants	Income	Infant mortality		F	<i>p</i> -value
2001	S	S	S	na	NS	44.4	3.79	0.04
2002	na	S	S	NS	NS	43.3	4.06	0.03
2003	NS	NS	S	na	NS	30.3	2.85	0.07

* Bold letters confirm significant findings in Table V.

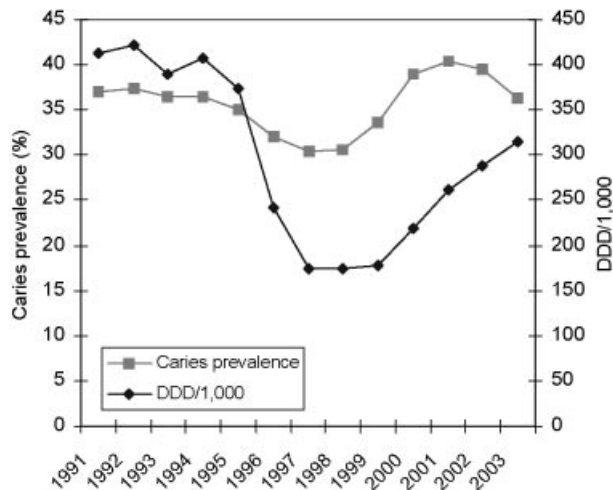


Figure 3. Percentage caries prevalence (d_3 threshold) among children 5 years of age and the annual sale of fluoride (F) tablets in terms of defined daily dose (DDD) per 1,000 persons under 15 years of age—Norway 1991 to 2003.

This finding is logical and in agreement with analyses showing a significant relationship between the sale of fluoride tablets and the number of surfaces filled in children treated in the Norwegian Public Dental Services [28]. The results of these ecological analyses are also supported by analyses at individual level [29,30], but there are exceptions [31] as also occurred in the present study (Table IV).

The sale of fluoride-containing toothpaste seems to have been fairly stable during the observation period (Table II), except that more paste containing 0.15% fluoride has been sold [25]. The average sale of fluoride tablets was 367 DDD/1,000 inhabitants under 15 years of age per day from 1992 to 1996 (range 242–422 DDD/1,000), but almost half that after a debate relating to the introduction of more restrictive recommendations for their use in June 1996 [25,26]. Sales remained low in the late 1990s (about 175 DDD per 1,000 inhabitants) but increased to 314 DDD by 2003 (Figure 3, Table II). It is known that the use of fluoride tablets is twice as common among Norwegian children younger than 7 years of age than it is among older children [27], and that about 50% of the youngest children may have been taking fluoride tablets before the restrictive recommendations were introduced.

With the exception of the increased sale of fluoride tablets after 1998 and the sale of fluoride-containing toothpaste, there is a lack of evidence about the possible role of other sources of fluoride exposure towards the observed time trend in caries experience.

While total sugar consumption has remained relatively stable in Norway [32], the intake of sweets and chocolates has increased from 4.6 kg in 1960 to 12.3 kg in 1990 [25] and 13.2 kg per person per year in 2003 (Table II). The sale of sugar-sweetened soft drinks increased from 83.1 liters per inhabitant in 1996 to 90 liters in 2000. Total consumption of carbonated beverages was on average 115.7 liters per person

per year (range 113–119 liters) during the period 1997–2003, of which between 77% and 81% was sugar-sweetened (Table II). A nationwide, 4-day dietary survey in 2001 found an average sugar intake of 55 g/day among 4-year-old Norwegian children and that about 90% of these children had an intake in excess of the recommended 10% of total energy intake from sugar [33]. Parents of children aged 3.5 to 4.5 years living in Oslo reported that 7% ate sweets or chocolates every day or most days in 2002, 17% added sugar to drinks, and 10% drank sugary drinks in bed [34]. The extent to which this pattern and level of sugar consumption has impacted on the caries experience of Norwegian 5-year-olds from 1997 to 2003 cannot be determined on the basis of the available information.

Systemic use of antibacterials may have contributed to explain the caries decline in industrialized countries [35]. The total sale of antibacterials for systemic use varied between 16 DDD and 18 DDD per 1,000 inhabitants per day from 1993 to 2003 (http://www.legemiddelbruk.no/dok/dok_8.htm, read 27 July 2004). If children 5 years of age and younger received a constant share of these sales, then it is unlikely that use of antibacterials can explain the reported increase and subsequent decrease in the prevalence of caries among Norwegian 5-year-olds.

More than 1,200 dentists and 300–400 dental hygienists served as examiners each year. It is therefore unlikely that diagnostic variability has biased the caries estimates at national and county level, because even at county level the number of examiners exceeded 30. Underestimation of the extent of caries cannot be precluded because of crude criteria (d_3 threshold), lack of trained and calibrated examiners, and optional use of radiographs [36,37]. On the other hand, the current caries criteria have been used since the 1980s and crude criteria have been found to reflect changes in caries prevalence [28]. Inter-examiner variability is thus an unlikely explanation for the increase and subsequent decrease in caries prevalence and experience among Norwegian 5-year-old children since 1997.

A shortage of dentists in the Public Dental Service may have reduced the amount of restorative care of primary teeth and possibly affected the observed caries experience. Although the possibility exists, the County Chief Dental Officers did not provide support for this contention as far as the increase from 1997 until 2000 was concerned, nor did the finding that the d_{3t} score tended to be higher in the counties with the least shortage of dentists [17]. Past [17] and present analyses have found that treatment coverage, number of full-time dentists, and the proportion of vacant positions for dentists and dental hygienists were not significantly associated with caries prevalence and experience.

The introduction of a high caries risk strategy combined with individualized recall intervals is another possible source of bias. This may have increased the proportion of children in need of operative treatment in

the material and thus tended to inflate the estimated caries prevalence rates, the d_3mft , and component scores. As the differences in treatment coverage from year to year were smaller within than between counties, the risk strategy has probably not affected the present findings.

Multivariate analyses revealed a significant association between the percentage immigrants and d_3mft (Table VI) but not with caries prevalence (Table V). The percentage of first and second generation immigrants 0–17 years of age increased from 5.3 in 1997 to 7.3 in 2003. The proportion of immigrants living in Oslo decreased from 40.3% in 1997 to 35.5% in 2003 [19]. The caries trend for 5-year-olds in Oslo followed the same pattern as in the other counties where the proportion of immigrant children was low. Therefore, it is unlikely that the observed time trend in caries prevalence and experience is due to these modest changes in the proportion of immigrant children in Norway.

Caution has to be exercised when interpreting these findings because aggregated data increase the risk of ecological fallacy. Even so, the results show that caries prevalence and experience increased among Norwegian 5-year-olds from 1997 to 2001 and that there was a fall from 2001 to 2003. None of the demographic and dental service predictors or the national sales figures for sweets (Table II) show marked shifts that may explain the caries increase and subsequent decrease between 1997 and 2003. On the other hand, the sale of fluoride tablets was significantly related to the variation in caries prevalence (Figure 3). Thus, the explanation for the deterioration in dental health of children 5 years of age after 1998 may be associated with reduced sales of fluoride tablets from 1996 to 1999 and uncertainty regarding the safety and use of fluorides. The study also demonstrates the importance of surveillance following changes in national guidelines for the prevention of dental caries.

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