Caries Distribution in the Dentition and Significant Caries Index in Swedish 4-Year-Old Children 1980–2002

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Purpose: To analyse possible changes in the severity and distribution of dental caries within the dentition in five groups of 4-year-old children examined with the same methods and criteria between 1980 and 2002.

Materials and Methods: The material consisted of retrospective caries recordings from cross-sectional studies performed in 1980, 1987, 1992, 1997 and 2002 in Umeå, Sweden. The distribution of dmfs within the dentition was analysed in the whole groups and in one third of each group with the highest dmfs-values (mSiC-index).

Results: When comparing the whole groups, no statistically significant changes were found over the years concerning total dmfs, or dmfs in molars and canines or in occlusal surfaces ($p > 0.05$). There was a significant increase in dmfs-values in incisors observed between 1980 and 1987, while a similar reduction was observed between 1987 and 1992 ($p < 0.05$). When comparing subgroups constituting 33% of those with the highest dmfs-values for all teeth in each group, the mean values of dmfs for all teeth was higher in 2002 than in 1997 (6.0 compared with 5.3), but the rank sum test of dmfs-values displayed a non-significant difference ($p > 0.05$). There was, however, a statistically significant increase in the dmfs-values for molars and canines between 1997 and 2002 ($p < 0.05$). Between 1987 and 1992, a statistically significant decrease in dmfs-values in incisors ($p < 0.01$) was found, while the opposite trend occurred between 1992 and 1997 ($p < 0.05$).

Conclusion: By analysing caries distribution within the dentition and in subgroups, trends can be detected over time that otherwise are obscured. The findings should be considered in future epidemiological studies, as even significant changes could be overlooked and disregarded.

Key words: caries, children, significant caries, subgroups

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The prevalence of dental caries in 4-year-old children in the city of Umeå, Sweden, has been recorded and analysed at regular intervals between 1967 and 2002 with the same methods and criteria. The changes in dmf-values and distribution of caries during this period have been reported in a series of publications (Samuelsson et al, 1971; Holm et al, 1975; Stecksén-Blicks et al, 1985; Stecksén-Blicks et al, 1989; Stecksén-Blicks and Holm, 1995; Stecksén-Blicks and Borssén, 1999; Stecksén-Blicks et al, 2004). In 1967, the mean dmfs-value was 7.8 and there was a marked decrease over the next decade. This decline levelled out after 1980 and no major changes on surface level have since occurred, but the mean dmft-values decreased by approximately 15% between 1980 and 2002 (Stecksén-Blicks et al, 2004). Concomitantly, the percentage of children above the mean dmfs-value has varied between 30% in 1980 and 22% in 1987. Comparisons of caries figures in the entire population may not, however, accurately reflect the skewed distribution of the disease

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and could therefore lead to important changes over time being overlooked. An analysis of the prevalence and changes within the dentition in the subgroup of the population with the highest caries prevalence could provide better information on changes in disease prevalence. It was therefore considered valuable to reanalyse data from the groups of 4-year-old children examined in 1980, 1997, 1992, 1997 and 2002. Such information could reflect oral hygiene and feeding practice and provide information on how preventive efforts should be targeted. The aim of this study was therefore to analyse possible changes in the severity and distribution of dental caries within the dentition in five cohorts of 4-year-old children examined with the same methods and criteria between 1980 and 2002.

MATERIALS AND METHODS

The material consisted of the recordings from the studies performed in 1980, 1987, 1992, 1997 and 2002 in the city of Umeå, Sweden. The group in 1980 was randomly selected from the population register while the groups from 1987, 1992, 1997 and 2002 constituted all 4-year-olds born during the same quarter and residing in the same inner-city area. In all the studies, the groups represented about 25% of all 4-year-old children in the area. The mean ages of the children were 4 years and 5 months in 1980 and 4 years and 1 month in 1987, 1992, 1997 and 2002. The same dentist was the principal investigator in all five studies (CSB) and examined all children in 1980 and 1987 and about 50% of the children in 1992, 1997 and 2002. Decayed, missed and filled surfaces were recorded with the same methods and criteria in all five groups according to definitions described by Koch (1967). The criterion for initial caries was a chalky white spot without a breakdown in the enamel surface. Bite-wing radiographs were taken when the approximal surfaces were not available for visual inspection. The dmfs-scores included all carious lesions on occlusal and approximal surfaces but not initial caries on buccal and lingual surfaces. A molar extracted due to caries was counted as three missing surfaces and an incisor as two missing surfaces. Before the start of the studies in 1992, 1997 and 2002, all examiners were calibrated on the criteria for caries diagnosis against CSB, who was the examiner in 1980 and 1987, until full agreement. Further details of the material are presented in previous publications (Stecksén-Blicks et al, 1985; Stecksén-Blicks et al, 1989; Stecksén-Blicks and Holm, 1995; Stecksén-Blicks and Borssén, 1999; Stecksén-Blicks et al, 2004).

The Significant Caries index (SiC index; Bratthall, 2000) was adopted and modified on the surface level for the primary dentition in order to select the children with the highest dmfs-values within each study group (mSiC-index). The selection was based on the distribution frequency of dmfs in each group and one-third with the highest values were selected. The cut-off point was dmfs = 2 and to include one-third of each group, a number of values representing children with a dmfs-value of 2 and all with higher values were assigned to the subgroups. For the entire group as well as the 33%-subgroups, the following indices were calculated and analysed separately: dmfs, dmfs all teeth; $dmfs_{mc}$, dmfs in molars and canines; $dmfs_{mca}$, dmfs in molars and canines, approximal surfaces only; $dmfs_{o}$, dmfs on occlusal surfaces; and $dmfs_{i}$, dmfs in incisors.

The dental care system had been basically the same during the whole period in the area. All parents had been offered dental health information on one or two occasions during their children's first year of life and all children had been provided with comprehensive dental care free of charge, with a strong caries preventive approach, from 3 years of age. The fluoride content of the drinking water was ~0.3 mg/l during the whole period.

Statistical methods

The distribution of caries was skewed and therefore a non-parametric ANOVA for several independent samples (Kruskall–Wallis test) was used to test differences in the dmfs-values between the five groups. For pairwise comparisons of differences in dmfs-values, the Mann–Whitney U-test for two independent samples was used. When relevant, the Bonferroni procedure, which is a rule for correction of p-values when doing pairwise comparisions, after a significant Kruskall–Wallis test was applied. The software Statistical Package for Social Sciences (SPSS, version 11.5, Chicago, Ill, USA) was used for all analyses. The level of statistical significance was set at 5%.

RESULTS

Data on caries prevalence for the entire groups are presented in Table 1. No statistically significant changes were displayed over the years concerning total dmfs, or dmfs in molar and canines and occlusal surfaces ($p > 0.05$). There was, however, a significant increase in dmfs-values in incisors between 1980 and 1987 ($p < 0.05$), while a similar reduction was observed between

Table 1 Decayed, missing and filled surfaces (dmfs) in all teeth, in molars and canines (total and approximal surfaces), in occlusal surfaces and in incisors in cohorts of 4-year-old children from 1980, 1987, 1992, 1997 and 2002

		1980 n = 93	1987 n = 126	1992 n = 163	1997 n = 206	2002 n = 182	p-value (overall test)
dmfs	mean ± SD median range	2.0 ± 3.0 0 0–13	2.0 ± 3.6 0 0–15	1.8 ± 3.0 0 0–15	2.0 ± 3.2 0 0–19	2.0 ± 3.7 0 0–21	0.74
$dmfs_{mc}$	mean ± SD median range	1.6 ± 2.4 0 0–11	1.3 ± 2.6 0 0–14	1.5 ± 2.7 0 0–15	1.5 ± 2.6 0 0–16	1.7 ± 2.8 0 0–14	0.29
$dmfs_{mca}$	mean ± SD median range	0.2 ± 0.8 0 0–4	0.2 ± 1.0 0 0–8	0.4 ± 1.5 0 0–8	0.3 ± 1.0 0 0–7	0.4 ± 1.4 0 0–8	0.32
$dmfs_{o}$	mean ± SD median range	1.3 ± 1.8 0 0–6	0.9 ± 1.8 0 0–8	1.0 ± 1.6 0 0–8	1.1 ± 1.7 0 0–8	1.2 ± 1.8 0 0–8	0.07
$dmfs_{i}$	mean ± SD median range	0.4 ± 0.9 0 0–4	0.6 ± 1.6 0 0–12	0.3 ± 0.9 0 0–6	0.5 ± 1.3 0 0–9	0.4 ± 1.3 0 0–8	0.01*

dmfs, dmfs all teeth; $dmfs_{mc}$, dmfs in molars and canines; $dmfs_{mca}$, dmfs in molars and canines, approximal surfaces only; $dmfs_{o}$, dmfs occlusal; $dmfs_{i}$, dmfs, incisors.
* indicates statistical significance ($p < 0.05$)

1987 and 1992 ($p < 0.05$). The corresponding data for the mSiC-index are shown in Table 2. Over the years from 1980 to 2002, there was statistically significant change in dmfs-values in molars and canines and in incisors ($p < 0.05$), while no differences were found in all teeth, approximal surfaces in molars or in occlusal surfaces ($p > 0.05$). The mean dmfs-value for all teeth was higher in 2002 compared with 1997 (6.0 compared to 5.3) but the rank sum test of dmfs-values displayed a non-significant difference ($p > 0.05$). There was a statistically significant increase in the dmfs-values for molars and canines between 1997 and 2002 ($p < 0.05$). Between 1987 and 1992, a statistically significant decrease in dmfs-values in incisors ($p < 0.01$) was seen, whereas the opposite trend occurred between 1992 and 1997 ($p < 0.05$).

The cumulative dmfs in the whole cohort and in subgroups with contrasting caries prevalence in 2002 is illustrated in Fig 1.

DISCUSSION

The present revaluation of epidemiological data was undertaken to gain more detailed information on time trends and possible changes in the caries distribution within the dentition that may reflect current cariogenic challenges as well as effects of preventive measures. In spite of minor fluctuations, 'classical' analyses of entire groups and dentitions displayed no significant caries changes on surface level between 1980 and 2002, which may be interpreted as the caries situation being under control. The novel finding of this study was that significant changes over time could be demonstrated by dividing the dentition into tooth groups and by creating subgroups of caries-active individuals. We chose to calculate incisors, molars/canines and occlusal surfaces separately since they may respond differently to challenging factors and preventive measures. For example, it is generally thought that fluoride exposure has a greater impact on smooth surfaces than fissures, while unfavourable feeding and bottle behaviour in the pre-school ages may cause caries in the upper primary incisors. The strength of the actual series is notable as the caries scoring was performed with the same methods and criteria over the years and the same dentist was the principal investigator in all the studies. Furthermore, the groups (except in 1980) consisted of all children in the city of Umeå born in the third quarter (July–September) with few dropouts and they were probably representative of their age group. On the other hand, the relatively small

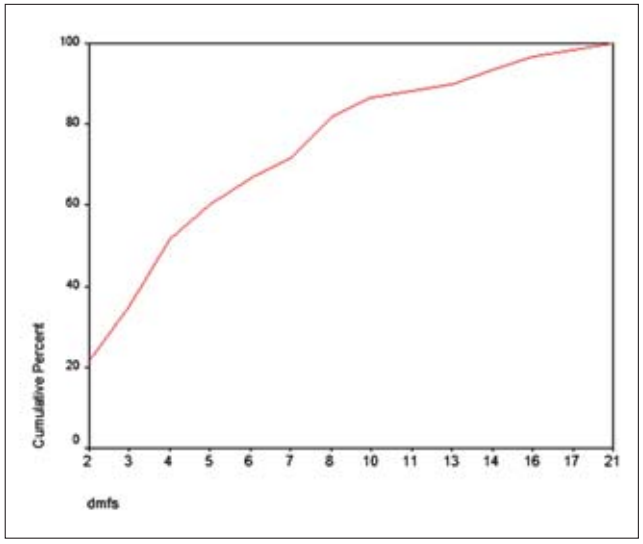

Fig 1a

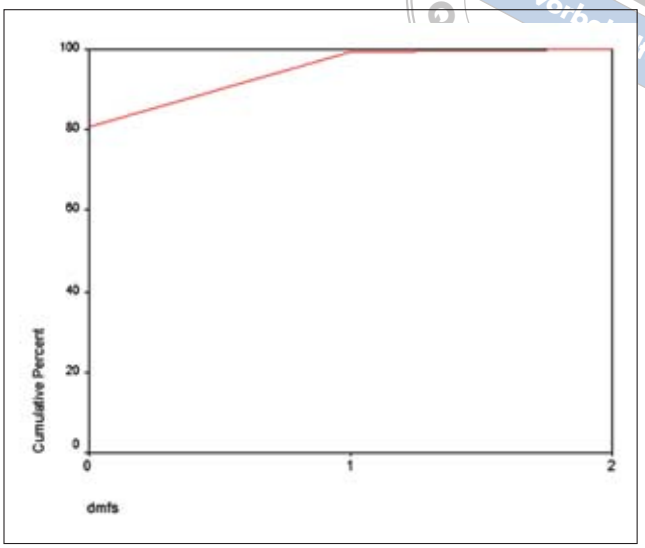

Fig 1b

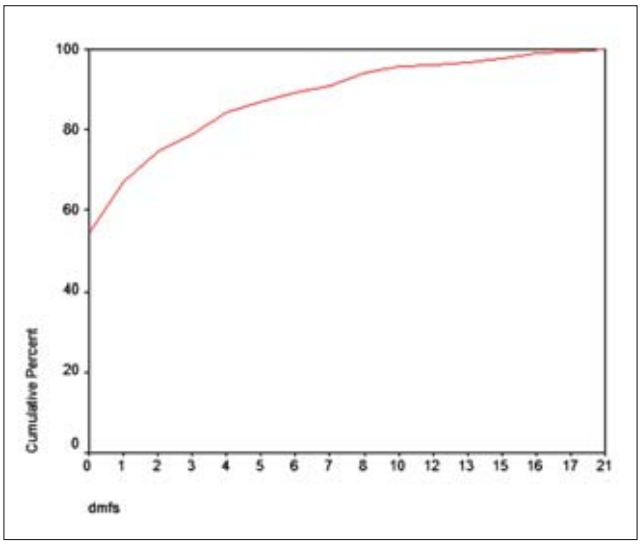

Fig 1c

Fig 1a to c Cumulative distribution frequency of dmfs in groups of 4-year-olds with contrasting dmfs in 2002. (a) The one-third subgroup with the highest dmfs-values. (b) The two-thirds subgroup with the lowest dmfs-values. (c) dmfs-values in the whole group.

sizes of the groups must be considered, especially concerning the statistical analyses of the high caries subgroups as discussed below.

The most caries-active individuals were selected with a modification of the SiC-index proposed by Bratthall (2000), and originally developed and proposed for comparison of 12-year-olds in different populations. The SiC-index is defined as the mean DMFT of the study group representing those one-third with the highest caries experience. In the present study, the index was modified on the surface level in the primary dentition and the group from 1980 was used as a baseline. For example, the mean dmfs in 1980 was 2.0 for the entire group compared with 5.6 with the mSiC-index and the corresponding values from 2002 were 2.0 and 6.0. An important general observation was that the findings of the mSiC-index only partly coincided with total groups concerning the total dmfs as well as the dmfs-indices of the different tooth groups. Based on the overall statistical tests for comparisons of the mSiC-index, only dmfs-values for molars and canines and incisors showed significant changes (Table 2). However, the Bonferroni adjusted p-values did not allow us to conclude which years differed significantly from each other. By looking at the unadjusted p-values when comparing years pairwise, our conclusion is that the significant change in dmfs for molars and canines was due to the change between 1997 and 2002 and the changes in $dmfs_i$ occurred between 1987–1992 and 1992–1997.

Table 2 Modified significant caries (mSiC) index in all teeth, molars and canines (total and approximal surfaces), occlusal surfaces and in incisors of the each cohort of 4-year-olds from 1980, 1987, 1992, 1997 and 2002

		1980 n = 31	1987 n = 42	1992 n = 54	1997 n = 68	2002 n = 60	p-value (overall test)
mSiC	mean ± S	5.6 ± 2.9	5.6 ± 4.4	5.2 ± 3.4	5.3 ± 3.8	6.0 ± 4.4	0.65
	median	5.0	4.0	4.0	4.0	4.0	
	range	3–13	2–15	2–15	2–19	2–21	
$mSiC_{mc}$	mean ± SD	4.4 ± 2.3	3.7 ± 3.5	4.4 ± 3.1	4.0 ± 3.3	4.9 ± 3.1	0.04*
	median	4.0	3.0	4.0	3.0	4.0	
	range	1–11	1–14	0–15	1–16	0–14	
$mSiC_{mca}$	mean ± SD	0.7 ± 1.3	0.6 ± 1.6	1.3 ± 2.3	0.9 ± 1.6	1.2 ± 2.3	0.25
	median	0	0	0	0	0	
	range	0–4	0–8	0–8	0–7	0–8	
$mSiC_o$	mean ± SD	3.5 ± 1.7	2.6 ± 2.3	2.8 ± 1.7	2.9 ± 1.9	3.2 ± 2.0	0.135
	median	4.0	2.0	3.0	3.0	3.0	
	range	0–6	0–8	0–8	0–8	0–8	
$mSiC_i$	mean ± SD	1.2 ± 1.3	1.9 ± 2.4	0.8 ± 1.5	1.3 ± 1.9	1.1 ± 2.2	0.01*
	median	1.0	0	0	0	0	
	range	0–4	0–12	0–6	0–9	0–8	

mSiC, dmfs all teeth; $mSiC_{mc}$, dmfs in molars and canines; $mSiC_{mca}$, dmfs in molars and canines, approximal surfaces only; $mSiC_o$, dmfs occlusal; $mSiC_i$, dmfs, incisors in the one-third with the highest dmfs-values.
* indicates statistical significance ($p < 0.05$)

One of the main findings displayed both in the total groups and in the subgroups was the fluctuation of the $dmfs_i$ index. This 'rise and fall' of caries in the incisors was interesting in the light of the past and present fluoride recommendation in Sweden. Before 1987, fluoride toothpaste was recommended only for children over 4 years of age. This was changed to 1.5 years after 1987 and there was a substantial increase in the use of fluoride toothpaste in young children because of this change in the official recommendations. In 1987, only 26% of the parents reported that they brushed their children's teeth twice per day or more compared with 36% in 1992, and 47% and 49% in 1997 and 2002 respectively. Thus increased used of fluoride toothpaste in children from tooth eruption combined with improved toothbrushing habits may have played a significant role for the decreased prevalence of caries in incisors. Although the widespread use of fluoride toothpaste has been linked to the decline in caries in many populations during the later parts of the 20th Century (Petersson and Bratthall, 1996), the scientific evidence for an effect on caries in the primary dentition is ranked as incomplete due to a limited number of clinical trials in this age group (Twetman et al, 2003). Daily supplementation of fluoride tablets was recommended to all children with low fluoride content in the drinking water between 1967 and 1987 but the compliance with the recommendation was low (Stecksén-Blicks and Holm, 1995). After 1987 it was prescribed in the form of lozenges only to children with high caries risk or high caries activity in efforts to institute individualised intervention for small children. The individual programmes also included advice on how to perform oral hygiene and sugar restriction (Vanobbergen et al, 2001). The influence of these programmes on dental health can, however, be questioned (Batchelor and Sheiham, 2002; Axelsson et al, 2004).

Although the role of sucrose as a factor affecting dental health has not been clear-cut in epidemiological data (Woodward and Walker, 1994), excessive

daily sucrose consumption in early childhood has been positively correlated to increased risk of caries in children (Grindefjord et al, 1995; Mariri et al, 2003; Routtinen et al, 2004). Fluoride has raised the threshold of sugar intake at which caries will develop but the increased cariogenic challenge in the form of sugar consumption between meals after 1987 displayed in the present groups of children (Stecksén-Blicks and Borssén, 1999) may, however, have contributed to the fact that the mean dmfs-value among children with the severest caries had increased in 2002. The fact that the mSiC-index in molars and canines was significantly higher in 2002 than in 1997 was definitely a cause of concern, especially since these caries-active children often represent individuals disadvantaged from a social point of view. These children include children with an immigrant status (Wennhall et al, 2002; Mariri et al, 2003). Focusing attention on the children with the highest caries scores may have a potential gain for the society as well as the individual.

In conclusion, the present paper show that analyses of the caries distribution within the dentition and in high-caries subgroups may exhibit significant time trends that not are disclosed in classical analysis of the entire population which, in turn, may lead to the incorrect conclusion that the caries situation is stable or even under control. The findings should be considered in future repeated epidemiological series, as it seems obvious that even significant changes can be overlooked and disregarded.

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