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Caries prevalence and background factors in Swedish 4-year-old children – a 40-year perspective

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Background. Periodic and well-controlled studies of caries and background factors are important for organizing dental care and how prevention should be addressed.

Aims. The aims of this study were to compare data on caries prevalence and background factors in 4-year-old children from 2007 with data collected periodically between 1967 and 2002 with the same methods and criteria, and to compare immigrant and non-immigrant children concerning caries prevalence and background factors.

Design. A cross-sectional study in 4-year-old children living in Umeå, northern Sweden ($n = 218$), was performed. Caries recordings included both cavitated and non-cavitated caries lesion, and bite-wing radiographs were used on indications. Data on oral hygiene, use of fluorides, general health, and medication and sugar consumption were collected using the same questions and questionnaire as in the previous studies.

Results. In 2007, 38% of the children displayed caries compared to 46% in 2002. The distribution of decayed, missing, or filled surfaces–primary teeth values was statistically significantly different in 2007 compared to 2002 ($P < 0.05$). The intake frequency of sugary between-meal products was generally lower, and toothbrushing frequency was higher in 2007 compared with data from the 2002 study. In children with immigrant background, the frequency of toothbrushing was statistically significantly lower, and snacking was more common ($P < 0.05$). Sixteen per cent had immigrant background and 59% had caries compared to 32% in the rest of the cohort ($P < 0.01$).

Conclusion. Important changes in caries prevalence of 4-year-old children have taken place since 2002 concurrently with a decreased intake of sugary between-meal products and increased toothbrushing frequency. Immigrant background had a significant association with caries prevalence in 2007.

Introduction

The main challenge in dentistry for young children is to maintain children's teeth healthy, and in these age groups primary caries prevention aims at establishing favourable oral hygiene and dietary habits. Epidemiological caries data and background factors collected in a series of crossectional studies in 4-year-olds with the same methods and criteria, in the city of Umeå, northern Sweden, displayed increased decayed, missing, or filled surfaces–primary teeth (dmfs) values among children with the highest values in 2002[1]. In 2003, another periodic study from southern Sweden[2] displayed a non-significant increase in caries in 3-year-olds. A large socioeconomic difference in caries prevalence with the highest values in children from weak socioeconomic groups has also been shown[3].

A number of epidemiological studies have shown a correlation between frequent sugar consumption in an early age and caries prevalence[4–7]. Lifestyle changes with an increasing consumption of sugary foods have been pinpointed as a possible reason for the recent unfavourable development of children's dental health. The consumption of sugary drinks has increased considerably in the population, and in many cases it has become an everyday product for children[8]. The lifestyle changes have also been ascribed the increasing frequency of overweight, sometimes already at 4 years of

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age[9]. Besides the changes in dietary habits, low physical activity among children has been suggested as a reason for the increasing overweight problem, and World Health Organization[10] states in a report on the prevention of chronic health conditions that key factors for both medical and dental health are diet, nutrition, and physical activity. Therefore, efforts to limit and reduce the sugar intake in young children are important targets for primary caries prevention and also a challenge for general health[10] in spite of that the compliance with an outcome of sugar restrictions to control caries not yet has been scientifically demonstrated[11].

Periodic well-controlled studies of caries and background factors are an important basis for organizing dental care and how prevention should be addressed. A study on caries and background factors in 4-year-old children using the same methods and criteria as in the studies performed in 1967, 1971, 1976, 1980, 1987, 1992, 1997, and 2002[12] provides a unique possibility to study possible changes in caries prevalence and background factors in 4-year-old children. The aims of this study were, therefore, to perform a new cross-sectional study on 4-year-old children's caries prevalence, oral hygiene habits, sugar consumption, general health, and medication, and to make comparisons with the earlier studies and to compare caries prevalence and background factors in immigrant and non-immigrant children.

Materials and methods

The study was performed with a cross-sectional design between August and December 2007, using the same methods and criteria as in the studies performed in 1967, 1971, 1976, 1980, 1987, 1992, 1997, and 2002. The examinations were carried out at the public dental health clinic were the child was registered, and performed as the dental health examination of 4-year-old children within the free, regular, and comprehensive dental care offered to all children up to 19 years of age. The study was performed as a quality guarantee project within the public dental health service. All children born during the third quarter of 2002 living in the catchments areas of three public dental health clinics in Umeå, a city in northern Sweden, with approximately 110.00 inhabitants, were invited to take part in the investigation ($n = 229$). The areas were the same as those in the earlier studies, and the number of children was proportional to the number of 4-year-olds in the respective clinic. Parents of the invited children received a letter with information about the study. Parents of 11 children (5%) did not want to take part of which two had private dentists and nine wanted to postpone their child's dental examination. The final material thus consisted of 218 children with a mean age of 4 years and 1 month.

In all the studies, the cohorts represented about 25% of all 4-year-old children in the area. Further details of the materials are presented in the previous publications[12–18]. The data from 1976 are not published separately.

The fluoride content of the piped drinking water had been stable and was 0.3 mg/L.

Clinical examinations

The examinations were carried out by five experienced dentists who were calibrated before the start of the study. Two of the examiners had also been examiners in previous studies. The principal examiner had been examiner in the studies in 1980, 1987, 1992, 1997, and 2002, and one of the examiners had been an examiner in 1997 and 2002. The calibration procedure included nine children and was performed until a joint agreement on the caries criteria was obtained. The opinion of the two examiners who had been involved in the previous studies constituted the golden standard. To check the interexaminer reliability, 55 of the children who had been examined by any of the three new examiners were randomly selected and their parents were asked to turn up for a re-examination by the two examiners who had performed the earlier studies. The kappa values were 0.95, 0.98, and 0.85, respectively.

Decayed, missed, and filled surfaces using a mirror and a probe were recorded with the same methods and criteria as in the earlier studies according to definitions described by Koch[19]. The criterion for initial caries was a chalky white spot without a breakdown in the

enamel surface. In 41 children (19%), bite-wing radiographs were taken because the approximal surfaces were not available for visual inspection. As in all the earlier studies, the dmfs scores were calculated for each child and included all carious lesions in enamel and dentine, but not enamel caries on buccal and lingual surfaces. A molar extracted because of caries was counted as three missing surfaces and an incisor as two missing surfaces.

As in the previous studies, a case history was taken from the accompanying parent concerning toothbrushing habits, use of fluoride toothpaste, general health, medication, and country of birth of the parents. Children who had at least one parent born outside Sweden with native language other than Swedish were classified as immigrant children.

Questionnaire

The accompanying parent was asked to fill in a standardized questionnaire to collect information about the frequency of the consumption of ten sugary snacks. The intake frequency was registered as follows: no intake, once per month, twice per month, once per week, two to three times per week, once per day, two to three times per day, and four times per day or more. Questions were also asked about eating or drinking at night and drinking between meals. In case there was a positive answer to any of these two questions, the parent was asked to specify the most common drinks. The same questionnaire had been used in all the previous studies except in the 1976 study.

Statistical methods

Data were processed using SPSS software (Statistical Package for the Social Sciences, version 15.0, SPSS, Inc., Chicago, IL, USA). As the distribution of caries was skewed, the non-parametric Mann–Whitney *U*-test for two independent samples was used to test differences in dmfs values between the samples in 2002 and 2007, and between children with and without immigrant background. The chi-squared test was used to compare the distribution of children with and without caries, and distribution of categorical variables between 2002 and 2007. A P value of less than 5% was considered statistically significant.

Results

Caries prevalence

Thirty-eight per cent of the 4-year-olds had cavitated and non-cavitated caries lesion in 2007. Comparisons with the earlier studies are displayed in Table 1, and the prevalence and distribution in 2007 are displayed in Table 1 and Fig. 1. The prevalence was 38% in 2007 and 46% in 2002 ($P > 0.05$), and the distribution of the dmfs values had a statistically significant difference between 2002 and 2007 ($P < 0.05$) (Fig. 1).

Sugar consumption

The reported frequency of consumption of the ten between-meal products is given in Table 3.

Table 1. Caries experience, frequency of toothbrushing, use of fluoride toothpaste, and immigrant status in 4-year-old children in Umeå, 1967 to 2007.

Year	1967	1971	1976	1980	1987	1992	1997	2002	2007
N	196	187	113	93	126	163	206	182	218
Caries experience									
Caries prevalence (%)	83	67	64	50	42	44	46	46	38
Children with caries (dmfs, mean ± SD)	–	–	–	4.0 ± 3.1	4.8 ± 4.7	4.4 ± 4.2	4.2 ± 3.6	4.4 ± 4.2	3.4 ± 3.7
Toothbrushing (%)									
Seldom/Irregularly	8	1	7	7	15	10	5	7	3
Once per day	92	99	93	33	59	54	48	44	26
Twice per day or more				60	26	36	47	49	71
Fluoride toothpaste (%)	*	*	*	53	60	92	99	99	98
Immigrants (%)	*	*	*	*	*	*	10	9	16

*Not recorded.
–, Data not available.

Table 2. Reported consumption of sugary snacks in 4-year-old children in Umeå in 2007; within the parentheses are the corresponding figures in 2002 given.

Product	Never	One to two times/month	Once/week	Two to three times/week	≥ Once/day
Sugar added to food	48.1 (34.5)	25 (19.2)	10.7 (20.3)	9.7 (13.7)	6.5 (10.4)
Buns/cakes/biscuits	0.5 (0)	15.2 (8.6)	43.3 (30.3)	34.6 (50.9)	6.4 (10.3)
Ice cream	0.5 (0)	22.1 (12.5)	51.6 (38.6)	24.4 (42.6)	1.4 (6.3)
Sugared drinks	3.7 (0.6)	22.0 (8.5)	44.9 (33.0)	24.3 (39.8)	5.1 (18.2)
Sweets	2.3 (0.6)	9.3 (3.9)	78.7 (80.1)	8.8 (15.3)	0.9 (0)
Marmalade/jam	16.0 (14.3)	30.5 (20.6)	25.8 (29.7)	23.0 (28.6)	4.7 (6.9)
Sweet soups	43.7 (20.7)	41.8 (36.2)	8.9 (23.6)	4.2 (18.4)	1.4 (1.2)
Dried fruit	29.0 (33.1)	43.8 (53.2)	17.2 (6.3)	10.0 (7.4)	0 (0)
Sweetened flakes	68.5 (42.9)	14.1 (21.7)	8.5 (16.6)	6.6 (12.6)	2.3 (6.3)
Chocolate drinks	37.3 (20.6)	36.4 (36.0)	13.8 (19.4)	8.8 (16.6)	3.7 (7.4)

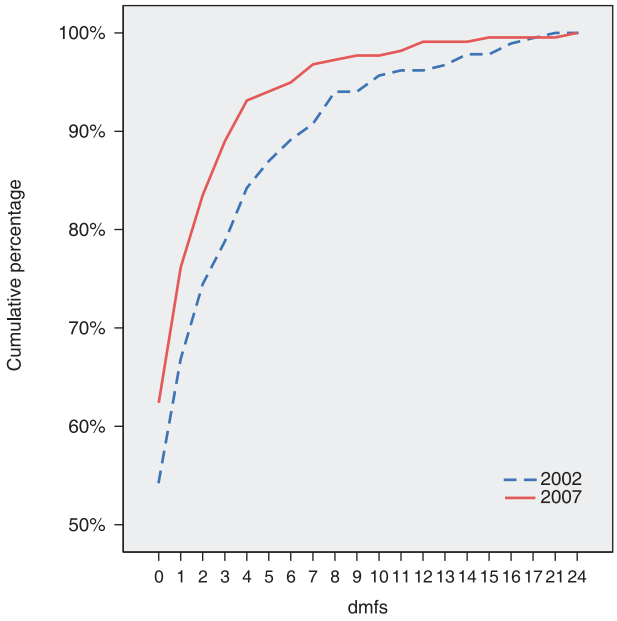

Fig. 1. The cumulative distribution frequency of decayed, missing, or filled surfaces (dmfs) in 4-year-old children in Umeå in 2002 (- - - -) and in 2007 (—).

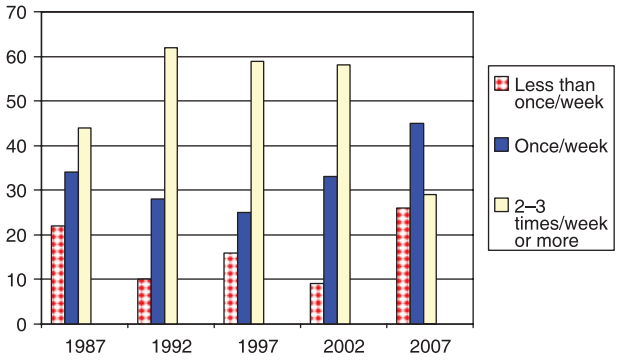

Fig. 2. Reported consumption of sugary drinks in 4-year-old children in Umeå from 1987 to 2007. Bars denote children in percentage.

The intake frequency was generally lower compared with data from the 2002 study. Sugared drinks were reported to be consumed daily by 5% of the children in 2007 compared to 18% in 2002 (Fig. 2).

Oral hygiene

The frequency of toothbrushing was higher in 2007 compared to 2002. Seventy-one per cent of the parents stated brushing the child's teeth twice per day or more often compared to 49% in 2002 ($P < 0.01$).

General health and medication

In 11% of the children, a general health problem was reported. Asthma or allergic conditions were the most common health problems, and medication for asthma was most common.

Immigrant background

Sixteen per cent of children were classified as immigrant children. Fifty-nine per cent of children with immigrant background had caries compared to 32% in the rest of the 2007 cohort ($P < 0.01$) (Table 3). The frequency of toothbrushing was statistically significantly lower in children with immigrant background ($P < 0.01$) compared to non-immigrant children. Eighteen per cent of the children were given sugared drinks every day compared to 3% in

Table 3. Decayed, missing, or filled surfaces (dmfs), toothbrushing frequency, use of fluoride toothpaste, snacking, participation in dental health information, general health, and medication in 4-year-old children with and without immigrant background in Umeå in 2007.

	Immigrant children (*n* = 35)	Non-immigrant children (*n* = 183)	*P**
Caries			
With caries (%)	59	32	< 0.01
dmfs			
Mean ± SD	3.85 ± 5.6	0.8 ± 1.4	
Median	1	0	
Range	0–24	0–7	
Oral hygiene measures (%)			
Toothbrushing			
Seldom, irregularly	6	2	
Once per day	47	22	
Twice per day or more	47	76	< 0.01
Fluoride toothpaste (%)	98	98	ns
Snacking (%)			
Sugared drinks every day	18	3	< 0.01
Sweets every day	6	0	ns
Drinking at night, except water	47	13	< 0.01
Dental health information at 2 years of age of the child (%)			
Yes	68	79	ns
General health problem (%)			
Yes	9	11	ns
Medication (%)			
Yes	12	14	ns

ns, not significant. *Mann–Whitney U-test for 2 independent samples was used for statistical testing.

non-immigrant children ($P < 0.01$), and sweets every day was given 6% of the immigrant children compared to 0% in non-immigrant children ($P > 0.05$). Drinking at night was more common in immigrant children ($P < 0.01$). No differences in general health and medication between the two groups were displayed. Sixty-eight per cent of the parents to immigrant children had participated in dental health information at 2 years of age of the child compared to 79% of parents to non-immigrant children ($P > 0.05$).

Discussion

In Sweden, the dental care for children has since 40 years ago had a preventive approach with start in an early age of the child. The concept with early start with prevention has been based on the thinking that initially children's teeth are healthy and that the dental health of the preschool child is important because it has a strong influence on the future dental health[20,21]. There was an obvious decline in caries prevalence in 4-year-old children from 1967 up to 1980, and it was ascribed the introduction of early dental health information to parents and an increased use of fluorides. The decline then levelled out, and in 2002 increased dmfs values were detected among those with the highest values[1], whereas a reverse of this trend is displayed in the 2007 data.

Reliability is essential when data are going to be compared with data collected earlier. The reliability of the present background data is considered to be very high as the same questions on oral hygiene, general health, and medication and the same questionnaire for sugar eating habits as in previous studies were used. The issue to keep the criteria for caries constant is a greater challenge, however. The calibration procedure before the start of the study was therefore performed meticulously. One definite strength of the data in the series is that the principal examiner had been the

same in the studies in 1980, 1987, 1992, 1997, 2002, and 2007, and had been calibrated against previous examiners, and one examiner had been examining in 1997, 2002, and 2007. As an extra measure to secure that the criteria for caries were the same as in the previous studies, 55 children (25% of the total material) who had been examined by the three new examiners were re-examined, with acceptable kappa values, by the two examiners who had been involved in the previous studies.

The caries prevalence in a population can be looked upon as the net result from the cariogenic challenge and factors counteracting the challenge. A deterioration of dental health in 5-year-olds in Norway took place between 1997 and 2001 concurrently with a reduction in the sale of fluoride tablets, whereas increased sales reduced caries up to 2003[22]. Between 1999 and 2004, increased number of fissure sealants and less caries were reported for adolescents and youths in the United States, whereas children aged 2–5 years displayed increased caries prevalence in primary teeth[23]. The better dental health showed in the 2007 data took place concurrently with a decreased sugar challenge and improved oral hygiene habits. Obviously, between 1997 and 2002, the preventive efforts in dentistry for young children in Sweden were not strong enough to combat the effects of the lifestyle changes with an increased consumption of sugary products detected already in the 1997 study[18]. Mainly because of the epidemic increase in overweight in the population in Sweden as well as in many other countries[9], during the last few years other actors have given public health messages to reduce the intake of sugary snacks in children[24] coinciding with the same message from dentistry. Dentists against sweets and soft drinks, a campaign launched by the Swedish Dental Society, have since 2004 drawn important public attention and has resulted in a decreased availability of sugar in schools and day-care centres[25]. The joint action seems to have been successful as there was a lower intake of sugary products in 2007 compared to 2002. From a public health perspective, a lower frequency of consumption of sugared drinks is an important finding as frequent consumption of sugared beverages has been pointed out to have an important association to caries in the primary dentition[6,7]. But it is also important because a systematic review of epidemiological and experimental evidence indicates that a large consumption of sugar-sweetened beverages is associated with weight gain and obesity[26]. The level of evidence for an association between caries and obesity is, however, not strong according to a systematic review, and only one study with high level of evidence showed direct association between obesity and dental caries[27]. Caries and obesity have, however, been shown to co-exist in children of low socioeconomic status[28]. Public health measures to discourage consumption of sugary drinks, improve dietary education, and access to appropriate foods for children could thus decrease the risk of both diseases.

It is generally accepted that fluoride plays an important role in caries prevention by reducing the demineralization process and promoting remineralization[29]. Toothpaste constitutes the most important vehicle for fluoride, and to benefit from fluoride in toothpaste teeth must be brushed regularly. Children with insufficient care of their teeth do, therefore, not receive an effective protection from fluoride nor the effect from plaque removal. In 2002, the Swedish Council for Technology Assessments[30] ranked the caries preventive effect of toothbrushing with fluoride toothpaste with the highest level of evidence. As a consequence, the importance of toothbrushing with fluoride toothpaste has been emphasized for all age groups in dental health programmes in Sweden. Although the scientific evidence for an effect on caries in the primary dentition is ranked as incomplete because of a limited number of clinical trials in this age group[31,32], parents have been encouraged to start brushing when the teeth erupt and to use a small amount of fluoride toothpaste twice per day from around 1 year of age of the child. In the 2002 study, statistically significant differences in dmfs values were displayed between children whose parents brushed their teeth twice per day or more compared those with lower frequencies of brushing[12]. A similar association between brushing frequency and dmfs values could also be seen in data from the 2007 study, but the relative preventive impact of the increased

brushing frequency cannot be ruled out with this study design. It is very likely, however, that it may have had an important impact on the decreased dmfs values. The caries prevalence remained almost on the same level between 1987 and 2002, and the interaction between the sugar challenge and brushing and its effect on caries can be followed by comparing data during the period. After 1987, the frequencies of brushing twice per day increased concomitantly with an increased sugar challenge[18], whereas the interaction of an increased brushing and a lower cariogenic challenge resulted in lower caries prevalence in 2007.

The skewed distribution of caries is a concern, and the high prevalence shown in children with immigrant background pinpoints an important future challenge. In an international comparison of health inequalities in caries in childhood, it was demonstrated that toothbrushing before the age of 1 and twice per day with adult involvement doubled the odds of being caries free[33]. Parents' perception of their ability to control their children's brushing and sugar snacking habits was the most significant predictor of whether or not favourable habits were reported. Alm *et al*.[21] showed that an early establishment of brushing children's teeth provided a foundation for a low experience of approximal caries in adolescents. Activities to support parental skills are therefore important. Community-based preventive strategies with toothbrushing and/or fluoridated milk programmes in primary schools[34] may be a parallel approach to the problem. Another challenge is to maintain the trend with decreased sugar consumption in these age groups. It is very important that sugar availability continues to be restricted in schools and day-care centres as behaviours in these venues may constitute a model for many parents' attitudes to their child's dietary habits and nutrition.

In conclusion, important changes in caries prevalence of 4-year-old children have taken place since 2002 concurrently with a decreased intake of sugary between-meal products and increased toothbrushing frequency. In 2007, the caries distribution was skewed and immigrant background had a significant association with caries prevalence and unfavourable health habits.

What this paper adds
- New information on a recent decline in caries prevalence in 4-year-old children concomitantly with improved oral hygiene habits and decreased sugar challenge.
- A 40-year perspective on caries and background factors in Swedish 4-year-old children.

Why this paper is important to paediatric dentists
- It highlights important information for how future prevention in preschool ages should be targeted.

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