

Caries prevalence in 2-year-old children in the city of Zurich

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Objectives To establish caries prevalence in 2-year-olds in the city of Zurich; and to investigate the relationship between caries prevalence and dietary habits, and oral hygiene practices in native children and children with immigrant background. **Method** 1,000 randomly selected 2-year-olds were invited to participate in a clinical examination, at which parents were interviewed about the child's oral hygiene and dietary habits. Caries diagnosis was based on visual inspection of all tooth surfaces and included both initial (d_1) and cavitated (d_2) lesions. Univariate and multivariate logistic regressions for two subgroups of children (children of Swiss and foreign-born mothers) were performed in order to assess the association between predictor variables and caries. **Results** 771 children were examined (participation rate 78%; mean age 2.4 years (age range 2.06 - 2.90 years)). Although the majority (94%) was born in Switzerland, 61% of children had immigrant backgrounds (mother not born in Switzerland). Cavitated teeth ($d_{2,mft}$) were observed in 12.6% of children (95% CI: 10.4 - 15.1%). Caries including initial lesions ($d_{12,mft}$) affected 25.3% of children (95% CI: 22.4 - 28.5%). There were 34 (4.4%) children with severe caries (all maxillary incisors cavitated). For children with caries, the mean $d_{2,mft}$ was 4.3 (\pm 2.8). Children with foreign-born mothers (mothers not born in Switzerland) exhibited a significantly higher caries prevalence than those with Swiss-born mothers (17.4% versus 5.0% with $d_{2,mft}>0$). **Conclusions** Children with foreign-born mothers exhibited significantly higher caries prevalence rates than those with Swiss-born mothers. Poor oral hygiene and night-time bottle use were identified as risk indicators for caries in all children. Further risk indicators identified in children of foreign-born mothers were a preference for sugar-containing non-milk drinks, no pacifier use, child's age and male gender.

Key words: Caries prevalence, early childhood caries, risk indicators

Introduction

In the Canton of Zurich caries prevalence and the severity of caries in the primary dentition of school-beginners (7-year-olds) have been monitored for decades. Trends observed over the years showed a distinct decrease in caries prevalence and severity from the 1960s to the 1980s (Steiner *et al.*, 1991). Caries severity increased slightly during the 1990s (Menghini *et al.*, 2003a).

Presently, approximately 50% of 7-year-olds in the Canton of Zurich have carious deciduous teeth (Menghini *et al.*, 2003a). Results from an oral health survey of kindergartens in the city of Winterthur in 2001 showed that 45% of 5-year-olds had deciduous caries (Menghini *et al.*, 2003b).

However, caries epidemiological studies involving younger children have never been conducted in Switzerland. The aim of the present investigation was therefore to establish caries prevalence in considerably younger children. In a consensus conference (Drury *et al.*, 1999) age classes of one year width were proposed. Accordingly, this study focussed on 24 to 36-month-old children, as this age group provided the earliest opportunity where a comprehensive clinical examination was possible. By this stage, most children have a full complement of primary teeth and have established dietary habits. This situation allows for various caries-related investigations in young children.

The sample was limited to children from the city of Zurich for various reasons: (1) participants could be selected via simple random sampling; (2) the favourable logistical situation would encourage participation (centrally-located examination venue with extended opening hours, easily accessible by public transport); and (3) since the city of Zurich has a considerably high proportion of children of foreign nationality (approximately 40%), the previously-identified problem of high caries prevalence in children with immigrant background (Marthaler *et al.*, 1996) could be studied here.

In summary, the objectives of this study were to: (1) establish the prevalence of caries in 2-year-olds in the city of Zurich. This initial estimation would provide a baseline for comparison in subsequent surveys, and (2) investigate the relationship between caries prevalence and (i) dietary habits, and (ii) oral hygiene practices in native children and children with immigrant background.

Materials and Methods

The target population comprised 1,582 children resident in the city of Zurich, who would be between 2.00 and 2.99 years old at the time of examination (in 2003). A sample of 1,000 children was needed to precisely estimate caries prevalence in the population (\pm 2.5%; 95% CI), assuming a low response rate of 65%. The Registration Office of the local authority of the City of Zurich per-

formed the random sample selection of 1,000 children and released the necessary personal details required for the study, according to the Data Protection Act.

Parents were sent introductory letters outlining the study aims and inviting them to participate with their children. The time-intensive recruitment process involved after-hours telephonic follow-ups as well as two further written invitations to non-responders unable to be contacted by telephone. Since 14 of the 1,000 selected children had moved away from the city, the sample size was corrected to 986.

Prior to the clinical examination, the adult accompanying the child (usually the mother) was interviewed. In addition to the questions listed in Table 2, the questionnaire contained other questions pertaining to the child's birthplace (Q1), mother's birthplace (Q2), use of fluoride tablets (Q4), breast-feeding (Q7), and daily consumption of pure milk (Q11). In the interview, Q12 was posed as follows: Which two drinks are most frequently consumed by the child? In the evaluation, this question was reformulated to read: Is one of the two most frequently consumed drinks a sugar-containing non-milk drink? This category comprised non-milk drinks with added sugars (either by the manufacturer or consumer), fruit juices and syrups. Sugar-containing non-milk drinks were considered more cariogenic than sugar-containing milk drinks (Levine, 2001).

The child was examined while seated on the accompanying adult's lap. The light source was a halogen lamp with fibre optics. Cottonwool rolls were used to dry the teeth and to remove plaque where necessary.

All surfaces of the primary teeth were examined for caries. Caries diagnosis was based on visual inspection with a plane mirror and CPI probe. The probe was used only to remove oral debris and to confirm cavitation (Drury *et al.*, 1999). The criteria used in the diagnosis of initial lesions (d_1) in pits, fissures and smooth surfaces were those reported by Drury *et al.* (1999). Cavitation, enamel discontinuity and undermined enamel were categorised as advanced lesions (d_2).

Before the caries examination, the labial surfaces of all four maxillary incisors were examined for plaque first visually and then with a CPI probe. All clinical observations were recorded on examination forms by the examiners.

Examinations were conducted by a dentist and two undergraduate dental students. The examiners were calibrated by the project leader, who re-examined 92 children in order to determine inter-examiner reliability. Kappa values for inter-examiner consistency in the diagnosis of caries were between 0.84 and 1.00 for d_2 mft, and 0.50 and 1.00 for d_{12} mft.

Two caries indices, namely d_{12} mft (initial lesions included) and d_2 mft (initial lesions excluded), were employed to measure dental caries. Confidence limits for the observed proportions with caries were calculated according to the method described by Wilson (1927).

First, univariate logistic regression analyses of all children were performed in order to assess the association between predictor variables and caries. Next, univariate logistic regressions and thereafter, multivariate logistic regressions for two subgroups of children were considered (children of Swiss and foreign-born mothers). Predictors

with significance levels $p < 0.1$ in the univariate models were taken into consideration as predictors in the multiple models. Backward logistic regression was applied for the automated multiple model selection.

Results

Of the 986 invited children, 771 were examined (participation rate of 78%). The mean age of the children was 2.4 (age range 2.06 - 2.90) years. Participants comprised 392 (50.8%) boys and 379 (49.2%) girls. Swiss children made up a predominant part of the sample (60.4%). There were 96 (12.5%) children from the Former Republic of Yugoslavia and 209 (27.1%) children of other nationalities. Whereas 94% of the children were born in Switzerland, this applied to only 39% of mothers (Table 1).

Overall and demographic-specific caries prevalence data are summarised in Table 1. Cavitated teeth (d_2 mft) were observed in 97 (12.6%) children (95% CI: 10.4 - 15.1%). The d_2 mft index comprised almost only untreated carious teeth (d-component). When initial lesions were included (d_{12} mft), caries affected 195 (25.3%) children (95% CI: 22.4 - 28.5%). There were 34 (4.4%) children with severe caries (all maxillary incisors carious). Analysis by tooth type showed that the maxillary incisors were most frequently affected, where initial (d_1) and cavitated (d_2) lesions were observed to a similar extent.

When nationality was considered, the highest prevalence of caries was observed in children from the former Yugoslavian states. Caries prevalence in these children differed significantly from Swiss children for all caries data presented in Table 1: 38.5% of ex-Yugoslavian children presented with cavitated lesions compared to 7.5% of Swiss children (OR= 7.7; $p < 0.001$). For d_{12} mft > 0 prevalence rates were 65.6% and 15.7% respectively (OR= 10.3; $p < 0.001$). Severe caries affected 18.8% of ex-Yugoslavian children and 2.4% of Swiss children (OR= 9.5; $p < 0.01$).

Caries prevalence increased with age. Significant differences were observed between the youngest and oldest children: 8.8% vs 42.9% (OR=7.8; $p < 0.01$). Children whose mothers were not born in Switzerland (i.e., foreign-born mothers) exhibited significantly higher caries prevalence rates than those with Swiss-born mothers. Cavitation was seen in 5% of children with Swiss-born mothers and 17.4% with foreign-born mothers (OR= 4.0; $p < 0.001$).

In children with caries, the overall mean d_2 mft was 4.3 (\pm 2.8). The demographic specific mean values were similar in all categories, ranging between 3.3 and 5.1 d_2 mft.

Figure 1 shows the skewed pattern of caries distribution with a clustering of values around zero dmft and only few cases of high d_2 mft.

Table 2 shows caries prevalence (d_2 mft) by behaviour related to oral hygiene and dietary habits. Only variables that were significantly related to caries prevalence in the univariate analysis are listed. Three variables were used to assess oral hygiene: plaque identified visually, plaque present on probing, and the regular practice of toothbrushing (Q3). Plaque on probing was most strongly associated with caries. Plaque was identified on probing in 441 children, 82 (18.6%) of whom had caries.

Table 1. Caries prevalence: overall and by demographic variables for 3 caries categories (d2mft>0; d12mft>0; all maxillary incisors carious)

	Number of children	Children with caries d2mft>0			Children with caries d12mft>0			Children with caries of all maxillary incisors d2mft=4		
		n	%	95% CI	n	%	95% CI	n	%	95% CI
All children	771	97	12.6	10.4-15.1	195	25.3	22.4-28.5	34	4.4	3.2-6.1
Age		Odds Ratio			Odds Ratio			Odds Ratio		
2.00-2.24	170	15	8.8	1.0	37	21.8	1.0	6	3.5	1.0
2.25-2.49	356	42	11.8	1.4	83	23.3	1.1	16	4.5	1.3
2.50-2.74	231	34	14.7	1.8	67	29.0	1.5	10	4.3	1.2
2.75-2.99	14	6	42.9	7.8**	8	57.1	4.8**	2	14.3	4.6
Gender										
Male	392	58	14.8	1.5§	119	30.4	1.7**	18	4.6	1.1
Female	379	39	10.3	1.0	76	20.1	1.0	16	4.2	1.0
Nationality										
Swiss	466	35	7.5	1.0	73	15.7	1.0	11	2.4	1.0
Ex-Yugoslavia	96	37	38.5	7.7***	63	65.6	10.3***	18	18.8	9.5**
Other nationality	209	25	12.0	1.7	59	28.2	2.1***	5	2.4	1.0
Mother's birthplace (Q2)										
Foreign-born	472	82	17.4	4.0***	164	34.7	4.6***	30	6.4	5.0**
Swiss-born	299	15	5.0	1.0	31	10.4	1.0	4	1.3	1.0

* p<0.05 § p<0.1
 ** p<0.01 CI = confidence interval of the proportion
 *** p<0.001

Percentage of children

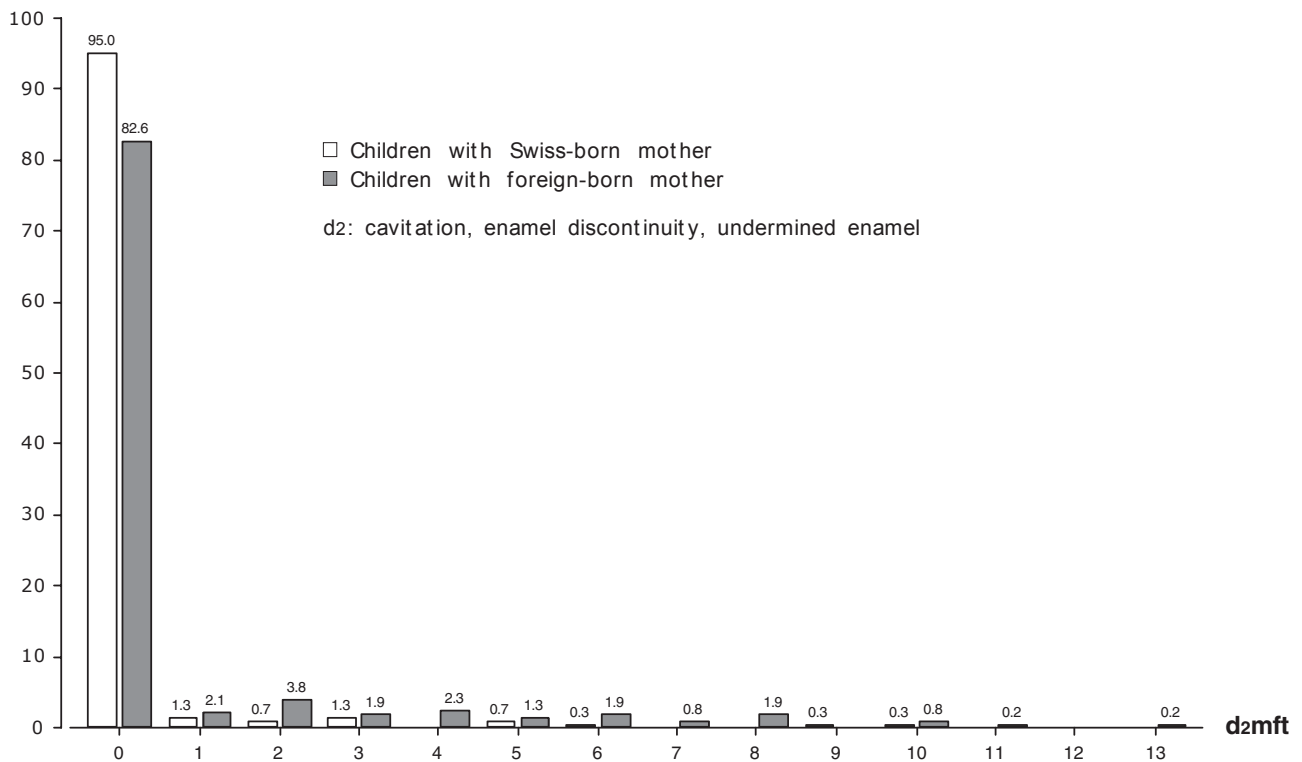


Figure 1. Frequency distribution of d2mft scores for 2-year-olds in Zurich comparing children with Swiss-born mothers to children with foreign-born mothers

Table 2. Caries prevalence by behavioural variables identified as statistically significant in univariate regression analyses

	Number of children	Children with caries d2mft>0		
		N	%	Odds Ratio
<i>Plaque identified visually</i>				
No	406 ^a	20	4.9	1.0
Yes	329 ^a	68	20.7	5.0***
<i>Plaque identified on probing</i>				
No	290 ^a	5	1.7	1.0
Yes	441 ^a	82	18.6	13.0***
<i>Q3 Does someone brush the child's teeth daily?</i>				
No	191	54	28.3	4.9***
Yes	580	43	7.4	1.0
<i>Q5 Is fluoridated salt used in the household?</i>				
No	70 ^b	3	4.3	1.0
Yes	680 ^b	92	13.5	3.4*
<i>Q6 Does the child use a pacifier?</i>				
No	429	69	16.1	2.1**
Yes	342	28	8.2	1.0
<i>Q8 Does the child snack on sugar-containing foods between meals more than once a day?</i>				
No	656 ^b	75	11.4	1.0
Yes	114 ^b	21	18.4	1.7*
<i>Q9 Does the child drink tap water more than once per day?</i>				
No	318	61	19.2	2.7***
Yes	453	36	7.9	1.0
<i>Q10 Does the child drink unsweetened mineral water more than once per day?</i>				
No	511	41	8.0	1.0
Yes	260	56	21.5	3.1***
<i>Q12 Is one of the two most frequently consumed drinks a sugar-containing non-milk drink?</i>				
No	375	26	6.9	1.0
Yes	396	71	17.9	2.9***
<i>Q13.1 Does the child use a baby bottle?</i>				
No	158	11	7.0	1.0
Yes	613	86	14.0	2.2***
<i>Q13.2 Does the child drink from the baby bottle when falling asleep or during the night?</i>				
No	447	26	5.8	1.0
Yes	324	71	21.9	4.5***

* p<0.05 ^{a,b}When added, total 'Number of children' is less than 771 due to missing data, where:
** p<0.01 ^aclinical plaque assessment was not possible in non-compliant children; and
*** p<0.001 ^bperson interviewed could not answer question

In comparison, caries affected 1.7% of the 290 children without plaque (OR=13.0; p<0.001).

Findings revealed a significant relationship between caries and no pacifier use of the 429 children reported not to use a pacifier, 16.1% were affected by caries. Caries prevalence of the 342 children using a pacifier was 8.2% (OR=2.1; p<0.01).

Responses for just over half the children examined (51.4%), showed that at least one of their two most frequently consumed drinks was a sugar-containing non-milk drink. Caries was observed in 17.9% of this group and in 6.9% of children without this habit (OR=2.9; p<0.001).

Almost 80% of the children still used a baby bottle. Forty-two percent of the children were given a baby bottle while falling asleep or during the night. Whereas caries prevalence in night-time bottle users was 21.9%, it was only 5.8% in children not given a bottle at night (OR=4.5; p<0.001). No evidence was found to show that night bottles with sugar-containing non-milk drinks increased the risk for caries more than other drinks contained in the bottle at night (data not shown).

Six hundred and fifty-six children (85.2%) reportedly did not eat sugar-containing foods between meals more than once per day. Caries prevalence for this group was 11.4% compared to 18.4% in the remaining 114 children that consumed sugar-containing snacks on a more frequent basis (OR=1.7; p<0.05).

The four models presented in Table 3 are based on multiple regression analyses. Poor oral hygiene (assessed by the presence of plaque on probing), and night-time bottle use were identified as risk indicators for caries in all four models. Further risk indicators were identified in children of foreign-born mothers: a preference for sugar-containing non-milk drinks, no pacifier use, child's age and male gender.

Discussion

Results presented may be considered a reliable estimate of caries prevalence in the population of the city of Zurich since participants were randomly selected and a satisfactory participation rate (78%) was obtained. In addition, participation by different nationalities corresponded well to the actual proportions in the population.

While numerous studies exist on caries prevalence in toddlers, few have focussed exclusively on 24 to 36-month-olds, and information for this age-group is often difficult to extract from data provided in reports. Furthermore, methodological differences and socio-demographic influences must be taken into consideration when comparing caries prevalence data. Table 4 shows the caries prevalence data of 2-year-olds from various countries, obtained from studies published since 1991. When comparing cavitated lesions only, caries prevalence for children in Zurich (13%) is similar to that in the United Kingdom (10 and 11%). Participants in the former study - reporting caries prevalence of 10% (Gibson and Williams, 1999) - were randomly selected. The lowest prevalence data (between 3 and 6%) were found in Scandinavian cities, however the sample selection was not randomised. Two studies from Sweden reported caries prevalence data including initial carious lesions as well. In this regard, the result for Zurich (25%) is high compared to 8% (in Jönköping) and 12% (in Stockholm).

In the present study, caries data analysed according to nationality and mother's birthplace indicated that children from families with immigrant backgrounds were more frequently affected by caries. Similar observations were made in studies by Grindejord *et al.* (1993), Verrips *et al.* (1992) and Wendt *et al.* (1991).

Unfavourable habits were widely spread in these young children. Plaque on maxillary incisor teeth was

Table 3. Risk indicators for caries identified in multiple logistic regression analyses

Target variable:	Children with foreign-born mother		Children with Swiss-born mother	
	d2mft	d12mft	d2mft	d12mft
Number of children:	445	445	286	286
Children with caries:	72	151	15	30
Odds ratios and significance of odds ratios				
Plaque identified on probing	12.99 ***	5.10 ***	6.25 *	17.12 ***
Night-bottle (Q13.2)	2.92 ***	1.72 *	6.81 **	3.35 **
Sugar-containing non-milk drink (Q12)	2.85 **	2.14 **		
No pacifier use (Q6)	1.97 *			
Age (months)	1.24 **	1.18 **		
Gender (male)		1.65 *		

* p<0.05
 ** p<0.01
 *** p<0.001

Table 4. Caries prevalence of 2-year-olds: overview of literature published since 1991

Author	Year of publication	Country	Target population	Age limits (months)	N§	Caries prevalence (%)	
						Excl. initial lesions	Incl. initial lesions
Wendt <i>et al</i>	1991	Sweden	Jönköping	23-26	299	5	8
Grindefjord <i>et al</i>	1993	Sweden	Stockholm (8 suburbs)	27-33	832	6	12
Pienihäkkinen <i>et al</i>	2004	Finland	Saarijärvi	?	226	3	
Holt <i>et al</i>	1996	UK	London (Camden)	24-35	123	11	
Gibson and Williams	1999	UK	UK	18-42	1006	10*	
Fujiwara <i>et al</i>	1991	Japan	Ibaraki	24-36	188	31*	
Mayanagi <i>et al</i>	1995	Japan	Sendai	?	136	42	
Drury <i>et al</i>	1999	USA	USA	24-36	?	8	
Douglass <i>et al</i>	2001	USA	Arizona (32 communities)	25-36	?	17-25	
Mattos-Graner <i>et al</i>	1996	Brazil	Piracicaba	25-36	150	43	58
Bönecker <i>et al</i>	2002	Brazil	Diadema	24-36	142		18
Al-Hosani and Rugg-Gunn	1998	UAE	Abu Dhabi (3 regions)	?	217	35-47	
Present study		Switzerland	Zurich	24-34	771	13	25

* computed mean of two age classes

§ only studies with N>100 were considered

found in about half of the children, indicating poor oral hygiene. Bottle feeding was a predominant practice observed in 80% of the children. Forty-two percent of the children were given a baby bottle while falling asleep or during the night. Furthermore, responses revealed a preference for sugar-containing non-milk drinks in about half the children.

Separate multivariate analyses were conducted for children of Swiss-born and foreign-born mothers. The decision to split the sample was brought about by the observation that unfavourable child-rearing practices were more prevalent in foreign-born mothers than in Swiss-born mothers (data not shown). Splitting provided greater insight into the statistical significance of the risk indicators in the subgroups and no interactions occurred.

Since only a small number of children presented with caries, constraints were placed on the number of independent variables selected for the multiple logistic regression analysis. The initial list of 20 predictors (questionnaire, age, gender, nationality, plaque identified visually, plaque identified on probing) was therefore reduced to ten variables. Five variables could be excluded because they were represented by other related variables (plaque observed visually and Q3 were represented by plaque on probing; Q9 by Q12; Q13.1 by Q13.2; nationality by mother's birthplace). Five further variables (Q1, Q4, Q7, Q11 and Q13.3) were not significantly related to caries prevalence in the univariate regression analysis including all children, and two variables (Q5 and Q10) resulted in biologically implausible associations (Table 2).

The results of the multivariate analyses showed that (1) poor oral hygiene (presence of plaque), (2) night

bottle use and (3) frequent consumption of sugar-containing non-milk drinks were strongly associated with higher caries prevalence (Table 3). Such habits can only definitively be identified as true risk factors in longitudinal studies. In a recent systematic review (Harris *et al.*, 2004) significant risk factors for caries in young children from seven cohort studies were listed. Some of the habits identified as risk factors were similar to the caries related habits in the present study: (1) poor oral hygiene (visible plaque, toothbrushing less than once per day); (2) sugary liquid during night; and (3) consumption of sugary drinks $\geq 2x/day$, sugary liquid when thirsty and soft drinks more than twice a week.

Age showed a positive association with caries in children of foreign-born mothers (OR = 1.24; 95% CI: 1.08-1.42). The odds of acquiring caries were found to increase by 24% with each additional month of life. In a quasi-longitudinal study conducted in Brazil during the periods 1995/97 and 1997/99, the increase in caries was greater in younger than in older preschool children, suggesting that the most important time for preschool children to develop caries is the first three years of life (Bönecker *et al.*, 2002). The strong increase in prevalence with age indicates that reports on prevalence studies should provide exact details regarding age (mean age, age limits).

For children of foreign-born mothers, using a pacifier was associated with lower caries prevalence. It can be speculated that the use of a pacifier reduces the consumption of food and drinks that contain high levels of sugar.

Dietary habits like multiple snacking episodes per day were not related to the prevalence of deciduous caries. Possibly as a result of the low prevalence of caries in children of Swiss-born mothers, only two risk indicators associated with caries were identified in this group (plaque on probing and night-time bottle use).

The findings confirm that parents of young children should be informed about oral health promoting habits in good time. Due to an integrated approach introduced in the Canton of Zurich in 2003, parental education provided postnatally by paediatricians and child care counsellors also incorporates oral health education, promoting the following behaviour: (1) start toothbrushing with fluoridated children's toothpaste (250 ppm F) upon eruption of the first primary tooth; (2) wean children off the bottle by 12 months; and (3) offer mainly milk and water as drinks to children.

Further, the introduction of a compulsory dental examination for 2-year-olds is planned and pending. If necessary, caries-arresting procedures should be immediately rendered during the examination as a cost-saving alternative to foreseeable later urgent interventions. The observation that very few children with caries examined during the study requested treatment thereafter, underlines the importance of this strategy.

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