Dental health of 6-year-old children in Alpes Maritimes, France

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Abstract

AIM: To describe the dental health status of 6-year-old children using the ICDAS-II advanced method and to evaluate the association between the known caries risk factors with the cavitated caries lesion (WHO basic method) or with both non-cavitated and cavitated caries lesion caries (ICDAS II). **METHODS:** In this cross-sectional study, a questionnaire was used to evaluate oral health and dietary habits of children. A clinical examination and a Cario analysis test (Pierre Fabre Oral care) were performed. **STATISTICS:** Logistic regression analyses were used to assess the association between caries and daily tooth-brushing, dietary habits, visible plaque and salivary factors. **RESULTS:** There were 341 children (52% female and 6.25±0.46 years of age) in this study. Using the ICDAS-II advanced method, 39% of the children were caries-free. This proportion was larger (67.2%) using the WHO method. In multivariate models, visible dental plaque and Streptococcus mutans count were associated with caries experience registered as ICDAS-II codes 1-6 or codes 3-6. The absence of daily tooth-brushing with fluoridated toothpaste was associated only with caries experience ICDAS-II codes 3-6. **CONCLUSION:** The use of WHO or ICDAS-II method changed the proportion of caries-free children but not the clinical caries risk factors associated with caries experience.

Introduction

To date, there have been very few dental epidemiological studies published on the French population [Cahen et al., 1993; Adam et al., 2005; Hescot et al., 2007]. They were based on the WHO basic method (presence of cavitated lesion) [WHO, 1997] to calculate the dmft and DMFT indices at 6, 9 and 12 years of age. They showed a reduction in caries experience; the dft reported was 3.21 in 1987, 2.68 in 1990, 1.69 in 1993 and 1.26 in 2006, whereas the DMFT was 0.52 in 1987, 0.22 in 1990, 0.06 in 1993 and 0.12 in 2006.

Unfortunately, these results do not show the treatment needs of the population, omitting the detection of non-cavitated carious lesions) [Pitts and Stamm, 2004; Bourgeois et al., 2005]. In fact nowadays, the necessity of early detection of carious lesions at the non-cavitated level is known as the key target in the overall effort to move away from operative towards non-operative preventive dentistry [Ekstrand et al., 1998; Kühnisch et al., 2008].

As the clinical appearance of carious lesions is complex, different diagnostic and precise visual caries detection methods have been proposed [Ekstrand et al., 1997, 1998; Nyvad et al., 1999], the International Caries Detection and Assessment System (ICDAS II) Advanced Method [ICDAS co-ordinating committee, 2005 and 2009; Ismail et al, 2007; Pitts, 2009] and UniViSS [Kühnisch et al., 2009]. They all have included non-cavitated caries lesions, that the WHO basic method does not register [Braga et al., 2009] but also other criteria (such as white opacities, brown discolourations, translucency and caries activity) in order to describe the clinical appearance of the carious lesion as precisely as possible and to avoid the limitations of the WHO criteria.

In 2005, the European Commission Health and Consumer Protection Directorate General edited a selection of essential oral health indicators in which the severity of carious lesions using ICDAS is now considered [Bourgeois et al., 2005]. This new approach to dental caries also considers elimination of caries-risk factors [Featherstone, 2004; HAS, 2005; Featherstone et al., 2007]. The French National Authority for Health (HAS) edited a guideline to assess the individual caries risk (ICR) of the patient that sought to assist dentists in determining the necessity for pit and fissure sealants in children and adolescents with a high ICR [HAS, 2005]. Using the principles of evidence-based dentistry, HAS proposed risk factors identified by cohort studies that focused on caries-risk assessment. These studies were carried out in countries with a socio-economic status similar to that of France. However, publications reviewing the distribution of these factors and their association with different levels of caries severity are currently unavailable in France. The aims of this study were firstly to describe the dental health status of 6-year-old children using the ICDAS-II advanced method at different levels of caries severity for comparison purposes and secondly to measure the association between the acknowledged risk factors and cavitated carious lesions, or with both non-cavitated and cavitated carious lesions.

Materials and methods

Study design A cross-sectional study was carried out from September 2008 to June 2009 in Alpes Maritimes (AM). Ethical approval was obtained from the University of Nice scientific and ethics review committee (CPP Sud Méditérannée V) and from the appropriate local and government agencies including the Agence Française de Sécurité SAnitaire des Produits de Santé (AFSSAPS).

Study population Alpes Maritimes is the 14th most densely populated department in France with 235 persons per sq km. It includes Nice, the sixth largest city in France [INSEE, 2009]. 9% of the 360 primary schools in the department are located in rural areas, the rest in urban areas. The urban population comprised schools of low (8.6 %) socio-economic status and others (91.4%) [INSEE, 2009]. The schools corresponding to a low socio-economic status were located in priority education areas (Zone d'Éducation Prioritaire: ZEP) defined by the French government (Ministry of National Education) and these ZEP schools received additional funding.

Sampling procedure As schools in France are classified into two groups based on ZEP and non-ZEP status, a random sample of these schools was selected from urban and rural areas to obtain the necessary sample size of 306 children. This was calculated based on the proportion of high caries-risk children of first grade level in Nice (94% of these children were among the ZEP and 84% were among the non-ZEP), a power of 80% and an alpha level of 5% [Zakarian et al., 2009]. To achieve this, six schools out of the 360 in Alpes Maritimes were randomly selected. All of the first grade children of these schools were invited to participate in this study. Thus, the total sample size for this study was 341 children. This grade level was retained because in France and in the other European countries, both dmft and the DMFT are registered at the age of 6 years. The inclusion criteria required each child's and parent/guardian's consent, and a three-year commitment to remain at the same primary school.

Data collection A questionnaire and a consent form to participate in the study were given to all of the parents of the first grade schoolchildren prior to a dentist's visit at the school. This self-administered questionnaire, validated in a previous study [Zakarian et al., 2009], sought information about the caries-risk factors as recommended by the HAS. Questions regarding their oral health habits, such as "not brushing the teeth daily with fluoridated toothpaste", "regular sweet consumption between meals" (i.e. the consumption of sugar-containing foods, sugar-containing drinks and sweets) and "the daily long-term use of medication containing sugar or causing hyposalivation" were included on the form.

The salivary tests consisted of collecting stimulated saliva samples (at least 1 hour after eating) in a tube (Cario Analyse®, Pierre Fabre Oral Care, France) that was ultimately sent to the Clinident Institute (Aix-en-Provence, France). The test assessed salivary buffering capacity (low, moderate or high) and the count (CFU/ml) of Streptococcus mutans (SM) and *Lactobacillus acidophilus* (LB) by a real-time polymerase chain reaction. Six samples (1.8%) were lost in the mail.

Clinical examinations These were performed by one experienced paediatric dentist (CJ) in classrooms using disposable intra-oral mouth mirrors, an air-water syringe (Trans'Care®Max, Satelec group, Acteon Equipment) and a LED headlight (Power-Spotlight®, Bisico). Before tooth brushing by the examiner (Happy Morning® brushes, Hager&Werken), dental plaque visible without disclosing agent but using a dental probe, was noted as present if scores 2 (thin plaque collected) or 3 (thick plaque collected) of the Silness and Löe Plaque Index [Loë and Silness, 1964] were registered on at least one tooth (on any surface).

Dental health status was recorded using the ICDAS-II advanced method [Pitts and Stamm, 2004; Ismail et al., 2007; Pitts, 2009]. Children's dental status were classified on three levels: caries-free children (all teeth were caries free, ICDAS-II code 0), children affected by cavitated carious lesions (ICDAS-II codes 3-6 classified as carious), as in the WHO basic method, and children with both non-cavitated and cavitated carious lesions (ICDAS-II codes 1-6 classified as carious), as in the ICDAS-II advanced method. The oral indices calculated were $d_{1\text{-}6}$mft (ICDAS-II codes 1-6 as decayed) and $d_{3\text{-}6}$mft (ICDAS-II codes 3-6 as decayed) for primary teeth, and $D_{1\text{-}6}$MFT-M1 and $D_{3\text{-}6}$MFT-M1 for the first permanent molars only, as recommended by the European Commission Health and Consumer Protection Directorate General, France [Bourgeois et al., 2005].

Statistical analysis Descriptive statistics were used to characterise the putative risk factors and the distribution of known confounders. Logistic regression analyses were performed to assess the association between caries level and the risk factors recommended by the HAS, as well as the salivary factors. The dependent variable was the presence of carious lesions (no = 0, caries = 1). Two series of analyses corresponding to two different cut off-points for caries severity were performed. Firstly, the group including all subjects with non-cavitated caries lesions and cavitated caries lesions (ICDAS-II codes 1-6) was compared with a group of caries-free children (ICDAS-II code 0). Secondly, the group of subjects with cavitated caries lesions only (ICDAS-II codes 3-6) were compared with a group of children who had ICDAS-II codes 0-2 for all their included teeth. The level of significance was set at 5%. In each class, two randomised children were examined twice one week apart by CJ using the ICDAS-II advanced method on first permanent molars, to measure intra-examiner reliability; the corresponding Kappa value was 0.79. Data were analysed using SPSS software (18.0, SPSS Inc., Chicago, USA).

Results

Among the 344 children invited to participate to this study, 341 (99.13%) accepted. The average age of the male participants (48%) was 6.25±0.46 years of age. Conversely, the 177 female (52%) participants had an average age of 6.30±0.46 years of age (p=0.062). In reference to the examined children, 10.8% (n=38) resided in a rural area and 11.1% (n=36) resided in low socio-economic status areas (corresponding to ZEP schools).

Table 1. *Caries experience in 6-year-old French children by school area.*

	Caries experiences (mean ± SD)				
Type of lesion	**Rural**	**Urban**	**ZEP**	**Non ZEP**	**Total**
Primary teeth ICDAS-II code 1-2	0.47 ± 0.69*	0.95 ± 1.39*	1.25 ± 1.56	0.86 ± 1.31	0.90 ± 1.34
Permanent molars ICDAS-II code 1-2	0.73 ± 1.40	0.60 ± 1.07	0.88 ± 1.07	0.59 ± 1.12	0.62 ± 1.11
Primary teeth ICDAS-II code 3-6	0.79 ± 1.30	0.99 ± 1.81	1.97 ± 2.65*	0.85 ± 1.59*	0.97 ± 1.76
Permanent molars ICDAS-II code 3-6	0.15 ± 0.57	0.19 ± 0.67	0.22 ± 0.61	0.18 ± 0.67	0.18 ± 0.66
D_{1-6}MFT	1.84 ± 2.31	2.47 ± 2.78	3.83 ± 3.37*	2.23 ± 2.60*	2.40 ± 2.73
d_{3-6}mft	1.37 ± 2.10	1.51 ± 2.47	2.58 ± 3.42*	1.37 ± 2.26*	1.50 ± 2.43
D_{1-6}MFT-M1	0.88 ± 1.58	0.83 ± 1.34	1.09 ± 1.30	0.81 ± 1.37	0.84 ± 1.37
D_{3-6}mft-M1	0.15 ± 0.57	0.23 ± 0.76	0.22 ± 0.61	0.22 ± 0.76	0.22 ± 0.74

d and D = Decayed, m and M = Missing, f and F = Filled primary teeth and first permanent molar; SD = standard deviation; ICDAS-II = International Caries Detection and Assessment System; * $p < 0.05$.

Only primary teeth were present in 48 children (14%) whereas 293 children (85.9%) had a mixed dentition including up to four permanent molars (mean=2.8,±1.6). Dental plaque was visible in the majority of the children (64.5%, n=220). There were 133 caries-free (ICDAS-II code 0) children (39%); 96 other children (28.2%) did not have clinically manifest cavitated carious lesions. The oral indicators were very similar for all the schools (Table 1).

Cavitated lesions The only statistically significant difference was noted for cavitated carious lesions of primary teeth. Children residing in ZEPs had more primary teeth with cavitated carious lesions than children from other areas. As a result, d_{1-6}mft and d_{3-6}mft differed statistically according to socio-economic status. Additionally, the only statistically significant difference between rural and urban schools concerned non-cavitated carious lesions (ICDAS-II codes 1-2) in primary teeth. The latter had no effect on D_{1-6}MFT.

Caries risk factors The associations of the caries-risk factors with the different level of caries severity are presented in Tables 2 and 3. While the tooth-brushing frequency (mean=1.6±0.5 times daily) varied by child, fluoridated toothpastes were systematically used. None of the children used long-term medication containing sugar or causing hyposalivation. In the crude logistic regression analyses, caries (ICDAS-II codes 1-6) was statistically significantly associated with the economic status of the school area (p=0.03), the consumption of more than one sugary snack per day (p=0.002), and/or sugary drinks between meals (p=0.003), the presence of visible dental plaque (p=0.001), a low buffering capacity (p=0.05), and a SM count superior to 10^5 CFU/ml (p=0.002) (Table 2). Five of these six caries-risk factors, consumption of more than one sugary snack per day (p=0.02), and/or sugary drinks between meals (p=0.01), presence of visible dental plaque (p=0.001), a low buffering capacity (p=0.02), and a SM count superior to 10^5 CFU/ml (p=0.001), in addition to the lack of daily toothbrushing with a fluoridated toothpaste (p=0.02), were also associated with cavitated caries lesions (ICDAS-II codes 3-6).

Statistical analysis In a multiple logistic regression analysis, visible dental plaque and a SM count greater than 10^5 CFU/ml were the only two factors that remained associated with carious lesions coded as either ICDAS-II 1-6 or 3-6 (Tables 2 and 3). Daily toothbrushing with fluoridated toothpaste also remained related to cavitated caries lesions.

Table 2. Logistic regression analysis to assess the associations between caries-risk factors and caries code 1-6 (cavitated and non-cavitated carious lesions) among 6-year-old French children.

		Caries-free (ICDAS-II code 0) n (%)	At least one carious lesion (ICDAS-II code 1-6) n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
School					
	Non-ZEP	125 (41.0)	180 (59.0)	1	1
	ZEP	8 (22.2)	28 (77.8)	2.43 (1.07, 5.51)	1.68 (0.67, 4.19)
Geographical area					
	Urban	117 (38.6)	186 (61.4)	1	Not in the model
	Rural	16 (42.1)	22 (57.9)	0.87 (0.44, 1.72)	
Gender					
	Masculine	60 (36.6)	104 (63.4)	1	Not in the model
	Feminine	73 (41.2)	104 (58.8)	0.82 (0.53, 1.27)	
Daily tooth-brushing with fluoride toothpaste					
	Yes	132 (39.5)	202 (60.5)	1	Not in the model
	No	1 (14.3)	6 (85.7)	3.92 (0.47, 32.94)	
More than 1 sugary snack per day					
	No	118 (43.1)	156 (56.9)	1	1
	Yes	15 (22.4)	52 (77.6)	2.62 (1.41, 4.86)	1.87 (0.95, 3.71)
Daily sweets					
	No	114 (40.4)	168 (59.6)	1	Not in the model
	Yes	19 (32.2)	40 (67.8)	1.43 (0.79, 2.59)	
Daily sugary drinks					
	No	111 (43.7)	143 (56.3)	1	1
	Yes	22 (25.3)	65 (74.7)	2.29 (1.33, 3.95)	1.58 (0.85, 2.91)
Dental plaque visible without disclosing agent [1]					
	No	61 (50.4)	60 (49.6)	1	1
	Yes	72 (32.7)	148 (67.3)	2.09 (1.33, 3.29)	1.84 (1.14, 2.97)
Buffering capacity [2]					
	Moderate / High	94 (42.9)	125 (57.1)	1	1
	Low	37 (31.9)	79 (68.1)	1.61 (1.00, 2.58)	1.35 (0.82, 2.22)
SM count [3]					
	$<10^5$	122 (42.8)	163 (57.2)	1	1
	$<10^5$	9 (18.0)	41 (82.0)	3.41 (1.60, 7.28)	2.73 (1.25, 6.02)
LB count [4]					
	$<10^5$	1 (50.0)	1 (50.0)	1	Not in the model
	$<10^5$	130 (39.0)	203 (61.0)	1.56 (0.10, 25.18)	

ICDAS-II = International Caries Detection and Assessment System; OR = bivariate odds ratio; 95% CI = 95% confidence interval. Only parents' answers were retained for multivariate model.
[1]Score 0 and 1 of the Löe and Silness [1964] index were considered as negative answers and the others (scores 2 and 3) as positive answers.
[2]Buffering capacities moderate and high were grouped together for the logistic regression.
[3]SM count<105 or >105 were regrouped together for the logistic regression.
[4]LB count<105 or > 105 were regrouped together for the logistic regression.

Table 3. *Logistic regression analysis to assess associations between caries-risk factors and caries code 3-6 (cavitated carious lesions) among 6-year-old French children.*

	Caries-free (ICDAS-II code 0-2) n (%)	At least one carious lesion (ICDAS-II code 3-6) n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Schools				
Non-ZEP	210 (68.9)	95 (31.1)	1	Not in the model
ZEP	19 (52.8)	17 (47.2)	1.98 (0.98, 3.97)	
Geographical areas				
Urban	205 (67.7)	98 (32.3)	1	Not in the model
Rural	24 (63.2)	14 (36.8)	1.22 (0.61, 2.46)	
Gender				
Masculine	106 (64.6)	58 (35.4)	1	Not in the model
Feminine	123 (69.5)	54 (30.5)	0.80 (0.51, 1.26)	
Daily tooth-brushing with fluoride toothpaste				
Yes	228 (68.3)	106 (31.7)	1	1
No	1 (14.3)	6 (85.7)	12.91 (1.53, 99.55)	11.56 (1.35, 98.73)
More than one sugary snack per day				
No	192 (70.1)	82 (29.9)	1	1
Yes	37 (55.2)	30 (44.8)	1.93 (1.10, 3.37)	1.41 (0.73, 2.75)
Daily sweets				
No	190 (67.4)	92 (32.6)	1	Not in the model
Yes	39 (66.1)	20 (33.9)	1.05 (0.58, 1.90)	
Daily sugary drinks				
No	180 (70.9)	74 (29.1)	1	1
Yes	49 (56.3)	38 (43.7)	1.87 (1.14, 3.12)	1.31 (0.71, 2.41)
Dental plaque visible without disclosing agent[1]				
No	100 (82.6)	21 (17.4)	1	1
Yes	129 (58.6)	91 (41.4)	3.36 (1.95, 5.77)	3.08 (1.71, 5.53)
Buffering capacity[2]				
Moderate / High	157 (71.7)	62 (28.3)	1	1
Low	68 (58.6)	48 (41.4)	1.79 (1.12, 2.87)	1.48 (0.88, 2.50)
SM count[3]				
<105	208 (73.0)	77 (27.0)	1	1
>105	17 (34.0)	33 (66.0)	5.24 (2.76, 9.95)	4.97 (2.51, 9.82)
LB count[4]				
<105	1 (50.0)	1 (50.0)	1	Not in the model
>105	224 (67.3)	109 (32.8)	0.49 (0.03, 7.86)	

ICDAS-II = International Caries Detection and Assessment System; OR = bivariate odds ratio; 95% CI = 95% confidence interval. Only parents' answers were retained for multivariate model.

[1]Scores 0 and 1 of the Löe and Silness [1964] index were considered as negative answers and the others (scores 2 and 3) as positive answers.

[2]Buffering capacity moderate and high were grouped together for the logistic regression.

[3]SM count<105 or >105 were regrouped together for the logistic regression.

[4]LB count<105 or > 105 were regrouped together for the logistic regression.

Discussion

In reference to the ICDAS-II advanced method, 39% of the 6-year-old children were caries-free (all teeth had ICDAS-II code 0), but 67.2% of the children within that same group were considered as caries-free when assessed according to the WHO basic method (all teeth had ICDAS-II codes ranging from 0 to 2). Our results confirmed those published by Braga et al. [2009] that recording both cavitated and non-cavitated lesions, as in the ICDAS-II advanced method, might detect associations more sensitively in a cohort study. Most children were classified as caries-free, when recording only the cavitated lesions following the WHO criteria, had non-cavitated lesions [Kühnisch et al., 2008; Braga et al., 2009]. Furthermore, the calculation of the DMFT/dmft indices where the detection threshold was at the level of cavitation, had either been claimed to be outmoded or insufficient given the current knowledge of dental caries [Bader et al., 2001; Pitts and Stamm, 2004]. On the contrary the ICDAS-II advanced method allows accurate recording of the severity of carious lesions, through non-cavitated stages, to frank cavitation, and has been reported to increase precision of caries detection over traditional methods [Kühnisch et al., 2008, Braga et al., 2009]. Furthermore, ICDASII is recommended for its accuracy in detecting caries, in permanent [Diniz et al., 2009] and primary molars [Shoaib et al., 2009]. Recording caries in accordance with ICDAS II codes has good reproducibility [Braga et al., 2009], as supported by the Kappa value (0.79) in our study.

Comparing the actual WHO proportion of caries-free children with older data from previous studies [Cahen et al., 1993; Adam et al., 2005; Hescot et al., 2007], we noted an improvement in oral health status among French 6-year-old children. The increase in the proportion of caries-free children from 1987 (32.2%) to 1991 (46.8%), was higher than that noted in the past decade: 56% in 1993 to 63.4% in 2006 [Cahen et al., 1993; Hescot et al., 2007]. Moreover, the caries-free estimate in this study was just slightly higher than that observed in 2006 [Hescot et al., 2007] and lower than the values noted among 5-year-olds in Finland in 1993 (78%) and in Sweden in 1991 (60%) [Axelsson et al., 1993; Vehkalahti et al., 1997]. This confirms the lower caries experience in the Mediterranean European countries compared with the Nordic countries [Cahen et al., 1993; Adam et al., 2005].

The d_{3-6}mft observed in the current study was lower than the dft (mean=2.48±3.22) in 1991 [Hescot et al., 2007]. Conversely, no clinical difference was noted in permanent teeth when comparing D_{3-6}MFT-M1 in the present study and DMFT in 1991 (mean=0.25±0.78) or 2006 (mean=0.12±0.15) [Hescot et al., 2007]. This may be because most of 6-year-old children had no or just recently erupted permanent molars.

Our results can be extrapolated to the population of schoolchildren at six years of age in Alpes Maritimes and in France. Such a comparison is plausible as our sample accounted for 11.1% of the children in ZEP schools. In France, an average of one child in six attends a school in a ZEP area [INSEE, 2009]. The only significant statistical difference in the oral health indicators between the ZEP and the non-ZEP schoolchildren was found for d_{3-6}mft (dmft). This was in accordance with the results reported in other national epidemiological studies [Cahen et al., 1993; Adam et al., 2005; Hescot et al., 2007] and was also the case for D_{1-6}MFT including all primary tooth cavitated and non-cavitated carious lesions. However, these differences were not obvious for D_{1-6}MFT-M1 and D3-6mft-M1, most likely because the majority of the participants had no or few permanent teeth.

The studied caries-risk factors included different individual behaviours and clinical data. Only univariate logistic regression showed that children who consumed sugary snacks or drinks more than once a day between meals had more caries (ICDAS-II codes 1-6 and codes 3-6). This variable was not significant in multivariate analysis, after the inclusion of the variable SM count for caries ICDAS-II codes 1-6 and of daily tooth-brushing with fluoridated toothpaste for caries ICDAS-II codes 3-6. This is in agreement with the literature concerning nutrition-related habits, especially cross-sectional studies based on univariate relationships [Marshall et al., 2003; Anderson et al., 2009]. By including dietary habits in the multivariate analyses, its significant association with caries experience disappeared. This was described in the narrative review of the literature by Rugg-Gunn and Murray [1983], where only one of the 16 papers found a strong association in the primary dentition. They concluded that the relationship between sugar consumption and caries was much weaker in the modern age of fluoride exposure. Controlling the consumption of sugar remains a justifiable part of caries prevention and warrants a place in oral health education, but it should not be used for an ICR assessment [Featherstone et al., 2007].

Multivariate logistic regression analyses assessing the association of socio-demographic characteristics, oral hygiene and dietary habits with the presence of at least one carious lesion (ICDAS-II codes 1-6 or ICDAS-II codes 3-6) showed that only daily toothbrushing with fluoridated toothpaste was related to the presence of cavitated caries lesions. No other factor was statistically associated with caries. As all of the children used fluoridated toothpaste, the significant difference between caries-free children (ICDAS-II codes 0-2) and others with cavitated caries lesions (ICDAS-II codes 3-6) could be due to the tooth brushing frequency. These results suggest that, when tooth brushing is performed at least once a day, the risk of caries progressing from ICDAS-II codes 1-2 to 3-6 will be reduced. Conversely, when children experiencing caries with ICDAS-II codes 1-6 were grouped together and compared with a caries-free group (all teeth ICDAS-II code 0), daily tooth brushing with fluoridated dentifrice did not significantly differ. Daily tooth brushing with

fluoride toothpaste may inhibit enamel lesions progressing to become cavitated caries lesions and this effect may be more important than its preventive effect on the initial non-cavitated caries lesions. This first hypothesis needs to be confirmed. A second, parallel hypothesis would relate to the different fluoride concentrations in toothpastes [Walsh et al., 2010]. This information was not available at the time of this study because the toothpaste brand was the only reported information.

Of the children that participated in this study, 64.5% had visible plaque. Only six children reported not brushing their teeth daily. These results could be due to a child's lack of manual dexterity at six years of age or due to the timing of the examination (taken place either in the morning on arrival at school or after lunch). This study and several others [Vanobbergen et al., 2001; Tagliaferro et al., 2008] found that visible plaque was one of the two clinical variables associated with caries experience, regardless of the ICDAS-II codes (1-6 and 3-6). This confirms the conclusions of Bellini et al. [1981] who stated that the quality of brushing is more important than its frequency for caries presence.

In this study, the second variable associated with ICDAS-II codes 1-6 or codes 3-6 caries lesions was the SM count included in the Cario-Analyse® salivary test. Previously mentioned in many other studies, this supports the importance of the SM count which plays a leading role in the initiation of caries [Thibodeau and O'Sullivan, 1999]. This study also showed that the LB count was not associated with the caries experience. In fact, the counts of SM and LB showed inverse distributions but only in subjects with caries ICDAS-II code 3-6 when LB counts were usually implicated in the progression of the caries.

Lastly, the buffering effect of saliva (Cario-Analyse®), tested for the first time in a school environment, showed a significant statistical association with the presence of ICDAS-II Codes 1-6 or 3-6 lesions, but only in univariate logistic regressions. This was in agreement with the results of Azrak et al. [2008] who used a different test based on colorimetric modification when in contact with the saliva.

Conclusion

The registration methods had a major effect on the proportion of 6-year-old children that were caries-free but did not greatly change the association between traditional risk factors for carious lesions at different levels of severity. The risk factors associated with cavitated carious lesions or both cavitated and non-cavitated lesions were plaque and the SM count. Daily tooth brushing with fluoridated toothpaste was negatively associated with cavitated carious lesions. The identification and the avoidance of all caries-promoting factors and regular exposure to fluoride remain essential for good oral health in the environment of Alpes Maritimes.

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References

Adam C, Eid A, Riordan PJ, Wolikow M, Cohen F. Caries experience in the primary dentition among French 6-year-olds between 1991 and 2000. Community Dent Oral Epidemiol 2005; 33:333-340.

Anderson CA, Curzon ME, Van Loveren C, Tatsi C, Duggal MS. Sucrose and dental caries: a review of the evidence. Obes Rev 2009; 10:41-54.

Axelsson P, Paulander J, Svärdström LG, Tollskog G, Nordensten S. Integrated caries prevention: effect of a needs-related preventive program on dental caries in children. Caries Res 1993;2 7:83–94.

Azrak B, Callaway A, Willershausen B, Ebadi S, Gleissner C. Comparison of a new chairside test for caries risk assessment with established methods in children. Schweiz Monatsschr Zahnmed 2008; 118:702-708.

Bader JD, Shugars DA, Rozier G et al. Diagnosis and management of dental caries. Evid Rep Technol Assess 2001; 36:1-4.

Bellini HT, Arneberg P, von der Fehr FR. Oral hygiene and caries. A review. Acta Odontol Scand 1981; 39:257-265.

Bourgeois D, Llodra JC, Norblad A, Pitts NB. European Commission Health and Consumer Protection Directorate-General. Health surveillance in Europe. A selection of essential oral health indicators. [Internet]. 2005 Available from: http://www.egohid.eu/Documents/ CATALOGUE%20 2005.pdf

Braga MM, Oliveira LB, Bonini GAVC, Bönecker M, Mendes FM. Feasibility of the International Caries Detection and Assessment System (ICDAS-II) in Epidemiological Surveys and Comparability with Standard World Health Organization Criteria. Caries Res 2009; 43:245–249.

Cahen PM, Obry-Musset AM, Grange D, Frank RM. Caries prevalence in 6- to 15-year-old French children based on the 1987 and 1991 national surveys. J Dent Res 1993; 72:1581-1587.

Diniz MB, Rodrigues JA, Hug I, Cordeiro RCL, Lussi A. Reproducibility and accuracy of the ICDAS-II for occlusal caries detection. Community Dent Oral Epidemiol 2009; 37:399-404.

Ekstrand KR, Ricketts DNJ, Kidd EAM. Reproducibility and accuracy of three methods for assessment of demineralization depth of the occlusal surface: an in vitro examination. Caries Res 1997; 31:224-231.

Ekstrand KR, Ricketts DNJ, Kidd EAM, Qvist V, Schou S. Detection, diagnosis, monitoring and logical treatment of occlusal caries in relation to lesion activity and severity: an in vivo examination with histological validation. Caries Res 1998; 32:247-254.

Featherstone JDB. The Continuum of Dental Caries Evidence for a Dynamic Disease Process. J Dent Res 2004; 83:C39-C42.

Featherstone JD, Domejean-Orliaguet S, Jenson L, Wolff M, Young DA. Caries risk assessment in Practice for Age 6 through adult. J Calif Dent Assoc 2007; 35:703-713.

HAS. Haute Autorité de Santé. (Assessment of caries risk and indications for pit and fissure sealants in children and in adolescents under 18). [Internet]. 2005. Available from: http://www.has-sante.fr

Hescot P, Roland E, Guegen R. La santé dentaire en France -2006. Le CAO des enfants de 6 ans et 12 ans. Monographie S.N.P.M.D. Paris : Post pressed; 2007.

INSEE. National Institute and Economic Studies. [Internet] 2009. Available from: http://insee.fr/fr/regions/provence

International Caries Detection and Assessment System (ICDAS) Coordinating Committee Criteria Manual—International Caries Detection and Assessment System (ICDAS II). Published 2005. Available online: http://www.icdas.org (assessed 10 August 2009).

International Caries Detection and Assessment System (ICDAS) Coordinating Committee Rationale and Evidence for the International Caries Detection and Assessment System (ICDAS II). Published 2005. Available online: http://www.icdas.org (assessed 10 August 2009).

Ismail AI, Sohn W, Tellez M et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Community Dent Oral Epidemiol 2007; 35:170-178.

Kühnisch J, Berger S, Goddon I et al. Occlusal caries detection according to WHO basic methods, ICDAS II and laser fluorescence measurements: results from an epidemiological study. Community Dent. Oral Epidemiol 2008; 36:475-484.

Kühnisch J, Berger S, Goddon I et al. Development, Methodology and Potential of the New Universal Visual Scoring System (UniViSS) for Caries Detection and Diagnosis. Int. J. Environ. Res. Public Health 2009; 6:2500-2509.

Loë H, Silness J. Periodontal disease in pregnancy II. Correlation between oral hygiene and periodontal condition. Acta Odontol Scand 1964; 22:121-135.

Marshall TA, Levy SM, Broffitt B et al. Dental Caries and Beverage Consumption in Young Children. Pediatrics 2003; 112:184-191.

Nyvad B, Machiulskiene V, Baelum V. Reliability of a new caries diagnostic system differentiating between active and inactive caries lesions. Caries Res 1999; 33:252-260.

Pitts NB, Stamm JW. International Consensus Workshop on Caries Clinical Trials (ICW-CCT)-final consensus statements: agreeing where the evidence leads. J Dent Res 2004; 83:Spec No. C:C125-8.

Pitts NB: Detection, Assessment, Diagnosis and Monitoring of Caries. Basel: Karger. 2009.

Rugg-Gunn AJ, Murray JJ. The role of sugar in the aetiology of dental caries. 2. The epidemiological evidence. J Dent 1983; 11:190-199.

Shoaib L, Deery C, Ricketts DNJ, Nugent ZJ. Validity and Reproducibility of ICDAS II in Primary Teeth. Caries Res 2009; 43:442–448

Tagliaferro EP, Ambrosano GM, Meneghim MC, Pereira AC. Risk indicators and risk predictors of dental caries in schoolchildren. J Appl Oral Sci 2008; 16:408-413.

Thibodeau EA, O'Sullivan DM. Salivary Mutans streptococci and caries development in the primary and mixed dentitions of children. Community Dent Oral Epidemiol 1999; 27:406-412.

Vanobbergen J, Martens L, Lesaffre E, Bogaerts K, Declerck D. Assessing risk indicators for dental caries in the primary dentition. Community Dent Oral Epidemiol 2001; 29:424-434.

Vehkalahti M, Tarkkonen L, Varsio S, Heikkila P. Decrease in and polarization of dental caries occurrence among child and youth populations, 1976-1993. Caries Res 1997; 31:161-165.

Walsh T, Worthington HV, Glenny AM et al. Fluoride toothpastes of different concentrations for preventing dental caries in children and adolescents. Cochrane Database Systematic Reviews [Internet] 2010. Available from http://onlinelibrary.wiley.com/o/cochrane/clsysrev/articles/CD007868/frame.html

World Health Organization. Oral Health Survey. Basic Methods, 4th edn. Geneva, Switzerland: WHO. 1997.

Zakarian B, Rossi C, Lupi-Pegurier L, Borg-Real C, Muller-Bolla M. Evaluation of individual caries risk of 6 year-old-children Epidemiological survey in Nice. Rev Francoph Odontol Pédiatr 2009; 4:138-143.