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The Influence of Smoking on Dental and Periodontal Status

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1. Introduction

Tobacco is one of the major toxic agents in our civilization. It's use is considered as one of the most common cause of mortality and morbidity in both developed and developing countries in present times. Of 260 million deaths which occurred in the developing world between 1950 and 2000, it is estimated that 50 million were due to smoking. Globally, smoking related mortality is set to rise from 3 million annually (1995 estimate) to 10 million annually by 2030, with 70 % of these deaths occurring in developing countries (Fagerström, 2002). Since 1970, smoking prevalence among men has slightly decreased, but among women, teenagers and children, smoking has increased dramatically. Sixty percent of children are exposed to Environmental Tobacco Smoke (ETS) at their homes (Mackay & Amos, 2003).

Tobacco is one of the most important risk factor for oral diseases including oral cancer, oral mucosal lesions, periodontal diseases, wound healing failure, dental implants failure, gingival inflammation, acute necrotizing ulcerative gingivitis and apthous ulcers (Vellappally et al., 2007; Jacob et al., 2007). There is substantial evidence suggesting that the risk of oral diseases increase with frequent use of tobacco and that quitting smoking results in reduced risk (Winn, 2001).

1.1 Smoking and dental caries

Smoking and its relation to dental caries is a subject of many opinions. From early reports in literature and in accordance with common belief smoking was thought to actually help to reduce dental caries (Hart, 1899; Gibbs, 1952). Schmidt, in 1951, reported that the increase in tobacco smoking was followed by a decrease in caries rate. Smoking increases thiocyanate level in saliva. Thiocyanate, a normal constituent of saliva, was found to have caries inhibiting effect (Reibel, 2003; Johnson & Bain, 2000). On the other hand, studies showed that smoking is associated with lower salivary cystatin activity and output of cystatin C is also reduced during gingival inflammation. Cystatins are thought to contribute to maintaining oral health by inhibiting certain proteolytic enzymes (Lie et al., 2001). In addition, studies have confirmed by earlier results that there were no significant differences in salivary flow rates between smokers and non-smokers (Reibel, 2003). The decreased buffering effect of smoker's saliva and the higher number of lactobacilli and *S. mutans group*

may indicate an increased susceptibility to caries (Schmidt, 1951; Kassirer, 1994). To date, several investigators have discovered a correlation between an increased smoking level and dental caries (Axelsson et al., 1998; Bruno-Ambrosius et al., 2005). For example, in 1952, Ludwick and Massler reported that individuals who smoked more than 15 cigarettes daily had significantly higher number of decayed, missing, and filled teeth. In 1971, Ainamo found that increased smoking results in significantly high number of decayed surfaces per dentition. In 1990, Zitterbart confirmed an association between smoking and the prevalence of dental caries in adult males. Smokers had a significantly higher DMFT (Decayed, Missing, and Filled Teeth) score, untreated decayed surfaces, and missing surfaces. More cigarettes consumed per day resulted in more missing tooth surfaces in a smoker's mouth (Zitterbart et al., 1990). Statistical analyses from a study in Sweden in 1991 showed that smoking, as a habit and an increased number of cigarettes smoked per day, are positively correlated with the increased number of decayed, missing and filled teeth and number of initially decayed proximal surfaces (Hirsch et al., 1991). Even though studies did not establish a causative relationship, the recent study done on American female population in 2006, showed a correlation between cigarette smoking and the presence of dental caries (Heng et al., 2006).

Most of the studies mentioned above have taken into consideration other contributing factors to dental caries development, such as age, tobacco habits other than smoking, oral hygiene habits, eating habits, preventive visits to dentist (dental recalls) and overall health standards. Therefore elucidating the exact strength of dental caries in relation to smoking is difficult to identify.

Association between smoking and dental caries is well documented in older age groups (Locker, 1992; Jette et al., 1993). Among the middle-age (Axelsson et al., 1998) or young adults (Sgan-Cohen et al., 2000) results are inconsistent. Non-smokers reported more frequent healthy oral health behavior than did daily smokers (Telivuo et al., 1995). Studies indicate that smokers not only had bad oral hygiene and less sophisticated outlook on health, but also had different eating habits, presumably consuming higher amount of sugar containing products like soft drinks and snacks (Axelsson et al., 1998; Hirsch et al., 1991). Daily smoking was associated with increased use of sugar in tea and coffee, and with more frequent alcohol consumption (Telivuo et al., 1995). It was also found that smokers have poorer brushing habits than non-smokers (Ainamo, 1971; Kelbauskas et al., 2005; Macgregor, 1985). Also current smokers were less likely to report regular preventive visits to dentists and were reluctant to use accessory dental aids such as dental floss (Locker, 1992).

In natural tobacco, sugar can be present in a level up to 20 $\%_{wt}$. In addition, various caries promoting factors such as sugars and sweeteners are added intentionally during tobacco manufacturing process (Talhout et al., 2006). Sugars used as cigarette additive include glucose, fructose, invert sugar (glucose/fructose mixture) and sucrose. In addition, many tobacco additives contain high amount of sugars, for example fruit juices, honey, molasses extracts, cones, maple syrup and caramel. The added sugars are usually reported to serve as flavor/casing and humectants. However, sugars also promote tobacco smoking, because they generate acids that neutralize the harsh taste and throat impact of tobacco smoke. Moreover, the sweet taste and the agreeable smell of caramelized sugar flavors are appreciated in particular by starting adolescent smokers (Talhout et al., 2006).

All the findings above can be argued for increased dental caries in smokers. Though a direct etiological relation is still lacking between smoking and dental caries, the above-mentioned

studies and findings point to the conjecture that smoking has some influence in high caries incidence. Further studies, clinical trials and experiments are needed to confirm the independent effect of smoking as one of the causes of dental caries.

1.2 Smoking and periodontitis

The manifestation and progression of periodontitis, a multifactorial disease with microbial dental plaque as the initiator, is influenced by a variety of determinants and factors. They include subject characteristics, social and behavioral factors, systemic factors, genetic factors, tooth-related factors, microbial composition of dental plaque and other emerging factors (Nunn, 2003). Cigarette smoking is a significant risk factor for periodontal disease (Tanner, 2005), demonstrated by an increased loss of attachment (Hymann & Reid, 2003; Amarasena et al., 2003; Razali et al., 2005), development and progression of periodontal inflammation (James et al., 1999; Genco, 1996) and increased gingival recession (Müller et al., 2002). It has been estimated that smoking accounts for half of all periodontal diseases. There is epidemiological evidence which shows that cigarette smoking is a stronger risk factor for the presence of periodontitis compared to the presence of certain suspected periodontal pathogens (Darby et al., 2005). The number of cigarettes smoked per day is a major risk determining factor, doubling the risk for those in the lowest consumption category and increasing it six fold in the subgroup smoking more than thirty cigarettes per day (Tomar & Asma, 2000; Winn, 2001). Former smokers have lower rates of periodontitis than present smokers (Alabandar et al., 2000; Calsina et al., 2002; Johnson & Hill, 2004; Krejci & Bissada, 1999; Spickerman et al., 2003; Van Winkelhoff et al., 2001). Longitudinal studies indicate that periodontal disease may progress faster in smokers in comparison to non-smokers (Beck et al., 1997; Winn, 2001). Further research on this topic is necessary to expand the spectrum of knowledge acquired till date and to apply it clinically.

The Community Periodontal Index of Treatment Needs (CPITN) was developed for the 'Joint Working Committee' of the World Health Organization (WHO) and Federation Dentaire Internationale (FDI) by Jukka Ainamo, David Barmes, George Beagrie, Terry Cutress, Jean Martin, and Jennifer Sandro-Infirri in 1982. The CPITN procedure is recommended for epidemiological surveys of periodontal health. It uses clinical parameters and criteria relevant to planning and prevention of periodontal diseases and it records the common treatable conditions namely periodontal pockets, gingival inflammation and dental calculus (Ainamo & Ainamo, 1994). The CPITN is not intended as a comprehensive assessment of total past and present periodontal disease experience and it does not record irreversible changes such as gingival recession or other deviations from periodontal health such as tooth mobility or loss of periodontal attachment (Peter, 1999). Association between cigarette smoking and various oral diseases such as leukoplakia and oral cancers has been well documented but the role of cigarette smoking in the causation of periodontitis, however has not been widely investigated in the Czech Republic. In this study, the CPITN index was used to evaluate the influence of cigarette smoking on periodontitis.

2. Aim of the study

The aim of the study was to evaluate the different approach of smokers and non-smokers to the oral health and to monitor the influence of smoking habits on the oral health, namely on the periodontium and the teeth.

3. Methods

A cross-sectional population-based study was conducted in Czech Republic on a representative sample of 1684 respondents within the age group of 30 to 69 years. The project was conducted in cooperation with the Department of Hygiene and Preventive Medicine of Charles University in Prague, Medical Faculty in Hradec Kralove and Department of Dentistry of University Hospital in Hradec Kralove.
The study consisted of two parts - self reported questionnaire inquiry and clinical examination of oral health status including examination of teeth, periodontium and oral mucosa. Clinical investigations were performed by the uniformly instructed dentists. To limit the select bias caused by the fact that hospitalized patients usually do not represent the common population the respondents were selected from the patients hospitalized in the University Hospital as well as from patients of three practicing dentists.

3.1 Questionnaire investigation

All participants of this study were requested to answer the questionnaire which included questions concerning their personal history, economic status, educational qualification, profession and other important etiological factors of oral health, which can play a role of so called „confounding factors", like general health status, frequency of dental visit, brushing habits and dental aids used. We were also interested (though very tentatively) in the eating habits, the suitable and non suitable food. We inquired into the consumption of food with the risk for oral health (confections, sweet drinks), as well as of the food with the protective effect (fruit, vegetable as a sources of natural antioxidants). Respondents could make their choice among the answers: „ regularly, daily, several times a week, several times a month, less frequently, never." Questions concerning alcohol consumption were also included in the questionnaire.
Detailed attention was given to smoking history. Regular smokers were defined as individuals who, at the time of examination, smoked at least one cigarette daily. Occasional smokers were individuals who smoked less than one cigarette per day. Former or ex-smokers were defined as individuals who smoked at least 1 cigarette per day for 6 consecutive months and those who did not smoke at least for the past 6 months from the time of the study. Finally, non-smoker was a person, who never smoked for the period longer than 6 months. We also took into account the number of cigarettes smoked each day or week and the number of years of smoking.
The last section of the questionnaire was focused on a subjective assessment of the oral health by the respondents themselves and on their information level about the smoking harmfulness. The questionnaire clarity and the time necessary for filling it up were traced in the pilot study.

3.2 Clinical investigation

Dental status and periodontal status were assessed by DMF (Decayed, Missing, and Filled Teeth) and CPITN (Community Periodontal Index of Treatment Needs) indices respectively, which at present are considered to be sufficiently valid for population studies.
The dentition was evaluated by recording the number of the decayed (D), missing (M) and filled (F) teeth, and number of decayed teeth with fillings (D+F) as well. The index DMF was then calculated as a sum of all these four quantities: DMF = D + M + F + (D + F). Thus, in the total sum each tooth was counted only once.

The periodontal status and treatment needs were evaluated by the help of CPITN index (Community Periodontal Index of Treatment Need) using the alternative of this index for individual use in adults where in the individual sextants, all teeth were examined with the exception of the third molars only. The CPI 0 means a healthy periodontium; CPI 1 indicates the gingival bleeding on gentle probing. The CPI 2 code is characterized by the presence of retention factors for plaque on the given tooth surface, most often by supragingival and/or subgingival calculus. Furthermore, CPI 3 coding indicated the presence of shallow pockets up to 4-5 mm, while CPI 4 indicated deep pockets 6 mm or more. In cases where there were two teeth only in some sextant, this was not taken into account (CPI X). Edentulous individuals were excluded from this study.
To judge the impact of some selected variables such as smoking and certain "confounding" factors on the oral health, or the periodontium we used the treatment needs category of the CPITN index, which is related to the health care needs of inflamed periodontium. The value TN 0 (no treatment needed) corresponds with the CPI 0 in the given sextant. Classification CPI 1 conforms with TN I (oral hygiene necessary), whereas CPI 2 and CPI 3 correspond with TN II (oral hygiene needed, clearing up the calculus and other retention factors for plaque). CPI 4 is equal to TN III, which indicates the need for complex treatment (oral hygiene adjustment, clear out, need of tooth extraction and its replacement, need for surgical treatment of periodontal pockets, fixation of rather unstable teeth and other therapeutic modalities).

3.3 Statistical analysis

The statistical evaluation was performed by using NCSS 2007 program. Descriptive statistics, χ^2 test and logistic regression were done. To compare quantitative data (e.g. the age), Kruskal – Wallis analysis of dispersion with subsequent multiple matching (ANOVA) has been used. To evaluate qualitative data (e.g. the level of education) the X^2 test of independence in the contingent tables or Fisher's exact test was used.
For calculating the odds ratio for the selected variables (such as smoking, health status, education, frequency of teeth brushing, taking part in preventive check ups, food consumption even after the evening teeth brushing) we employed the method of multiple logistic regression.

4. Results

4.1 Results of questionnaire part of the study

During the 3 years period of data collection, we investigated 1 684 respondents. Participants were chosen randomly, with age above 69 years and less than 30 years being the only exclusion criterion. Our sample consisted of 792 males and 922 females with mean age of 44.2 years. There were 489 current smokers (369 regular and 120 occasional ones), 261 former smokers and 934 non-smokers among them (table 1).
The level of respondents´ education in individual groups is illustrated in table 2. People with the basic education represented 28.3%, 7.9% were skilled with graduation exam, 41.6% passed the high school and 22.2% had the university education. Majority of the respondents with the basic education (44%) were found to be regular smokers. The highest number among university educated persons (28.2%) was identified as non-smokers. Quite surprisingly, we found relatively high prevalence of people with the high school education as regular and occasional smokers. These results are significantly different ($p < 0.001$).

Smoker:	Males		Females		Total	
	n	%	n	%	n	%
Regular	206	26.0	163	18.2	369	21.9
Occasional	63	8.0	57	6.4	120	7.1
Ex-smoker	161	20.3	100	11.2	261	15.5
Non-smoker	362	45.7	572	64.2	934	55.5
Total	792	100.0	922	100.0	1684	100.0

Table 1. Classification according to cigarette smoking and gender ($p < 0.001$; χ^2 test)

Education	Regular smoker	Occasional smoker	Ex-smoker	Non-smoker	Total
Basic	44.0	25.0	26.8	23.0	28.3
Vocational	9.8	11.7	10.3	6.0	7.9
High school	35.8	45.0	44.1	42.8	41.6
University graduation	10.4	18.3	18.8	28.2	22.2
Total	100.0	100.0	100.0	100.0	100.0

Table 2. Educational qualification of respondents in percentage ($p < 0{,}001$; χ^2 test)

Table 3 shows the average monthly income per head in the family of our respondents. In our study, 3.7% of investigated persons belonged to the lowest income group, 30.4% in the middle, and 47.3% in the higher income group. About 5% of respondents did not know the exact family income, and 13.7% of them refused to answer. The income differences between smokers and non-smokers were not statistically significant ($p= 0{,}665$). From these results we can only find not statistically lower frequency of people with the higher incomes in the group of smokers.

Income/moths/person	Regular smoker	Occasional smoker	Ex-smoker	Non-smoker	Total
Not willing to disclose	14.5	15.1	11.7	13.7	13.7
< 5000 CZK	4.7	4.2	3.5	3.3	3.7
5000 – 10000 CZK	30.7	23.5	28.8	31.6	30.4
> 10000 CZK	44.1	51.3	52.1	46.8	47.3
Do not know	6.0	5.9	3.9	4.6	4.9
Total	100.0	100.0	100.0	100.0	100.0

Table 3. Characteristics according to the income, it means the net monthly earnings per person in the family ($p = 0{,}665$; χ^2 test)

As for the attitude towards oral health, we can conclude that the participation in the preventive check-ups by dentist was far from being optimal (table 4). In Czech Republic, the dental health care system provides its citizens the opportunity to participate in dental prevention programs two times yearly and this check ups are free of charge, paid from health insurance. From the results of our study we can see that prevention twice a year was performed by 64.8% respondents only, whereas 22.8% visited the dentist once a year. Nevertheless, the attitude of non-smokers and smokers towards preventive dental check-ups were different; whereby non-smokers visited their dentists more often than smokers and former smokers. Among regular smokers, 6.3% visited the dentist once in two years, 7.9% respondents took part in check-ups less frequently; and 8.7% never attended preventive check-ups. These findings were found to be statistically significantly different ($p < 0.001$).

Preventive check-ups	**Regular smoker**	**Occasional smoker**	**Ex-smoker**	**Non-smoker**	**Total**
2 times a year	52.3	63.0	62.8	70.6	64.8
Once a year	24.8	26.1	23.0	21.6	22.8
Once in 2 years	6.3	2.5	5.0	3.1	4.1
Less frequently	7.9	6.7	6.1	2.9	4.8
Never	8.7	1.7	3.1	1.8	3.5
Total	100.0	100.0	100.0	100.0	100.0

Table 4. Percentage of respondents participating in preventive dental check-ups ($p < 0{,}001$; χ^2 test)

We also found a different approach of smokers and non-smokers to the oral hygiene (table 5). Most of the investigated persons (87.6%) brushed their teeth twice or even three times a day. The majority of them were non-smokers, former or occasional smokers. Almost 90% of respondents from these groups brushed their teeth 2 – 3 times a day. The regular smokers did so in 78.2% only. More than 15% of regular smokers brushed their teeth once a day only and another 6.5% of them even less often. Results are statistically significant ($p < 0.00l$).

	Regular smoker	**Occasional smoker**	**Ex-smoker**	**Non-smoker**	Total
3 times a day or more	7.3	7.6	5.8	14.7	11.2
2 times a day	70.9	83.1	83.8	75.6	76.4
Once daily	15.2	7.6	7.7	8.8	9.9
Less frequently	6.5	1.7	2.7	1.0	2.5
Total	100.0	100.0	100.0	100.0	100.0

Table 5. Tooth brushing frequency (%); $p < 0.001$; χ^2 test

Almost all the probands (98.3 %) used the tooth brush and tooth paste. Dental floss and interdental brushes were used by non-smokers and former smokers ($p = 0{,}001$). Regular use

of mouth wash were being performed regularly (12.7%) or occasionally (48.9 %) mainly by non-smokers and former smokers ($p < 0.0l5$).

Table 6 illustrates the eating habits of our respondents. We enquired about the consumption of risky foods (confectionary, sweet drinks) as well as protective ones (fruit, vegetable as a source of natural antioxidants). In this table we also included the questions concerning alcohol consumption.

Statistical evaluation revealed the consumption of sweets to be generally high. Nearly 14% of our respondents consumed confectioneries regularly or on a daily basis (13.8%), or at least several times a week (35.1 %). There was a statistically significant difference between smokers and non-smokers. The regular and former smokers consumed much less sweets than occasional smokers and non-smokers ($p < 0.001$). Also the consumption of sweetened drinks was rather high, 18.7% of respondents consumed sweetened drinks daily and more than one quarter of investigated persons (27.1%) had such drinks several times a week. The consumption of sweetened drinks was more popular among smokers compared to non-smokers ($p < 0.001$).

In case of a healthy diet consumed by the respondents such as the use of fruits and vegetables, the trend was just opposite. Fruits and vegetables were consumed regularly by 53% of respondents, significantly more often by the non-smokers and former smokers ($p < 0.001$).

The regular daily consummation of beer and wine was agreed by 7.5% of respondents. The regular smokers were leading this ladder ($p < 0.001$). 1.4% of investigated persons agreed to have consumed spirits on a regular daily basis. The regular smokers represented a marked majority, statistically significant ($p < 0.001$).

	Regular smoker	**Occasional smoker**	**Ex-smoker**	**Non-smoker**	Total
Sweets $p < 0.001$; χ^2 test					
Regular daily	13.2	15.3	12.6	14.2	13.8
Sweet drinks (soft drinks, coca-cola, juices) $p < 0.001$; χ^2 test					
Regular daily	27.0	23.5	16.5	15.4	18.7
Fruits and vegetables $p < 0.001$; χ^2 test					
Regular daily	38.0	47.5	54.9	58.9	52.9
Beer and vine $p < 0.001$; χ^2 test					
Regular daily	11.9	6.8	10.7	5.1	7.5
Distilled liquors $p < 0.001$; χ^2 test					
Regular daily	2.8	2.6	2.0	0.4	1.4

Table 6. Eating habits of respondents (in percentages)

An important difference between smokers and non-smokers was also found in the consumption of food and sweetened drinks after the evening teeth brushing (table 7), which was more frequent in smokers with comparison to non-smokers.

„After having brushed teeth in the evening:	**Regular smoker**	**Occasional smoker**	**Ex-smoker**	**Non-smoker**	Total
I never **eat or drink any sweet drinks or beer or milk"**					
Yes, that is true.	34,7	48,3	52,6	61,6	53,4
I usually do not eat or drink sweet drinks"					
Yes, that is true.	48,9	46,6	38,2	33,2	38,3
I still eat some food and drink sweet drinks"					
Yes, that is true.	16,4	5,2	9,2	5,3	8,3

Table 7. Food and sweet drinks consumption after the evening teeth brushing (%); χ^2 test

The last part of the questionnaire was aimed to the subjective assessment of oral cavity status by respondents themselves, on assessment of the quality of life in connection with the oral health, and finally on the knowledge of respondents regarding the harmfulness of smoking. Table 8 shows that half of respondents (53.6%) evaluated appearances of their own dentition as good, 44% were unsatisfied and 2.2% were not interested in evaluation. When taking into account the history of smoking we can see that non-smokers were satisfied with their dental health more often (57.9%) when compared with those with the smoking history. The lowest degree of satisfaction was found among the regular smokers. These findings were statistically markedly significant ($p < 0.001$). The status of teeth, gingivae and oral mucosa were considered to be in good condition by 49.6% of the investigated individuals. One quarter of total number considered this status as bad and 25.4% were not able to answer this question. When answering this question the non-smokers considered their oral health status being good more often than regular or even former smokers ($p < 0.001$). Regular and former smokers thought that their oral health is poorer when compared with the rest of population ($p< 0.001$).

Level of respondents' knowledge regarding the harmful effects of smoking is illustrated in table 9. According to our opinion these results were rather favorable. Nearly all the members of our study (95.6%) knew that smoking harms the health. Nevertheless, smokers showed statistically much poorer knowledge when compared with the non-smokers ($p < 0.001$). The awareness concerning negative influence of smoking on oral cavity was found to be low. Positive answer was obtained from 90.5%, but smokers response was markedly less frequent (78.9%) when compared to non-smokers or former smokers ($p < 0.001$). For the question whether they were informed about the negative effects of smoking on one's health by their dentist, the positive response rate was only 49%, mainly answered by regular smokers. On the contrary, the non-smokers were not informed ($p < 0.001$), which means that the health education was performed rather selectively, most often targeted on the smokers.

Questions:	**Regular smoker**	**Occasional smoker**	**Ex-smoker**	**Non-smoker**	Total
"Are you satisfied with the appearance of your teeth?" $p < 0.001$; χ^2 test					
- satisfied	44,0	58,5	50,0	57,9	53,6
- non-satisfied	52,7	41,5	48,4	39,8	44,1
- I am not interested in it	3,3	0,0	1,6	2,3	2,2
"How do you assess the health status of your teeth, gingivae and oral mucosa?" $p < 0.001$; χ^2 test					
- good	36,2	53,8	42,0	56,6	49,6
- bad	32,9	22,7	28,4	21,2	25,0
- I don't know	31,0	23,5	29,6	22,2	25,4
"In comparison with the others, do you think your oral health is": $p< 0.001$; χ^2 test					
- better	19,7	17,9	24,8	34,0	28,3
- the same	52,6	65,8	50,0	50,8	52,2
- worse	27,7	16,2	25,2	15,2	19,6

Table 8. Subjective assessment of oral health by respondents (%)

Questions:	**Regular smoker**	**Occasional smoker**	**Ex-smoker**	**Non-smoker**	Total
"Do you think smoking is harmful for your health? " $p < 0.001$; χ^2 test					
- yes	89,4	95,8	98,5	97,2	95,6
"Do you think smoking has bad influence on your oral health?" $p < 0.001$; χ^2 test					
- yes	78,9	85,0	95,8	94,3	90,5
"Were you informed about the negative effect of smoking on your health by your dentist?" $p < 0.001$; χ^2 test					
- yes	59,6	52,5	52,9	42,6	48,6

Table 9. Knowledge of respondents about the health consequences of smoking (%)

4.2 Results of clinical part of the study

4.2.1 Influence of smoking on DMF index

The assessment of a dental status showed that smokers had a significantly higher DMF index when compared to non-smokers (17.2 vs. 16; $p = 0.001$) (table 10), which had been caused mainly due to a higher number of decayed teeth (D) (1.06 vs. 0.7; $p = 0.003$), missing teeth (M) (5.65 vs. 4.53; $p < 0.001$) and decayed teeth with fillings (D+F) (1.46 vs. 1.03; $p = 0.04$).

Variables	Number of decayed teeth (D)		Number of missed teeth (M)		Number of filled teeth (F)		Number of decayed teeth with fillings (D+F)		DMF index	
	Mean ± s.d.	p-value	Mean ± s.d.	p-value	Mean ± s.d.	p-value	Mean ± sd.	p-value	Mean ± s.d.	p-value
Smoking:										
- smokers	1,06 ± 1,94	0,003 (**)	5,65 ± 6,82	<0,001 (***)	9,18 ±5,52	0,008 (**)	1,46 ± 2,56	0,046 (*)	17,23 ± 7,35	0,001 (**)
- non-smokers	0,70 ± 1,50		4,53 ± 5,93		9,84 ± 5,26		1,03 ± 1,76		16,05 ± 7,06	
Age:										
- younger 50	0,83 ±1,75	0,21 (NS)	2,88 ± 3,79	<0,001 (***)	9,58 ± 5,10	0,11 (NS)	1,20 ± 1,98	0,842 (NS)	14,41 ± 6,52	<0,001 (***)
- 50 or older	0,91 ±1,66		9,06 ± 8,01		9,57 ± 5,89		1,27 ± 2,48		20,70 ± 6,62	
Sex:										
- males	1,01 ±1,91	0,008 (*)	5,14 ± 6,67	0,508 (NS)	9,24 ± 5,29	0,028 (*)	1,28 ± 2,20	0,649 (NS)	16,56 ± 7,37	0,879 (NS)
- females	0,73 ±1,52		4,89 ± 6,03		9,83 ± 5,45		1,17 ± 2,14		16,57 ± 7,05	
Education:										
Basic	1,17 ± 2,32	<0,001 (***)	6,75 ± 7,30	<0,001 (***)	9,35 ± 5,66	0,020 (*)	1,37 ± 2,39	0,301 (NS)	18,60 ± 7,26	<0,001 (***)
Vocational	1,14 ± 1,80		4,62 ± 5,64		9,21 ± 5,05		1,25 ±1,76		16,10 ± 6,71	
High school	0,65 ± 1,25		4,65 ± 6,18		10,00 ± 5,32		1,14 ± 2,15		16,36 ± 6,93	
University	0,74 ± 1,35		3,56 ± 4,88		9,11 ± 5,23		1,20 ± 2,02		14,51 ± 7,16	
Preventive check-ups:										
Two times a year	0,66 ± 1,28	<0,001 (***)	4,52 ± 5,61	<0,001 (***)	10,10 ± 5,42	<0,001 (***)	1,10 ± 2,11	0,003 (**)	16,33 ± 7,02	<0,001 (***)
Once a year	0,91 ± 1,56		4,79 ± 6,10		9,13 ± 5,13		1,37 ± 2,12		16,12 ± 7,16	
Once in 2 years	1,34 ± 1,68		6,93 ± 8,16		7,60 ± 4,59		1,44 ± 2,31		17,00 ± 7,82	
Less frequently	1,54 ± 2,23		7,48 ± 8,54		8,78 ± 5,14		1,59 ± 1,93		19,38 ± 7,52	
Never	2,90 ± 4,80		9,46 ±10,05		5,09 ± 4,59		1,89 ± 3,21		19,19 ± 8,32	
Tooth brushing frequency:										
3 times or more	0,62 ± 1,32	<0,001	5,70 ± 7,40	<0,001	8,81 ± 5,43	<0,001	0,86 ± 1,15	0,677	15,92 ± 7,26	<0,001 (***)
2 times/day	0,79 ± 1,49		4,56 ± 5,77		9,81 ± 5,33		1,24 ± 2,22		16,31 ± 7,08	

Variables	Number of decayed teeth (D)		Number of missed teeth (M)		Number of filled teeth (F)		Number of decayed teeth with fillings (D+F)		DMF index	
	Mean ± s.d.	p-value	Mean ± s.d.	p-value	Mean ± s.d.	p-value	Mean ± sd.	p-value	Mean ± s.d.	p-value
Once daily	1,33 ± 2,06	(***)	6,50 ± 7,82	(***)	9,14 ± 5,44	(***)	1,28 ± 2,10	(NS)	18,28 ± 7,52	
Less frequently	2,32 ± 4,61		9,31 ± 8,35		6,30 ± 5,45		2,15 ± 3,62		19,57 ± 7,81	
Eating after evening tooth brushing:										
- Yes	1,85 ± 2,93	<0,001 (***)	7,33 ± 7,86	<0,001 (***)	8,07 ± 5,45	<0,001 (***)	1,60 ± 2,69	0,540 (NS)	18,82 ± 7,68	<0,001 (***)
- No	0,77 ± 1,54		4,68 ± 6,00		9,76 ± 5,33		1,19 ± 2,10		16,30 ± 7,09	

Table 10. The impact of some variables on the DMF index value
s.d. = standard deviation

On the contrary, the mean number of teeth with fillings (F) was significantly higher in non-smokers than smokers (9.84 vs. 9.18; p = 0,008), which most probably corresponds with better participation of non-smokers in the follow-ups.
Smoking is one of many confounding factors which deteriorate the status of dentition and oral health in general. From the other variables of our study (table 10), the most influential predictors of dental status or DMF value are as follows: the age (linear relation), the level of education achieved (non-linear relation), taking part in preventive dental check-ups (non-linear relation), tooth brushing frequency (non-linear relation), and consumption of food/beverages after evening tooth brushing. Among the respondents in higher age group, there was a higher number of missing teeth (M). In our sample, the average number of missing teeth in respondents younger than 50 years reached 2.88, while in the age group of 50-69, it was 9.06 ($p < 0.001$). The number of missing teeth was higher in respondents with a lower educational status, lower frequency of preventive dental visits (less than once a year), lower frequency of tooth brushing (less than twice a day) and among those who consumed food/beverages after the evening tooth brushing. The number of decayed teeth was also higher in patients with a lower education, among those who brushed their teeth less than twice daily, among those who visited dentist less frequently and among those who consumed food/beverages after the evening tooth brushing. The same factors influenced significantly the number of filled teeth; nevertheless in this case it was a non-linear relation.

4.2.2 Influence of smoking on the periodontium

Negative influence of smoking on the periodontium was even more conclusive (table 11). While the non-smokers recorded higher prevalence of CPI 0 (healthy periodontium) in all sextants, the smokers had in all sextants a higher prevalence of CPI 3, or resp. CPI 4 (shallow or deep gingival pockets). Lower levels of CPI 1 (gingiva bleeding on probing) among smokers were undoubtedly caused by vasoconstriction effect of nicotine on the vessels of gingival plexus and an increasing keratinization of gingival epithelium.

Smoking is of course only one of the factors that affect the periodontal status. A wide range of demographic factors, such as age, educational level and socioeconomic factors, have been identified as associated with chronic inflammatory diseases (Gamonal et al., 1998). In table 12 we present the percentage of respondents with the highest CPI findings according to the level of age, sex, education, participation in preventive dental check-ups, tooth brushing frequency and smoking history. According to the results of χ^2 test of independence in contingency tables, all these variables had a statistically significant influence on CPI ($p< 0.001$).

	CPITN 0	**CPITN 1**	**CPITN 2**	**CPITN 3**	**CPITN 4**
1st sextant (p=0.076; χ^2 test)					
Smokers	5.6	27.2	13.9	34.5	7.3
Non-smokers	9.1	33.7	13.8	29.5	6.8
2nd sextant (p=0.016; χ^2 test)					
Smokers	17.4	31.7	24.0	15.0	5.2
Non-smokers	25.3	37.3	19.3	10.4	3.7
3rd sextant (p=0.021; χ^2 test)					
Smokers	7.0	23.7	16.4	32.8	9.8
Non-smokers	11.5	31.3	17.2	25.6	6.8
4th sextant (p=0.043; χ^2 test)					
Smokers	5.6	30.0	14.3	30.3	11.5
Non-smokers	10.2	35.2	14.1	27.2	6.5
5th sextant (p=0.007; χ^2 test)					
Smokers	4.2	14.3	58.9	15.7	3.5
Non-smokers	8.6	18.8	59.0	8.1	3.1
6th sextant (p=0.011; χ^2 test)					
Smokers	5.9	27,9	15,3	30,0	11,5
Non-smokers	10.2	37,1	14,4	24,5	6,8

Table 11. CPITN score (%) of smokers and non-smokers in each sextant

The primary aim of our survey was to assess the influence of smoking on oral health. Using the method of multivariable logistic regression we determined the odds ratio (OR) for eight selected variables on mean number of decayed teeth (D) and on periodontitis with TN III score. The reference value was set as number of D = 0 (e.g. absence of decayed teeth) and absence of CPI 4 (e.g. no deep gingival pockets were found). As a reference level for each of selected variable (odds = 1) the best particular value was considered, which means non-smoker, younger age, women, university educated respondent who brushes his/her teeth twice a day or even more often and those who participates in the dental preventive follow-ups twice a year.

	CPI 0	CPI 1	CPI 2	CPI 3	CPI 4
Smoking (χ^2 test; $p < 0,001$)					
Regular	1,1	9,2	27,4	36,9	25,4
Occasional	1,7	16,1	33,1	34,7	14,4
Ex-smoker	1,2	11,0	30,3	42,1	15,4
Non-smoker	1,8	18,6	30,7	35,2	13,7
Age (χ^2 test; $p < 0,001$)					
30-49 years	2.1	19.4	32.1	35.2	11.2
50-69 years	0.4	6.8	22.1	43.2	27.4
Sex (χ^2 test; $p < 0,001$)					
Males	1.3	12.4	26.1	41.7	18.4
Females	1.7	18.0	31.3	33.9	15.1
Education (χ^2 test; $p < 0,001$)					
Basic school	0,6	9,1	27,4	38,8	24,1
Vocational	0,8	17,6	26,7	39,7	15,3
High School	2,2	15,8	32,2	36,6	13,2
University	1,9	20,9	30,7	32,9	13,6
Participation on preventive check-ups (χ^2 test; $p < 0,001$)					
2 times a year	2,0	18,1	33,4	33,6	13,0
Once a year	0,5	11,1	26,0	42,7	19,6
Once in 2 years	0,0	10,4	23,9	40,3	25,4
Less frequently	3,9	5,3	22,4	36,8	31,6
Never	0,0	5,7	11,3	49,1	34,0
Tooth brushing frequency (χ^2 test; $p < 0,001$)					
3 times a day	2,3	25,4	32,2	25,4	14,7
2 times a day	1,5	15,0	31,3	38,1	14,1
Once daily	1,2	8,0	21,0	40,1	29,6
Less frequently	2,6	5,1	17,9	28,2	46,2

Table 12. Percentage of respondents with highest CPI in relation to selected variables

Our results in table 13 showed that incidence of decayed teeth is enhanced mainly by the consumption of food/beverages after evening tooth brushing (OR=1.68; p=0.011) and low participation in preventive check-ups (OR=1.77; p= 0.0013). Smoking increased the risk of decayed teeth as well (OR=1.23), but the result was not significant (p=0.061). Nevertheless, our findings confirmed the fact that there exists a dose and effect relationship with smoking. Though not statistically significant in our study, the number of dental caries occurrence increased in individuals who smoked more than 10 cigarettes per day.

Different results were found when assessing the influence of smoking on periodontium (table 14). The risk for periodontitis with TN III score (which means the findings of CPI 4) was statistically increased with age (OR=2.63; p<0.001), low tooth brushing frequency (OR=2.18; p<0.001), and low participation in dental prevention check-ups (OR=1.8; p=0.007). Smoking increased the risk as well (OR=1.33), but the result was not significant (p=0.065). Nevertheless, the risk markedly increases with the number of cigarettes smoked. Smoking 11 or more cigarettes a day increased the risk of periodontitis (CPITN III), which emphasizes the need for a complex dental care (OR=1.98, p=0.0043). Smoking of 10 or less cigarettes per day increases the risk of periodontitis (CPITN III grade) as well, but in this case, not significantly (OR = 1.67; p= 0.027).

	OR	**CI-L**	**CI-U**	**p-value**
Age	0.99	0.77	1.26	0.908 (NS)
Sex	1.13	0.91	1.41	0.262 (NS)
Preventive check-ups once a year	1.28	1.00	1.65	0.054 (NS)
Preventive check-ups low frequently	1.77	1.25	2.50	0.0013 (*)
Basic education, skilled	0.98	0.74	1.31	0.903 (NS)
High school	0.78	0.59	1.03	0.082 (NS)
Tooth brushing frequency once a day or less frequently	1.27	0.9	1.79	0.177 (NS)
Smoking associated illnesses	1.13	0.81	1.57	0.479 (NS)
Illnesses without association with smoking	1.11	0.82	1.51	0.497 (NS)
Eating after evening tooth brushing	1.68	1.12	2.51	0.011 (*)
Smoking	1.23	0.99	1.54	0.061 (NS)
- smoking to 10 cig,/day	0.99	0.69	1.41	0.941 (NS)
- smoking 11 and more cig/day	1.23	0.84	1.81	0.293 (NS)

Table 13. Impact of selected variables on number of decayed teeth (reference value D= 0)
OR = odds ratio, CI-L = lower 95% confidence interval, CI-U = upper 95% confidence interval
NS (non-significant) = $p \geq 0.05$; * = $p < 0.05$; ** = $p < 0.01$; *** $p < 0.001$

	OR	CI-L	CI-U	P value
Age	2,63	1,92	3,59	< 0,001 (***)
Sex	0,93	0,69	1,26	0,654 (NS)
Preventive check-ups once a year	1,45	1,04	2,02	0,03 (*)
Preventive check-ups less frequently	1,8	1,17	2,76	0,0073 (**)
Basic education, skilled	1,33	0,9	1,99	0,157 (NS)
High school	0,92	0,61	1,37	0,679 (NS)
Tooth brushing frequency once a day or less frequently	2,18	1,45	3,27	< 0,001 (***)
Smoking associated illnesses	1,39	0,94	2,07	0,102 (NS)
Illnesses without association with smoking	0,97	0,65	1,46	0,894 (NS)
Eating after evening tooth brushing	1,07	0,66	1,74	0,793 (NS)
Smoking	1,33	0,98	1,79	0,066 (NS)
- smoking to 10 cig./day	1,67	1,06	2,61	0,027 (*)
- smoking 11 and more cig/day	1,98	1,24	3,16	0,0043 (**)

Table 14. Impact of selected variables on necessity of complex therapy (TN III)
OR = odds ratio, CI-L = lower 95% confidence interval, CI-U = upper 95% confidence interval
NS (non-significant) = $p \geq 0.05$; * = $p < 0.05$; ** = $p < 0.01$; *** $p < 0.001$

5. Discussion

Our study confirmed the differences in attitudes of smokers and non-smokers to oral health. The percentage of subjects with basic education was significantly higher among regular smokers and percentage of those with a university degree was highest among non-smokers. These findings are consistent with the results of previous studies conducted in other developed countries. Researchers of a study performed in Australia noted that those living in low socio-economic status areas were more likely to smoke (Najman et al., 2006). A study published in the Journal of Canadian Dental Association stated that a higher percentage of current smokers had education less than high school (Millar & Locker, 2007) and a study conducted in America stated that inequalities in smoking exist, as evidenced by persistent class-based disparities and the growing number of smokers in the lower socio-economic groups (Sorenson et al., 2004).

It has been undoubtedly documented, that after the first Surgeon General's report in 1964, the profile of cigarette smokers in U.S.A., and consequently in the other developed countries, has reversed. Cigarette smokers nowadays are more likely to be poor and less educated. The well educated people may have higher levels of health literacy, and were more responsive to messages of health-promoting and disease-prevention behaviours and beliefs. Additionally, the poor ones may have lower information on the health risks of

smoking, the fewest resources, and the least access to cessation services. Socio-economic disadvantage is associated with persistent smoking, and consequently the burden of smoking-related disease falls disproportionately on those with lower social-economical status (Harwood et al., 2007). In contrary to this, we have found high prevalence of current smokers in the group of respondents with highest income in Czech Republic. This fact reflects great underestimation of generally well-known health risks of smoking by smokers, as well as high social tolerance to this negative habit in our country.

Smokers and non-smokers also differ in participation in dental prevention. Majority of Czech respondents visit the dentist for preventive check-ups twice a year. This can be explained by the fact that the regular preventive dental check-ups are covered by the Health Insurance in Czech Republic. Nevertheless, despite free dental preventive check-ups, smokers participate in these check-ups less frequently than the non-smokers do.

The differences according to the smoking habits were found also in chosen oral hygiene habits. The non-smokers had better brushing habits (brushed their teeth more frequently, used inter-dental tooth brush, dental floss and mouth wash more often and were more consistent in not eating anything after evening tooth brushing) compared to smokers. Non-smokers also abstained from eating anything after evening brushing more consistently than smokers.

Significant difference between smokers and non-smokers has been found in eating and drinking habits. Current smokers, mainly occasional smokers, consumed sweetened drinks more frequently in comparison with non-smokers or ex-smokers. In case of consumption of fruits and vegetables the trend was opposite. Non-smokers consumed fruits and vegetables more often than smokers, who, on the contrary, had higher alcohol intake.

Majority of factors mentioned above explains the differences in clinical findings in smokers and non-smokers. Smoking is considered to be an independent and most potent risk factor for chronic periodontal disease. The social and behaviour factors, which are typical among the population group of smokers, can aggravate the clinical findings.

Taking the gender of the respondents into consideration, we did not find the influence of gender on the highest (maximum) CPITN outcome. On the contrary, it has been reported that although there is no established, inherent difference between men and women in their susceptibility to periodontitis, men have been shown to exhibit worse periodontal health than women and this difference has been documented in different populations. Several periodontal diseases have been found to be more prevalent among males, even after oral hygiene, socio-economic status and age were considered, and hormonal conditions have been proposed which may explain this difference (Grossi et al., 1994).

The age of Czech respondents significantly influenced the maximum CPITN outcome. Early evidence demonstrated that both the prevalence and severity of periodontitis increases with aging, suggesting that age may be a marker for periodontal tissue support loss. A national survey conducted in 1986 in Brazil using CPITN methodology to assess the periodontal status estimated that 5.2 % and 7.4 % of subjects in the age groups 35 to 44 and 50 to 59 years had one or more teeth with probing depth of ≥ 5.5 mm (CPITN 4) (Sorenson et al., 2004) and another national survey in the United Kingdom using CPITN estimated that 42 % of 35 to 44 year olds and 70 % of 55 to 64 year olds had CAL > 3.5 mm (Morris et al., 2001). The fact that older age group (50-69 years) of the Czech study population having a higher percentage of maximum CPITN scores 3 and 4, indicating pathological pockets, may have been caused by the cumulative effect of prolonged exposure to external risk factors including cigarette smoke rather than an age-related, intrinsic abnormality. Although there is no established,

inherent difference between men and women in their susceptibility to periodontitis, periodontal disease is often reported in epidemiological studies to be more prevalent and severe in males than in females at comparable ages (Gamonal et al., 1998; (Borrell & Papapanou, 2005), and similar results were found in the Czech population.

Education significantly influenced the maximum CPITN outcome in Czech study population. Previous studies have documented differences in periodontal health by socio-economic indicators, i.e., income and education, but these indicators have rarely been investigated as independent variables of main interest.

Socio-economic indicators are robust markers of periodontitis. Their role in periodontal disease can be attributed to differential access to resources and opportunities that may influence preventive behaviours. Evidence also suggests that education has a greater influence than income in favourably affecting the level of periodontitis in the population (Borrell & Papapanou, 2005). University and mainly vocational school graduates of Czech population having a higher percentage of maximum CPITN score 0, indicating healthy periodontium, can be attributed to the factors mentioned above.

Preventive dental visits and brushing frequency significantly influenced the maximum CPITN outcome of the Czech population. A general principle in preventive efforts towards chronic diseases is to focus on changeable causal or modifying factors. Regarding periodontal diseases, such factors are those related to life style, such as oral hygiene, regularity of dental visits and tobacco use. Comparative studies between the Eastern European countries and the Western societies showed that socio-economically less-developed Eastern European countries displayed a higher fraction with mild-to-moderate periodontitis than the Western well-developed societies. Particularly the Scandinavian countries, where a comprehensive public dental health care system with emphasis on prevention and regular dental visits has existed for more than 100 years, displayed high proportions of healthy subjects and even a low prevalence of severe periodontal disease (Gjermo, 2005). One study reported, that the subjects, who had a dental check-up at least once a year, had a significantly less gingivitis, calculus and periodontal pockets compared to those, who made less frequent visits (Lang et al., 1994). However, the same group of authors failed to find a relationship between dental insurance and improved periodontal health (Lang et al., 1995), although those with insurance were more likely to visit the dentist (Jack & Bloom, 1988). Differences among the populations of the world in terms of periodontal status, oral cleanliness and oral health behaviour probably reflect the social and economic development of the various regions. Cultural differences may also affect the attitudes towards dental health and dental care in populations (Gjermo, 2005). Lack of use of preventive care may reflect a general attitude toward preventive care, differences in willingness or ability to pay for dental services or differences in the availability of dental care.

The findings from this study concerning the fact that non-smokers exhibited a higher percentage of healthy periodontium compared to smokers, corroborates the results of several previous studies (Beck et al., 1997; Kelbauskas et al., 2003; Tanner et al., 2005; Torrungruang et al., 2005; Winn, 2001). This study also reconfirmed the relationship between smoking and a reduced gingival bleeding on probing, which has been well documented in previous studies (Dietrich et al., 2004; Müller et al., 2002; Tomar & Asma, 2000). This may be due to vasoconstrictive action of nicotine and as a result of a profound influence on vascular dynamics and cellular metabolism (Bergström & Bergström, 2001).

Smoking, as a strong and consistent risk indicator for periodontitis in the presence of calculus, an indicator of oral hygiene, has been documented in logistic regression model (Do, 2003), and smokers have been reported to exhibit a low awareness of their health (Gjermo, 2005). From this study it was evident that smokers had a higher prevalence of supragingival and/or subgingival calculus compared to non-consumers.

6. Conclusion

In conclusion, the present study shows that despite good access to dental care in Czech Republic, cigarette smoking exerts a strong and chronic effect on periodontium and reduces bleeding on probing. The current understanding of the importance of tobacco smoking as the most potent risk factor for chronic periodontal disease now has to be applied to the clinical management of the disease. Treatment of smoking patients not including corrective measures against the smoking habits should be regarded as unethical. The outcomes of this particular survey proves that it is mandatory to implement a more rigorous anti-smoking campaign in the dental practice.

7. Acknowledgement

Project was supported by the Ministry of Health Grant Agency No. NR 8781-3/06.

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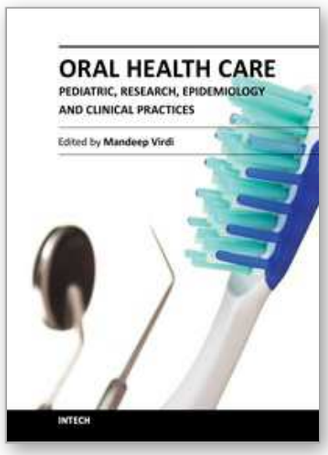

Oral Health Care - Pediatric, Research, Epidemiology and Clinical Practices

Edited by Prof. Mandeep Virdi

ISBN 978-953-51-0133-8
Hard cover, 302 pages
Publisher InTech
Published online 29, February, 2012
Published in print edition February, 2012

Oral health care in pediatric dentistry deals with complete oral health, including preventive aspects for children right from their conception to adolescence, encompassing all the spheres of dentistry including various specialties. It also includes planning a preventive program at individual and community levels. The current research interests in oral health care include studies regarding the role of stem cells, tissue culture, and other ground-breaking technologies available to the scientific community in addition to traditional fields such as anatomy, physiology, and pharmaceuticals etc of the oral cavity. Public health and epidemiology in oral health care is about the monitoring of the general oral health of a community, general afflictions they are suffering from, and an overall approach for care and correction of the same. The oral health care-giver undertakes evaluation of conditions affecting individuals for infections, developmental anomalies, habits, etc. and provides corrective action in clinical conditions. The present work is a compendium of articles by internationally renowned and reputed specialists about the current developments in various fields of oral health care.

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