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Cigarette smoking as an oral health risk behavior in adolescents: a cross-sectional study among Polish youths

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ABSTRACT: The aim of this study was to evaluate the relationship between cigarette smoking and the condition of the teeth and periodontium and the oral health behavior of 18-year-olds. Cross-sectional studies on 1,611 18-year-olds from Poland were conducted in 2017. The questionnaire provided socio-economic data, information about health-related behavior (cigarette smoking and oral health behavior), and absence from school due to oral pain. The dentition status (DMFT and DMFS), periodontal status (gingival bleeding, depth of periodontal pockets, loss of attachment), and need for endodontic treatment or tooth extraction were clinically assessed. Cigarette smoking was reported by 25% of participants (15% reported every day smoking). Adolescents who smoked cigarettes regularly had a higher mean number of decayed teeth (2.40±3.21 vs. 1.95±2.66) and similar periodontal status. Cigarette smoking increased the risk of oral hygiene neglect (63% vs. 69%), dietary mistakes (25% vs. 13%), failure to make dental appointments (32% vs. 43%), occurrence of oral pain (28% vs. 27%), absence from school due to pain (13% vs. 6%), and the need for endodontic treatment or tooth extraction (11% vs. 5%). The socio-economic factors and sex of the subjects decreased the influence of smoking only on oral hygiene neglect. Cigarette smoking by adolescents seems to be an independent risk factor for serious dietary mistakes, failure to benefit from oral healthcare, and more dynamic damage of teeth, which lead to pain and even tooth loss. Therefore, these aspects should be included in the risk assessment of oral disease and incorporated into educational programs promoting a healthy lifestyle.

KEY WORDS: cigarette smoking, dietary habits, dental caries, adolescents

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Introduction

Habitual cigarette smoking is a social problem in many countries worldwide. Cigarette smoking usually begins in adolescence, and its frequency varies between countries, ranging from 8% to even 50% of 15-year-olds (Giannakopoulos et al. 2009; Ciecierski et al. 2011; Panatto et al. 2013). In 2009, the Global Youth Tobacco Survey revealed that 19% of Polish youths aged 13–15 years smoked cigarettes, with 5.6% of boys and 7.4% of girls smoking cigarettes daily (Ciecierski et al. 2011). Adolescents begin to smoke cigarettes in order to satisfy specific needs associated with their age, such as experimenting or highlighting their independence from adults' control. Cigarette smoking is also perceived as a behavior that brings comfort and facilitates communication with peers. Unfortunately, unhealthy behaviors tend to persist into adulthood, thus increasing health risks for the smoker as well as for those exposed to second-hand cigarette smoke (Rodrigues et al. 2016).

The negative influence of cigarette smoking on human health, including oral health, is unquestionable. In the context of the oral cavity, cigarette smoking is a risk factor for oral carcinoma, periodontitis, black tongue, leukoplakia, inhibited wound healing after dental procedures, irritation of minor palatal salivary glands, teeth discoloration, and bad breath (Hecht 2003; Millar and Locker 2007; Heikkinen et al. 2008). The possible association of tobacco smoking with dental caries has also been suggested (Benedetti et al. 2013). Negative outcomes of cigarette smoking depend on the length and intensity (the number of cigarettes smoked) of the addiction. However, studies conducted among adolescents have shown that even a relatively short period of cigarette smoking may negatively influence oral health (Heikkinen et al. 2008; Cinar et al. 2011; Holmén et al. 2013). In addition, worse attitudes and oral health behaviors among smokers in comparison to non-smokers have been reported (Ayo-Yusuf et al. 2009; Hasselkvist et al. 2014; Wang et al. 2017). Therefore, cigarette smoking might have a negative impact on oral health in adolescents not only as a result of the influence of nicotine and cigarette smoke, but also as a result of unhealthy behaviors, which tend to be more common among smokers than non-smokers. Like cigarette smoking, such behaviors might be strengthened and become life-long habits. Health-related behaviors of 18-year-olds, who are beginning their adult lives, will be a predictor not only of their own health but also of the health of future generations, as they will be role models for their children.

Although studies have been conducted on Polish adolescents smoking cigarettes, they did not concern the oral health condition (e.g. Ciecierski et al. 2011). Therefore, the aim of the current study was to assess the frequency of cigarette smoking among 18-year-olds in Poland, the association between cigarette smoking and the condition of the teeth and periodontium, and the oral health-related behaviors in this group.

Materials and methods

This cross-sectional study was conducted in 2017, and it was limited to 18-year-olds attending vocational and secondary public schools located in all 16 regions of Poland. From each region, either one province, which had an urban–rural character, or two provinces, one of which was

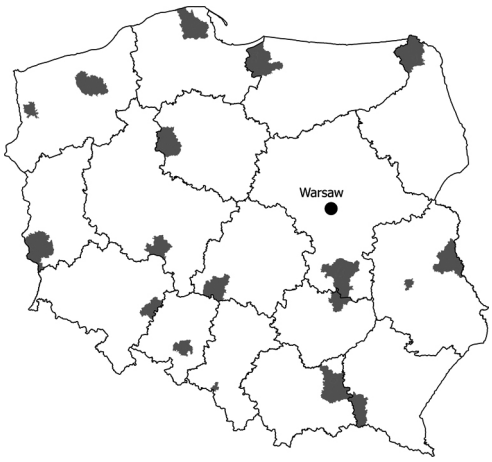

Fig. 1. Map of Poland with marked areas covered by the research

typically urban and the other a typical rural one, were selected. Thus, the population studied came from both rural and urban areas of each Polish region (Fig. 1).

Schools were selected in a multi-layered grouping (district, commune, and city). Pupils from schools whose directors agreed to participate in the study were invited to participate in the study. The study included pupils present on the day that the dental examiners visited their schools and who had given their written permission to participate in the study. The size of the study group was estimated based on data from the Polish Central Statistical Office, which indicated a population size of 18-year-olds of 390,602. Unfortunately, because a dozen school heads declined to allow their schools to participate in the study, in some cases, supplementary research had to be carried out. The study began in November 2017 and was completed in three weeks to try to ensure consistency. The supplementary research was performed no later than three weeks after the first research.

A total of 1,611 18-year-olds (764 males and 847 females) were enrolled in the study, including individuals from both urban and rural regions of Poland. All individuals were asked to complete a questionnaire and a clinical oral examination following the World Health Organization guidelines (WHO 2013).

The questionnaire covered:

1. socio-economic status (parents' level of education, financial status of the family);
2. cigarette smoking and frequency of smoking (every day, a few times a week, and sporadically – a few times a month or less than once a month);
3. hygiene-related habits (frequency of tooth brushing, using dental floss);
4. dietary habits (number and type of meals, frequency of consumption of selected products);
5. oral pain and absence from school due to oral pain, benefiting from oral healthcare.

The condition of the teeth and periodontium in each dentition quadrant was clinically examined under artificial lighting, using a World Health Organization 621 probe (WHO 2013). The number of decayed teeth (DT), the number of teeth extracted due to caries (MT), and the number of filled teeth (FT) were considered, and the Decayed, Missing and Filled Teeth Index (DMFT) was calculated. The teeth with signs of pulpal or periapical diseases (deep caries, pulp exposure, abscesses) and unrestorable teeth with extensive structural damage were classified as teeth with endodontic treatment or extraction. The presence or absence of gingival bleeding after probing and the periodontal pocket depths (considered unhealthy at ≥4 mm) around each tooth were assessed. Loss of attachment was

recorded around the index teeth: 17/16, 11, 26/27, 31, 46/47.

Clinical examinations were performed by general dental practitioners following prior training and calibration. The Cohen's kappa coefficient between the reference examiner and other examiners regarding the condition of teeth and periodontium ranged from 0.857 to 1.000, which constituted high inter-examiner reliability.

Comparison of the means between the two groups (smoking vs. non-smoking) was carried out using a t-test. The association between cigarette smoking and other variables (including hygiene-related behaviors and oral health) was assessed using simple and multiple logistic regression analyses. To avoid a confounding effect of the other variables, the results were presented as an odds ratio (OR) for simple regression and an adjusted odds ratio (AOR) for multiple regression, where socio-economic factors were included in the statistical models as covariates. The confounding factors for calculating AOR were selected based on Spearman's correlation coefficient. In all analyses, the statistical significance value was set at $p<0.05$. Statistical analysis was performed using Statistica 13 software (https://www.statsoft.pl/statistica_13).

Results

Almost a quarter (25%, 399/1,611) of the respondents admitted to regular cigarette smoking. In this respect, no statistical differences were found between the sexes ($p=0.173$; Table 1).

However, correlations between sex and oral health behavior and dietary habits were statistically significant ($p<0.0001$). Females demonstrated good oral hygiene (tooth brushing, using dental floss, and following a diet containing fruits and vegetables) significantly more frequently than males, while males expressed a preference for unhealthy eating habits significantly more often than females (Table 2).

Spearman's correlation coefficient analysis did not confirm the association between cigarette smoking and urban or rural region of residence, level of parents' education, and economic status of the family. However, these factors were significantly correlated with oral hygiene and dietary habits. The values of the correlation coefficients ranged from 0.56 to 0.131 ($p<0.05$).

Simple logistic regression analysis indicated that cigarette smoking is associated with poor oral health behavior and increased consumption of unhealthy food. Studies have shown that caring for oral hygiene (tooth brushing and regular dental appointments) is easier for non-smokers, while dental appointments are "forced" for smokers due to toothache. The AOR model confirmed a lower frequency of dental appointments within the last 12 months and follow-up dental appointments among adolescents who smoked cigarettes regularly (Table 3).

Table 1. Association between cigarette smoking with sex

Habits	Total	Males	Females	*p*-value
Cigarette smoking	399/1611;25%	201/764;26.3%	198/847;24%	0.173
every day	243/1611;15%	129/764;17%	114/847;14%	0.055
few times a week	86/1611;5%	38/764;5%	48/847;6%	0.537
few times a month	70/1611;4%	34/764;5%	36/847;4%	0.844

The analysis of the relationship between cigarette smoking and dietary behaviors showed that young people who smoked cigarettes had irregular meals more frequently, consumed less fresh fruit and vegetables, and admitted to more frequent consumption of crisps, cakes, and sweet and/or fizzy beverages. Therefore, the AOR model confirmed that the risk of unhealthy eating habits is higher in adolescents who regularly smoke cigarettes (Table 4).

The final analysis focused on the relationship between cigarette smoking and oral health status (Table 5). The analysis excluded the prevalence of loss of attachment (gingival packets≥4mm) because it was observed only in 3/399 (1%) smokers and 12/1,212 (1%) non-smokers. Adolescents who smoked regularly had significantly more unfilled cavities compared with 18-year-olds without this behavior. The probability of experiencing oral pain or discomfort resulting in absence from school was also higher.

Table 2. Significant differences in health-related behavior and food consumption in the study group according to sex

Habits	Total	Males	Females
Tooth brushing at least twice a day	1096/1611;68%	403/764;53%	693/847;82%
		$p<0.001$*	
Using dental floss	630/1611;39%	215/764;28%	415/847;49%
		$p<0.001$*	
Consumption of			
more than 3 snacks during the days	240/1611;15%	145/764;19%	95/847;11%
		$p<0.001$*	
fresh fruits and vegetables every day or a few times a day	797/1611;49%	338/764;44%	459/847;54%
		$p<0.001$*	
sweet fizzy drinks every day or a few times a day	356/1611;22%	208/764;27%	148/847;17%
		$p<0.001$*	
crisps every day or a few times a day	146/1611;9%	91/847;11%	55/764;7%
		$p<0.001$*	

*Statistical significance at $p<0.05$.

Table 3. Association between cigarette smoking with oral hygiene habits (OR – odds ratio, AOR – adjusted for socio-economic factors)

Habits	Cigarette smoking		Results of logistic regression			
	Yes (n=399)	No (n=1212)	OR	*p*	AOR	*p*
Tooth brushing at least twice a day	253/399;63%	839/1212;69%	0.77	0.031*	0.80	0.087
Using dental floss	149/399;37%	475/1212;39%	0.93	0.511	0.97	0.822
No dental appointment within last 12 months	61/399;15%	123/1212;10%	1.60	0.005*	1.58	0.007*
Dental appointment due to toothache	98/399;25%	207/1212;17%	1.58	<0.001*	1.57	<0.001*
Follow-up dental appointment	126/399;32%	523/1212;43%	0.60	<0.001*	0.62	<0.001*

*Statistical significance $p<0.05$.

Table 4. Association between cigarette smoking with food consumption (OR – odds ratio, AOR – adjusted for socio-economic factors)

Habits	Cigarette smoking		Results of logistic regression			
	Yes (n=399)	No (n=1212)	OR	*p*	AOR	*p*
Missed breakfast	98/399;25%	160/1212;13%	2.14	<0.001*	2.15	<0.001*
<3 main meals a day	42/399;11%	50/ 1212;4%	2.73	<0.001*	2.74	<0.001*
>3 snacks a day	51/399;12%	83/1212;7%	1.99	<0.001*	1.95	<0.001*
Fresh fruit/vegetables#	171/399;43%	628/1212;52%	0.70	0.002*	0.71	0.004*
Doughnuts, cakes#	27/399;7%	31/1212;3%	2.77	<0.001*	2.68	<0.001*
Sweet fizzy beverages#	139/399;35%	207/1212;17%	2.60	<0.001*	2.57	<0.001*
Sugar-free fizzy beverages#	83/399;21%	167/1212;14%	1.64	<0.001*	1.64	<0.001*
Sweetened juices#	116/399;29%	206/1212;17%	2.00	<0.001*	1.98	<0.001*
Crisps#	69/399;17%	72/1212;6%	3.31	<0.001*	3.25	<0.001*

#Consumption a few times a day or every day.
*Statistical signifance at $p<0.05$.

Table 5. Association between cigarette smoking and parameters of dental and periodontal status and treatment required (OR – odds ratio, AOR – adjusted for socio-economic factors)

Parameters	Cigarette smoking		Results of logistic regression			
	Yes (n=399)	No (n=1212)	OR	*p*	AOR	*p*
DMFT > 0	375/399;94%	1126/1212;93%	1.19	0.458	1.22	0.413
DMFT#	6.54±4.31	6.49±4.19		*p*=0.826		
Decayed teeth#	2.40±3.21	1.95±2.66		*p*=0.006*		
Missing teeth#	0.15±0.50	0.13±0.50		*p*=0.454		
Filled teeth#	3.99±3.31	4.41±3.54		*p*=0.038*		
DMFS#	10.21±8.87	9.59±8.00		*p*=0.192		
Healthy periodontium	276/399;69%	833/1212;69%	1.02	0.868	1.03	0.767
Bleeding after probing the pocket	123/399;31%	374/1212;31%	1.00	0.991	0.98	0.884
Gingival pockets ≥4mm	3/399;1%	12/1212;1%	0.47	0.223	0.43	0.189
Oral pain/discomfort	107/399;27%	263/1212;28%	1.32	0.035*	1.38	0.018*
Absence at school due to oral pain	53/399;13%	68/1212;6%	2.58	<0.001*	2.63	0.001*
Need for endodontic treatment or tooth extraction	43/399;11%	66/1212;5%	2.10	<0.001*	2.09	0.001*

#Mean±SD.
*Statistical significance at $p<0.05$.

Discussion

The present study confirmed that cigarette smoking still constitutes a common risky behavior among adolescents. Studies into the scale of the problem among adolescents conducted in younger age groups revealed that cigarette smoking initiation can take place even in childhood, and they highlighted the risk of entrenching the habit (Giannakopoulos et al. 2009; Panatto et al. 2013; Rodrigues et al. 2016). Due to a legal ban on cigarette smoking by minors, survey research conducted among adolescents under 18 years old, even anonymously, is susceptible to error. Eighteen-year-olds in Poland, who are still adolescents, acquire the rights of adults and are free from parental control. In this case, the risk of

underestimation of the frequency of cigarette smoking seems to be lower. Few studies have investigated cigarette smoking in 18-year-olds, and their results varied. A study of 1,002 subjects aged 17–18 years old conducted in Kosovo showed that as many as 40% of boys and 31% of girls smoked cigarettes, of which 7% of girls and 12% of boys smoked every day (Idrizovic et al. 2015). A similar prevalence was reported for Bosnian-Herzegovinian adolescents (55% of males and 40% of females were smokers, including 35% and 15% considered to be daily smokers, respectively) (Sekulic et al. 2012, 2014). The present study group contained 25% who were smokers, of which 15% were daily smokers. A lower frequency of daily smoking in Poland was reported in a nationwide survey on attitudes towards tobacco smoking conducted in 2017, which showed that only 9% of male adolescents and one female in 100 aged 15–19 years old admitted to daily cigarette smoking (Trząsalska et al. 2017). However, these results concern individuals aged 15–19 years old, which hinders the direct comparison of data. The present study did not reveal any difference according to sex. A similar percentage of smokers and absence of statistically significant differences between sexes (15% of males and 13% of females) were reported among Australians aged 18–24 years old, although in older age groups the prevalence of cigarette smoking was higher among men (Greenhalgh et al. 2017). In the present study, the percentages of 18-year-old male and female smokers were 17% and 14%, respectively, with a *p*-value on the edge of statistical significance ($p=0.055$).

In the examined group, female sex was a positive factor for good oral health behaviors. Many studies prove that the assessment of oral health risk behavior is a complex issue (Cinar et al. 2011; Hasselkvist et al. 2014; Rodrigues et al. 2016). The socio-economic factors are also relevant to the assessment of oral health risk behavior. In the present study, the above-mentioned factors turned out to be poorly related to oral health behaviors (low values of Spearman's correlation coefficients), and their impact on cigarette smoking among adolescents was not confirmed. However, the present study demonstrated that cigarette smoking was associated with inappropriate oral health behavior and unhealthy eating (Tables 3 and 4). Many studies have also shown that cigarette smoking increases the risk of irregular meals, contributes to more frequent consumption of fizzy/sweetened drinks and fast foods, and decreases the consumption of fruit and vegetables, dairy products, and breakfast (Yorulmaz et al. 2002; Larson et al. 2007). A study by Wang et al. (2017) revealed that cigarette smoking decreased the chances of eating breakfast (AOR=0.58), eating vegetables (AOR=0.81), eating fruit (AOR=0.81), and drinking milk (AOR=0.69), but increased the risk of drinking non-alcoholic beverages (AOR=2.05) and eating fast food (AOR=1.21). We also observed a higher risk of too frequent consumption of snacks and frequent consumption of sweet, starchy products such as doughnuts (sugar-coated rolls), sweet and/or fizzy beverages, and crisps in adolescents who smoked. In addition, cigarette smoking reduced the chance of regular consumption of main meals, especially breakfast, as well as consumption of fresh fruit and vegetables. It should be highlighted that the influence of cigarette smoking remained constant even when the socio-economic and gender

variables were introduced as confounding factors into the logistic regression analysis (AOR).

Such a close association between cigarette smoking and hygiene-related behaviors was not identified in the present study. Simple logistic regression analysis revealed that the probability of twice daily tooth brushing is reduced in adolescent smokers. However, when socio-economic factors are regarded as confounding factors (AOR), the impact of cigarette smoking was statistically insignificant (Table 3). This might result from adolescents (especially girls) attempting to prevent tooth discoloration and/or odor from the mouth due to cigarette smoke.

Many researchers emphasize that the negative effects of cigarette smoking by adolescents on oral health are largely due to inappropriate oral health behavior (Petersen et al. 2008; Hasselkvist et al. 2014). Hirsh et al. (1991) demonstrated a positive correlation between cigarette smoking and DMFT as well as the number of carious lesions on proximal surfaces. However, a meta-analysis published in 2013 indicated that there was no strong evidence of the association between cigarette smoking and dental caries (Benedetti et al. 2013). In our study group, we did not observe significantly higher DMFT or DMFS values in smokers than in subjects without such behaviors. However, DT values were markedly higher, while FT values were lower, indicating considerable neglect of dental care. We also noticed that cigarette smoking decreased the probability of attending dental appointments. The association between cigarette smoking and neglect of dental treatment was also reported in other studies (Sgan-Cohen et al. 2000).

In the examined study group, subjects who regularly smoked cigarettes reported dental appointments due to toothache and oral pain or discomfort as reasons for school absences more frequently than the rest of the group. Similar associations were observed by other researchers. For example, a study conducted in Finland among 15/16-year-olds revealed that smoking cigarettes at least once a week increased the risk of oral pain by 1.3 times (Lahti et al. 2008). In Korean adolescents aged 12–18 years old who smoked cigarettes, the risk of oral symptoms (chipped or broken teeth, toothache, painful or bleeding gums) was 1.2 times higher than in non-smokers (Do 2016). The present study showed that even the introduction of confounding factors (socio-economic factors and oral health behaviors) into the logistic regression analysis did not reduce the association between cigarette smoking and the prevalence of oral pain or discomfort and absence from school due to oral pain. Cigarette smoking increased the risk of pain or discomfort by 1.3 times and the risk of dental appointment due to pain by 1.5 times. The risk of absence from school due to oral pain more than doubled (Table 5). Likewise, the risk of the occurrence of conditions requiring endodontic treatment or tooth extraction rose by over two times. This is certainly related to exposure to a cariogenic diet and neglect of dental care. However, it should be considered whether the dynamics of disease processes in dental tissue in smokers is not influenced by the weakened defense mechanism of dental pulp. It is acknowledged that nicotine reduces blood supply to tissues. Stimulating catecholamine secretion causes vasospasms. This reduces the concentration of prostacyclin

(PGI2), which leads to an increase in platelet aggregation, the formation of microthrombi, and capillary closure. It also hinders erythropoiesis and disrupts immune response mechanisms. Nicotine metabolites, among other things, impede collagen production and provoke connective tissue diseases.

Both the systemic effects of nicotine as well as the local thermal and toxic effects of cigarette smoke result in numerous oral diseases. It is beyond doubt that cigarette smoking increases the risk of severe periodontal disease. According to the results of the National Health and Nutrition Examination Survey, people smoking cigarettes at the age of 20 are four times more likely to develop periodontitis (Tomar and Asma 2000). Periodontal lesions were observed in adolescents who smoke. Ayo-Yusuf et al. (2009) reported more frequent gingival bleeding, while Heikkinen et al. (2008) demonstrated higher values of periodontal indices, such as visible plaque index, root calculus index, and PD≥4 mm. However, the periodontal statuses in smokers and non-smokers were similar in our study. We did not observe more frequent gingival bleeding among smokers. Other researchers even reported less frequent occurrences of gingivitis and gingival bleeding in smokers than non-smokers (Gupta et al. 2016). This might result from vasospasms caused by cigarette smoke and by the suppression of an inflammatory response. It is important because reduced gingival bleeding in smokers may conceal early symptoms of periodontal disease and hinder the diagnostic process. The impact of smoking on the periodontium also depends on the length and intensity of the addiction. In our study group of 18-year-olds, it was not a habit that had continued for many years, and only 60% of the subjects categorized themselves as smokers (smoking cigarettes every day), while the rest smoked less frequently. This could be the reason for the comparable frequency of periodontal lesions in smokers and non-smokers observed in this study.

The analysis of the influence of cigarette smoking on the periodontium should not ignore the potential effects of inappropriate dietary habits, which could lead to vitamin and calcium deficiencies. Dietary calcium deficiency during puberty constitutes a risk factor for developing osteoporosis later in life. Inadequate amounts of fruits and vegetables might lead to vitamin C deficiency, thus influencing the condition of the gingivae. In addition, vitamin C demand in smokers is higher than in non-smokers. This is because vitamin C, an antioxidant, plays a crucial role during smoking, which is accompanied by the formation of free radicals. Thus, inappropriate eating habits could have more harmful consequences in smokers than in non-smokers (Larson et al. 2007).

Conclusion

Scientific rationale for the study

Cigarette smoking by young people is indicative of a tendency to unhealthy behaviors that may persist into adult life. Such unhealthy behaviors negatively affect their oral health, increase the burden of oral diseases, and send the wrong message to the next generation. It is important to know the prevalence of cigarette smoking among 18-year-olds, who enter an independent adult life, and the relationship among smoking cigarettes, oral health, and oral health behaviors.

Principal findings

Adolescents who smoked regularly had significantly more unfilled cavities, more often suffered from oral pain or discomfort, and had worse dietary habits in comparison to 18-year-olds without these behaviors.

Practical implications

The results of this study confirm the negative effects of cigarette smoking on oral health behaviors and on the oral cavity in general. Cigarette smoking should be considered an independent risk factor for dietary errors and failure to benefit from dental healthcare by adolescents, which lead to dynamic damage of their teeth. These aspects should be taken into account while designing educational programs for adolescents, promoting a healthy lifestyle and patient-tailored education in dental surgeries.

Ethical approval and informed consent

The study was approved by the Bioethics Committee at the Medical University of Warsaw (KB/134/2017 of 6 June 2017).

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Conflict of interest

The authors have no conflicts of interest to disclose.

Authors' contributions

DO-K conceptualized and designed the study, critically reviewed and revised the manuscript for important intellectual content; JT participated in the analytical framework for the study, drafted the manuscript; UK coordinated and supervised data collection, participated in the analytical framework for the study; DG performed the final data analyses. All authors read and approves the final version of the manuscript to be published.

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References

Ayo-Yusuf OA, van den Borne B, Reddy PS, van Wyk PJ, and Severson HH. 2009. Longitudinal association of smoking-related attitude to oral health with adolescents' smoking onset. J Public Health Dent 69(1):29–33.

Benedetti G, Campus G, Strohmenger L, and Lingström P. 2013. Tobacco and dental caries: a systematic review. Acta Odontol Scand 71(3/4):363–71.

Ciecierski CC, Cherukupalli R, and Weresa MA. 2011. The Economics of tobacco and tobacco taxation in Poland. 1st edition. Paris: International Union Against Tuberculosis and Lung Disease.

Cinar AB, Christensen LB, and Hede B. 2011. Clustering of obesity and dental caries with lifestyle factors among Danish ado-

lescents. Oral Health Prev Dent 9(2):123–30.

Do KY. 2016. Do impact of health risk factors on the oral health of Korean adolescents: Korea youth risk behavior web-based survey, 2013. J Dent Hyg Sci 16(3):193–99.

Giannakopoulos G, Panagiotakos D, Mihas C, and Tountas Y. 2009. Adolescent smoking and health-related behaviours: interrelations in a Greek school-based sample. Child Care Health Dev 35:164–70.

Greenhalgh EM, Bayly M, and Winstanley MH. 2017. Prevalence of smoking–young adults. In: MM Scollo, MH Winstanley, editors. Tobacco in Australia: Facts and issues. [e-book] Melbourne. Available through: http://www.tobaccoinaustralia.org.au/chapter-1-prevalence/1-4-prevalence-of-smoking-young-adults

Gupta N, Gupta ND, Goyal L, Moin S, Khan S, Gupta A, and Garg S. 2016. The influence of smoking on the levels of matrix metalloproteinase-8 and periodontal parameters in smoker and nonsmoker patients with chronic periodontitis: A clinicobiochemical study. J Oral Biol Craniofac Res 6(Suppl 1):39–43.

Hasselkvist A, Johansson A, and Johansson AK. 2014. Association between soft drink consumption, oral health and some lifestyle factors in Swedish adolescents. Acta Odontol Scand 72(8):1039–46.

Hecht SS. 2003. Tobacco carcinogens, their biomarkers and tobacco-induced cancer. Nat Rev Cancer 3:733–44.

Heikkinen AM, Pajukanta R, Pitkäniemi J, Broms U, Sorsa T, Koskenvuo M, and Meurman JH. 2008. The effect of smoking on periodontal health of 15- to 16-year-old adolescents. J Periodontol 79:2042–47.

Hirsch JM, Livian G, Edward S, and Noren JG. 1991. Tobacco habits among teenagers in the city of Göteborg, Sweden, and possible association with dental caries. Swed Dent J 15(3):117–23.

Holmén A, Strömberg U, Magnusson K, and Twetman S. 2013. Tobacco use and caries risk among adolescents – a longitudinal study in Sweden. BMC Oral Health 13:31.

Idrizovic K, Zenic N, Tahiraj E, Rausavljevic N, and Sekulic D. 2015. Cigarette smoking among 17–18 year old adolescents – prevalence and association with sociodemographic familial sport and scholastic factors. Med Pr 66(2):153–63.

Lahti S, Sipilä K, Taanila A, and Laitinen J. 2008. Oral pain and associated factors among adolescents in northern Finland. Int J Circumpolar Health 67(2/3):245–53.

Larson NI, Story M, Perry CL, Neumark-Sztainer D, and Hannan PJ. 2007. Are diet and physical activity patterns related to cigarette smoking in adolescents? Findings from project EAT. Prev Chronic Dis 4(3):A51.

Millar WJ, and Locker D. 2007. Smoking and oral health status. J Can Dent Assoc 73(2):155.

Panatto D, Amicizia D, Domnich A, Lai PL, Cristina ML, Signori A, Boccalini S, Sulaj K, and Gasparini R. 2013. Tobacco smoking among students in an urban area in Northern Italy. J Prev Med Hyg 54(2):97–103.

Peker I, and Alkurt MT. 2009. Oral health attitudes and behavior among a group of Turkish dental students. Eur J Dent 3(1):24–31.

Petersen PE, Jiang H, Peng B, Tai BJ, and Bian Z. 2008. Oral and general health behaviours among Chinese urban adolescents. Community Dent Oral Epidemiol 36:76–84.

Rodrigues PRM, Padez CMP, Ferreira MG, Gonçalves-Silva RMV, and Pereira RA. 2016. Multiple risk behaviors for non-communicable diseases and associated factors in adolescents. Rev Nutr 29(2):185–97.

Sekulic D, Ostojic M, Ostojic Z, Hajdarevic B, and Ostojic L. 2012. Substance abuse prevalence and its relation to scholastic achievement and sport factors: An analysis among adolescents of the Herzegovina-Neretva Canton in Bosnia and Herzegovina. BMC Public Health 12(1):274.

Sekulic D, Ostojic M, Vasilj M, Coric S, and Zenic N. 2014. Gender specific predictors

of cigarette smoking in adolescents: An analysis of sport participation, parental factors and religiosity as protective/risk factors. J Subst Abuse 19(1–2):89–94.

Sgan-Cohen HD, Katz J, Horev T, Dinte A, and Eldad A. 2000. Trends in caries and associated variables among young Israeli adults over five decades. Community Dent Oral Epidemiol 28:234–40.

Tomar SL, and Asma S. 2000. Smoking-attributable periodontitis in the United States: findings from NHANES III. National Health and Nutrition Examination Survey. J Periodontol 71(5):743–51.

Trząsalska A, Staszyńska M, and Krassowska U. 2017. A report from a nationwide survey on attitudes towards smoking tobacco Kantar Public for the Chief Sanitary Inspectorate. Available from https://gis.gov.pl/wp-content/uploads/2018/04/Postawy-Polak%C3%B3w-do-palenia-tytoniu-Raport-2017.pdf.

Wang M, Wang H,. Fei F-R, Xu C-X, Du X-F, and Zhong J-M. 2017. The associations between cigarette smoking and health-related behaviors among Chinese school-aged adolescents. Tob Induc Dis15:27.

World Health Organization. 2013. Oral Health Surveys: Basic Methods. Geneva: WHO.

Yorulmaz F, Akturk Z, Dagdeviren N, and Dalkilic A. 2002. Smoking among adolescents: relation to school success. socioeconomic status nutrition and self-esteem. Swiss Med Wkly 132(31/32):449–54.