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Developmental defects of enamel in the population of Polish adolescents aged 18 years old: the prevalence and selected socio-demographic factors. A cross-sectional study**

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Keywords

developmental defects of enamel, hypoplasia, DDE Index, Dean's Index

Summary

Introduction. There has been a lack of current epidemiological data regarding the prevalence of developmental defects of enamel in Polish adolescents.
Aim. To evaluate the prevalence of developmental defect of enamel in the permanent dentition in the population of adolescents aged 18 years old, including the impact of selected sociodemographic factors.
Material and methods. A cross-sectional study conducted in 2017 covered adolescents aged 18 years old attending schools in 16 Polish voivodeships, selected by stratified sampling. Sociodemographic factors such as sex, place of residence, parents' education level and subjective economic status were collected with a survey. The condition of enamel was assessed with the use of DDE Index modified by Clarkson and Dean's Indicator by dentists specially trained and calibrated for this study. Prior to its initiation, the study was approved by the Bioethics Committee of the Medical University in Warsaw (Ref. No.: KB/134/217 of 6.06.217).
Results. A total of 1611 adolescents were examined (with 52.6% female and 50.5% were residents of rural areas). Developmental defects of enamel were identified in 16.3% of the participants of the study, most frequently in the form of demarcated opacities (10.4%). In 2.7%, they were classified as fluorosis, most frequently questionable. Maxillary central incisors and first premolars were most frequently affected. In 2.5% of the examined adolescents, the defects involved single teeth, whereas in 0.6% the defects were generalised. Defects not classified as fluorosis were more commonly identified in males. There were statistically significant differences in the prevalence between voivodeships, with defects most commonly observed in participants from southern voivodeships. No other sociodemographic factors, however, were identified as significant.

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Conclusions. The highest prevalence of demarcated opacities suggests the significance of local factors in the aetiology of developmental enamel defects of permanent dentition in Poland. Fluorosis is a rarely encountered entity. The lack of the significance of sociodemographic factors and the regional differences in the prevalence of developmental defects of enamel suggest the need for further research, aimed at identifying geographical risk factors.

Introduction

Developmental defects of tooth enamel (DDE) are an important health problem, detrimental to a person's quality of life. They may affect the appearance, increase teeth sensitivity, predispose for the development of caries, abrasion and erosion (1-3). In a study performed among adolescents aged 16 years old, 18.8% of the participants avoided showing their teeth when smiling due to DDE, 8.7% avoided social contacts and 5.7% had experienced mocking by peers (4).

DDE may be either quantitative, involving a decreased enamel thickness or local lack of enamel (hypoplasia), or qualitative, presenting as opacities or discoloration of enamel (1, 2). Depending on the putative factor at work during amelogenesis and the time frame of exposure, DDE may be generalised, or affect groups of teeth or single teeth. The defects found in single permanent teeth are caused by an injury or infection, e.g. of the primary predecessor (5, 6). In the case of defects involving a group of teeth or all teeth, various genetic and environmental factors may play a role (7-21), such as environmental pollution and a low socioeconomic status (13-21).

In 1990, a country-wide study evaluated the prevalence of DDE in Poland, confirming the role of the fluoride level in the drinking water and systemic factors for DDE aetiology (12, 22). The study covered adolescents living in areas supplied with naturally fluoridated drinking water and those with artificially fluoridated water. Since 1996, drinking water in Poland has not been artificially fluoridated any more. Hence the need for the update of the epidemiological data.

Aim

This study has been aimed at evaluating the prevalence of DDE in permanent dentition in the population of Polish adolescents aged 18 years old, including the impact of selected sociodemographic factors.

Material and method

The survey and the clinical examination covered adolescents 18 years old who were students of vocational and higher secondary schools country-wide. The participants provided their written consent for the participation in the study. The schools were selected by stratified sampling. In each of the voivodeships, poviats, communities (all Polish administrative units, *województwa*, *powiaty* and *gminy*, respectively) and then schools were randomly selected.

The study complied with WHO criteria (23) and was performed by 22 dental examiners (dentists) who were specially trained and calibrated. Inter-rater reliability between the reference examiner and other examiners ranged from 0.802 to 1.00 Cohen's kappa coefficient, whereas intra-rater reliability was 0.998.

The survey was conducted with the use of a questionnaire including questions about sex, place of residence (urban/rural, which voivodeship), parents' education level, family economic status in the participant's opinion.

In the clinical examination, performed in artificial light with the WHO 621 probe, the teeth were evaluated for the presence and type of developmental enamel defects and their distribution. The defects were classified based on their macroscopic appearance according to DDE Index modified by Clarkson as diffuse or demarcated opacities, enamel hypoplasia, discolouration and "other" (a combination of more than one type of defects) (24). The following types of hypoplasia were accounted for: pits, grooves and enamel missing on dental surface or the incisal edge. Following WHO recommendations, Dean's index was used to evaluate dental fluorosis (25).

Prior to its initiation, the study was approved by the Bioethics Committee of the Medical University in Warsaw (Ref. No.: KB/134/217 of 6.06.217).

The obtained results were statistically analysed. Means between two groups (urban vs rural area or male vs female) were compared with Student's t-test, whereas percent values were compared with the chi-square test. The statistical significance level was set at $p \leq 0.05$. The statistical analyses were performed with Statistica 12.0 software.

Results

A total of 1611 adolescents aged 18 years old were examined. The studied group comprised 847 females (52.6%) and 764 males (47.4%), and 797 (49.5%) residents of urban areas and 814 (50.5%) residents of rural areas. In different voivodeships, the number of participants ranged from 99 in Łódzkie Voivodeship to 110 in Małopolskie Voivodeship (mean 100.68 ± 2.52). The participants most frequently stated their family's economic status as "average" (55.5%), followed by "above average" (23.7%), and least frequently as "below average" (2.9%). 17.9% did not provide their subjective economic status at all. The group's composition according to parents' level of education have been shown in figure 1.

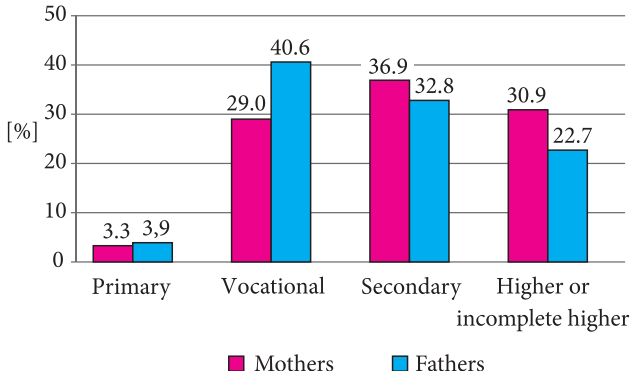

Fig. 1. The level of education of the parents of the examined adolescents aged 18 years old

DDE were found in 16.3% of the examined adolescents, including 2.7% defects classified as fluorosis. The prevalence of DDE and the mean number of the affected teeth have been shown in table 1. The most common type of DDE were demarcated opacities (168/10.4%), followed by diffuse opacities (65/4.0%), hypoplasia (25/1.6%), discolouration (2/0.1%) and a combination of different defects (10/0.6%). Out of 26 noted cases of hypoplasia, dental surface hypoplasia (14/53.8%) and pits (9/34.6%) were the most commonly encountered, whereas grooves (2/7.7%) and missing enamel on the incisal edges (1/3.9%) were less frequent.

Demarcated opacities were found in 1.8% of all examined teeth, diffuse opacities in 1.2% and hypoplasia – in 0.1%. The defects most commonly involved the enamel of maxillary central incisors and first premolars (fig. 2). Diffuse opacities were more evenly distributed than demarcated opacities and hypoplasia.

DDE in single teeth were found in 41 adolescents (2.5%), including 33 (2%) participants with demarcated opacities and 8 (0.5%) with hypoplasia. Most commonly, they involved maxillary incisors (1.7%), less frequently maxillary premolars (0.8%) and mandibular premolars (0.1%). Generalised defects were found in 9 participants of the study (0.6%). In 4 (0.25%) of them they were diffuse opacities, in 3 (0.19%) demarcated opacities and in 2 (0.12%) – a combination of defects.

No cases of moderate and severe fluorosis were identified. Most cases were classified as questionable fluorosis (1.5%), less frequently very mild fluorosis (0.9%) and very rarely as mild fluorosis (0.2%).

The prevalence and the mean number of teeth with DDE not classified as fluorosis were significantly higher in males (tab. 1). No similar trends were noted in the case of fluorosis cases, except for questionable fluorosis, which more frequently affected females than males (2.1 vs. 0.8%, $p = 0.027$).

The prevalence of DDE in given voivodeships ranged from 0% in Lubelskie Voivodeship to 63.6% in Małopolskie Voivodeship ($p < 0.001$). Fluorosis cases were noted only in Pomorskie (Wejherowo), Kujawsko-Pomorskie, Zachodniopomorskie (Szczecin), Śląskie (Jastrzębie Zdrój), Dolnośląskie (Oława), Warmińsko-Mazurskie (Elbląg), Opolskie (Krapkowice) and Małopolskie (Tarnów) Voivodeships (fig. 3). Mild fluorosis was identified in a total of 4 examined adolescents, 3 residents of Dolnośląskie Voivodeship and 1 resident of Pomorskie Voivodeship (Wejherowo) (tab. 2).

Spearman's rank correlation did not confirm a relationship between the presence of DDE and their type and either parents' level of education or the subjective economic status.

Tab. 1. The prevalence of DDE in the population of adolescents aged 18 years old according to the place of residence (urban vs. rural) and sex

	DDE overall		DDE not classified as fluorosis		Fluorosis	
	Number of affected adolescents %	Mean number of teeth ± SD	Number of affected adolescents	Mean number of affected teeth ± SD	Number of affected adolescents	Mean number of affected teeth ± SD
Urban areas	143/17.9%	1.32 ± 5.02	119/14.9%	0.91 ± 3.34	24/3.0%	0.41 ± 2.76
Rural areas	120/14.7%	1.09 ± 4.73	101/12.4%	0.79 ± 3.34	19/2.3%	0.30 ± 2.29
p	0.082	0.338	0.140	0.472	0.399	0.371
Females	130/15.3%	1.11 ± 4.82	102/12.0%	0.69 ± 2.88	28/3.3%	0.42 ± 2.70
Males	133/17.4%	1.31 ± 4.95	118/15.4%	1.03 ± 3.78	15/2.0%	0.28 ± 2.33
p	0.264	0.410	0.047*	0.041*	0.095	0.271
Total	263/16.3%	1.21 ± 4.88	220/13.7%	0.85 ± 3.34	43/2.7%	0.35 ± 2.53

*statistical significance

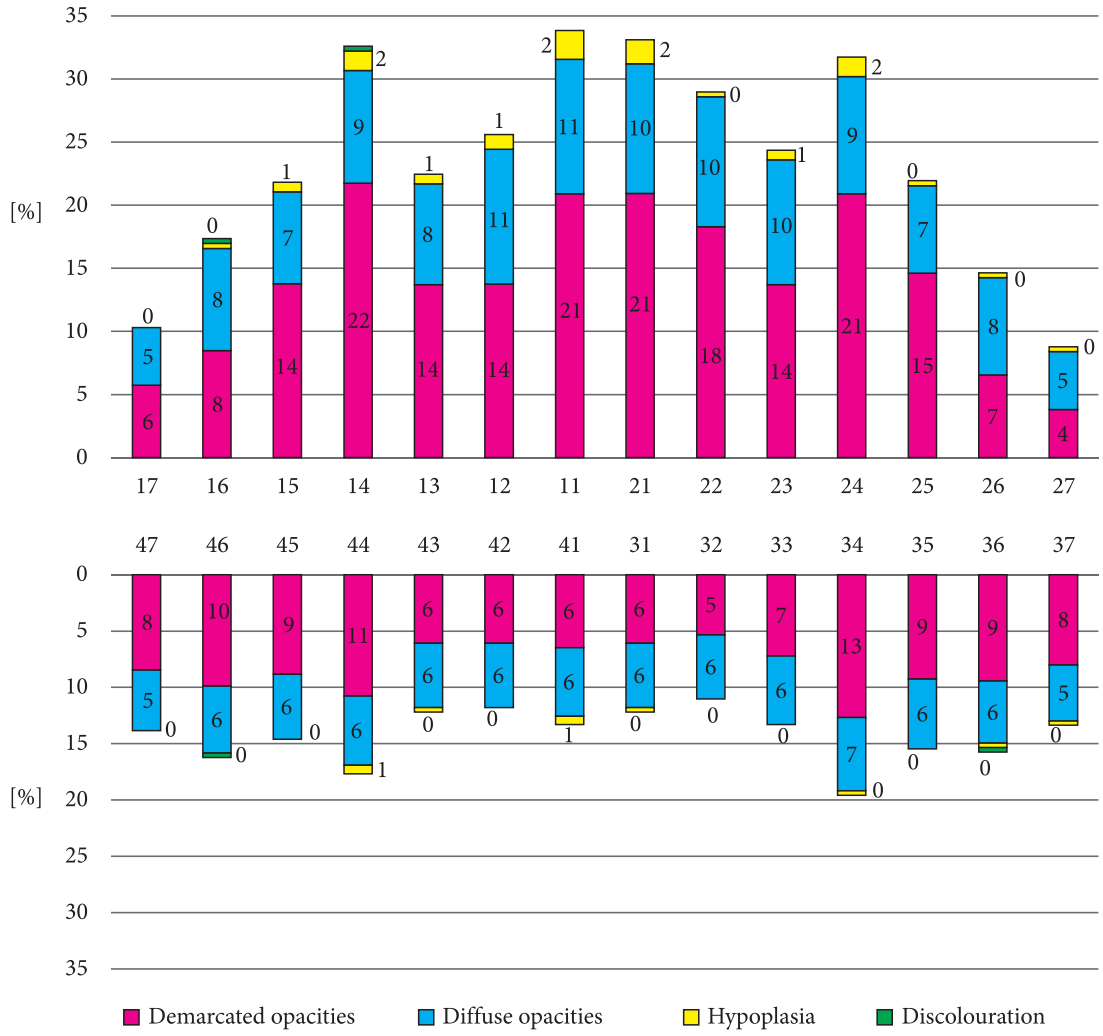

Fig. 2. The distribution of DDE according to given teeth in the entire examined population of adolescents aged 18 years old

Discussion

According to the results of studies that have been published since 2000, the prevalence of DDE in developed countries ranges from 6.7% in the age group of 8-12 year-olds (21) to 67.1% in the age group of 16 yea-olds (4). In the population of 18 year-olds examined in this study, DDE were found in 16.7%, which falls within the range noted in populations of adolescents from other European countries (8% in Portugal (26), 32.8% in Bosnia and Herzegovina (27), 51.2% in Spain (9). In other areas of the world, DDE prevalence is 46.4% in Brazil (28), 35.2% in Hong Kong (15), 29-57% in Sri Lanka (16) and 66.2% in India (29).

The most common type of DDE found in our study were opacities, which is also in line with data cited in literature. In our group, these were mostly demarcated opacities, accounting for 64.4% of all observed defects. Similar findings were obtained by Ravindran and Saji (30). In their study, the most common defect in a population of adolescents 12-15 years old were demarcated opacities, and the least common one – a combination of diffuse opacities and hypoplasia or a combination of demarcated and diffuse opacities and hypoplasia (30). In Spanish teenagers, demarcated opacities affected 4.4% of the examined teeth, diffuse opacities – 3.3%, and hypoplasia – 0.8% (9). Contrary to the findings cited above, in the group of adolescents studied by Sujak et al., diffuse opacities accounted for 63.5% of the observed DDE (4). Similarly, Chauhan and Chauhan in their study conducted in India found the most common DDE type to be diffuse opacities (25.3%), followed by demarcated opacities (23.1%), whilst hypoplasia was the least common (2.9%) (29).

In our study, DDE most often affected maxillary central incisors and premolars. According to numerous studies, DDE are most typically located in central incisors, whilst first molars, not premolars are the second most common location (1, 9, 31-34). In the study by Ravindran and Saji, the right maxillary first premolar was, in fact, the least frequent location of DDE (30).

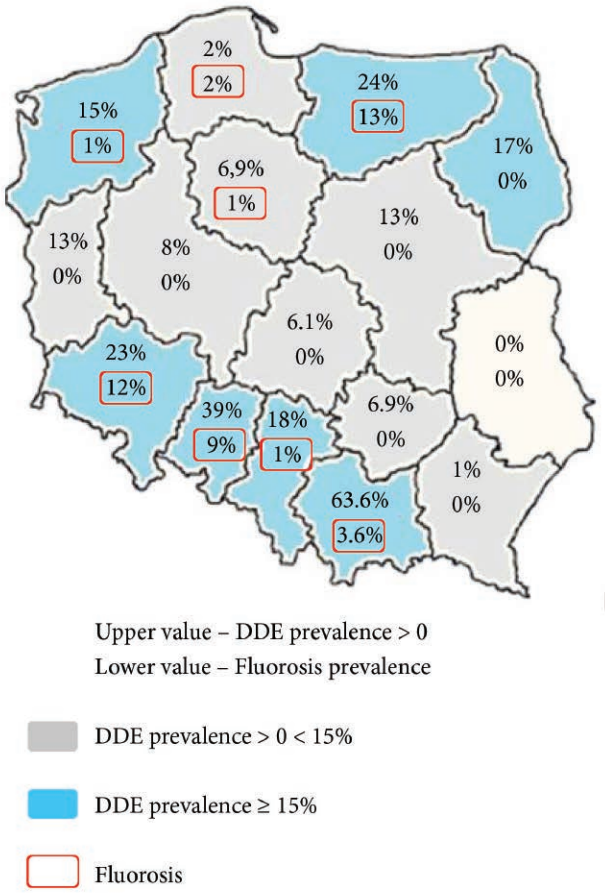

Fig. 3. The total prevalence of DDE and the prevalence of fluorosis in adolescents aged 18 years old according to the voivodeship

The differences in the distribution of DDE may be due to their different aetiology, as suggested by the differences in the prevalence of demarcated and diffuse opacities, the participants' age and the used methodology of the studies. Most of the cited studies were performed in younger age groups. The distribution of the defects in the population of 18 year-olds was also impacted by the fact that 12.1% of them had at least one permanent tooth missing, most frequently the first molar (35). In our study, demarcated opacities were the most common. In every fifth examined adolescent, a single incisor or premolar was involved, suggesting an important role of local factors. The distribution of diffuse opacities, most typically caused by systemic factors, was more even than of demarcated opacities and hypoplasia. Fluoride exposure is one of the recognised putative factors. The prevalence of DDE has been demonstrated to increase with high fluoride levels in the drinking water. In a study by Ekanayake and vand der Hoek, the prevalence of DDE increased from 29% at fluoride concentration in the drinking water of < 0.3 mg/l, to 35% at 0.3-0.5 mgF/l, 43% at 0.5-0.7 mgF/l, to 57% at the concentration of > 0.7 mgF/l (16). Balmer et al., who compared the prevalence of DDE in Sidney, Australia (0.9-1.5 mgF/l in the drinking water) and in Leeds, Great Britain (< 0.1 mgF/l in the drinking water), noted not only higher mouth prevalence of DDE in Australia, but also higher tooth prevalence (51.6 vs. 27.3%) (14). Slightly different results were obtained in a Polish country-wide study evaluating DDE prevalence in permanent teeth, conducted 27 years ago in the age group of 12-14 years old (22). Interestingly, the study demonstrated

Tab. 2. The severity of fluorosis in the studied population of adolescents aged 18 years old in given voivodeships

Voivodeship	No fluorosis	Equivocal fluorosis	Very mild fluorosis	Mild fluorosis
	n/%			
Warmińsko-Mazurskie	87/87.0%	11/11.0%	2/2.0%	0/0.0%
Dolnośląskie	88/88.0%	5/5.0%	4/4.0%	3/3.0%
Opolskie	91/91.0%	1/1.0%	8/8.0%	0/0.0%
Małopolskie	106/96,4%	4/3.6%	0/0.0%	0/0.0%
Pomorskie	98/98.0%	1/1.0%	0/0.0%	1/1.0%
Śląskie	99/99.0%	0/0.0%	1/1.0%	0/0.0%
Kujawsko-Pomorskie	100/99.0%	1/1.0%	0/0.0%	0/0.0%
Zachodniopomorskie	99/99.0%	1/1.0%	0/0.0%	0/0.0%
p	< 0.001*	< 0.001*	< 0.001*	0.002*

considerable differences in the prevalence of DDE according to the region, regardless of the fluoride concentration in the drinking water in a given region. In areas with trace fluoride levels, the prevalence ranged from 15.00% in Zabrze, to 35.83% in Kraków, 38.52% in Oleśnica, to 81.66% in Lublin (the area of the city with the non-fluoridated water supply). In regions supplied with artificially fluoridated water (1.0 ppm F), the prevalence of DDE ranged from 31.66% in Rabka to 56.66% in Lublin (the area of the city with fluoridated water supply) and 56.85% in Wrocław. In regions with excessive natural fluoride in the drinking water, the prevalence was 60.00% (Lubliniec, 1.6 ppm F) and 97.00 % (Nysa ≥ 4 ppm F) (22).

In our study, however, the prevalence of fluorosis was 2.7%, with over 50% of fluorosis cases classified as questionable. As little as 0.2% of all examined adolescents were diagnosed with mild fluorosis. 16.3% of all identified DDE were classified as fluorosis. Poland is one of the countries with low fluoride levels (< 0.5 ppm F/l) in the drinking water (< 0.5 ppm F/l) in most of its territory.

Aside from the 1990 country-wide study cited above, fluorosis was also reported in publications presenting the results of locally conducted studies, in most cases performed in locations with excessive fluoride concentration in the drinking water. Wochna-Sobańska et al. reported fluorosis in 18.2, 33.4 and 35.7% adolescents aged 12 years old, who were residents of locations where the fluoride level in the drinking water was respectively 1.25, 1.35, 1.60 mg/l, and absence of fluorosis cases at a fluoride level in the drinking water of 0.25 mg/l (36). Fluorosis is also found in regions with low fluoride levels in the drinking water, due to exposure to fluoride from other sources, such as personal hygiene products and foods. An increased risk for permanent teeth hypoplasia has been demonstrated in children who were exposed to adult toothpaste in their first three years of life (19). On the other hand, Wong et al. did not find a statistically significant correlation between the occurrence of DDE and personal hygiene habits, such as the age at which toothpaste was introduced, the type of toothpaste used, its amount per each use, or the frequency of brushing teeth (15). On the other hand, it has been demonstrated that infant formulas prepared with drinking water with fluoride concentration > 0.5 mg/l may cause excessive daily fluoride exposure in infants (37). The possibility of excessive infant exposure to fluoride even when the fluoride concentration in the drinking water is optimal has been confirmed by a study conducted in Wielkopolskie Voivodeship in Poland. At a fluoride level in the drinking water not exceeding 0.4 mg/l, fluorosis was identified in 17% of children and adolescents aged 6-14 years old, with 11% of the examined children and adolescents presenting with defects located in the first molars and permanent incisors (38). According to the most recent comprehensive literature review published in 2015, the prevalence of appearance-affecting fluorosis is 8% at 0.1 mgF/l in the drinking water, 12% at 0.7 mgF/l and 15% at 1 mgF/l. According to its authors, however, the mildest form of fluorosis is only visible for trained examiners and does not affect the appearance (39).

In our study, there were considerable differences in the prevalence of DDE, including fluorosis, depending on the region of the country. Mouth prevalence was higher in the southern and northern regions of Poland than in its central regions. For instance, no DDE were found in any of the examined adolescents in Lubelskie Voivodeship, compared with as many as 63.6% affected by DDE in the Małopolskie Voivodeship. Southern (Dolnośląskie, Opolskie and Małoposkie) and northern (Warmińsko-Mazurksie) voivodeships also showed the highest prevalence of fluorosis, whilst in the remaining voivodeships, the prevalence ranged from 0 to 2%.

One of the reasons for the differences in the prevalence of DDE in different regions of the world and even within one country may be the impact of sociodemographic factors, including environmental factors, lifestyle, diet etc. In our study, we found no statistically significant differences in the prevalence of DDE between urban and rural areas or between female and male participants, even though the prevalence of DDE in males and residents of urban areas was higher than in females and residents of rural areas. Similar findings were obtained in some other studies (40, 41). We did not identify any impact of parents' education level or subjective economic status on the prevalence of DDE. In a study by Ford et al., on the other hand, the socioeconomic status was identified as an important predictor of permanent teeth hypoplasia (19). Wong et al., however, did not confirm the correlation, pointing to the difficulties in obtaining retrospectively reliable information regarding the possible putative factors of DDE and the need for further research (15).

Conclusions

The higher prevalence of demarcated opacities than other types of DDE in the general population of adolescents aged 18 years old, frequently found in single teeth, suggests the important role of local factors in the aetiology of DDE in Poland. Fluorosis is a rare condition, classified as questionable in most cases.

A lack of correlation between the studied socioeconomic factors and the differences in the prevalence of DDE in different regions of Poland points to the need for studies aimed at identifying the risk factors associated with a given geographical region.

Conflict of interest

None

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