Acta Odontologica Scandinavica, 2013; 71: 475–481

informa
healthcare

ORIGINAL ARTICLE

Prevalence and severity of dental erosive wear among a group of Norwegian 18-year-olds

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Abstract

Objective. The aim was to study prevalence, distribution and severity of erosive wear in a group of 18-year-olds. ***Materials and methods.*** A total of 1456 adolescents were screened for erosive wear as part of their regular visit at the Public Dental Health Service (PDHS) clinics in Oslo. Of 554 (38%) registered with erosive wear, 267 accepted a second examination to record lesion distribution and severity, performed by one previously calibrated clinician. A tested erosive wear system (VEDE) was used. Occlusal surfaces of the first and second molars in both jaws and the labial and palatal surfaces of the upper incisors and canines were selected as index surfaces. ***Results.*** Of the 267 individuals with erosive wear, 13.5% were without lesions, 54.3% had erosive wear in enamel only, whereas 32.2% had at least one lesion extending into dentine. The upper central incisors (46%) and first lower molars (44%) were the most affected teeth with the highest presence on the palatal surfaces. Cuppings were registered in 62% of the individuals, usually in addition to erosive lesions on other surfaces. Eighty-five per cent of the cuppings were on first molars and 34% on the mesio-buccal cusp. Males had significantly more lesions into dentine compared with females ($p = 0.03$). There was a significant association between presence of erosive lesions and DMFT ($p < 0.01$), but no association between lesions and socio-economic or national background. ***Conclusions.*** A high proportion of adolescents had erosive wear. Cuppings were a common finding.

Key Words: *adolescents, dental erosion, prevalence, severity*

Introduction

A number of epidemiological studies of dental erosion among children and adolescents have been published [1–6], showing a high variation in prevalence. Among adolescents aged 14–17 years prevalence data between 14–100% has been reported, mostly confined to enamel and higher in males [7]. Presence on maxillary, anterior teeth has been commonly found in some studies [8–10], whereas others have recorded lesions in molar teeth mostly [2,11].

The associations between the presence of dental erosions and dental caries, socio-economic factors and national background have shown inconclusive results. Some studies [3,12] have demonstrated a significantly higher caries experience among children with high prevalence of dental erosion, whereas others [13,14] could not verify this association. Furthermore, several studies have reported that children with low socio-economic status have more erosive lesions compared with others [1,4,6,15], while other studies do not confirm these findings [3,13,14,16,17]. Results from studies comparing national background and ethnicity with erosive wear are also ambiguous [15,18].

The reported variations [7,19] may be explained by different populations and age groups studied and/or different indices and examination standards. In addition, many studies report on tooth wear prevalence in general. Although the terms dental erosion and dental erosive wear are often considered synonymous, dental erosive wear is in the present paper considered as clinically manifest erosion-facilitated wear. Furthermore, the importance of testing a scoring system has been pointed out previously [20]. Therefore, prior to initiating the present study the scoring system applied, Visual Erosion Dental Examination (VEDE), was tested [21].

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(Received 26 November 2011; revised 29 February 2012; accepted 2 April 2012)

ISSN 0001-6357 print/ISSN 1502-3850 online
DOI: 10.3109/00016357.2012.696689

So far, no epidemiological study of dental erosive wear among Norwegian adolescents has been performed. The aim of the present study was to assess the prevalence of dental erosive wear and to describe the distribution and severity in the dentition among a group of 18-year-olds and to study possible associations with caries experience, socio-economic- and national backgrounds.

Study population

Sample size calculation was performed prior to initiating the study and assumed a dental erosion prevalence of 25%. This assumption was based on reported prevalence values of 5–22% from other Scandinavian countries [8,10,22], a non-response rate of 30% and a drop-out of 26% [23]. A sample of 265 was needed (95% CI).

The study was conducted in all Public Dental Helath Service (PDHS) clinics in Oslo, the capital of Norway during 2008 and was designed as a cross-sectional, descriptive study. All 18-year-olds scheduled for clinical examination in the PDHS clinics (n = 3206) were invited to participate, providing ~50% of all 18-year-olds in Oslo.

Methods

Information and calibration meetings

Participating dentists and dental hygienists (one or two in each clinic) in the PDHS clinics (n = 20) attended information meetings accompanied by several lectures on dental erosive wear presented by the main author (AM). Furthermore, instruction in the use of the VEDE system was provided and the pictorial manual was distributed to the clinicians [21]. The information meetings were repeated twice during the data collection period.

The first author (AM) was previously calibrated both on clinical intra-oral photographs (together with four examiners) and on a group of adolescents (together with two examiners) [21]. For the calculation of the intra-examiner agreement, 30 adolescents (600 surfaces) were re-examined 10–21 days after their initial examination. Furthermore, the measuring system VEDE has been tested and previously described [21].

Clinical examination

The examination of the adolescents was performed by a dentist or a dental hygienist at their respective PDHS clinic as part of the regular dental recall examination. The examination was carried out in a fully equipped dental clinic using standard lighting, mouth mirrors and probes. The teeth were dried by compressed air and, if necessary, cotton rolls were used to remove food debris. The presence of erosive wear was registered on all teeth and surfaces without the severity grading (yes/no erosion). Suspected lesions were also included. All participants registered with dental erosive lesions were subsequently offered a second examination to record the distribution and severity of the lesions by one trained and calibrated clinician (AM) [21]. In addition, 20 adolescents, one from each PDHS clinic, without registered erosive lesions were also re-examined by the trained clinician to record possible under-registration (Figure 1). Twenty surfaces per participant were examined: the occlusal surfaces of the first and second molars in both jaws and the labial and palatal surfaces of the upper incisors and canines. Dental erosive wear was classified by the VEDE system according to the following criteria: score 0: no erosion, score 1: initial loss of enamel, no dentine exposed; score 2: pronounced loss of enamel, no dentine exposed; score 3: exposure of dentine, $<^1/_3$ of the surface involved; score 4: $^1/_3$–$^2/_3$ of the dentine exposed; score 5: $>^2/_3$ of dentine exposed. In cases of doubt, the lower score was recorded and only lesions that were considered as obvious dental erosive wear defects were registered, including cuppings/grooves of the molar cusps. The cuppings were classified as score 1: initial loss of enamel, no dentine exposed; score 2: pronounced loss of enamel, no dentine exposed; score 3: exposure of dentine. The differentiation between enamel and dentine cuppings was based on colour, depth of the cuppings and whether there was sensitivity or not in the cupping. When index surfaces were either filled, bonded with a retainer, considered to have attrition and wedge-shaped defects or the tooth had been extracted, the surfaces and teeth were recorded as missing and excluded.

Caries experience was measured as DMFT (decayed, missed, filled teeth) and was based on already existing values found in the participant's dental record. Surfaces were defined as decayed if the caries lesions extended into dentine. The participants were defined as having no caries experience when $D_{0\text{-}2}MFT = 0$ and as having caries experience when $D_{3\text{-}5}MFT > 0$.

The adolescents were asked about their place of residence and the national background. According to the area of residence, socio-economic status was categorized into the east- and west-end of the city of Oslo (east-end: low income, west-end: high income). The distinction between these areas is defined by Statistics in Norway based on the household net income [24]. National background was recorded according to mother's and participant's country of birth. Their national origin was combined into one variable and thereafter dichotomized as western origin (both mother and participant born in a western country) or non-western origin (either mother or participant born in a non-western country). Non-western origin included the individuals with

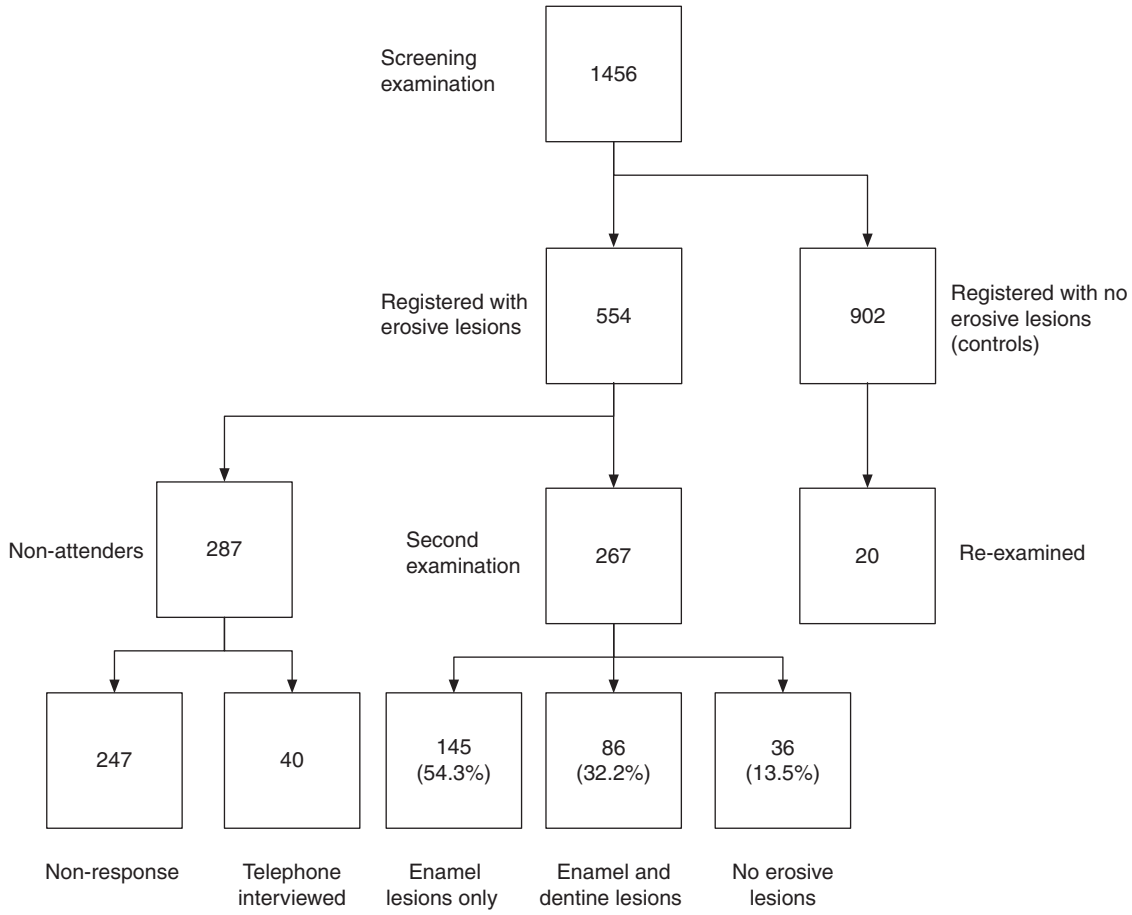

Figure 1. Study design and numbers of subjects at each phase of the study.

birth place from Eastern Europe, Turkey, Asia, Africa, South and Central America [25].

Statistical analysis

The statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS, Inc. Chicago, IL, version 16). The absolute frequencies and proportions were obtained for data analysis (descriptive) and bivariate analysis (Chi-squared test) for testing possible associations between the variables. The level of significance was set at 5%. Calculation of weighted kappa (κ_w) was undertaken using a spreadsheet programme (Microsoft Excel). Cohen's kappa was rated as suggested by Landis and Koch [26]: <0.40; 0.41–0.60; 0.61–0.80; 0.81–1.0.

Table I. Characterization of the 267 examined individuals regarding the presence and severity of dental erosive wear.

	Number of individuals % (n)	≤2 surfaces %	>2 surfaces %
No erosive lesions	13.5 (36)		
Enamel lesions only (score 1 and 2)	54.3 (145)	13	87
Enamel and dentine lesions (score 1–5)	28.8 (77)	53*	47*
Dentine lesions only (score 3–5)	3.4 (9)	100	0

*Proportion with dentine exposure.

Ethical considerations

The study was approved by the local Regional Committee for Medical Research Ethics and The Norwegian Social Science Data Services. Written, informed consent was obtained from all participants.

Results

The mean inter-examiner reliability on a surface by surface basis was 0.77 (κ_w) (on photographs) and 0.73 (on patients), indicating substantial agreement [21,26], while the intra-examiner was 0.95 (κ_w), indicating a very good level of agreement [26].

Of 3206 individuals invited to participate in the study, 1750 declined and 1456 were initially examined (45% of all 18-year-olds scheduled for clinical check-up), 53% females and 47% males. Comparing the examined participants with those

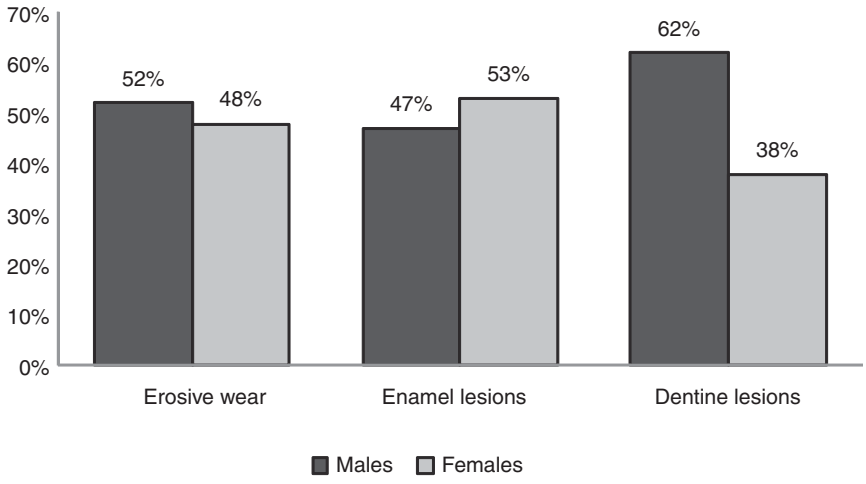

Figure 2. Proportions of male and female participants with erosive wear (enamel and dentine lesions) during the second examination ($n = 231$).

who declined to participate revealed no DMFT or gender difference. Mean DMFT was 4.0 and 3.9, respectively, and male distribution was 47% and 48%, respectively.

Among 1456 individuals, erosive lesions were registered in at least one tooth among 554 (38%) adolescents, more frequently in males than females (45% men, 32% females; $p < 0.01$). A second examination on distribution and severity of the lesions was completed on 267 (48%) participants, while 287 did not attend this examination (Figure 1). When re-examining the participants (50% males and 50% females), 13.2% ($n = 36$) had no signs of erosive wear, 54.3% ($n = 145$) had enamel erosion only and 32.2% ($n = 86$) had dentine exposure (Figure 1). Of these, a combination of enamel and dentine involvement was seen among 77 participants, while nine had dentine lesions only (Table I). A significantly ($p = 0.03$) higher frequency of dentine lesions was found in males (Figure 2). Lesions on both molars and anterior teeth were seen in 119 (52%) of the individuals, followed by lesions on molars only ($n = 83$, 36%) and on anterior teeth only ($n = 29$, 12%).

The proportions of dental erosive wear by severity and by tooth are shown in Table II. A slightly higher frequency of erosive lesions was observed on upper central incisors (46%) compared with first molars (44%). Enamel lesions dominated in all teeth, but dentine lesions were most frequently seen on first molars (30%). The localization and severity of erosive lesions are shown in Figure 3.

Of 231 participants with erosive lesions, cuppings were seen in 62% ($n = 144$), usually in combination with erosive wear on other surfaces (56%). The occlusal surfaces of the first molars had highest frequency of the cuppings ($n = 225$, 85%) and the cuppings were usually confined to enamel, although dentine involvement was found in 21%. The lower first molars were most often affected (50% of tooth 36 and 36% of tooth 46, $p = 0.71$). The mesio-buccal surface of first molars was affected in 34% of cases and the only one with dentine exposure. No dentine exposed cuppings were registered on the second molars.

All 20 adolescents with no registered erosive lesions in the screening session were without lesions also when re-examined by the trained clinician.

Of 1456 individuals, the DMFT status was recorded for 1426 (98%) participants. By the age of 18, 76% ($n = 1079$) had caries experience (DMFT >0). Of those, 39% ($n = 419$) had erosive lesion, statistically

Table II. The distribution of erosive lesions by tooth surface.

Tooth surfaces in different tooth groups	No erosive wear % (n)	Erosive wear % (n)	Enamel lesions % (n)	Dentine lesions % (n)
B and P surfaces of upper central incisors	54 (606)	46 (523)	97 (510)	3 (13)**
B and P surfaces of upper lateral incisors	72 (718)	28 (276)	95 (261)	5 (15)
B and P surfaces of upper cuspids	93 (950)	7 (71)	94 (67)	6 (4)
O surface of first molars	56 (583)	44 (465)	70 (326)	30 (139)
O surface of second molars	96 (1020)	4 (44)	93 (41)	7 (3)

*B: buccal surfaces; P: palatal surfaces; O: occlusal surfaces
**Two of the upper central incisors could not be scored due to presence of a retainer.

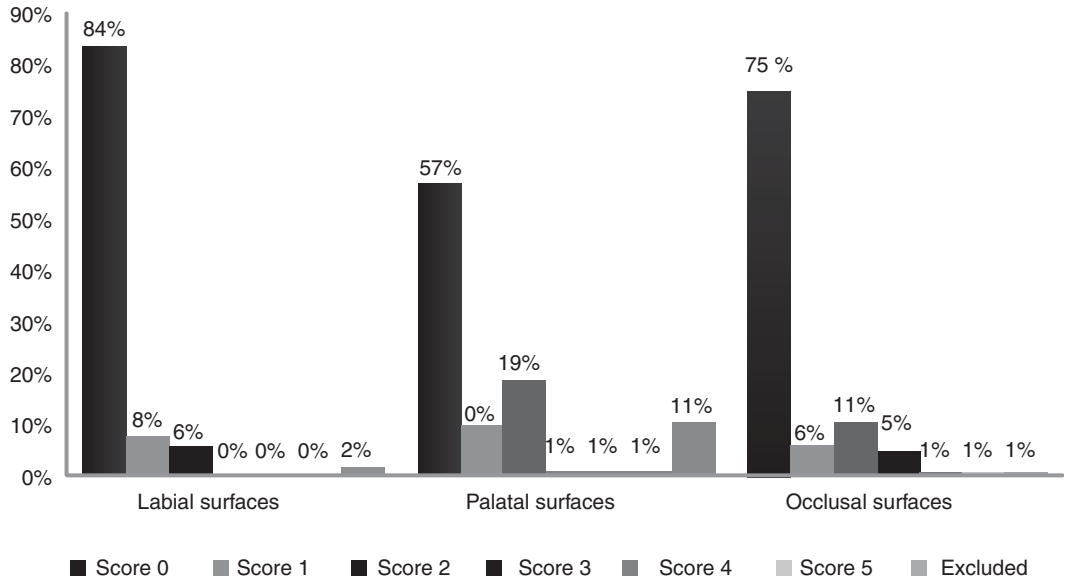

Figure 3. The distribution of erosive scores (%) on surface level.

($p < 0.01$) more than the adolescents with DMFT = 0, 32% ($n = 110$). No statistically significant difference was found between prevalence and different socio-economic status (38% in both groups) and different national background (37% and 38% in western and non-western origin groups, respectively).

Non-attendance

Of 287 participants who did not attend the second examination, the drop out was as follows: 96 declined to participate and 191 never showed up for their appointment. A telephone interview was used in order to contact and collect information from all the non-responders. Forty individuals (14%), 24 males and 16 females, responded. The main reasons reported were lapse of memory (28%) or lack of time (25%). The rest stated dental fear or already knowing about the presence of dental erosive wear as the main reasons for non-attendance.

A comparison of the examined participants ($n = 267$) with non-attenders ($n = 287$) regarding known background characteristics revealed no differences in relation to sex, DMFT values and socio-economical and national background factors.

Discussion

Although comparing different studies may be difficult due to wide methodological variations, the prevalence of 38% among Norwegian 18-year-olds registered in this study is higher than found in other Scandinavian countries [2,5,27]. It should be emphasized that, despite information and calibration meetings, there are some concerns on the assessment of erosive lesions. Great variations between examiners when recording erosive lesions have been reported [10]. To reduce these differences only yes/no to presence of dental erosion was recorded in the screening session. Although in this simple registration method 13.5% were without erosive lesions (false-positives) when 267 individuals were re-examined. An over-registration was expected as the clinicians were encouraged to also record suspected lesions. This over-registration could not be assigned to the VEDE system as the clinicians only registered the presence of erosive lesions (no severity grading), but must be taken into account when interpreting the prevalence in the present study.

The 18-year-old study group was selected for several reasons. At this age, the selected index teeth, first and second molars and anterior teeth have been present and exposed to erosive challenges for several years. In young people there is a higher probability of finding erosive lesions only, as attrition and abrasion are less present compared with older individuals [28,29]. Furthermore, the adolescents in this age group are more likely to co-operate during the examination, compared with younger participants. In Norway they are offered a final free-of-charge examination at the PDHS clinics, which assures a high attendance. Whether the study sample examined is representative of this age group cannot be definitely claimed. However, all 18-year-olds scheduled for free check-up during 2008 were invited to participate. Furthermore, comparison of the participants with non-attenders regarding known background characteristics revealed no differences in relation to sex, DMFT values and socio-economical and national background factors.

A higher prevalence of erosive wear was found in males than in females. This is in agreement with previous reports [1,5,10,12,14,15]. Significantly

more males had also extensive wear involving dentine. A study by Smith et al. [30] showed that females have significantly thicker enamel than males. Furthermore, Bardsley et al. [16] suggested that the reason why males have more lesions than females may be due to differences in the strength of musculature, biting forces and consumption of carbonated drinks, the last being in agreement with other studies [1,5].

Dental erosive wear was predominantly found on the palatal surfaces of maxillary anterior teeth and on the occlusal surfaces of lower first molars. This is also found in other studies [1,2,9–11,17,27]. It has been suggested that the abrasive effect of the tongue in combination with erosive components may contribute to a greater loss of tooth structure on the palatal surfaces [31,32]. The finding that the central incisors were more affected with erosive lesions than laterals could be explained by the later eruption of the laterals.

A high prevalence of lesions on lower first molars has also been reported previously [2,11,12,14] and may be explained by the significantly thinner enamel in lower molars than in upper molars and that the enamel thickness is less in first molars compared with second and third molars [30]. In the present study, the majority (52%) had erosive lesions on both molars and front-teeth, while 36% had lesions on molars only. The result supports the finding of a cross-sectional and longitudinal investigation on study models [11], where the authors conclude that the molars, especially the lower first molars, may be the site of the initial onset of dental erosion. Dentine erosive lesions were mostly found in lower first molars, while lesions confined to enamel dominated in upper anterior teeth. This distribution was also reported in the Dutch study [4] and could be explained by the fact that these molars are the first permanent teeth to erupt and thus are exposed during a longer period of time.

More than 60% of the participants were registered with cuppings on molars in addition to erosive lesions on other surfaces. In line with previous reports [2,4,33], the cuppings were registered on the lower first molars in 85% of the participants, especially on the mesio-buccal cusp tips, where the most severe lesions also were observed. Kono et al. [34] showed that the enamel layer at and near the tip of the cusp in both upper and lower first molars is thin and it has been suggested that cupping can occur when deeper enamel regions with lower microhardness are exposed [35]. It could be claimed that cupping is the most uncertain criterion of dental erosions, since it can be an effect of abrasion as well as of erosion. However, in industrialized countries, abrasion is not expected to be a significant factor in young people and therefore cupping occurring at younger ages can be a result of erosive challenge [28,29].

Erosive lesions were significantly more frequent in adolescents with caries experience than among those with no caries experience. This trend has also been found by others [3,12] and may reflect, as suggested by Dugmore and Rock [3], more frequent cariogenic and erosive diets among people with higher levels of caries experience. It has also been shown that children with high levels of caries experience consume soft drinks more frequently than those with low caries experience [36].

Although some studies have found a higher prevalence of erosive lesions in individuals within higher economic groups [17], others have found the opposite [1,4,6]. Our results demonstrated no correlation between dental erosive wear and socio-economic status, in accordance with the results by Dugmore and Rock [3]. Comparing socio-economic status in different countries is difficult due to different social structures. The association between erosive wear and national background has been studied to a limited extent. The study by Dugmore and Rock [15] revealed a significantly higher proportion of Caucasian children with erosions (63%) compared with Asian children (48%), while the results of the present study revealed no significant association.

This study has shown that more than one third of the 18-year-olds had dental erosive wear, usually confined to enamel. The prevalence was higher in males than in females and in individuals with caries experience. The most affected teeth were maxillary anterior incisors and mandibular first molars and a common finding was cuppings as one of the signs of erosive wear.

Acknowledgments

The authors would like to thank the participants in the study and the Public Dental Health Service (PDHS) of the city of Oslo for co-operation during the study period.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Al-Dlaigan YH, Shaw L, Smith A. Dental erosion in a group of British 14-year-old, school children. Part I: prevalence and influence of differing socioeconomic backgrounds. Br Dent J 2001;190:145–9.

[2] Arnadottir IB, Holbrook WP, Eggertsson H, Gudmundsdottir H, Jonsson SH, Gudlaugsson JO, et al. Prevalence of dental erosion in children: a national survey. Community Dent Oral Epidemiol 2010;38:521–6.

[3] Dugmore CR, Rock WP. The prevalence of tooth erosion in 12-year-old children. Br Dent J 2004;196:279–82.

[4] El Aidi H, Bronkhorst EM, Huysmans MC, Truin GJ. Dynamics of tooth erosion in adolescents: a 3-year longitudinal study. J Dent 2010;38:131–7.

[5] Hasselkvist A, Johansson A, Johansson AK. Dental erosion and soft drink consumption in Swedish children and

adolescents and the development of a simplified erosion partial recording system. Swed Dent J 2010;34:187–95.
[6] Margaritis V, Mamai-Homata E, Koletsi-Kounari H, Polychronopoulou A. Evaluation of three different scoring systems for dental erosion: a comparative study in adolescents. J Dent 2011;39:88–93.
[7] Jaeggi T, Lussi A. Prevalence, incidence and distribution of erosion. Monogr Oral Sci 2006;20:44–65.
[8] Arnadottir IB, Saemundsson SR, Holbrook WP. Dental erosion in Icelandic teenagers in relation to dietary and lifestyle factors. Acta Odontol Scand 2003;61:25–8.
[9] Johansson AK, Johansson A, Birkhed D, Omar R, Baghdadi S, Carlsson GE. Dental erosion, soft-drink intake, and oral health in young Saudi men, and the development of a system for assessing erosive anterior tooth wear. Acta Odontol Scand 1996;54:369–78.
[10] Larsen MJ, Poulsen S, Hansen I. Erosion of the teeth: prevalence and distribution in a group of Danish school children. Eur J Paediatr Dent 2005;6:44–7.
[11] Ganss C, Klimek J, Giese K. Dental erosion in children and adolescents–a cross-sectional and longitudinal investigation using study models. Community Dent Oral Epidemiol 2001; 29:264–71.
[12] Bardolia P, Burnside G, Ashcroft A, Milosevic A, Goodfellow SA, Rolfe EA, et al. Prevalence and risk indicators of erosion in thirteen- to fourteen-year-olds on the Isle of Man. Caries Res 2010;44:165–8.
[13] Auad SM, Waterhouse PJ, Nunn JH, Moynihan PJ. Dental caries and its association with sociodemographics, erosion, and diet in schoolchildren from southeast Brazil. Pediatr Dent 2009;31:229–35.
[14] Truin GJ, van Rijkom HM, Mulder J, van't Hof MA. Caries trends 1996–2002 among 6- and 12-year-old children and erosive wear prevalence among 12-year-old children in The Hague. Caries Res 2005;39:2–8.
[15] Dugmore CR, Rock WP. The progression of tooth erosion in a cohort of adolescents of mixed ethnicity. Int J Paediatr Dent 2003;13:295–303.
[16] Bardsley PF, Taylor S, Milosevic A. Epidemiological studies of tooth wear and dental erosion in 14-year-old children in North West England. Part 1: the relationship with water fluoridation and social deprivation. Br Dent J 2004;197: 413–16.
[17] van Rijkom HM, Truin GJ, Frencken JE, Konig KG, van 't Hof MA, Bronkhorst EM, et al. Prevalence, distribution and background variables of smooth-bordered tooth wear in teenagers in the hague, the Netherlands. Caries Res 2002; 36:147–54.
[18] Okunseri C, Okunseri E, Gonzalez C, Visotcky A, Szabo A. Erosive tooth wear and consumption of beverages among children in the United States. Caries Res 2011;45:130–5.
[19] Kreulen CM, Van 't SA, Rodriguez JM, Bronkhorst EM, Creugers NH, Bartlett DW. Systematic review of the prevalence of tooth wear in children and adolescents. Caries Res 2010;44:151–9.
[20] Berg-Beckhoff G, Kutschmann M, Bardehle D. Methodological considerations concerning the development of oral dental erosion indexes: literature survey, validity and reliability. Clin Oral Investig 2008;12(Suppl 1):S51–8.
[21] Mulic A, Tveit AB, Wang NJ, Hove LH, Espelid I, Skaare AB. Reliability of two clinical scoring systems for dental erosive wear. Caries Res 2010;44:294–9.
[22] Jarvinen VK, Rytomaa II, Heinonen OP. Risk factors in dental erosion. J Dent Res 1991;70:942–7.
[23] Wang NJ, Schiøth JT. Ikke møtt til avtalt time-et problem? Nor Tannlegeforen Tid 2000;110:874–7.
[24] Statistics Norway. Income. Statistisk sentralbyrå. 2011. Available online at http://www.ssb.no/inntekt_en/. [last accessed 19 October 2011].
[25] Statistics Norway. Immigration and immigrants. Statistisk sentalbyrå. 2010. Available online at http://www.ssb.no/english/subjects/00/00/10/innvandringen/. [last accessed 19 October 2011].
[26] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–74.
[27] Esmark L. The incidence of tooth erosions in a group of 12–17 year old Danish adolescents. Tannlegeblædet 2009; 113:662–5.
[28] Ganss C. How valid are current diagnostic criteria for dental erosion? Clin Oral Investig 2008;12(Suppl 1):S41–9.
[29] Van't Spijker A, Rodriguez JM, Kreulen CM, Bronkhorst EM, Bartlett DW, Creugers NH. Prevalence of tooth wear in adults. Int J Prosthodont 2009;22:35–42.
[30] Smith TM, Olejniczak AJ, Reid DJ, Ferrell RJ, Hublin JJ. Modern human molar enamel thickness and enamel-dentine junction shape. Arch Oral Biol 2006;51:974–95.
[31] Amaechi BT, Higham SM, Edgar WM, Milosevic A. Thickness of acquired salivary pellicle as a determinant of the sites of dental erosion. J Dent Res 1999;78:1821–8.
[32] Gregg T, Mace S, West NX, Addy M. A study *in vitro* of the abrasive effect of the tongue on enamel and dentine softened by acid erosion. Caries Res 2004;38:557–60.
[33] Johansson AK, Lingstrom P, Birkhed D. Comparison of factors potentially related to the occurrence of dental erosion in high- and low-erosion groups. Eur J Oral Sci 2002;110: 204–11.
[34] Kono RT, Suwa G, Tanijiri T. A three-dimensional analysis of enamel distribution patterns in human permanent first molars. Arch Oral Biol 2002;47:867–75.
[35] Meredith N, Sherriff M, Setchell DJ, Swanson SA. Measurement of the microhardness and Young's modulus of human enamel and dentine using an indentation technique. Arch Oral Biol 1996;41:539–45.
[36] Kleemola-Kujala E, Rasanen L. Dietary pattern of Finnish children with low high caries experience. Community Dent Oral Epidemiol 1979;7:199–205.