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Risk indicators associated with dental erosion among Jordanian school children aged 12–14 years of age

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Aim. To identify potential risk indicators of dental erosion (DE) among 12- to 14-year-old Jordanian school children.

Design. A random cross-sectional sample was selected from Amman, Irbid, and Al-Karak governorates. A weighted multistage random sampling system was used to yield 3812, 12- to 14-year-old school children from 81 schools. The study utilized a self-reported questionnaire of factors reported in the literature and thought to be associated with DE. Full mouth recording using the tooth wear index modified by Millward *et al.* (1994) was performed by a single calibrated examiner.

Results. Logistic regression analysis defined the risk indicators that were simultaneously associated with DE with geographical location, medical condition including frequent mouth dryness, and having frequent bouts of vomiting or using a cortisol inhaler, dietary habits including consumption of carbonated beverages, lemon, sour candies, and sports drinks, keeping soft drinks in the mouth for a long time, brushing teeth following soft beverages or drinking lemon juice at bed time.

Conclusions. Dental erosion is a multifactorial condition in which mouth dryness, vomiting, cortisol inhaler use, keeping soft drinks in the mouth, drinking beverages at bed time, consumption of lemon, sour candies, and having confectionary as snacks are risk indicators, and area of residence are all potential factors.

Introduction

Dental erosion (DE) is the irreversible loss of dental hard tissue due to a chemical process of acid dissolution not involving bacterial plaque and not directly associated with mechanical or traumatic factors or with dental caries[1]. Clinically, DE is presented as shallow smooth silky concavities with round edges and smooth surfaces which are often plaque and stain free[2,3]. In recent years, the dental profession has increasingly become concerned by the seemingly very widespread nature of DE.

Dental erosion is a multifactorial condition, and the possible aetiological factors of erosion are chemical, biological and behavioural in origin[4]. Sources of erosive acids can be either intrinsic or extrinsic. Intrinsic acid sources include acids of gastric origin. These acids come in contact with teeth in cases of gastro-oesophageal reflux, excessive vomiting or rumination, drug side effects, nervous system disorders and bowl diseases[5]. Extrinsic acid sources can be classified into dietary acids, medications and environmental acids[2,6–10].

Addressing the aetiology of DE is a challenging aspect. Researches have continually demonstrated the high susceptibility of dental hard tissue to acidic challenge, which can be modified by the interplay between chemical, biological and behavioural factors. It is likely that many potential supposed factors can occur simultaneously or sequentially, which makes identification of a definite aetiological factor almost impossible. The multifactorial and complex aetiology may actually be used to explain the variation in the presentation, distribution and severity of defects seen clinically in individuals with DE. It is therefore important to identify those at risk of developing clinical problems, so they can be targeted through preventive programmes.

Most studies of the aetiology of DE have been carried out mostly in Western European

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countries[8,11–13]. Recent reports have included the United States of America [14,15] and Asia[16], but representative studies on DE prevalence in Arab countries are scarce[17,18]. No studies were found to address the risk indicators of DE in Jordan.

The aim of this study was to identify potential risk indicators of DE among Jordanian school children.

Materials and methods

The Institutional Review Board (IRB) at Jordan University of Science and Technology approved the study protocol. In this cross-sectional study, a cluster random sample was selected from Amman, Irbid, and Al-Karak governorates which represent the Northern, Middle, and Southern parts of Jordan, respectively. A multistage cluster random sampling was adopted to select the students. Firstly, the Ministry of Education in Jordan supplied a list of schools teaching 6th, 7th, and 8th grade children. The total number of schools in the three governorates was 1514: 851 schools were in Amman, 450 were in Irbid, and 213 were in Al-Karak. A random selection of 5% of each type of the schools (governmental, private, and United Nations Relief and Works Agency (UNRWA)), (males, females, and mixed)) was performed using the random tables. A total number of 81 schools were selected: 45 from Amman, 25 from Irbid, and 11 from Al-Karak. In the rare case that a school refused to participate in the study, another school was selected randomly from a replacement school list for each school category in each governorate. Schools for students with special needs were excluded.

The second stage of sampling comprised selection of 25% students from 6th, 7th, and 8th grades of the previously selected schools. The study population included 4086 students: 2272 from Amman, 1425 from Irbid, and 389 from Al-Karak.

Selected students were given copies of the questionnaire prepared for this study with consent forms to be signed by their parents or their legal guardians. Cover letters were also attached to the questionnaires to providing additional information about the aim of this project and asking parents to kindly allow their children to participate. Only those with written consent were included in the study. The diagnostic criteria of DE for each surface were determined according to Smith and Knight (1984) Tooth Wear Index (TWI)[19] as modified by Millward *et al.*[20]. All surfaces of permanent teeth were examined for loss of enamel surface characteristics and/or exposure of dentin or pulp. Participants were considered as having DE if they had at least one surface that exhibited signs of DE. Students who exhibited changes in dental structure, such as amelogenesis imperfecta, dentinogenesis imperfecta, hypoplasia, diffuse opacities, white spot lesions, tetracycline staining, and fluorosis, were excluded from the study. Excluded teeth also included partially erupted teeth, teeth with orthodontic bands or brackets, extensive restorations and crowns, fractured teeth, surfaces with composite restorations, and fissure sealants.

The clinical examination was conducted with students sitting in an ordinary chair in their class rooms using daylight supplemented with a head light. Teeth were dried with gauze and, when necessary, cotton rolls were used to remove debris. A full mouth examination for DE was performed using a mirror, and information was recorded on a prepared examination form by a research assistant.

All examinations were carried out by a single examiner who was trained and calibrated by a university assistant professor of paediatric dentistry by examining 20 patients aged between 12 and 14 years who attended the Jordan University of Science and Technology dental clinics before the commencement of the study. There was a 98.4 percentage of agreement between the two examiners.

To assess intraexaminer reliability during the study period, approximately 300 participants of the total sample were examined twice. Thus, for every 25 students examined, the first two students in that group were re-examined. The kappa value of intraexaminer reliability was 0.98.

The study utilized a self-reported questionnaire that was an Arabic version of the questionnaire used in the National Diet and Nutrition Survey in the United Kingdom[21].

The questionnaire was divided into five sections as follows: first, demographical details of the student including age, gender, school type, residence, parental education level and monthly income. Second, medical history including gastrointestinal diseases, gastro-oesophageal reflux symptoms, frequent vomiting, neurological and psychological diseases, autoimmune diseases, and frequency of medications used. Students with asthma were asked about the use of inhaler. Third, dental history included dental sensitivity, clenching or grinding, use of mouth guards, oral hygiene practices and preventive measures including tooth brushing and mouth wash use. Current intakes of fluoride were recorded as well. Fourth, dietary habits indicating the type and frequency of intake of fruit drinks, herbal tea, milk, coffee, carbonated drinks, water, and citrus fruits. The frequency of bedtime drinks and foods were also included. Fifth, recreational history including regular sport, swimming, and intake of sports drinks.

Data were entered into the Statistical Package for Social Sciences (SPSS), version 17 (SPSS Inc., Chicago, IL, USA). Data analysis included descriptive statistics, comparisons of means and test of association. Statistical analyses of association of DE with various categorical variables were performed using chi-square procedures. Probability values $P \leq 0.05$ were considered statistically significant. Stepwise Logistic regression procedures were carried out to identify factors collectively associated with DE. Odds ratios were also calculated with 95% test-based confidence intervals for the associated variables.

Results

Questionnaires were sent to 4086 students. The signed consent forms and filled questionnaires were returned by 3812 students (1938 males and 1874 females) resulting in a response rate of 93.3%. The mean age of all students was 12.8 years (SD, 0.8). Two-thirds of the sample were from governmental schools, about a quarter from private schools and 9% were from UNRWA schools. About half of the sample were from Amman governorate, a third from Irbid governorate and 9% were from Al-Karak governorate.

Of 3812 school children, 1229 child had DE (32.2%). The distribution of the sample according to their medical conditions and medication known to be associated with DE are outlined in Table 1. DE was found in 39% of students with medical conditions compared with 25% of those without medical conditions ($P < 0.001$). Approximately 60% of asthmatic students and 64% of those using corticosteroid inhalers exhibited signs of DE. Students who reported regular bouts of heart burn, indigestion, and acid taste in their mouths had a significantly higher prevalence (74.1%) of DE, followed by those who had occasional occurrence of these symptoms (57.5%), whereas only 28.2% of students who never experienced these symptoms had DE ($P < 0.001$). About 80% and 48% of participants who had complained of oral and eye dryness, respectively, had DE compared with 30% and 32% of those with no history of dryness, respectively. The more frequent bouts of vomiting were significantly associated with more proportion of DE ($P < 0.001$). A statistically significantly number of students who have frequent headaches (37.5%), stomach disease (46.0%), and neurological and psychological disease (45.0%) exhibited DE compared with those who have not had these interventions or illnesses (31.1, 31.9%, and 31.9%, respectively). Using chewable vitamin C, iron tonics, and antacid drugs in general was significantly associated with DE ($P < 0.001$). Approximately 74% of those regularly consuming chewable vitamin C experienced DE compared with 37.7% of those who occasionally consume the medication. The occasional users of iron tonics syrup and the antacid drugs exhibited signs of DE in about 41% and 42% of cases.

Table 2 demonstrates the association between DE and tooth sensitivity, clenching and grinding, pain or fatigue of the jaw muscles and history of using night guards. Among those who regularly experience tooth sensitivity to hot or cold food or drinks, 42% had signs of DE compared with 36% among those who occasionally experience such sensitivity. About 58% of students who reported regular

Table 1. Association of medical conditions and medication use with dental erosion.

Medical problem	Category	DE		*P*-value
		Yes N (%)	No N (%)	
Medical condition	Yes	743 (39.1)	1156 (60.9)	<0.001*
	No	486 (25.4)	1427 (74.6)	
Asthma	Yes	56 (59.6)	38 (40.4)	<0.001*
	No	1173 (31.5)	2545 (68.5)	
Corticosteroid inhaler	Yes	33 (63.5)	19 (36.5)	<0.001*
	No	23 (54.8)	19 (45.2)	
Frequent bouts of heart burn, indigestion, acid taste in the mouth	Regularly	20 (74.1)	7 (25.9)	<0.001*
	Occasionally	276 (57.5)	204 (42.5)	
	Never	933 (28.2)	2372 (71.8)	
Frequent oral dryness	Yes	165 (80.1)	41 (19.9)	<0.001*
	No	1064 (29.5)	2542 (70.5)	
Frequent eye dryness	Yes	28 (47.5)	31 (52.5)	0.012*
	No	1201 (32.0)	2552 (68)	
Having bouts of vomiting:	Regularly	12 (85.7)	2 (14.3)	<0.001**
	Occasionally	202 (72.7)	76 (27.3)	
	Never	1015 (28.8)	2505 (71.2)	
Having bouts of vomiting: Allergies	Yes	319 (36.4)	558 (63.6)	0.003*
	No	910 (31.0)	2025 (69)	
Ear infection	Yes	141 (36.4)	246 (63.6)	0.063
	No	1088 (31.8)	2337 (68.2)	
Frequent headaches	Yes	256 (37.5)	427 (62.5)	0.001*
	No	973 (31.1)	2156 (68.9)	
Stomach disease	Yes	40 (46.0)	47 (54)	0.006*
	No	1189 (31.9)	2536 (68.1)	
Neurological and psychological disease	Yes	49 (45.0)	60 (55)	0.004*
	No	1180 (31.9)	2523 (68.1)	
Chewable vitamin C	Yes	268 (40.0)	402 (60.0)	<0.001*
	No	961 (30.6)	2181 (69.4)	
	Regularly	31 (73.8)	11 (26.2)	<0.001*
	Occasionally	237 (37.7)	391 (62.3)	
	Never	961 (30.6)	2181 (69.4)	
Iron tonics (syrup)	Yes	165 (43.1)	218 (56.9)	<0.001*
	No	1064 (31.0)	2365 (69.0)	
	Regularly	23 (65.7)	12 (34.3)	<0.001*
	Occasionally	142 (40.8)	206 (59.2)	
	Never	1064 (31)	2365 (69.0)	
Antacid drugs	Yes	161 (42.3)	220 (57.7)	<0.001*
	No	1068 (31.1)	2363 (68.9)	
	Regularly	12 (50)	12 (50)	<0.001*
	Occasionally	149 (41.7)	208 (58.3)	
	Never	1068 (31.1)	2363 (68.9)	

*The chi-square analysis is significant at level $\leq$ 0.05.
**Fisher's exact test is significant at level $\leq$ 0.05.

tooth sensitivity to air had DE. Among students who reported regular clenching or grinding of their teeth during the day or night, 53% and 50% of them, respectively, had DE. Table 2 also presents the association between preventive dental measures and DE. Brushing the teeth regardless of the frequency, the use of toothpaste, visiting dentists regularly or use of home-applied fluoride had no significant association with DE ($P > 0.05$). The use of tooth gel, mouth wash, and professionally applied fluoride was significantly associated with the occurrence of DE ($P < 0.05$). Approximately 83% of students who brushed their teeth following vomiting episodes suffered from DE compared with (70.8% and 70%) who only rinsed their mouth or did nothing ($P < 0.001$), whereas only 28.9% of the students who did not experience frequent vomiting episodes had

Table 2. Association of dental conditions and preventive measures with DE.

Dental history	Frequency	DE		*P*-value
		Yes N (%)	No N (%)	
Teeth sensitivity to hot or cold food and drinks	Yes	628 (36.3)	1104 (63.7)	<0.001*
	No	601 (28.9)	1479 (71.1)	
	Regularly	78 (41.9)	108 (58.1)	<0.001*
	Occasionally	550 (35.6)	996 (64.4)	
	Never	460 (27.9)	1191 (72.1)	
	Not noticed	141 (32.9)	288 (67.1)	
Teeth sensitivity to air	Yes	385 (47.8)	420 (52.2)	<0.001*
	No	844 (28.1)	2163 (71.9)	
	Regularly	56 (58.3)	40 (41.7)	<0.001*
	Occasionally	329 (46.4)	380 (53.6)	
	Never	673 (28.0)	1727 (72.0)	
	Not noticed	171 (28.2)	436 (71.8)	
Clenching or grinding of teeth during the day	Yes	194 (46.7)	221 (53.3)	<0.001*
	No	1035 (30.5)	2362 (69.5)	
	Regularly	42 (53.2)	37 (46.8)	<0.001*
	Occasionally	152 (45.2)	184 (54.8)	
	Never	846 (30.2)	1958 (69.8)	
	Not noticed	189 (31.9)	404 (68.1)	
Clenching or grinding of teeth during the night	Yes	148 (47.3)	165 (52.7)	<0.001*
	No	1081 (30.9)	2418 (69.1)	
	Regularly	39 (50.0)	39 (50.0)	<0.001*
	Occasionally	109 (46.4)	126 (53.6)	
	Never	862 (30.6)	1958 (69.4)	
	Not noticed	219 (32.3)	460 (67.7)	
Pain or fatigue of the jaw muscles	Yes	231 (42.5)	312 (57.5)	<0.001*
	No	998 (30.5)	2271 (69.5)	
	Regularly	25 (47.2)	28 (52.8)	<0.001*
	Occasionally	206 (42.0)	284 (58.0)	
	Never	822 (30.1)	1907 (69.9)	
	Not noticed	176 (32.6)	364 (67.4)	
Use of mouth guard	Yes	22 (34.4)	42 (65.6)	0.713
	No	1207 (32.2)	2541 (67.8)	
Using tooth paste	Yes	1087 (32.0)	2309 (68)	0.381
	No	142 (34.1)	274 (65.9)	
Using tooth gel	Yes	170 (39.2)	264 (60.8)	0.001*
	No	1059 (31.3)	2319 (68.7)	
Using mouth wash	Yes	561 (35.7)	1009 (64.3)	<0.001*
	No	668 (29.8)	1574 (70.2)	
Using professionally applied fluoride	Yes	203 (37.2)	342 (62.8)	0.007*
	No	1026 (31.4)	2241 (68.6)	
Using home-applied fluoride	Yes	168 (31.3)	369 (68.7)	0.609
	No	1061 (32.4)	2214 (67.6)	
Tooth brushing	Yes	1097 (32.1)	2317 (67.9)	0.676
	No	132 (33.2)	266 (66.8)	
Frequency of teeth brushing	2+/day	339 (32.7)	698 (67.3)	0.621
	1/day	497 (31.1)	1101 (68.9)	
	1/week	261 (33.5)	518 (66.5)	
	Never brush	132 (33.2)	266 (66.8)	
Last visit to dentist	6 month	474 (32.3)	995 (67.7)	0.976
	Last year	295 (32.0)	628 (68.0)	
	1 + year	272 (32.8)	557 (67.2)	
	Never	188 (31.8)	403 (68.2)	
Following vomiting episodes:	Brush teeth	43 (82.7)	9 (17.3)	<0.001*
	Rinse mouth	155 (70.8)	64 (29.2)	
	Do nothing	14 (70.0)	6 (30.0)	
	No vomiting	1017 (28.9)	2504 (71.1)	
Following drinking carbonated drink or fruit juice, usually:	Brush teeth	113 (64.9)	61 (35.1)	<0.001*
	Rinse mouth	328 (27.6)	860 (72.4)	
	Do nothing	788 (32.2)	1662 (67.8)	

DE. The same trend was found in those brushing their teeth following a carbonated drink or fruit juice ($P < 0.001$).

The association of drinking habits in general and drinking habits at bedtime with DE is presented in Table 3. Among those who drank carbonated beverages, one-third was diagnosed with DE. The method of intake of soft drinks was found to influence the erosion potential, preferring to drink soft beverages directly from the cup was significantly more associated with DE than using a straw

Table 3. Association of drinking habits in general and drinking habits at bedtime with DE.

		DE		
Dietary habits in general	**Frequency**	**Yes N (%)**	**No N (%)**	***P*-value**
Drinking carbonated drinks	Yes	1179 (33.6)	2333 (66.4)	<0.001*
	No	50 (16.7)	250 (83.3)	
Usual drinking method	With a straw	105 (32.1)	222 (67.9)	0.026*
	Without straw	289 (36.2)	510 (63.8)	
	Use both ways	835 (31.1)	1851 (68.9)	
Keeping the drink in the mouth after drinking	Short time	196 (81.3)	45 (18.7)	<0.001*
	Long time	27 (84.4)	5 (15.6)	
	Drink it immediately	1006 (28.4)	2533 (71.6)	
Favourite party drink	Sports drinks	39 (97.5)	1 (2.5)	<0.001**
	Coffee with sugar	10 (43.5)	13 (56.5)	
	Herbal tea	6 (42.9)	8 (57.1)	
	Pepsi	349 (40.9)	504 (59.1)	
	Lemon juice	47 (36.4)	82 (63.6)	
	7up	41 (35.0)	76 (65)	
	Miranda	59 (34.7)	111 (65.3)	
	Shani	137 (34.2)	264 (65.8)	
	Cola	70 (32.0)	149 (68)	
	Red tea with sugar	14 (28.6)	35 (71.4)	
	Apple juice	53 (28.2)	135 (71.8)	
	Orange Juice	63 (25.2)	187 (74.8)	
	Milk	61 (24.2)	191 (75.8)	
	Fruit juice	105 (23.3)	346 (76.7)	
Vegetarian	Yes	1152 (32.1)	2436 (67.9)	0.481
	No	77 (34.4)	147 (65.6)	
Frequency of drink or eat in bed or during night after brushing the teeth?	Every night	536 (39.6)	818 (60.4)	<0.001*
	Day by day	238 (35.7)	429 (64.3)	
	Once a week	192 (30.5)	437 (69.5)	
	Never drink	263 (22.6)	899 (77.4)	
The usual type of drink in bed or during the night after brushing the teeth:	Lemon juice	30 (96.8)	1 (3.2)	<0.001**
	Carbonated drinks	162 (91.0)	16 (9)	
	Coffee with sugar	8 (66.7)	4 (33.3)	
	Squash	5 (62.5)	3 (37.5)	
	Apple juice	22 (57.9)	16 (42.1)	
	Herbal tea	6 (42.9)	8 (57.1)	
	Orange Juice	36 (38.7)	57 (61.3)	
	Red tea with sugar	105 (34.4)	200 (65.6)	
	Water	459 (30.8)	1032 (69.2)	
	Milk	95 (30.0)	222 (70)	
	Others	20 (26.3)	56 (73.7)	
	Never drink	263 (22.6)	901 (77.4)	
The usual food in bed or during the night after brushing the teeth	Lemon	47 (94.0)	3 (6.0)	<0.001**
	Fruit juice	18 (21.2)	67 (78.8)	
	Sour candies	64 (92.8)	5 (7.2)	
	Orange	64 (43.8)	82 (56.2)	
	Apple	292 (37.1)	495 (62.9)	
	Never eat	324 (23.5)	1055 (76.5)	

*The chi-square analysis is significant at level ≤ 0.05.
**Fisher's exact test is significant at level ≤ 0.05.

($P = 0.026$). Prolonged retention of drinks in the mouth significantly influenced the erosive potential compared with cases in which students swallowed the drinks immediately ($P < 0.001$). The drinks that were consumed by students who had a higher proportion of DE were in descending order: sports drinks (97%), coffee with sugar (44%), herbal tea (43%), Pepsi (40.9%), lemon juice (36%), 7up (35%), Miranda (35%), and Shani (34%). Contrary to expectations, being a vegetarian was not associated with the diagnosis of DE ($P = 0.48$). DE was found to be significantly associated with the frequency of having drinks or foods at bedtime ($P < 0.001$). Approximately 40% of the students who drank or ate every night at bed time had DE compared with those who carried out this habit less frequently. More than 90% of students who drank lemon juice and carbonated drinks at bed time had DE. In addition, a high proportion of students who drank coffee, squash, and apple juice were diagnosed with DE (67%, 63%, and 58%, respectively). Foods that were consumed at bed time by students who have higher proportion of DE in descending order were lemon (94%), sour candy (93%), orange (44%), apple (37%), and yogurt (35%).

Table 4 presents the frequency of consumption of selected foods with DE. Overall, consumption of lemons, tinned fruit, mayonnaise, vinegar, pickles, spicy food, and sour candies were significantly associated with DE ($P < 0.001$). The highest prevalence of DE was found among students who ate sour candies and vinegar (54% and 53%, respectively), followed by students who ate lemon (46%), tinned fruit (42%), spicy food (39%), pickles, and mayonnaise (35%). Regarding the frequency of intake, as the frequency of consumption of the above mentioned foods increased, the proportion of students affected with DE increased significantly ($P < 0.01$). On the other hand, consuming yogurts and cheese foods was not associated with less DE ($P > 0.3$).

Table 5 illustrates the frequency of consumption of some drinks that might be associated with DE. Generally, consumption of fruit juice, carbonated drinks, sports drinks, herbal tea, and coffee was significantly associated with DE ($P < 0.001$). The highest proportion of students with DE was found among those consumed sports drinks (93%), followed by coffee (44%). One-third of students who drank herbal tea, carbonated drinks, diluted fruit juice, and natural fruit juice had DE. When the frequency of intake was considered, the proportion of students with DE increased as the frequency of drink increased ($P < 0.001$). Milk, as a protective dietary item, did not show any association with DE ($P = 0.87$).

The prevalence of DE was significantly higher ($P < 0.001$) among students who reported practicing sports, swimming and always having sports beverages following sporting activities compared with those who are not sport practitioners. Approximately 33% and 38% of the students who practised sports and swam in pools had DE compared with those who did not practise these sports (23% and 28%, respectively). The proportion of students with DE significantly increased as the frequency of these sport increased.

The best-fit logistic regression model for the statistically significant variables are presented in Table 6**.** Place of residence was significantly associated with the DE ($P < 0.001$); students living in Irbid were about 2.5 times more likely to have DE than those living in Amman and Al-Karak (OR = 2.4; 95% CI, 1.53–3.85; OR = 2.6; 95% CI, 2.24–3.01, respectively).

Logistic regression considered the use of corticosteroid inhaler, frequent mouth dryness and experiencing bouts of vomiting as risk indicators for DE. Students using cortisol inhalers as treatment of asthma were about five times more likely to have DE than those who did not (OR = 4.8; 95% CI, 2.26–10.17). Students who reported suffering from mouth dryness were about 4.5 times more likely to develop DE compared with those who did not (OR = 4.5; 95% CI, 2.75–7.21). The odds of having DE in those with occasional bouts of vomiting were about 3.4 times compared with those who did not experience vomiting (OR = 3.4; 95% CI, 2.25–5.05).

Moreover, dietary habits had also a significant association with DE, keeping the drinks

Table 4. Association of some food with DE.

Dietary habits	Frequency	DE Yes N (%)	DE No N (%)	*P*-value
Orange	Yes	1126 (32.3)	2358 (67.7)	0.734
	No	103 (31.4)	225 (68.6)	
	≥ 2/day	138 (47.8)	151 (52.2)	
	Once/day	289 (37.6)	479 (62.4)	
	2–4/week	374 (33.3)	748 (66.7)	
	Once/week	325 (24.9)	980 (75.1)	
	Never	103 (31.4)	225 (68.6)	
Lemon	Yes	869 (45.7)	1034 (54.3)	<0.001*
	No	360 (18.9)	1549 (81.1)	
	≥ 2/day	113 (91.9)	10 (8.1)	<0.001*
	Once/day	198 (83.9)	38 (16.1)	
	2–4/week	244 (68.3)	113 (31.7)	
	Once/week	314 (26.5)	873 (73.5)	
	Never	360 (18.9)	1549 (81.1)	
Apple	Yes	1161 (32.3)	2439 (67.7)	0.958
	No	68 (32.1)	144 (67.9)	
	≥ 2/day	282 (43.8)	362 (56.2)	
	Once/day	336 (34.8)	630 (65.2)	
	2–4/week	326 (29.6)	776 (70.4)	
	Once/week	217 (24.4)	671 (75.6)	
	Never	68 (32.1)	144 (67.9)	
Tinned fruit	Yes	515 (41.6)	723 (58.4)	<0.001*
	No	714 (27.7)	1860 (72.3)	
	≥ 2/day	48 (56.5)	37 (43.5)	<0.001*
	Once/day	78 (53.4)	68 (46.6)	
	2–4/week	131 (44.3)	165 (55.7)	
	Once/week	258 (36.3)	453 (63.7)	
	Never	714 (27.7)	1860 (72.3)	
Curry spicy food	Yes	731 (38.9)	1146 (61.1)	<0.001*
	No	498 (25.7)	1437 (74.3)	
	≥ 2/day	161 (55.1)	131 (44.9)	<0.001*
	Once/day	153 (42.5)	207 (57.5)	
	2–4/week	194 (41.7)	271 (58.3)	
	Once/week	223 (29.3)	537 (70.7)	
	Never	498 (25.7)	1437 (74.3)	
Yogurt	Yes	1151 (32.1)	2439 (67.9)	0.342
	No	78 (35.1)	144 (64.9)	
	≥ 2/day	299 (36.0)	532 (64)	
	Once/day	425 (34.4)	809 (65.6)	
	2–4/week	279 (27.8)	726 (72.2)	
	Once/week	148 (28.5)	372 (71.5)	
	Never	78 (35.1)	144 (64.9)	
Tomato ketchup	Yes	931 (33.0)	1889 (67.0)	0.085
	No	298 (30.0)	694 (70.0)	
	≥ 2/day	96 (53.9)	82 (46.1)	
	Once/day	161 (42.0)	222 (58.0)	
	2–4/week	265 (32.6)	547 (67.4)	
	Once/week	409 (28.3)	1038 (71.7)	
	Never	298 (30.0)	694 (70.0)	
Mayonnaise	Yes	717 (34.5)	1361 (65.5)	<0.01*
	No	512 (29.5)	1222 (70.5)	
	≥ 2/day	57 (64.8)	31 (35.2)	<0.01*
	Once/day	82 (41.0)	118 (59.0)	
	2–4/week	208 (40.2)	310 (59.8)	
	Once/week	370 (29.1)	902 (70.9)	
	Never	512 (29.5)	1222 (70.5)	
Vinegar	Yes	284 (52.5)	257 (47.5)	<0.01*
	No	945 (28.9)	2326 (71.1)	
	≥ 2/day	35 (87.5)	5 (12.5)	<0.01*
	Once/day	50 (66.7)	25 (33.3)	
	2–4/week	75 (67.6)	36 (32.4)	
	Once/week	124 (39.4)	191 (60.6)	
	Never	945 (28.9)	2326 (71.1)	
Pickles	Yes	977 (34.7)	1842 (65.3)	<0.01*
	No	252 (25.4)	741 (74.6)	
	≥ 2/day	189 (67.7)	90 (32.3)	<0.01*
	Once/day	227 (48.5)	241 (51.5)	
	2–4/week	236 (27.8)	612 (72.2)	
	Once/week	325 (26.6)	899 (73.4)	
	Never	252 (25.4)	741 (74.6)	
Sour candies	Yes	792 (53.9)	677 (46.1)	<0.01*
	No	437 (18.7)	1906 (81.3)	
	≥ 2/day	131 (93.6)	9 (6.4)	<0.01*
	Once/day	160 (93.0)	12 (7.0)	
	2–4/week	233 (79.8)	59 (20.2)	
	Once/week	268 (31.0)	597 (69.0)	
	Never	437 (18.7)	1906 (81.3)	
Cheese	Yes	1153 (32.1)	2444 (67.9)	0.315
	No	76 (35.3)	139 (64.7)	
	≥ 2/day	375 (32.9)	765 (67.1)	
	Once/day	454 (33.8)	888 (66.2)	
	2–4/week	232 (31.4)	506 (68.6)	
	Once/week	92 (24.4)	285 (75.6)	
	Never	76 (35.3)	139 (64.7)	

*The chi-square analysis is significant at level ≤ 0.05.
**Fisher's exact test is significant at level ≤ 0.05.

in mouth for a long time increased the risk of DE by 2.7 times compared with those who swallowed the drinks immediately (OR = 2.7; 95% CI, 2.17–3.25). Students who brushed their teeth after drinking soft beverages were 2.2 times more likely to have DE than those who did not brush after having a soft drink (OR = 2.2; 95% CI, 1.34–3.77). Additionally, rinsing the mouth after having a soft drink significantly decreased the probability of having DE (OR = 0.7; 95% CI, 0.57–0.95).

The results revealed that lemon juice had harmful effect on teeth; students who drank lemon juice at bedtime were 23 times more likely to have DE (OR = 23; 95% CI, 2.16–252.06). The odds were almost 18 when lemon was consumed more than twice daily, 8 and 4 when it was consumed only once daily or 2–4 times per week (OR = 18; 95% CI, 8.35–40.84; OR = 7.8; 95% CI, 4.84–

Table 5. Association of some drinks with DE.

Dietary habits	Frequency	DE		*P*-value
		Yes N (%)	No N (%)	
Natural fruit juice	Yes	1058 (33.2)	2124 (66.8)	0.003*
	No	171 (27.1)	459 (72.9)	
	≥2/day	137 (45.1)	167 (54.9)	<0.01*
	Once/day	247 (37.9)	404 (62.1)	
	2–4/week	275 (30.9)	614 (69.1)	
	Once/week	399 (29.8)	939 (70.2)	
	Never	171 (27.1)	459 (72.9)	
Diluted fruit juice	Yes	955 (33.5)	1894 (66.5)	0.004*
	No	274 (28.5)	689 (71.5)	
	≥2/day	141 (48.1)	152 (51.9)	<0.01*
	Once/day	297 (36.5)	516 (63.5)	
	2–4/week	279 (29.5)	668 (70.5)	
	Once/week	238 (29.9)	558 (70.1)	
	Never	274 (28.5)	689 (71.5)	
Carbonated drinks	Yes	1174 (33.6)	2324 (66.4)	<0.01*
	No	55 (17.5)	259 (82.5)	
	≥2/day	375 (90.4)	40 (9.6)	<0.01*
	Once/day	315 (48.8)	330 (51.2)	
	2–4/week	334 (24.5)	1030 (75.5)	
	Once/week	150 (14.0)	924 (86)	
	Never	55 (17.5)	259 (82.5)	
Sports drinks	Yes	442 (92.5)	36 (7.5)	<0.01*
	No	787 (23.6)	2547 (76.4)	
	≥2/day	48 (96.0)	2 (4)	<0.01**
	Once/day	67 (94.4)	4 (5.6)	
	2–4/week	121 (91.7)	11 (8.3)	
	Once/week	206 (91.6)	19 (8.4)	
	Never	787 (23.6)	2547 (76.4)	
Coffee with sugar	Yes	334 (44.2)	422 (55.8)	<0.01*
	No	895 (29.3)	2161 (70.7)	
	≥2/day	60 (56.1)	47 (43.9)	<0.01*
	Once/day	75 (48.7)	79 (51.3)	
	2–4/week	71 (42.0)	98 (58.0)	
	Once/week	128 (39.3)	198 (60.7)	
	Never	895 (29.3)	2161 (70.7)	
Herbal tea	Yes	472 (35.3)	865 (64.7)	<0.01*
	No	757 (30.6)	1718 (69.4)	
	≥2/day	44 (47.3)	49 (52.7)	<0.01*
	Once/day	76 (48.1)	82 (51.9)	
	2–4/week	136 (41.1)	195 (58.9)	
	Once/week	216 (28.6)	539 (71.4)	
	Never	757 (30.6)	1718 (69.4)	
Red tea with sugar	Yes	1139 (32.6)	2360 (67.4)	0.168
	No	90 (28.8)	223 (71.2)	
	≥2/day	491 (34.0)	952 (66.0)	
	Once/day	377 (32.7)	775 (67.3)	
	2–4/week	175 (33.5)	347 (66.5)	
	Once/week	96 (25.1)	286 (74.9)	
	Never			
Milk	Yes	925 (32.2)	1950 (67.8)	0.878
	No	304 (32.4)	633 (67.6)	
	≥2/day	204 (34.7)	384 (65.3)	
	Once/day	269 (28.2)	684 (71.8)	
	2–4/week	235 (35.1)	435 (64.9)	
	Once/week	217 (32.7)	447 (67.3)	
	Never	304 (32.4)	633 (67.6)	

*The chi-square analysis is significant at level $\leq$ 0.05.
**Fisher's exact test is significant at level $\leq$ 0.05.

Table 6. Logistic regression analysis of variables associated with DE.

Variable	Regression coefficient	Standard error	*P*-value	EXP (B)	95% CI for EXP (B)	
					Lower	Upper
Residence			0.000			
Irbid	0.887	0.236	0.000	2.427	1.529	3.850
Corticosteroid inhaler			0.000			
Asthmatic student use corticosteroid inhaler	1.567	0.384	0.000	4.791	2.256	10.174
Frequent oral dryness	1.494	0.246	0.000	4.453	2.749	7.213
Having frequent bouts of vomiting			0.000			
Occasionally	1.215	0.206	0.000	3.372	2.253	5.046
Keep soft drinks in mouth for a while			0.000			
For long time	0.978	0.103	0.000	2.659	2.174	3.251
After having a carbonated drink or fruit juice, usually			0.000			
Brushing the teeth	0.809	0.264	0.002	2.246	1.340	3.765
Rinse the mouth	−0.302	0.130	0.020	0.739	0.573	0.954
The Usual drink at bedtime			0.000			
Carbonated drinks	2.053	0.348	0.000	7.792	3.936	15.424
Lemon Juice	3.150	1.214	0.009	23.327	2.159	252.060
Intake of lemons			0.000			
More than 2 time daily	2.916	0.405	0.000	18.462	8.346	40.839
Once daily	2.057	0.244	0.000	7.820	4.844	12.623
2–4 time/week	1.381	0.185	0.000	3.980	2.771	5.715
Intake of sour candies			0.000			
More than 2 time daily	3.198	0.347	0.000	24.475	12.394	48.330
Once daily	2.885	0.412	0.000	17.905	7.987	40.137
2–4 time/week	2.102	0.206	0.000	8.186	5.464	12.264
Once a week	0.390	0.132	0.003	1.477	1.140	1.914
Intake of sports drinks			0.000			
More than 2 time daily	3.376	0.580	0.000	29.252	9.379	91.234
Once daily	2.629	0.790	0.001	13.865	2.949	65.196
2–4 time/week	2.513	0.376	0.000	12.339	5.900	25.805
Take Confectionary as snacks (Yes)	0.302	0.129	0.019	1.352	1.051	1.740
Using home-applied fluoride (No)	0.357	0.179	0.046	1.429	1.006	2.030

Exp (B) = Odds Ratio (OR).

12.62; and OR = 4; 95% CI, 2.77–5.72, respectively). On the other hand, the odds were 7.8 times when student had carbonated drinks at bedtime (OR = 7.8; 95% CI, 3.94–15.42). Sour candies were significantly associated with DE. Students who consumed sour candies more than twice daily were almost 24 times more prone to have DE than those who did not eat them at all (OR = 24; 95% CI, 12.39–48.33), students who consumed sour candies once daily were about 18 times more likely to have DE than those who did not (OR = 18; 95% CI, 7.99–40.14), for student who consumed sour candies 2–4 time per week, the odds were eight times (OR = 8; 95% CI, 5.46–12.26). Those who consumed it at least once weekly were about one and a half times more likely to have DE than those who did not eat sour candies at all (OR = 1.5; 95% CI, 1.14–1.91).

Logistic regression defined sports beverages as a causative indicator of DE. The odds of having DE increased by the increase in the frequency of beverages consumption; students who drank sports beverages more than two times daily were almost 29 times more prone to have DE than those who did not drink it at all (OR = 29; 95% CI, 9.38–91.23), students who had this drink once daily were about 14 times more likely to have DE than those who did not (OR = 14; 95% CI, 2.95–65.12) and for those who drank sports beverages 2–4 time per week, the odds were nearly 12 times than those who did not (OR = 12; 95% CI, 5.90–25.81). Regarding snacks, having confectionary was significantly associ-

ated with DE ($P = 0.019$), were odds of having DE in students consuming confectionary as snacks was 1.4 times (OR = 1.4; 95% CI, 1.05–1.74). Logistic regression analysis of the results demonstrated the protective potential of fluoride against DE. Students not using fluoride were 1.4 times more likely to develop DE than those who did (OR = 1.4; 95% CI, 1.01–2.03).

The results of this study revealed that the risk indicators that were simultaneously associated with DE were geographical location, medical condition including frequent mouth dryness and having frequent bouts of vomiting, using cortisol inhaler, dietary habits including keeping soft drinks in the mouth for long time, drinking lemon juice and carbonated beverages at bed time, frequent consumption of lemon, sour candies, and sports drinks, and having confectionary as snacks.

Discussion

Effective detection, prevention and early intervention are important if they are planning to have an adult lifetime without complex restorative treatment.

Much of the advice offered to prevent or minimize DE is grounded on information from case reports, *in vitro* and some *in vivo* work. The supposition was demonstrating that extrinsic sources of acids, predominantly dietary factors, are the cause of erosion in this age group[22,23]. Others acknowledge that this may be too simplistic and that other factors such as oral hygiene levels, social, cultural, medical, occupational, and geographical area are also relevant factors[13,24]. As in some studies, however, authors have failed to show relationships with some of these factors even though erosion was prevalent in their study samples[20,24]. Therefore, almost all known factors related to medical conditions, oral hygiene, and diet that were reported to be associated with erosion were investigated in the present study.

Geographical factors influencing the prevalence of erosion can be attributed to social class, lifestyle, fluoridated water, and dietary habits. The low erosion prevalence in Al-Karak may be related to the high prevalence of fluorosis (39%)[25], which may have lead to exclusion of subjects with DE in this study.

Dental erosion associated with the use of asthmatic medications may be primarily attributed to the fact that the majority of these medications are acidic and possess direct erosive threat to the dentition. In addition, they potentially decrease the salivary buffering capacity and flow rates[26,27]. The frequent use of such medications is followed by the consumption of acidic drinks to compensate for oral dryness and overcome the bitter taste of the drug. In addition, medical conditions such as vomiting, heart burn, and gastric problems were more commonly reported in asthmatic patients and thus contributing to DE[26,27]. Dugmore and Rock (2003) did not find this association, however[28].

The association of hyposalivation (regardless of the cause) with DE had been reported in the literature[29–31]. Järvinen *et al.* (1991) pointed out that the risk of developing DE was increased by five times in patients with reduced unstimulated whole salivary flow rates[7]. The salivary flow rate was an important factor in eliminating any harmful agents and dietary acids from the mouth[32]. Moreover, the composition of saliva is highly dependent on the salivary flow rate[7].

Having frequent bouts of vomiting as a potential risk indictor of developing DE was documented in the literature[22,33,34]. Frequent bouts of vomiting are associated with a large group of psychosomatic disorders including eating disorders and stress-induced psychogenic disorders[5,22,35,36]. In this study, neurological and psychological diseases were highly associated with DE in the bivariate analysis but not proven to be as risk indicators of DE in the logistic regression analysis.

Pronounced tooth wear was more evident when associated with tooth brushing as softened enamel seemed more susceptible to be removal by mechanical forces, like attrition and abrasion[37]. It has been reported that rinsing the mouth after drinking beverages has a lesser association with DE and even can be considered a protective measure[38].

Holding acidic beverages in the mouth before swallowing increased the contact time of the acidic substance with teeth and was

likely to be the main driving force leading to erosion in many individuals[6,39]. Johansson *et al.* (2004) in an *in vivo* study reported that holding the drink in the mouth before swallowing led to the most pronounced drop in the intraoral pH than any other drinking method[40]. Having acidic drinks (Lemon and carbonated drinks) at night-time after tooth brushing was considered as a risk indicator for having DE because brushing teeth removes the tooth pellicle which protects teeth from erosive attacks. Additionally, the decrease or absence of salivary flow during sleeping, subsequently affects the saliva protective ability[2,3]. These facts were in line with our results. Our results were in accordance with other studies indicating consumption of lemon, sour candies, sports, and carbonated beverages, and lemon juice consumed at bed time are considered a risk indicators of DE[6,24,28]. Al-Dlaigan *et al.* (2001) found that the consumption of fruit drinks, squashes, and carbonated beverages played a major role in the presence of the condition[13]. Millward *et al.* (1994) examined 101 school children and found a high severity of DE associated with high consumption of soft drinks, particularly sports drinks[20]. O'Sullivan and Curzon (2000) found in their case–control study that young patients with erosion consumed significantly larger quantities of carbonated beverages and cordials than did the controls[6].

In conclusion, this study examined almost all factors reported in the literature and thought to be associated with DE. The finding of this study support that DE is a multifactorial condition.

Why this study is important for paediatric dentists

- The results of this study signals paediatric dentist to be aware that children with mouth dryness, vomiting, and those using cortisol inhalers, in addition, to those who keep soft drinks in their mouths, drinking lemon juice, and carbonated beverages specially at bed time, are more likely to exhibit DE and might need more attention and proper counselling.

Conflict of interest

The authors declare no conflict of interest.

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