Prevalence and Extrinsic Risk Factors for Dental Erosion in Adolescents

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Objective*: This manuscript examined the prevalence and extrinsic risk factors for dental erosion (DE) in early and middle adolescents in Pasto, Colombia.* ***Study design:*** *Dental erosion was evaluated in a random sample of 384 individuals aged 10-15 years attending three primary and high schools in this cross-sectional study. Clinical dental assessment for DE was done using O'Sullivan index. Data on general sociodemographic variables and extrinsic risks factors were obtained. Descriptive and univariate binary logistic regression analyses were performed.* ***Results****: Dental erosion was observed in 57.3% of individuals. The univariate binary logistic regression analysis showed that frequency of drinking natural fruit juices (OR 2.670, 95% CI 1.346 – 5.295, P=0.004) and their pH (OR 2.303, 95% CI 1.292 – 4.107, P=0.004) were more associated with the odd of DE in early adolescence. However, a high SES (OR 10.360, 95% CI 3.700 – 29.010, P<0.001) and frequency of snacks with artificial lemon taste (OR 3.659, 95% CI 1.506 – 8.891, P=0.003) were highly associated with the risk of DE in middle adolescence.* ***Conclusions:*** *The results suggest that DE is a prevalent condition in adolescents living in a city in southern Colombia. The transition from early to middle adolescence implies new bio-psychosocial changes, which increase the risk for DE.*

Key words: *Tooth erosion, prevalence, risk factors, diet, adolescents.*

INTRODUCTION

Nutrition and diet can affect the development and integrity of the oral cavity as well as the progression of oral diseases.[1] The clinical term dental erosion is used to describe the physical results of a pathologic, chronic, localized loss of dental hard tissue that is chemically etched away from the tooth surface by acid and/or chelation but without bacterial involvement as characterizes dental caries. The acids responsible for erosion are not products of the intraoral flora, but rather they are from extrinsic dietary, occupational factors or intrinsic sources.[2-5]

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Dental erosion (DE) has been informed for several decades; however, the frequency and distribution of DE may have changed through the years. In their 2006 report, Jaeggi and Lussi[6] reviewed the prevalence, incidence and distribution of dental erosion in preschool children aged 2-5 years. In this year, the prevalence of erosion ranged from 6 to 50% on primary teeth. In their 2014 report[7] they stated that dental erosion prevalence had increased in this same age group ranging from 1 to 79% on these teeth. With regard to erosion distribution, males experienced more dental erosion than females in the two reports. This entity in adolescent population has been reported for 15 countries in the last decade, with an estimated prevalence of 31.11% ± 18.27% ranging from 5.5% and 74% with different scoring systems.[8-28]

This condition may be caused by extrinsic and intrinsic factors. Extrinsic factors are the most common factors associated with DE. They include diet, medication or occupational exposures. With regard to dietary intake, consumption of acidic food, citric, tartaric, maleic, ascorbic acids[29] and a low pH drinks such as carbonated beverages[30] are most likely related to DE. Alcohol consumption may increase DE among individuals consuming this beverage because loss of enamel has been particularly associated with wine, for example. Wine tasters had a higher prevalence and more severely erosive teeth surfaces than a control group.[31] Experimentation with alcohol in adolescence is common as a finding and is linked to the dramatic physical, lifestyle and especially emotional changes in this

period of life. The Organization of American States informed that consumption of alcohol in 14-years-old and younger ranges from 5.9% to 57.6% progressively increasing over time.[32] It has been estimated that 80% of those 13-17-years-old have used alcohol during their lifetime.[33] For this reason, dental erosion may be related to this behavior; however, few studies have evaluated this association. Moreover, low pH medications (asthma medicines)[34] and occupational exposures, *i.e* chromic acid[35] are considered potential risk factors, as well.

Dental erosion is an entity that impacts on oral health and functioning. The hard tissues loss might lead to dentin hypersensitivity as well as a poor appearance due to the loss of dental enamel and dentin. Restorative treatment of large losses of enamel and/or dentin can be both challenging and expensive. Further, in extensive and more severe loss of tooth structure, clinicians also may observe sequelae such as temporomandibular joint disorders.[36] In adolescents who clench or grind their teeth, a common habit in this period of life[37,38] a loss of dental hard tissue may alter the occlusion and increase the risk of facial pain.

We have chosen to evaluate this condition in adolescents because the ages comprised in this study are important for designing oral health prevention programs. Since dental erosion may cause dental esthetic problems, early adolescents (10-13 years) may be concerned about this enamel loss because of they are more interested in their appearance. Further, middle adolescents (14-16 years) may also be interested in this loss as they begin to be aware of the consequences of their choices for the future.[39]

Pasto, Nariño is a city localized in the southwest Colombia, near the border with Ecuador. As a tropical zone, the acid fruits and natural fruit beverages consumption is very popular as well as the intake of acid-flavored candies. Since consumption of these beverages has been reported to increase the risk for dental erosion, a better understanding of the prevalence, distribution and potential associations between risk factors and DE in early and middle adolescence is warranted, to help guide the development of oral public health programs and implementation of a nutrition policy to reduce the likelihood of DE in our community. To evaluate this condition, an observational study was designed to determine the prevalence of DE and identify potential extrinsic risk factors in a sample of adolescents from Pasto, Colombia.

MATERIALS AND METHOD

A cross-sectional study of adolescents (10-15 years) of Pasto, Colombia was executed. This sample of adolescents was guided by the 2005 Colombian census, which aimed to cover the population of our municipality, as well as, all of regions of our country. This census registered a total of 87,711 among 10-15 year-old population that were distributed according ages as follows: 14,895 (10years); 14,420 (11years); 14,664 (12years); 14,617 (13years); 14,526 (14years) and 14,589 (15years). We calculated a representative sample size of this population at a 95% level of confidence with a 5% of margin of accuracy and expected prevalence of 50%. A sample of 384 individuals was obtained and was distributed through proportional allocation having an account the values of this census according to age (Table 1) and gender was taken through a male to female ratio of 1.1:1.

Table 1. Summary of sampling distribution

Age/ SES	SES Low	SES Middle	SES High	TOTAL	
				F	%
10yrs	22	22	22	66	17.2
11yrs	21	21	21	63	16.4
12yrs	22	22	22	66	17.2
13yrs	21	21	21	63	16.4
14yrs	21	21	21	63	16.4
15yrs	21	21	21	63	16.4
TOTAL	**128**	128	128	384	100

We focused our study in early adolescence (ages 10 to 13 years) and middle adolescence (ages 14 to 16 years). We elected not to include those 16 years old because this group of adolescents starts the process of becoming young adults and implies developmental additional changes such as defining a personal sense of identity, increasing more balance between the influence of family and peers on them and being available to measure risk taking. In our community some secondary school students complete their studies aged between 11-16 years instead of 12-17/13-18 years, which may influence adolescents' behavior since they gradually take on adulthood roles expected of them more quickly.

A sample of adolescents was obtained from Pedagógico, San Felipe and San Francisco Javier primary and high schools in Pasto, Colombia. The Ethics Committee of Health Sciences gave its approval prior to the study performance. A signed consent letter was asked to College students older or equal to 18 year-old to be part of the calibration process and written parents' consent was required for the 10-15 year-old group to participate.

The sample was equally distributed among the three socioeconomic groups by selecting these three schools that were the largest and most representative of each SES strata in order to attain a real perspective of the oral health condition in the community. We acquired the list of all children aged 10 to 15 years from these three schools and created groups according to age and sex (12 groups per school). We then selected 10 or 11 subjects from each of these groups using a random number table. Adolescents were excluded from the study if they wore orthodontic appliances, presented hypodontia or missing teeth such as incisors or first molars, enamel defects that included enamel loss, fractured tooth or severe dental caries, the presence of obvious and extensive wear facets on the teeth or had intrinsic factors for dental erosion (bulimia). A physical examination to evaluate some signs for bulimia such as the Russell' sign, bilateral parotid enlargement and the presence of telogen effluvium[40-42] was done. If someone had one of these signs, some questions related to regular changes in weight, episodes of over-eating, periods of starvation or episodes of binge eating followed by efforts to avoid gaining weight were asked to parents to confirm a potential case of this disorder.

Dental Erosion Clinical Assessment

Dental erosion was diagnosed according to the clinical criteria of O'Sullivan index.[43] This index has been especially designed for epidemiologic studies and taken to record the distribution, severity, and number of affected teeth. Dental assessments were authorized by the students' well-being office and were performed in one of

students' health services offices where natural illumination was optimal. The ideal light source is natural light. For this reason, the individuals were examined always around mid-day for getting an accurate diagnosis. Since the time of the day and weather conditions affect sunlight, the examination was performed in similar conditions according these two variables. We want to clarify that our locality has little variations of weather and light through the year, due to it is located in the tropical zone of Latin-American.

Individuals were seated on a chair. Teeth were manually cleaned with cotton rolls and fluoride rinse if they were not clean enough. Teeth were isolated with these rolls placed on the buccal sulcus before the assessment. The "tooth by tooth" examination was done directly using basic dental instruments (plane mouth mirror, #3 single-sided MIR3HD-explorer, Shephard's Hook EXS236 #30-dressing pliers, DPU17 Hu-Friedy®) from different angles to detect whether teeth morphology was affected by erosion, and we used different sizes of dental photography mirrors (BriteSources® MPH-01-02-03-04-05) in cases where the examiner needed to take a picture to confirm the diagnosis. Since primary dentition is less resistant to erosive wear than permanent teeth[44] and this dentition (specifically canines and molars) has been at least 8 years in an oral environment, only permanent teeth were evaluated in order to avoid bias. A confounding factor such as normal progression of wear may suggest values between 3.7 μm at 6 months and 5.56 μm/month to 18.3μm/month[45], however, an increased loss may be more evident in primary teeth because of their susceptibility.

Examiner´s Calibration

Two examiners were trained and calibrated prior to conduct of the study. Different severity levels of dental erosion were observed in the calibration process which included oral photographs of scientific literature and as well as private practice clinical cases of our dental school's clinical professors with severity codes of 2, 3 and 4 according to O'Sullivan dental erosion index. Standard dental morphology was studied to recognize ridges (perikymata), cingulum, depressions, grooves or pits in order to memorize the shape and contour of the normal dentition and manage them readily when we diagnose dental erosion. In addition, the two examiners independently evaluated once 10 freshman dental students with different patterns of dental erosion at the Clínica Odontológica, Universidad Cooperativa de Colombia. Clinical photos of affected teeth were taken when there was a disagreement between the examiners. A posterior discussion of O'Sullivan criteria adopted for the diagnosis of dental erosion was carried out using these clinical intraoral images.

To measure the reproducibility of the diagnostic criteria, 10% of the sample was assessed (40 adolescents). Within each dental examination section carried out at the three schools, 12-16 students were re-examined two times by each examiner. For each student, upper incisors (4 teeth) and lower molars (4 teeth) were evaluated. These students were not included in the whole sample. Only subjects with orthodontic appliances or with enamel hypomaturation were excluded in this evaluation.

Extrinsic Risks Factors

Data on general socio demographic variables such as age, sex and socioeconomic status were obtained. Socioeconomic status was registered using the government of Colombia parameters (1-2 strata = low class, 3-4 strata = middle class and 5-6 strata = high class). These parameters are based on income and housing quality indicators. We recorded extrinsic risks factors such as acid diet consumption per week (p/w), *i.e.* soft drinks intake (natural or artificial fruit juices, carbonated drinks, lemon tea or sport beverages), snacks with artificial lemon taste and sour candies consumption or a salt-lemon blend (a popular mixture eaten in this region of Colombia), alcohol consumption per month (p/m) (we included this variable since in adolescence, many individuals begin to experiment with alcohol). In addition, information about medication intake was collected for the adolescents 15 minutes before the clinical examination. Since students access to diverse food in schools, we interviewed to adolescents rather than their parents. The questionnaire was designed in accordance with the Piaget's Cognitive Development Theory especially concrete operational stage for those participants, approximately between ages 7 to 11 years old. Children during this stage are able to reason logically as long as the reasoning applied to concrete and specific examples.[46] For this reason, the questions were designed to collect accurate feedback from these students (*e.g. Do/ Did you drink a soft drink today/yesterday?).*

The pH values were established for the most popular beverages (natural and artificial drinks) prior to this investigation. In order to prevent bias, the surveys were administered by two training researchers who were blinded to the DE examination outcomes.

Statistical analysis

The data were analyzed with the Statistical Package for Social Sciences (version 19, SPSS, Chicago, IL, USA). Descriptive measures were obtained for the prevalence and characteristics of dental erosion. Risk factors were expressed as Odds Ratios (ORs) and 95% Confidence Intervals (CI) and estimated by using a univariate binary logistic regression analysis. The level of statistical significance was set at 5%.

RESULTS

The preliminary examinations of DE were used to estimate the intraexaminer (0.83) and interexaminer (0.74) reliability through Cohen's Kappa coefficient (Table 2). Both values indicated a good agreement[47] for reproducibility of DE diagnosis.

Dental erosion diagnosis

One hundred eighty-two male and 202 female school children, aged 10-15 years (12.5±1.7) were examined. A total of 8189 teeth were evaluated (10yrs=836, 11yrs=873, 12yrs=1268, 13yrs=1688, 14yrs=1760 and 15yrs=1764) and 2081 teeth showed signs of dental erosion in 220 individuals (57.3%, 95% CI 52.1%–61.9%). Males had slightly more signs of erosion (n=120, 54.4%) than females (n=100, 45.5%) (P=0.378). Of the 220 individuals with dental erosion, 37 (16.8%) were aged 10yrs, 35 (15.9%) were aged 11yrs, 32 (14.5%) were aged 12yrs, 44 (20%) were aged 13yrs, 36 (16.4%) were aged 14yrs and 36 (16.4%) were aged 15yrs (P=0.281). The most frequently affected surfaces were labial or buccal only (99.8%). With regard to severity of DE, most affected tooth surfaces exhibited a matte appearance of the enamel surface with no loss of contour (98.4%) and, basically, had less than half of the surface involved (Table 3). Dental erosion occurred most commonly on incisors 216 (62.1%) followed by molars 72 (20.7%) and premolars 60 (17.2%).

Table 2. Examiner Agreement on Criteria of O'Sullivan Index using Kappa by Cohen Index

Criteria of O'Sullivan Index	Intra-examiner 1 variability	Intra-examiner 2 variability	Inter-examiner variability
Site on erosion on each tooth	0.878	0.858	0.773
Grade of severity	0.828	0.865	0.710
Area of surface affected by erosion	0.739	0.812	0.743
Average Intra-examiner	2.445/3 =0.815	2.535/3 = 0.845	2.226/3
Average Intra and Inter examiners	0.830		0.742

Table 3. Percentage of site tooth, grade of severity, and area of the surfaces affected by dental erosion in a 10-15 years-old group.

		Criteria of O'Sullivan Index	Teeth	%
Site on erosion on each tooth	Code A	Labial or buccal only	1736	83.4
	Code B	Lingual or palatal only	2	0.1
	Code C	Occlusal or incisal only	-	-
	Code D	Labial and incisal/occlusal	2	0.1
	Code E	Lingual and incisal/occlusal	-	-
	Code F	Multi-surface	341	16.4
Grade of severity (worst score for an individual tooth recorded)	Code 0	Normal enamel.	-	-
	Code 1	Matt appearance of the enamel surface with no loss of contour.	2048	98.4
	Code 2	Loss of enamel only (loss of surface contour).	33	1.6
	Code 3	Loss of enamel with exposure of dentine (enamel-dentin junction visible).	-	-
	Code 4	Loss of enamel and dentine beyond enamel-dentin junction.	-	-
	Code 5	Loss of enamel and dentine with exposure of the pulp.	-	-
	Code 9	Unable to assess (e.g. tooth crowned or large restoration).	-	-
Area of surface affected by erosion	Code -	Less than half of surface affected.	1986	95.4
	Code +	More than half of surface affected.	95	4.6

Extrinsic Risk Factors

Early adolescents most commonly consumed acid food such as natural juices (n=248, 96.1%), carbonated drinks (n=210, 81.4%), salt-lemon blend (n=165, 64.0%) and food with artificial flavors being snacks with lemon taste (n=160, 62.0%) and sour candies (n=119, 46.1%) were most popular. Middle adolescents only drank significantly less carbonated beverages (n=86, 68.3%) than early adolescents (n=210, 81.4%) (P=0.004). With regard to the ingestion of the other acidic food that subjects consumed, there were not significant differences in these stages. Beverages such as sports drinks and lemon tea, were not popular in these groups. In general, twenty seven (7%) of all participants used alcohol at least one time every month. According to adolescence stage, six early adolescents (2.3%) reported having at least one alcoholic drink p/m while twenty one middle adolescents (16.7%) had one (P=0.001). Seven early adolescents (2.7%) took at least one type of prescription, while fourteen middle adolescents (11.1%) took the same amount (P=0.001). Middle adolescents take more medications to control asthma (1.6%) in comparison to early teenagers (0.4%). Vitamins were taken more often by middle adolescents (1.6%) than early adolescents (0.4%). The three adolescents with asthma treatment had dental erosion.

Early adolescents

A significant risk for dental erosion was observed in those aged 13 yrs (OR 1.908, 95% CI 1.067 – 3.412, P=0.028). There were no statistical differences in the risk for DE between males and females (OR 0.955, 95% CI 0.583 – 1.565, P>0.05). However, variables such as middle socioeconomic status (SES) (OR 3.048, 95% CI 1.725 – 5.385, P<0.001) and high SES (OR 2.804, 95% CI 1.596 – 4.925, P<0.001) increased the odd of DE, while low SES (OR 0.114, 95% CI 0.063 – 0.208, P<0.001) was less likely to be associated with this condition. Ingestion of natural fruit juices pH (OR 2.303, 95% CI 1.292 – 4.107, P=0.004), frequency of intake of these juices p/w (OR 2.670, 95% CI 1.346 – 5.295, P=0.004) and salt-lemon-blend (OR 1.889, 95% CI 0.971 – 3.676, P=0.059) increased the odd of DE. In the same way, consumption (OR 2.128, 95% CI 1.275 – 3.553, P<0.004) and frequency (OR 1.872, 95% CI 1.056 – 3.321, P=0.031) of snacks with artificial lemon taste were associated with DE. Furthermore, drinking alcohol at least one time p/m (OR 3.028, 95% CI 0.334 – 27.473, P=0.301) was clinically associated with DE but no statistically (Table 4).

Table 4. Odds ratios (OR) and 95% confidence intervals (CIs) for dental erosion and extrinsic risk factors in adolescents

Risk Factors			Early Adolescents 10-13 yrs			Middle Adolescents 14-15 yrs			All of Adolescents 10-15 yrs		
			OR	95% CI	P*	OR	95% CI	P*	OR	95% CI	P*
Socio-demographic	Sex	Male*	0.955	0.583 – 1.565	0.856	1.933	0.944 – 3.959	0.070	1.200	0.800–1.799	0.378
		Female									
	Socio-economic stratus	Low	0.114	0.063 – 0.208	<0.001	0.074	0.029 – 0.184	<0.001	0.100	0.060 – 0.164	<0.001
		Middle	3.048	1.725 – 5.385	<0.001	1.560	0.727 – 3.346	0.252	2.421	1.538 – 3.812	<0.001
		High	2.804	1.596 – 4.925	<0.001	10.360	3.700 – 29.010	<0.001	4.048	2.490 – 6.578	<0.001
Acid Diet	Fruit juices pH	0-3*	2.303	1.292 – 4.107	0.004	1.428	0.591 – 3.451	0.427	2.007	1.240 – 3.249	0.004
		>3									
	Frequency of natural fruit juices p/w	0-7	2.670	1.346 – 5.295	0.004	1.267	0.479– 3.039	0.690	2.048	1.188 – 3.533	0.009
		>7*									
	Artificial fruit juices pH	0-3*	1.164	0.570 – 2.376	0.676	0.577	0.187 – 1.782	0.337	0.907	0.501 – 1.642	0.748
		>3									
	Frequency of artificial juices p/w	0-7	4.606	0.546 – 38.820	0.124	N/A	N/A	N/A	5.357	0.653 – 43.972	0.081
		>7*									
	Carbonated drinks pH	1-3	1.461	0.825 – 2.589	0.193	1.056	0.445 – 2.502	0.902	1.327	0.825 – 2.132	0.243
		>3*									
	Frequency of carbonated drinks p/w	0-3	0.814	0.477 – 1.391	0.452	1.360	0.566 – 3.266	0.491	0.940	0.598 – 1.478	0.789
		>3*									
	Total of beverages pH	0-3*	1.334	0.812 – 2.192	0.255	1.836	0.862 – 3.910	0.114	1.466	0.971 – 2.214	0.068
		>3									
	Frequency of total beverages p/w	0-14	1.596	0.938 – 2.715	0.083	3.250	1.332 – 7.927	0.008	1.942	1.237 – 3.049	0.004
		>14*									
	Salt-lemon-blend	Yes	0.833	0.497 – 1.396	0.487	0.557	0.264 – 1.176	0.123	0.730	0.477– 1.116	0.145
		No									
	Frequency of salt-lemon-blend	0–1	1.889	0.971 – 3.676	0.059	3.059	1.251 – 7.477	0.012	2.247	1.319 – 3.825	0.002
		>1*									
	Snacks with artificial lemon taste	Yes	2.128	1.275 – 3.553	0.004	2.083	1.016 – 4.272	0.044	2.106	1.390 – 3.193	<0.001
		No									
	Frequency of snacks with artificial lemon taste	0-3	1.872	1.056 – 3.321	0.031	3.659	1.506 – 8.891	0.003	2.310	1.431 – 3.730	0.001
		>3*									
	Sour candies	Yes	1.541	0.935 – 2.539	0.089	2.459	1.157 – 5.226	0.018	1.780	1.176 – 2.693	0.006
		No									
	Frequency of sour candies	0-3	1.678	0.856 – 3.290	0.129	3.357	1.321 – 8.535	0.009	2.152	1.250 – 3.703	0.005
		>3*									
Alcohol Consumption	Alcohol p/m	Yes	3.028	0.334 – 27.473	0.301	2.286	0.829 – 6.303	0.104	2.243	0.925 – 5.438	0.067
		No									
	Frequency of alcohol p/m	0-1	N/A	N/A	N/A	2.754	0.844 – 8.984	0.083	3.137	1.029 – 9.568	0.035
		>1*									

Risk Factors			Early Adolescents 10-13 yrs			Middle Adolescents 14-15 yrs			All of Adolescents 10-15 yrs		
			OR	95% CI	P*	OR	95% CI	P*	OR	95% CI	P*
Medication	Medication intake	Yes	1.888	0.359 – 9.918	0.446	11.678	1.477– 92.314	0.011	4.782	1.384 – 16.520	0.007
		No									
	Asthma treatment	Yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		No									

*P values were derived by univariate binary logistic regression. P<0.05 is considered as significant.
† p/w per week.
‡ p/m per month.

Middle adolescents

The social and economic background was related to DE, high SES (OR 10.360, 95% CI 3.700 – 29.010, P<0.001) increased the risk for DE, while low SES (OR 0.074, 95% CI 0.029 – 0.184, P<0.001) also reduced strongly the odd of this condition. Concerning acid diet, frequency of total beverages p/w (OR 3.250, 95% CI 1.332 – 7.927, P=0.008) and frequency of salt-lemon-blend (OR 3.059, 95% CI 1.251 – 7.477, P=0.012) were associated with DE. A close to being statistically difference was found in the odd of DE between males and females (OR 1.933, 95% CI 0.944 – 3.959, P=0.070) in this stage.

Similarly, consumption (OR 2.083, 95% CI 1.016 – 4.272, P<0.044) and frequency (OR 3.659, 95% CI 1.506 – 8.891, P=0.003) of snacks with artificial lemon taste increased the likelihood of DE. In this stage, the consumption (OR 2.459, 95% CI 1.157 – 5.226, P=0.018) and frequency (OR 3.357, 95% CI 1.321 – 8.535, P=0.009) of sour candies were associated with DE. Medication intake increased the risk for DE (OR 3.927, 95% CI 1.118 – 13.798, P=0.022) in both, early and middle adolescence. However, middle adolescents had a higher risk for DE associated with these medications (OR 9.557, 95% CI 1.194 – 76.497, P=0.011). Additionally, drinking alcohol (OR 2.286, 95% CI 0.829– 6.303, P=0.104) and alcohol consumption at least two times p/m (OR 2.754, 95% CI 0.884– 8.984, P=0.083) were clinically but not statistically associated with DE in this period of adolescence. However, frequency of alcohol p/m increased the risk for DE in all of adolescents (OR 3.137, 95% CI 1.029– 9.568, P=0.035) (Table 4).

DISCUSSION

We evaluated the rates of dental erosion (DE) with O'Sullivan index and risk factors associated with this condition in a representative sample of adolescents aged 10 to 15years. Overall, 57.3% of this sample had DE. Wang *et al* [48] in Guangzhou, Southern China in 12-13-year-old subjects observed a global prevalence of 27.3%. In addition, Correr *et al* [49] reported a 26% DE prevalence in 12 year-old in a study of Piracicaba, SF, Brazil. Our findings are different from those observed by Peres *et al* [50] in Brazil who reported a prevalence of 12% in those aged 12 years and by Kumar *et al* [51] who estimated a prevalence of 8.9% in 11 to 14-year-old individuals in South India. However, our dental erosion prevalence distributed by age showed close results to the reported by these authors, in our study 35 subjects with DE (15.9%) belonged to 11yrs group, 32 (14.5%) to 12yrs group, 44 (20%) to 13yrs group, and 36 (16.4%) to 14yrs group. Although we did not find sex differences previous reports state a variation.[52]

A possible reason for our findings of a higher general prevalence of DE may be that we included two groups of ages more (10 and 15 year-old groups) and the 13 year-old group was not included in some of these studies, a critical age group for our study. We also found differences in socioeconomic status and our associated risk factors that seem to interact in different way to than the other reports. Furthermore, our calibration that also used photographs in some cases might have improved inter examiner reliability in diagnosis and provided more accurate estimates of mild dental erosion (teeth had less than half of surface affected). In addition, we want to clarify we did not include subjects with some enamel defects such as enamel hypoplasia, enamel hypomaturation or severe fluorosis because mild dental erosion is difficult to assess in those occurrences. Even though almost of all participants may be in low-risk for these enamel defects, a severe dental erosion might be diagnosed in subjects with those entities. Moreover, a mild bruxism could be confused with DE because of there are some similarities in the clinical manifestations of dental erosion in this condition or the researchers could overestimate the severity of dental erosion when an individual had both, DE and mild bruxism at the same time. On the other hand, our findings revealed that the incisors were the teeth most affected, especially on labial or buccal surfaces, which is consistent with other reports.[53,54]

The adolescence is a period of preparation for adulthood during which several physical and emotional experiences occur. A relevant outcome in our study was that 13 year-old individuals showed a higher odd of DE (OR 1.908, 95% CI 1.067 – 3.412, P=0.028) than the other age groups. This age can be considered as a cut-off point in the transition from early to middle adolescence. It is characterized by maturation and an evolving personality, impulsivity, rebellion, and deviation from established adult norms.[55,56] Moreover, subjects not only experience these changes but also social evolution and economic independence which determining their own identity in this age. Furthermore, it is important to mention in adolescence social interactions influence human behavior powerfully. Thus, in our study high socioeconomic status was a variable associated with the presence of DE in both early (OR 2.804, 95% CI 1.596 – 4.925, P<0.001) and middle (OR 10.360, 95% CI 3.700 – 29.010, P<0.001) adolescence.

The major sources of income for adolescents are allowances, gifts and earnings. Teenager's purchases are discretionary items like toys, clothing, entertainment, and snacks. Early adolescents may spend their money on sweets, as time passes they are more likely to purchase gifts for others.[57] In our community, adolescents aged

around 10 years of age they start to receive an allowance from their parents and usually get gifts from their family, especially grandparents. However, some of them still bring food from their homes. In early adolescence parents still have some control of their sons and daughters eat. Frequency of consumption of snacks might result from the fact that adolescents get more amount of money as they are getting older. The relation between SES and dental erosion is clear, in our undeveloped country. High socioeconomic status individuals increase their consumption of risk food such as snacks, because of they have more economic resources. We also found that low SES buffers the odd of DE with OR 0.114, 95% CI 0.063 – 0.208, P<0.001 and OR 0.074, 95% CI 0.029 – 0.184, P<0.001 in early and middle adolescence respectively. These outcomes are consistent with the Ruhm's[58,59] findings which suggest that a lower income exerts a strong protective effect on health. So, a reduced ingestion of erosive food may be due to the fact that they are unable to buy it, thus, decreasing the risk of DE.

In our study we found that the intake (OR 2.459, 95% CI 1.157 – 5.226, P=0.018) and frequency (OR 3.357, 95% CI 1.321 – 8.535, P=0.009) of sour candies were associated with DE in middle adolescence but not in the early stage. Muller-Bolla *et al* [60] also found in 14-year-old French adolescents with a daily acidic candies consumption increased the risk for DE (OR 3.2, 95 % CI 1.2–8.0) in the same stage. Moreover, in early and middle adolescence, the consumption of snacks with artificial lemon taste (OR 2.128, 95% CI 1.275 – 3.553, P<0.004) and (OR 2.083, 95% CI 1.016 – 4.272, P<0.044) was almost similar in relation to the risk for DE. However, frequency of snacks with artificial lemon taste was higher in middle adolescence (OR 3.659, 95% CI 1.506 – 8.891, P=0.003) than early adolescence (OR 1.872, 95% CI 1.056 – 3.321, P=0.031) increasing the odd of DE in this group. The *in vitro* study by Beyer *et al*.[61], concluded that the erosive effects of acids with equivalent acidic taste lead to different erosion levels on human dental enamel. Even though components such as citric acid (acid used in snacks or sour candies) promote a minor loss of hardness, those results suggests that it still leads to a dissolution.

There were no sex differences in the odd of DE. However, a trend was found in the risk for DE among males and females in middle adolescence (OR 1.933, 95% CI 0.944 – 3.959, P=0.070). Male in this stage of adolescence are more engaged in participating in sports since they may function as culturally invented courtship rituals that reliably advertise participant quality to the opposite sex, a very important aspect in adolescence.[62] Sports-practicing adolescents may have a high consumption of beverages (artificial and natural juices or carbonated drinks) because of dehydration and this would favor the odd of DE. For this reason, it is interesting that in middle adolescence, intake frequency of total beverages p/w (OR 3.250, 95% CI 1.332 – 7.927, P=0.008) increased the risk for DE. In early adolescence, however, the pH of natural fruit juices (OR 2.303, 95% CI 1.292 – 4.107, P=0.004) and frequency of these juices p/w (OR 2.670, 95% CI 1.346 – 5.295, P=0.004), were more associated with the odd of DE.

Acidic soft drinks that include fruit juices and carbonated beverages have been known to induce the dissolution or erosion of dental enamel.[63] It has been demonstrated that a single acidic attack is of minor importance but repeated exposure impairs the ability of the saliva to deal with the acid. Hence, the danger is the frequent use of soft drinks over time.[64] It was surprising that carbonated drinks were not associated with dental erosion contrary to recent reports in the literature.[65,66] However, we found that there was a clinical but not statistical association between these beverages and DE in early adolescents. This is likely how school cafeterias in primary and high schools function in our locality. These places frequently sell small glasses of soft drinks (artificial juices and carbonated beverages) rather than bottles of those drinks. Thus, students are likely drinking lesser amount of liquid every day than individuals from other countries.

The lemon, a citrus fruit, has been related to diverse health benefits in that it includes bioactive components such as citric acid, polyphenol and ascorbic acid.[67] Ingesting citrus fruits such as lemon may be a natural preference because of the presence of ascorbic acid. Alvarez and Kravetz[68] reported that on a daily basis, in captive capybaras accustomed to food containing ascorbic acid preferred to continue eating the same food. However, excessive and frequent citrus fruit consumption can cause damage to the human dentition.[69] Kumar *et al*[51] reported that 11- to 14-year-old individuals in South India had an odd of dental erosion between 2.34 and 13.41 when they consumed lemon more than one time p/w. In our locality the frequency of consumption of salt-lemon-blend p/w in early adolescents (OR 1.889, 95% CI 0.971 – 3.676, P=0.059) and middle adolescents (OR 3.059, 95% CI 1.251 – 7.477, P=0.012) was also associated with an increased odd of DE.

Further, we found that 7% of all participants used alcohol at least one time every month. There was a significant difference between early (2.3%) and middle (16.7%) adolescents. The pathway from early to middle adolescence is marked by more sophisticated social interactions with peers. For that reason, during this developmental period they are susceptible to being influenced by a negative environment and might be tempted by more risky behaviors such as smoking, alcohol drinking or drug use.[70] Univariate logistic regression analysis also indicated that frequency of alcoholic beverages p/m was significantly associated with a higher odd of DE (OR 3.137, 95% CI 1.029 – 9.568, P=0.035). However, this association was not statistically significant in middle adolescence in relation to DE (OR 2.754, 95% CI 0.844 – 8.984, P=0.083). Even though pH of these drinks may be higher than soft drinks, some of them are similar to pH of wine which is recognized to increase the risk of developing DE.[71] George *et al* [72] showed there was a significant correlation between years of wine tasting and age of participants with dental erosion. El Aidi *et al* [73] also reported in a 3-year longitudinal study in a group of adolescents that alcoholic mixed drinks significantly increases the odd of DE (OR = 1.82).

Similarly, a regular medicines intake increased the odd of DE (OR 4.782 95% CI 1.384 – 16.520, P=0.007). Although, middle adolescents had an increased risk for DE associated with these medications (OR 11.678, 95% CI 1.477 – 92.314, P=0.004). We found more frequent ingestion of certain medicines related to DE such as asthma. In patients with this condition, for instance, a reduction in the buffering capacity and salivary flow rate due to β-2 agonist and acidity of medication may increase the exposure of teeth to acids.[74] In addition the ingestion of more vitamins that may include chewable vitamin C (ascorbic acid) would favor the risk for DE.

At puberty, the combination of biological awakening of the reproductive system and social meaning that makes this an important

bio-cultural event, a rite of passage, in all human groups.[75] With adolescence comes not only physical growth, but also emotional, psychological, social, and mental change.[76] Among the emergence of adolescents' health concerns, there have been radical changes in the diets of young people.[77] National surveys indicate that intake of total energy, carbohydrates, sugars, and soft drinks have increased significantly among early and middle adolescents aged 10 to 15 years[78] that can lead to diseases and conditions such as weight increasing, obesity and dental erosion. For this reason, investigating dietary patterns has important public health implications because dietary intake is modifiable.[79] Our results show there is a need for designing oral health promotion and preventive approaches that focus on early and middle adolescence stages, acid diet pattern, alcohol intake and medication among this group from schools in Pasto, Colombia. With this comprehensive understanding, screening for dental erosion, food restrictions policies, interaction with parents and Student Wellbeing Officer could be an approach to control DE in this population.

Cross-sectional studies are limited because they only provide information at one time point or a short period. These studies are typically used to calculate the prevalence of the one condition (disease) of interest in a population but there is no control over data collection that includes exposure to risk factors. Since they are conducted at one time point, sequences of events are not given, being impossible to infer causal relationships. A second limitation is the size of our sample. Even though we estimated one derived from a probability sample technique, larger samples increase the chance of significance because they more reliably reflect the population characteristics. Finally, a third limitation concerns the fact that in-person interviews were obtained from adolescents, which means that may be inaccurate and recall to bias.

CONCLUSIONS

The findings have demonstrated that dental erosion (DE) in adolescents living in a city in southern Colombia was a prevalent condition and related to several factors. Further, those risk factors for DE depend on the adolescence period. Frequency of drinking and pH of natural fruit juices and consumption of snacks with artificial lemon taste were more associated with DE in early adolescence while a high socioeconomic status, frequency of total beverages p/w, snacks with artificial lemon taste, sour candies were with highly associated with the odd of DE in middle adolescence. The transition from early to middle adolescence implies new bio-psychosocial changes, which may increase the risk for DE.

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