

# Prevalence and Risk Factors of Dental Erosion in American Children

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**Objectives:** The purpose of this study was to assess the prevalence and characteristics of dental erosion in children aged 2-4 years old and 12 years old. **Study design:** 243 subjects were recruited from daycare centers, preschools, and grade schools; they received dental examinations assessing their condition of dental erosion, including both depth and area of tooth surface loss on four maxillary incisors. Questionnaires were given to the subjects to obtain socio-demographic, oral health behaviors at home, and access to dental care. Dental erosion was analyzed and risk factors were assessed using Chi-Square and logistic regression analysis. **Results:** The subjects were 60% Caucasians, 31% Black, 7% Hispanic and others were 2%. 34% of children could not get the dental care they needed within the past 12 months and 61% of all children brushed their teeth twice or more daily. Overall, 12% of study children had dental erosion with 13% for 2-4 years old and 10% for 12 years old, with the majority of erosive lesions within enamel. Family income (OR 3.98,  $p=0.021$ ) and acidic fruit juice consumption (OR 2.38,  $p=0.038$ ) were significant risk factors for dental erosion, even after controlling for other factors, such as source of drinking water and oral hygiene using logistic regression analysis. **Conclusions:** Dental erosion is a relatively common problem among the children in this study and it is seen as a multi-factorial process.

**Keywords:** tooth surface loss, dental erosion, tooth wear, children

## INTRODUCTION

Dental erosion is an irreversible loss of dental hard tissues by a chemical process without bacterial involvement. It can occur in primary and permanent dentitions, and can affect any tooth surface with the facial, occlusal, and lingual tooth surfaces most involved.<sup>1,2</sup> Erosive lesions can be caused by intrinsic or extrinsic acids which may lead to irreversible damage to the dentition. Erosion differs from carious lesions because the acid that causes erosion is not of bacterial origin.<sup>3</sup> Initially, the tooth surface softens due to loss of calcium and phosphate, but eventually there will be an apparent loss of tooth structure. Initially tooth surface softens due to loss of calcium and phosphate, but eventually there will be a apparent loss of tooth structure. The clinical appearance of dental erosion includes broad concavities on smooth surface enamel and increased incisal translucency, which can have undesirable esthetic implications. Furthermore, loss of enamel can lead to dentin exposure and hypersensitivity, even progressing as far as pulp exposure in some extreme cases.<sup>4</sup>

Epidemiological studies of dental erosion have reported a wide range of prevalence, depending on tooth type, age groups, indices of measurement, population samples, and the training and calibration of examiners.<sup>5-9</sup> For example, a study in Sudan on children aged 12-14 years old reported that 74% were found with mild to moderate tooth surface loss with no pulpal involvement; and factors such as erosive foods, socio-economic status, and gender were not associated with tooth surface loss.<sup>5</sup> Another study in Brazil on 12 and 16 year old children showed that dental erosion was present in about 20% of the cases, mostly not involving the pulp. The study also reported that there were no differences among gender and other socioeconomic factors, including family income.<sup>6</sup> A study in England found positive associations with dental erosion and drinking fruit juices and that dental erosion was present more in children who were boys, Caucasians, and had caries.<sup>8</sup> A study in Germany concluded that children ages 2-7 had a 32% presence of erosion.<sup>9</sup> A similar study of 5-7 year old children in Greece concluded that 45.6% had moderate to severe erosion involving dentin.<sup>10</sup> And finally, a study in Saudi Arabia of concluded that 34% of 5-6 year olds and 26% of 12-14 year old children had erosion into dentine or dentine and pulp.<sup>11</sup> Comparable studies have been very limited in the United States. A study analyzed the data from the 2003-2004 U.S National Health and Nutrition Examination Survey (NHANES) and reported 46% of children aged 13-19 years had dental erosion on at least one tooth with maxillary teeth being more prevalent.<sup>12</sup>

Dental erosion has become a growing concern in developed countries, particularly in Europe.<sup>13-14</sup> Due to the increased consumption of carbonated soft drinks and fruit juice, its prevalence and severity is expected to continue increasing. Many risk factors have been identified in past studies on erosion. For example, certain medical conditions like vomiting with bulimia or anorexia, along with regurgitation in gastro-esophageal reflux disease.<sup>15</sup> Binge drinking with alcoholics

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could also be another reason for dental erosion.<sup>16</sup> Certain medications which have ascorbic, liquid hydrochloric or acetylsalicylic acids.<sup>17-18</sup> Excessive overall consumption or increased frequency of consumption of acidic fruits, pure fruit juices and acidic drinks.<sup>17-19</sup> Other potential risk factors include a person's occupation<sup>20-22</sup> and illegal drug use.<sup>23</sup> Although these studies have identified several risk factors most of them used convenience samples and had many drawbacks in study design; therefore, the evidence is not conclusive and the etiology of dental erosion is not well understood.

There is not nearly enough information available about dental erosion and its prevalence. Studies on dental erosion were very limited in the United States, in particular those designed specifically to assess this condition. A number of risk factors were identified but the evidence is inconclusive and some results of the studies were contradicting. Therefore, using data collected in an oral health survey from the Greater Kansas City area, this report describes the prevalence of dental erosion and assess the risk factors associated with the condition among children.

**MATERIALS AND METHOD**

The study was a cross-sectional study. The Kansas City metropolitan area includes 6 counties and has a population of about 2 million people. The sample group consisted of 60% are Caucasians, 20% African Americans, 10% Hispanics, and 10% others. The sampling scheme was based on the concept of stratified random sampling. First, the numbers of children in each county were obtained and the names of daycare centers, preschools, and grade schools were collected. Random samples of those groups were then selected. After the potential sites were chosen, a stratified random sampling method was then used to assure appropriate representation of ethnic minorities, Medicaid-eligible children and children from Maternal and Child Health (MCH) programs. Therefore, stratification factors included county, age group, race/ethnics, and percentage of children eligible to free/reduced price lunch program. However, several preschools were added upon the request of Reach Healthcare Foundation for an assessment of these specific sites. After a specific class was selected in a participating daycare center, preschool, or grade school, the whole class was invited to participate in the study and the invitation letter and informed consent form were sent to the child's parents. To be eligible for the study, parents must sign and return the consent form and they must be residents of the Kansas City Metropolitan area. Children were recruited from the REACH Foundation's six-county service area among 2 groups: preschool children 2-4 years of age and secondary school-aged children 12 years of age. These two age groups were selected to represent erosion in the primary and permanent dentition. Sample size for the survey was calculated using caries data on 2-5 years old and 12-15 years old from the National Health and Nutrition Examination Survey (NHANES) 1999-2002 (24). The required numbers of children were 267 for 2-4 years old and 218 for 12 years old. After the University of Missouri-Kansas City Institutional Review Board (IRB) approved the study, invitation letters were mailed to the parents of children in the selected age groups through school administration.

**Dental Health Examination**

After receiving consent from the parents, children were examined by four trained and calibrated dental hygienists who used equipment, which included portable chairs and lights. Disposable dental

explorer and mirror were used without drying the teeth. Before the start of the study, a half-day training and calibration session was conducted for four examiners using lecture and clinical photos. Five children were recruited for calibration purpose and four examiners repeated clinical examinations on each child until 100% percent agreement was achieved.

The core set of oral health measures included clinical variables that were consistent with the measures used by the Healthy People 2010 oral health objectives.<sup>25</sup> The clinically measured variables included gingivitis, calculus, dental plaque, dental caries, dental erosion, and urgency of dental care. This report focused on dental erosion and thus only erosion data was reported. Dental erosion was observed and recorded by trained dental hygienists. The index for dental erosion was adapted and modified from the index of Tooth Surface Loss (TSL) used in the 2003 National Children's Dental Health Survey in the UK.<sup>26</sup> The scoring system was specific depending on the depth and area of the affected tooth and certain criteria were given to accurately match the condition of the tooth with the level of erosion. The buccal and lingual surfaces of primary and permanent maxillary incisors were assessed for prevalence of erosion. Depth was measured on whether the erosion was in the enamel only, or if it had dentinal exposure or if there was pulpal exposure. Surface loss area loss was measured by less than 1/3 surface loss, from 1/3 to 2/3 surface loss, or greater than 2/3 surface loss. This scale is presented in table 1.

Questionnaires were sent to and filled out by the parents along with invitation letters and informed consent forms. The consent forms were signed and returned to the school nurses or administrators. Data from the questionnaire included: home care (tooth brushing, use of fluoridated toothpaste, use of mouth-rinse)-access to dental care (dental visits, dental insurance, barriers), and use of preventive dental services. Basic socio-demographic information, such as race, gender, parental education, family income, was also collected. The reading level was set at elementary school grade 5 and the questionnaire was reviewed and revised by a professional who had extensive experience in editing English writing in the University. It was pretested prior to formal implementation by 5 mothers who have young children and their suggestions were incorporated into the revised questionnaire.

**Table 1.** Tooth Surface Loss

Depth:	
Code	Criteria
0	Normal
1	Enamel-only loss of surface characteristics
2	Enamel and dentine-loss of enamel, exposing dentine
3	Enamel into pulp-loss of enamel and dentine resulting in pulpal exposure
9	Assessment can not be made
Area:	
Code	Criteria
0	Normal
1	Less than one third of surface involved
2	One third-up to two thirds of surface involved
3	More than two thirds of surface involved
9	Assessment can not be made

**Table 2.** Association of children's characteristics and dental erosion (N = 243)

Variables	% of Sample	Erosion present	P-value
Gender	Male 46%	13	0.48
	Female 54%	11	
Age group	2-4 years 68%	13	0.54
	12 years 32%	10	
Eligibility for free/reduced price lunch program	Yes 53%	13	0.55
	No 47%	11	
Race	Caucasian 60%	13	0.60
	Non-Caucasian 40%	11	
Parent's education	High school or less 22%	9	0.66
	Some college or college degree 59%	13	
	Postgraduate 19%	10	
Family income	<\$60,000 65%	15	0.02
	\$60,000 or more 35%	5	
Dental insurance	Yes 68%	11	0.91
	No 32%	12	
Dental visit in last 12 months	Yes 59%	10	0.45
	No 41%	13	
Tooth brushing	1 time per day 39%	11	0.42
	Twice or more per day 61%	15	
Primary source of drinking water	Tap water 83%	11	0.15
	Bottled water 17%	15	
Breast feeding	None 34%	12	0.52
	<6 months 41%	18	
	>6 months 25%	10	
Acidic fruit juice consumption	< once per day 61%	8	0.03
	Once or more daily 39%	17	
Carbonated beverage consumption	< once per day 84%	11	0.36
	Once or more daily 16%	14	

The initial questionnaire included 20 questions. A revised questionnaire included only 13 questions in order to collect the most essential information and take minimal time for the parents.

The characteristics of the children were first described. The overall rate and specific condition of each maxillary incisor was calculated based on the depth and area of tooth surface loss to determine the level of dental erosion. Bivariate analysis of the relationship between individual risk factors and dental erosion was conducted using Chi-square test. The individual risk factors included gender, age group, race, eligibility for free/reduced lunch program, parent's education, family income, dental insurance, dental visits, tooth brushing, drinking water source, breast feeding, use of acidic fruit juice, and use of carbonated beverages. After bivariate screening, those risk factors with P value <0.05 were selected for multivariable logistic regression analysis. This data is presented in table 2.

## RESULTS

Of the 573 children examined, only 243 subjects were used for analysis which included 164 children of 2-4 years old and 79 children of 12 years old. The remaining 330 children were excluded due to incomplete data on questionnaire survey. The characteristics of the study sample are seen in Table 2. Basically, among 243 subjects,

about half were females, sixty percent were Caucasians, and the majority of children drank mainly from the city tap water. About half of the subjects were eligible for free or reduced lunch. Sixty five percent had a family income less than \$60,000, and 59% had been to a dentist in the past year.

The prevalence of dental erosion is shown in Table 3. The overall prevalence of dental erosion in this study was 12%. About 13% of 2-4 year olds had dental erosion and 10% of 12 year olds had dental erosion, respectively. In the 2-4 year olds, maxillary right (E) and left (F) central incisors exhibited the most erosion. Depth and surface area loss occurred most prominently within the enamel layer, with less than 1/3 surface area loss. Dentinal and pulpal exposure varied from 0.6% to 1.2% and only 1.2-1.8% had surface area loss greater than 1/3 of the total surface area. In the 12 year olds, there were 79 subjects, of which left central incisor had the most depth and area of surface loss. All of the surface loss for 12 year olds was contained in enamel only and within 1/3 total tooth surface

Dental erosion related to the children's characteristics is presented in Table 2. In bivariate analysis of potential risk factors and dental erosion, no significant association was found between dental erosion and risk factors such as gender, race, eligibility for free/reduced lunch program, parent's education, dental visit, tooth

**Table 3.** Dental erosion prevalence (N=243)

Age group	Maxillary Incisors	Depth of surface loss (%)				Area of surface loss (%)			
		Normal	Enamel only	Dentinal exposure	Pulpal exposure	Normal	<1/3 surface	1/3-2/3 surface	>2/3 surface
2-4 years old (N=164)	Right Lateral	92.0	6.8	0.6	0.6	92.0	6.8	0.6	0.6
	Right Central	86.0	12.2	0.6	1.2	86.0	12.2	0.6	1.2
	Left Central	86.6	11.5	0.6	1.2	86.6	11.5	0.6	1.2
	Left Lateral	91.5	6.7	1.2	0.6	91.5	6.7	1.2	0.6
12 years old (N=79)	Right Lateral	94.8	5.2	0	0	94.8	5.2	0	0
	Right Central	97.4	2.6	0	0	97.4	2.6	0	0
	Left Central	92.3	7.7	0	0	92.3	7.7	0	0
	Left Lateral	94.8	5.1	0	0	94.8	5.1	0	0

brushing frequency, drinking water source, and breastfeeding. Only family income and consumption of acidic fruit juice were significantly associated with dental erosion. Fifteen percent of children from families with annual family income <\$60,000 had dental erosion while only about 5% of children from families with annual family income \$60,000 or more had dental erosion (relative risk 2.97, 95% confidence level CI 1.01-8.86, p=0.02). Seventeen percent of children who consumed acidic fruit juice once daily or more had dental erosion while 8% of children who consumed less than one per day had dental erosion (relative risk 2.15, 95% CI 1.00-4.96, p=0.03).

Based on the results from bivariate analysis, family income and the consumption of acidic fruit juice were selected for multivariable logistic regression analysis. Literature indicates that age, race, and the consumption of carbonated beverages usually are contributing factors to dental erosion; therefore, they were also selected for multivariable logistic regression analysis. Five predictor variables were entered into a multivariable logistic regression model. The results are

**Table 4.** Logistic regression analyses of dental erosion and five predictor variables (N=243)

	Risk group	Odds ratios (95% CI)	P-value
Age group	12 years old	0.76 (0.46-1.26)	0.29
Race	Caucasian	1.93 (0.76-4.95)	0.16
Family income	\$60,000 or less	4.46 (1.35-14.70)	0.01
Acidic fruit juice consumption	Once or more daily	2.46 (1.07-5.67)	0.03
Carbonated beverage consumption	Once or more daily	1.89 (0.69-5.21)	0.22

shown on Table 4. After controlling for other important factors, low family income (odds ratio 3.98, 4.46, 95% CI 1.35-14.70, p=0.01) and frequent consumption of acidic fruit juice (odds ratio 2.38, 2.46, 95% CI 1.07-5.67, p=0.03) remain significant. Frequent consumption of acidic fruit juice increased the risk 2.38 times for dental erosion, while children from families with lower family income level had 3.98 times risk of dental erosion compared to those children from families with higher family income level. Race, age group, and consumption of carbonated beverage were not significant predictors for dental erosion in multivariable logistic regression model.

**DISCUSSION**

There were 243 participants analyzed for dental erosion. The data collected provided us with some important information concerning the primary and permanent dentitions and the current prevalence of dental erosion in a local sample in the United States; it also demonstrated some risk factors of significance. Our study found dental erosion to be a relatively common problem with 13% of 2-4 years old and 10% of 12 years old having dental erosion on maxillary incisors. The study on preschool-aged (3-5 yrs) children in China reported lower prevalence of about 6% of their subjects, with 85% of the cases only being present in enamel.<sup>6</sup> However, several other studies indicated higher prevalence. For example, the 2003 National Children’s Dental Health Survey suggested that 53% of five years old had tooth surface loss on primary maxillary incisors and about one third of 12-15 years old had tooth surface loss on permanent maxillary incisors.<sup>26</sup> The 2003-2004 U.S National Health and Nutrition Examination Survey (NHANES) reported 46% of children aged 13-19 years had dental erosion on at least one tooth with maxillary teeth being more prevalent.<sup>8</sup> It has to be noted that the UK study only examined maxillary incisors, while the study using the 2003-2004 NHANES data utilized a full mouth examination. Compared to those studies, our study included the youngest children.

Dental erosion may have a multifactorial etiology. This study suggested two important risk factors: family income and acidic fruit



juice consumption. Socioeconomic factors relating to prevalence of dental erosion has been explored in the past but with different results. According to a study done in 1994 by Millard *et al.*,<sup>10</sup> 80% of children with a low socioeconomic background had low rates of dental erosion, while children with a higher socioeconomic background displayed a much higher prevalence of dental erosion. However, our study indicated that children from low income families were at a higher risk for dental erosion. This is consistent with a study in England on 14 year old children also showed that low socioeconomic groups showed more erosion.<sup>27</sup> The study of preschool-aged (3-5 yrs.) children in China showed that dental erosion was linked with the family's economic status and parental education. More frequent consumption of fruit drinks also increased the risk for dental erosion.<sup>6</sup> Another study suggested a definite relationship between dental erosion and acidic dietary intake from fresh fruits, soft drinks, and carbonated beverage consumption.<sup>28</sup> Our study showed that frequent consumption of acidic fruit juice increased the risk of dental erosion more than 2 times. However, carbonated beverage use didn't show as much an impact on dental erosion with increased consumption.

Dental erosion has become a growing concern in developed countries, particularly in Europe.<sup>9</sup> Due to the increased consumption of fruit juice and carbonated soft drinks, its prevalence and severity is expected to continue increasing. However, the etiology of dental erosion is complex and we have to examine more than dietary factors alone. Some eating disorders may contribute to the problem of dental erosion. In recent years, the public awareness of erosion has not increased while the overall rate of dental erosion has increased. Studies have documented that dental erosion is the major cause of tooth wear in children.<sup>8,13</sup> Significance of identifying dental erosion at an early stage is of utmost importance. Dental erosion is an irreversible process, and therefore must be carefully evaluated for in each visit. The condition is irreversible, and it may continue unchecked into adulthood unless the causes are addressed. Significant tooth structure loss may require more extensive dental treatment or possible extraction. Therefore, detection of dental erosion at a young age is crucial. The dentist may manage erosion by first performing a thorough history and comprehensive examination. This should include questioning the parent or guardian about dietary and oral habits to make a complete diagnosis and identify the etiology of any observed issues. Once the dentist has become aware of any erosion or unusual tooth wear a definitive treatment plan can be produced that may include: removal of the causative factor(s); fluoride treatment; baking soda rinse; remineralizing agents (e.g. MI paste); mouth guard; etc.

Diagnosing and treating erosion and tooth wear at an early age will prevent future treatment that many times includes endodontic procedures and full coverage restoration. This type of preventative dentistry will save the patients family or government body significant future expense in addition to the many visits and discomfort of extensive treatment.

## CONCLUSION

This study analyzed several contributing factors along with the characteristics of dental erosion and could be a starting point for a more in depth look at the most significant factors to reduce erosion. A longitudinal study can be performed that uses subjects with a certain amount of erosion present who are followed after altering some of the major contributing factors.

Several study limitations must be recognized. The study sample was a local group of children, which could not be representative to all children in the United States. Some randomization procedures were employed, but it was not a true random sample because some schools were over-sampled based on the request of the funding agency. Due to incomplete data on questionnaire survey, not all children who received a dental examination could be used for the analysis. Moreover, only partial mouth examination was implemented which only included four maxillary incisors. This undoubtedly would underestimate the true prevalence of dental erosion among these children. Despite these limitations, this cross-sectional study provided some valuable information on dental erosion in the children in the United States and several key risk factors were recognized.

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