

**Joint Report of the American Dental Association Council on Access, Prevention and Interprofessional Relations and Council on Scientific Affairs to the House of Delegates:
Response to Resolution 73H-2000
October 2001**

Background: The consumption of soft drinks, including carbonated beverages, fruit juice and sport drinks, in the United States has increased by 500% over the past 50 years; this trend shows no indication of leveling off.¹ From 1989-91 to 1994-95, the average daily consumption increased from 195 ml to 275 ml in the general population and from 345 ml to 570 ml among adolescent boys.² Currently, Americans consume more than 53 gallons of carbonated soft drinks per person per year; the amount surpassed all other beverages, including milk, beer, coffee and water.¹ The U.S. market includes nearly 450 different soft drinks, with the total retail sale over \$60 billion annually.³

The continuing increase in soft drink consumption among adolescents raised a national concern about the health effects of soft drinks. Sugar-containing soft drinks can be cariogenic⁴ and their low pH can cause erosion in teeth.⁵ Phosphorus (phosphoric acid) content of soft drinks may reduce calcium absorption and contribute to osteoporosis.⁶ Heavy consumption of sugar-containing soft drinks can also lead to excessive amount of sugar intake, and is thus hypothesized to be associated with the current epidemic of obesity⁷ and type II diabetes⁸ among children in the United States.

Review of the Literature

Oral Health Issues: As reported in 2000, the most common source of added sugars in the U.S. diet was non-diet soft drinks,⁹ which accounted for one third of intake.¹⁰ Increased sugar in the diet increases the risk of dental caries.¹¹ There are few studies reported in the literature that evaluate the role of soft drinks in the development of dental caries. Data from a study from NHANES I reported in 1984, showed an increased risk of caries with increasing soft drink consumption.⁴ A recent analysis of the third National Health and Nutrition Examination (NHANES III) suggested an association between sugared soda consumption and permanent tooth caries. Persons who consumed sugared soda three or more times daily had 17-62% higher dental caries than those who consumed no sugar soda.¹² In a study of schoolchildren in England, a 3% higher risk of caries with an average increase of one can of soft drink per week was reported.¹³ Though all these studies, summarized in Table 1, were cross-sectional, and did not control for other dietary variables, they consistently demonstrate that soft drinks increased the risk of dental caries. Non-nutritive sweeteners found in diet soft drinks may not be directly cariogenic because tooth decay producing bacteria cannot ferment aspartame, saccharine, acesulfame-K, cyclamate and sucralose to produce acids.

Table 1
Epidemiological Studies of Soft Drink Consumption and Dental Caries

Study	Type	Population	Results	Comments
Dental Caries				
Ismail <i>et al.</i> , 1984 ⁴	Cross-sectional, population based	NHANES I; representative sample of the U.S. 1971-1974; age 9-29 years; n=3194	Positive association between caries risk and soft drink consumption	Not adjusted for other diet
Jones <i>et al.</i> , 1999 ¹³	Cross-sectional, population based	Random sample of 14-year old school children in northwest England, 1994-1995, n=6014	Positive association between decayed missing filled teeth (DMFT) and average weekly consumption of soft drinks	Adjusted for tea, coffee and added sugar to tea and coffee
Heller <i>et al.</i> , 2001 ¹²	Cross-sectional, population based	NHANES III; representative sample of the U.S.; age 17 years and older; n=15,585	Positive association between decayed missing filled surfaces (DMFS) and daily sugared soda consumption	Adjusted for age, gender and poverty level

Dental Erosion: Dental erosion is the physical result of pathologic, chronic and localized loss of hard tissues from the tooth surface by a chemical process without bacterial involvement.¹⁴ It has been widely accepted that acid in foods and beverages plays a major role in the development of the erosion. The pH value is clearly an important variable in the erosive potential of beverages, but not necessarily the only factor. The total acid level (titratable acid) is considered more important than pH level, because it will determine the actual H⁺ available to interact with the tooth surface.¹⁵ Type of acid, calcium chelating properties, temperature, and exposure time are also important to the erosivity of beverages.^{15,16}

Most soft drinks contain one or two common food acidulants - phosphoric acid and citric acid. Occasionally, other acidulants such as malic acid or tartaric acid are also used. Animal studies have shown that phosphoric acid is very erosive at pH 2.5 but much less so at pH 3.3. Citric, malic and tartaric acids are considered to be especially erosive because of their acidic nature and the ability to chelate calcium at higher pH.⁵ Citric acid was more erosive than malic acid when formulated to experimental drinks at high pH.^{17, 18}

Few studies reported the prevalence of dental erosion among the U.S. population, although the problem is common. The earliest study from Southern California examined 10,000 extracted

teeth and showed that 18% had erosive lesions, with incisors most commonly affected.¹⁹ A recent study revealed no significant difference between the prevalence of erosion among adolescents in Scotland (37%) and in Maryland (41%).²⁰ Epidemiological studies shown in Table 2 reported a link between excessive soft-drink consumption and high prevalence of dental erosion.^{21,22} However, these studies did not adjust for important potential confounders such as snack consumption. In vitro model showed that primary teeth were as susceptible to erosion as permanent teeth.²³ An animal study showed that acidic sport drink caused severe erosion with total loss of supragingival enamel and exposure to dentin. The erosion lesions were less severe and exposed dentinal tubules were partly occluded, when fluoride was added to the sport drink.²⁴ Drinking through a straw positioned toward the back of the mouth may reduce the erosive potential of soft drinks.²⁵ Adding calcium, phosphorus and fluoride may also reduce erosivity.

Table 2

Epidemiological Studies of Soft Drink Consumption and Dental Erosion

Study	Type	Population	Results	Comments
Erosion				
Moazzez <i>et al.</i> , 2000 ²¹	Comparison study	11 cases with erosion, ten controls aged ten-16 years	Positive association between reported consumption of carbonated drinks and dental erosion	Unadjusted analysis. Small sample
Johansson <i>et al.</i> , 1997 ²²	Comparison study	19 persons with high vs. 19 with low erosion	Positive association between erosion and soft-drink consumption	Adjusted only for type of cleaning aid and gingival bleeding index. Small sample

In vitro studies shown in Table 3 have shown that soft drinks with low pH can cause erosion in permanent^{26, 27} and deciduous teeth.²⁸ The erosion increases with decreasing pH.²⁹ The fluoride concentration is not sufficient to prevent erosion substantially.²⁹ For any given level of pH there is less erosion with increasing calcium content.¹⁷

Table 3
In Vitro Studies of Soft Drink Consumption and Dental Erosion

Study	Type	Results	Comments
Larsen MJ, 2001 ²⁹	In vitro	Inverse association between pH of drinks and calcium fluoride dissolved from the tooth and erosion. High fluoride concentration had limited effect on erosion	Permanent human teeth
Larsen MJ, 1999 ²⁷	In vitro	Inverse association between pH of drink and solubility of enamel apatite. High buffering effect associated with greater erosion. Positive association with calcium and phosphorus and enamel erosion	Permanent human teeth
Hughes JA, 2000 ¹⁷	In vitro	Inverse association with pH and erosion. Less erosion with increase calcium content	Permanent human teeth
Hughes JA, 1999 ²⁶	In vitro	No enamel erosion with water, increased erosion with drinks of decreasing pH	Randomized, placebo controlled, crossover study, with water as control, with 54 human teeth
Grando LJ, 1996 ²⁸	In vitro	Enamel erosion seen with lemon juice, and sugar containing, carbonated beverages with and without caffeine	108 deciduous teeth in three groups

Nutrition and Child Development Issues: In recent years there has been a large increase in childhood obesity and diabetes in North America.³⁰ Several studies have linked increased obesity⁷ and diabetes⁸ to increased consumption of soft drinks. It has been a concern that increased beverage choices may influence the caloric intake and nutritional choices of children. Between 1970 and 1997, the USDA surveys indicated an increase of 118% of per capita consumption for carbonated drinks, and a decline of 23% in the per capita consumption of milk.¹ This has led researchers to study the impact of carbonated soft drinks on the displacement of nutrients and other beverages such as milk and juice. During 1994-96, Americans aged two years and older consumed the equivalent of 82 g of carbohydrates per day from added sweeteners, which accounted for 16% of total energy intake. Intake of carbohydrates from added sweeteners exceed levels compatible with meeting current dietary recommendations.¹⁰

Energy intake (caloric intake) was positively associated with the consumption of non-diet soft drinks. Mean adjusted energy intake for school-aged children who consumed an average of nine ounces of soda or more per day was 188 kcal/day higher than that for non-consumers of soft drinks.³¹ Those in the highest soft drink consumption category consumed less milk and fruit juice compared with those in the lowest consumption category (non-consumers). Even though children who consume more soft drinks had more calories per day in the diet than those who did not, their intakes of protein, riboflavin, folate, vitamins A and C, phosphorous and calcium were lower.³¹

A significant association of cola beverage consumption and increased risk of bone fractures has been recently reported among teenage girls^{6,32} and among female former athletes.³³ An animal study has supported that heavy intake of cola soft drinks have the potential of reducing femoral mineral density.³⁴ However, modest intake of carbonated beverages does not appear to have adverse effects on bone mineral density in older women.³⁵ Potential mechanisms exist for the association between soft drink consumption and bone fractures or osteoporosis. First, the phosphorus content of soft drinks may limit calcium absorption and thus contribute to bone loss. Second, soft drink consumption may replace milk intake and indirectly influence bone mineral density.³⁶

Beverages contributed 20-24% of energy across all ages and soft drinks provided 8% of energy in adolescents. Soft drink energy contribution was higher among overweight youths than among non-overweight youths.³⁷ Ludwig and co-workers⁷ studied ethnically diverse schoolchildren aged 11.7 years on average and found that each additional daily serving of soft drink was associated with an average increase in body mass index of 0.24 (95% CI 0.10-0.39) kg/m² over two years, after adjusting for demographic and dietary variables, physical activity and total calories. A daily serving of a soft drink also increased the risk of obesity by 60% (RR=1.60, 95% CI 1.14-2.24).⁷

Since diet sodas do not contain sugar it may seem they would not directly cause caries, or increased caloric intake. However, the limited existing evidence suggests that low-sugar drinks do not reduce caloric intake in lean, non-dieting³⁸ or overweight dieting subjects.³⁹ A study has suggested that adolescent soda drinkers can suffer from caffeine self-administration and withdrawal.⁴⁰ Also, soft drinks have a low pH and can potentially cause dental erosion, to which fluoride can offer little protection.²⁹ Children who used soft drinks had lower intakes of several important nutrients as compared to children who did not use soft drinks, suggesting that soft drinks, including diet soda, could displace nutritious foods in the diet.³¹

Though there is limited epidemiological evidence assessing the association between oral health and soft drink consumption, it consistently indicates that soft drinks adversely affect dental caries and enamel erosion (Tables 1, 2). Moreover numerous in vitro and animal studies have consistently shown enamel erosion with the use of soft drinks (Table 3). Given this evidence, it would seem appropriate to encourage children and adolescents to limit their intake of soda.

Public Health Issues and Association Policy

Public Health, Public Policy and Local Decision-Making Issues: In 2000, the United States General Accounting Office (GAO) reported on the growing visibility of commercial activities in U.S. public elementary and secondary schools for the last ten years, a period characterized by tightened school budgets.⁴¹ Commercial activities noted included sales of products to children, direct and indirect advertising and market research. The sales of soft drinks under exclusive contracts were the most common and lucrative type of commercial activities at the schools visited by the GAO for the report, although it was noted that soft drink revenue represented a small percentage of the districts' budgets. The United States Department of Agriculture's (USDA) Dietary Guidelines for Americans encourage consumers to limit intake of beverages and foods high in added sugars that may crowd out other healthy foods from the diet.⁹ USDA has identified sweetened soft drinks as one major source of added sugar.

National health organizations have published several documents including a position paper on nutrition integrity in schools,⁴² a statement on the use and misuse of juice drinks in pediatrics,⁴³ a statement on healthy school nutrition environments,⁴⁴ a paper on health effects of soft drink consumption⁴⁵ and a statement on vendable foods.⁴⁶

In 2001, the USDA published a report for Congress on foods sold in competition with school meal programs.⁴⁷ This report defines competitive foods and beverages as those: 1) having minimal nutritional value; and 2) sold via vending machines and school stores. The sale of competitive foods in schools: introduces diet related health risks, may stigmatize participation in school meal programs, may affect the viability of school meal programs and conveys a mixed nutritional message. The report calls upon Congress to work with the USDA to forge national nutrition policies consistent with nutrition standards.

Advocacy organizations have been developed to support limiting commercial activities in schools. Examples include the Center for Commercial Free Schools, which published a citizen's guide for adopting commercial free school board policies⁴⁸ and Commercial Alert, which also developed a draft model school board policy.⁴⁹

American Dental Association Policy: As an organization that has long recognized the link between good oral health and sound nutrition, the American Dental Association recommends that both children and adults limit eating and drinking between meals and, when snacking, give preference to nutritious foods. Research shows that the frequent ingestion of sugar-containing foods and beverages is a major risk factor in the frequency and severity of dental caries. Research also shows that a balanced diet, including foods from the major food groups (fruits, vegetables, breads and grains, meats and poultry, and dairy products), helps provide the body with the nutrients it needs to maintain health.

Consistent with its mission of promoting oral health, the Association opposes targeting in promotion and advertising that has the potential to increase children's consumption of foods and beverages low in nutritional value and high in decay-enhancing carbohydrates.

The Association opposes contractual arrangements that influence consumption patterns that promote increased access to soft drinks (beverages containing sugars, carbonation and/or acidic products) for children (Appendix I). As set forth earlier in this paper, the scientific support for such a policy is primarily related to what is known about sugar containing soft drinks; namely, that frequent exposures to sugar-sweetened soft drinks increases risk for dental caries. In addition, soft drink promotion is likely to lead to the consumption of beverages low in nutritional value. While certain science is suggestive of possible enamel erosion due to frequent consumption of carbonated and/or acidic soft drinks, that science is preliminary. The Association opposes school contracts promoting increased access to soft drinks in general since, to the best of the Association's knowledge, these inevitably include the promotion of sugar containing products as well as other non-nutritious soft drink products.

When decisions about exclusive vendor contracts in schools have the potential to influence consumption patterns and promote increased access to soft drinks for children, the Association believes that the best interests of the children's health and welfare should be a primary discussion point along with revenue needs. The Association encourages state and local dental societies to work in their communities to ensure that school food and vending services offer nutritious selections. The Association also continues to distribute and make available educational materials for the profession and the public about nutrition and oral health.

Summary: This paper presents a summary of currently available scientific literature on the oral health effects of soft drink consumption. The paper also provides examples of public statements and reports on commercialism in schools and exclusive soft drink contracts in schools. This information is offered by the Council on Access, Prevention and Interprofessional Relations and the Council on Scientific Affairs as requested in the Association's 2000 policy on exclusive soft drink contracts in schools (Appendix I).

APPENDIX I

AMERICAN DENTAL ASSOCIATION POLICY – 2000 (*Trans.2000:457*)

Resolved, that the American Dental Association, through its appropriate agencies, gather the scientific facts and supporting data concerning the oral health effects of the increasing consumption of beverages containing sugars and/or carbonation, and/or acidic products commonly known as “soft drinks,” and be it further

Resolved, that the American Dental Association develop educational materials (for example a pamphlet) for use by constituent and component societies to educate school districts and the public on the health implications of consuming “soft drinks,” and be it further

Resolved, that the Association encourage constituent and component dental societies to work with education officials, pediatric and family practice physicians, dietetic professionals, parent groups, and all other interested parties, to increase awareness of the importance of maintaining healthy vending choices in schools, and to encourage the promotion of beverages of high nutritional value, and be it further

Resolved, that the American Dental Association opposes contractual arrangements that influence consumption patterns that promote increased access to “soft drinks” for children, and be it further

Resolved, that the ADA develop a white paper supporting this position.

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