

Soft Drinks: Hard on Teeth



With soda pop decay contributing to an alarming increase in caries among young people, dentistry finds itself fighting another kind of access problem: sweetened beverages within reach 24 hours a day.

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Soft drinks are popular beverages. These cool, bubbly drinks are being consumed everywhere. In fact, you may very well have a can sitting next to you as you read this article. In the United States, it is culturally acceptable to consume soft drinks any time of the day.

Carbonated soft drinks account for

more than 27% of Americans' beverage consumption.¹ In 1997, Americans spent more than \$54 billion to buy 14 billion gallons of soft drinks. Today Americans consume more than 56 gallons per year, or more than one-and-a-half 12 ounce cans per day for every man, woman, and child.

Dentists are becoming increasingly concerned that over-consumption of soft drinks may result in greater amounts of dental disease. In a letter copied in the December 1997 *Journal of the American Dental Association*, Dr. Paul

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Clinical Feature

Readhead from Ames, Iowa was curious to know if any other dentist had noticed significant increase in decay among teenagers and adults due to patients drinking either regular or diet Coke® or Pepsi®. Dr. Readhead noticed, looking at the ingredients of the soft drinks, that most of them, especially the colas, contain phosphoric acid, and some, citric acid. The patients he had identified who were experiencing this decay were noted to have had above average oral hygiene and very little previous decay.

Acid Versus Enamel

It is well known by the medical profession that disease loves acid,² and this is particularly true of dental caries. Dental caries, by definition, is tooth demineralization caused by acidic byproducts of the bacterial fermentation of dietary sugars. The resulting caries lesion involves gradual demineralization of subsurface enamel and

dentin, leaving the outer 20- to 50-micrometer-thick surface preserved more or less intact.³

With the consumption of acidic, carbohydrate-rich soft drinks, teenagers are at high risk for caries development, which can be quite aggressive (Figure 1). Eight- to 17-year-old children are at greatest risk. Normally, as the young, immature enamel is bathed by salivary ions and the intercrystalline spaces fill, it becomes progressively harder and more mature. Mature enamel appears as a very dense, less penetrable, glassy hard structure that is fairly resistant to acid attack.

However, enamel maturation takes time. The newly erupted enamel in teenagers is immature, and the crystalline structure is porous, chalky, and

easily penetrated and dissolved by acids.⁴ Even in the absence of carbohydrates, soft drinks can be destructive to teeth. These acidic, or low pH, beverages can contribute to the demineralization of dental hard tissues.

Dental erosion is the loss of tooth structure by a chemical process not involving bacteria.⁵ Initially, enamel will demineralize and dissolve, with the surface appearing dull. Acids can also enter the pits and pores of enamel and cause subsurface structure loss.⁶ The solubility of hydroxyapatite increases logarithmically with decreasing pH.

Erosion may be caused by either intrinsic or extrinsic sources. The intrinsic causes have been documented to include cases of anorexia nervosa and bulimia, as well as any gastrointestinal disorder that involves increased outputs of gastric acids. Extrinsic sources include acidic medicines such as vitamin C and aspirin, aerosol acid chemicals in the work environment, or the frequent consumption of acid food-stuffs or drinks.

Simple pH monitors have shown that all types of soft drinks are very acidic, especially the colas, which can have a pH of 2.4 or less (Table I). In order to neutralize a glass of cola, it takes 32 glasses of high pH alkaline water.² Exposure of enamel to Coca-Cola® for one hour leads to significant reduction in microhardness, and scanning electron microscopic evaluation has revealed surface irregularities.⁷

Soft Drink Consumption

Children start consuming soft drinks at a remarkably young age, and consumption increases through young adulthood. Twenty percent of one- and two-year-old children consume soft drinks.⁸ Those toddlers drink an

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Figure 1.



Photograph of a 16-year, two-month-old male with rampant caries secondary to soft drink consumption. This teenager presented for consultation after referral from a general dentist. The previous dental examination at 14 years, five months of age showed no dental caries. Contributing etiology was the consumption of three to four cans of Mountain Dew per day while at school. Patient reported starting to consume these large quantities upon entering high school, where vending machines were readily available.

average of seven ounces — nearly one cup — per day.

The consumption of soft drinks has increased in the United States over the past decades. United States Department of Agriculture Food Consumption Surveys (1977-1978, 1987-88, 1994-96) have found that almost half of all children between six and eleven years of age consume soft drinks, with the average child consuming 15 ounces per day, up slightly from 12 ounces in 1977-78. The most avid consumers are 12- to 29-year-old males. Boys between 12 and 19 years of age who consume soft drinks take in an average of almost two 12 ounce sodas (28.5 ounces) per day. Teenage girls also drink large amounts (20 ounces/day), although slightly less than their male counterparts.

Another analysis⁹ found that one fourth of males 13 to 18 years old drank two or more cans of soft drinks a day, while one out of 20 drank five or more cans per day. One-fourth of 13- to 18-year-old females drank two cans per day, and one out of 20 drank three or more cans per day.

Nutritional Impact

Soft drink vending machines have added to this substantial increase in soft drink consumption. Comparison of the results of the 1965-66 USDA Food Consumption Survey with those one decade later showed that the percentage of toddlers who consumed soft drinks increased from 30% to 40%. Furthermore, in the 1977-78 survey, the typical (50th percentile) teenager drank about one half of the current consumption. Data from the USDA surveys indicate that the proportion of adolescent boys and girls consuming soft drinks on any given day increased by 74% and 65%, respectively.¹⁰

Concomitantly, milk consumption has dropped in children over this same period. For example, the proportion of adolescent girls drinking milk dropped

from 72% in 1977-79 to 57% in 1994.¹⁰ Data from national surveys indicate that calcium intakes of a considerable proportion of U.S. children, teenagers in particular, are well below the Recommended Daily Allowance (RDA).¹¹ For instance, data from a 1989 survey indicated that just 39.5% of girls aged 12-18 were consuming 75% or more of the RDA for calcium.¹² Guenther¹³ found that soft drink intake was negatively associated with milk, calcium, magnesium, vitamin A, and vitamin C intake in U.S.

Milk consumption has dropped in children over this same period.

teenagers. Furthermore, children who consume more than 26 ounces of soft drinks per day were four times more likely to consume less than eight ounces of milk per day.¹⁴ Nearly a tenth of the calories consumed by American teenagers come from nutritionally empty sodas, which they drink at the expense of calcium rich milk. As a result, many young Americans today are reaching the age of maximum bone growth with bones highly prone to osteoporosis.

Soft drinks and fruit juices have

Table 1.

pH and Sugar Content of a Variety of Soft Drinks and Other Popular Beverages.

Beverage	pH	Sugar (gm/serving)	Beverage	pH	Sugar (gm/serving)
Coca-Cola			Orange Slice	3.12	50
Classic	2.53	39	Squirt	2.85	40
Diet	3.39	0	Minute Maid		
Cherry	2.53	42	Orange Soda	2.80	47
Sprite	3.42	26	Lipton's		
Surge	3.02	46	Iced Tea	3.86	22
7-Up			Lemon Iced Tea	2.90	33
Regular	3.19	26	Nestea Iced Tea	3.04	22
Diet	3.67	0	Gatorade		
Pepsi			Citrus Cooler	2.97	14
Regular	2.49	42	Lemon Lime	2.97	14
Diet	3.05	0	Snapple		
Mountain Dew			Plain Tea	3.93	25
Regular	3.22	31	Lemon Iced Tea	2.98	25
Diet	3.34	0	Pink Lemonade	2.54	26
Dr. Pepper			Diet Pink		
Regular	2.92	27	Lemonade	3.10	0
Diet	3.41	0	Lemonade	2.56	30
Barq's Root Beer			Diet Lemon		
Regular	4.61	45	Iced Tea	2.55	0
Diet	4.55	0	Raspberry		
A&W Root Beer	4.41	31	Iced Tea	2.95	29
Diet Rite	3.46	0			

Clinical Feature

minimal nutritional content. All contain negligible amounts of the RDA for vitamins, minerals, and protein.¹⁴ Nutritionists warn that sweetened beverages can curb a child's appetite and displace protein and calcium rich foods needed for proper growth.

High soft drink consumption can also lead to excessive energy (caloric) intake, which may contribute to childhood obesity, a growing problem among our children.¹⁵ Sodas are the largest single source of added sugars. A 12-ounce soft drink contains on average 150 dietary calories. The percentage of overweight youths aged 6 to 17 years has more than doubled in the past 30 years.¹⁶ It is estimated that approximately 11% of U.S. youths are now seriously overweight.¹⁶

Food acceptance by young children has been shown to be largely dependent upon two characteristics: sweetness and familiarity.¹⁷ There is evidence that continuous exposure to sweets

sustains a neonate's preference for sweets.¹⁸ Studies have shown that sweet preference changes with exposure to sugars,¹⁹ and the more sugars people consume, the higher their threshold for sweetness, indicating an increased risk for caries.

Marketing

Soft drink companies market their products by sending the message that soft drinks are healthy to consume at all times of the day. A quote from M. Douglas Ivester, Coca-Cola's® chairman and CEO, defending marketing in Africa, said, "...actually, our product is quite healthy. Fluid replenishment is a key to health... Coca-Cola® does a great service because it encourages people to take in more and more liquids."¹⁸

The soft drink industry has consistently portrayed its products as being positively healthful, saying they are 90% water and contain sugars found in nature.⁸ A poster provided to teachers by the National Soft Drink Association states:

"As refreshing sources of needed liquids and energy, soft drinks represent a positive addition to a well-balanced diet... These same three sugars also occur naturally, for example, in fruits... In your body it makes no difference whether the sugar comes from a soft drink or a peach."

Soft drink companies are among the most aggressive marketers in the world.⁸ Advertising budgets of soft drink manufacturers are enormous compared to public service campaigns promoting the consumption of fruits, vegetables, healthful diets, and low-fat milk. In 1997, Coca-Cola®, which accounts for 44% of the soft drink market in the U.S., spent \$277

million on advertising, while the four major soft drink companies spent \$631 million. Between 1986 and 1997, these companies spent \$6.8 billion on advertising.⁸

Companies make sure that their products are always readily available. Thus, in 1997, 2.8 million soft drink vending machines dispensed 27 billion drinks worth \$17.5 billion.²⁰ Coca-Cola® soft drinks are sold at two million stores, more than 450,000 restaurants, and 1.4 million vending machines.²¹

Soft drink manufacturers market and sell their products by contracting with school systems.

The School Connection

One of the ways that soft drink manufacturers market and sell their products is by contracting with school systems. Pepsi® and Coca-Cola® are the two main contractors in schools.²² For example, in November 1997, one of Colorado's largest school districts entered into a partnership with Pepsi® and U.S. West® to build a five million dollar football stadium. Within the agreement, Pepsi® obtained exclusive rights to sell its products in the district's 140 schools.

Soft drink company partnerships have become so commercial that there have been letters sent from school officials in Colorado to their schools warning them that if their school didn't "dramatically" increase sales, the district's schools could lose significant revenue from their soft drink partner. Stating that he didn't want to pressure teachers, the administrator suggested that the principals "allow students virtually unlimited access to the soft drink machines, move them where they would be accessible to the students all day, and permit students to purchase and consume vended

Soft Drinks are Hard on Teeth: Minimize the Risk

- Drink carbonated soft drinks and sweetened liquids (like fruit juice) in moderation.
- Drink fluoridated water and use a fluoride toothpaste.
- Swish out your mouth with water to dilute the sugar and acid.
- Use a straw to keep sugars and acids away from your teeth.
- Never consume soft drinks or juice at bedtime. (The liquid pools in your mouth and coats your tongue and teeth.)
- Throw the cap away to prevent ongoing sipping.
- Read the labels — sweetened drinks are high in sugar.
- Get regular dental cleanings to remove plaque (bacteria) build-up on your teeth.

products throughout the day”, and even “consider allowing students to drink their soft drink products in the class”.²²

A 1996 study of 55 high schools in a large metropolitan area found that 11% of the schools offered soft drinks in vending machines during school hours.²³ As more liberal school policies have taken effect recently, this will most likely increase. We recently conducted a phone survey of Minnesota school districts and found that the vast majority do have contracts with soft drink manufacturers. The annual revenue per district is approximately \$150,000, with some districts even receiving “signing bonuses”.

Conclusion

As you may imagine, although the erosion and caries processes are as different as their histological appearance, the two conditions occurring concurrently could be deleterious to dental hard tissues. As dental professionals, we need to educate our patients about the consequences of soft drink consumption and provide suggestions to minimize the risk. We also need to be active in educating school administrators on the negative impact soft drinks have on students’ teeth.

The place where children spend a great portion of their day and where they are influenced greatly by their surroundings is their school. Schools are therefore the most suitable environment to provide health information to children in order to achieve the goal of health promotion programs. It is quite a contradiction to teach principles of good nutrition in health education, then adjourn the class to the reality that the children have high accessibility to soft drinks right outside the classrooms. ■

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