REVIEW ARTICLE

An Overview of the Types of Soft Drinks and Their Impact on Oral Health: Review of Literature

Zafeiria Mavrogiannidou[1], Vasiliki Boka[2], Aristidis Arhakis[3]

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Abstract

Aim: The present study is to review the literature about soft drinks, their types, history, ingredients as well as their effect on oral health.

Background: Soft beverages are predominantly consumed by children, adolescents, and young adults. They are categorized into various types, such as carbonated drinks, still and juice drinks, fruit juices, bottled waters, and sports and energy drinks. While their popularity continues to surge, their potential implications for oral health are a matter of concern, thus necessitating this review.

Review results: Soft drinks, either carbonated or noncarbonated, typically contain water, a sweetening agent, and flavoring and are often sold as ready-to-drink or dilutable beverages. While sports drinks replenish water and electrolytes to aid athletic performance, they vary in terms of isotonicity. Diet drinks, on the other hand, are sugar-free carbonated beverages. Energy drinks boost energy, with caffeine being a common ingredient. The high acidity and frequent consumption of these beverages can lead to dental erosion, caries development, and discoloration of resin composites. Additionally, decreased bracket retention, corrosion of stainless-steel brackets, and discoloration of elastomeric materials have been associated with orthodontic patients. Overconsumption of soft drinks may also increase the risk of periodontal disease.

Conclusion: Given the increasing consumption of soft drinks and their significant impact on oral health, it is crucial for healthcare professionals to have a comprehensive understanding of their potential implications. Further studies in this field are necessary to establish a more definitive link.

Clinical significance: Dentists should advise young patients about the consequences of frequent soft drink consumption and provide positive recommendations to eliminate the risk.

Keywords: Caries, Dental erosion, Soft drinks, Sugar-sweetened beverages.

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Introduction

Soft drinks are one of the most important types of drinks in the beverage industry, and their sales have increased significantly in recent decades. The most frequent consumption of soft drinks is made by children, teens, and young adults. Boys consume significantly more soft drinks than girls, and adult males aged 19–24 are the next highest consumers.[1] According to Ridder, the country with the highest consumption of soft drinks in 2019 was Mexico, with 630 8-ounce servings per capita per year, followed by the United States and Brazil in second and third place, respectively.[2] According to the British Soft Drinks Association Annual Reports, during the period 2011–2021, carbonated soft drinks and no/low-calorie soft drinks were the most common in consumption among overall soft drinks. In the year 2021, sales of soft drinks increased by 2.2%, with 69.2% of soft drinks sold in the United Kingdom being with no/low sugar.[3] Moreover, current data show that the daily consumption of soft drinks in the United States of America is about 600 mL/person, while in the United Kingdom, it is 240 mL/person, with double this amount appearing in younger people.[4]

Soft beverage drinks can be classified into several groups based on their sugar contents, carbonation level, ingredients, and functionality. These groups include carbonated drinks, still and juice drinks, dilutables, fruit juices, bottled waters, and sports and energy drinks. Drinks such as hot chocolate, tea, coffee, milk, tap water, alcohol, milkshakes, and undiluted fruit and vegetable juices are not considered soft drinks.[5]

Sports and energy drinks are functional drinks popular among adolescents, young adults, and athletes.[6,7] Sports beverages are used to improve physical performance before, during, or after exercise.[8,9] Energy drinks, consumed by 30–50% of adolescents and young adults, are used to boost energy, enhance physical and mental performance, alertness, emotions, and wakefulness, elevate mood, improve concentration, increase metabolism, and enable weight loss.[6,7] Another version of carbonated soft beverages, diet drinks, are basically destined for athletes, diabetics, and people who want to lose weight, improve athletic performance and endurance, and reduce their sugar or calorie intake.[10]

Soft drinks, in recent times, are becoming more and more available on the market with an increase in their use, resulting in a major concern considering their health implications. The purpose of this literature review is to provide information regarding soft drinks, especially sports, energy, and diet beverages, their history

[1]General Dental Practitioner, Thessaloniki, Greece

[2,3]Department of Pediatric Dentistry, School of Dentistry, Faculty of Health Sciences, Aristotle University of Thessaloniki, Thessaloniki, Greece

Corresponding Author: Aristidis Arhakis, Department of Pediatric Dentistry, School of Dentistry, Faculty of Health Sciences, Aristotle University of Thessaloniki, Thessaloniki, Greece, Phone: +30 2310999454, e-mail: arhakis@dent.auth.gr

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and ingredients, as well as the effects on dental health associated with overconsumption and certain ingredients.

Soft Drinks

Soft drink, also known as soda, pop, or soda pop, is a nonalcoholic beverage that contains carbonated or noncarbonated water, natural or artificial sweetening agent, and flavoring. Additionally, the term "hard drink" is used for beverages that contain alcohol.[11] The sweetener added to a soft drink may be sugar, high-fructose corn syrup, sucrose, fruit juice, a sugar substitute (in the case of diet drinks), or some combination of these.[12] Natural flavors are derived from fruits, nuts, berries, roots, herbs, and other plant sources.[13] Soft drinks may also contain edible acids, caffeine, colorings, preservatives, and other ingredients (Table 1).

The initial idea of carbonated soft drinks came from ancient Greece and Roman empires, who observed the medical effects of carbonated water being produced by the natural springs. In the mid-1700s, Torbern Bergman and Joseph Priestley were the first two who managed to mimic the beneficial effects of carbonization in the laboratory. This was only the beginning of the huge variety of soft drinks being developed across Europe and the United States of America. It took no time for people to love these sugary soft drinks, not only because they were presented as "fun summer drinks" but mainly due to the fact that pharmacists described them as possible stimulants that could cheer the user up. Throughout the years, Coca-Cola, created by John Pemberton in 1886, has been the leading soft drink from one side of the world to the other.[14]

The most important categories of soft drinks are:

- Ready-to-drink essence-flavored beverages
- Ready-to-drink beverages containing fruits or fruit juice
- Non-ready-to-drink beverages: squash/syrups or fruit powders ready-to-drink after dilution with water at home.[15]

Sports Drinks

Sports drinks are functional beverages that contain flavoring, carbohydrates, minerals, electrolytes such as sodium, potassium, chloride, and sometimes vitamins or other nutrients.[8] These beverages are intended to replenish water and electrolytes lost through sweating during athletic performance, prevent dehydration, and supply carbohydrates to boost energy.[8,9]

In 1927 William Owen came up with the idea of a drink called "Glucozade," which could provide quick, assimilable energy, calories, and fluids to anyone suffering from a common illness. "Glucozade" (shortened to "Lucozade") was acquired by the Beecham Company in 1938 and, supported by brilliant marketing campaigns, became one of the most popular brands in Britain. It wasn't until the mid-1980s that "Lucozade" made its appearance in the rising market of sports drinks.[16] However, "Gatorade" was the first drink created, especially in order to boost athletes' performance in training, by Robert Cade, who was a physician and football coach trying to help his team get through the exhausting summer training.[17] So, that was the beginning of the "performance-enhancing beverage" era (Table 1). Gatorade's early start is the main reason why it remains the number 1 sports drinks brand in the United States of America today.[16] There are three main categories of sports drinks, all of which contain various levels of fluid, electrolytes, and carbohydrates, and each drink serves a different purpose[5]:

- Isotonic drinks contain similar concentrations of salt and sugar as in the human body (6–8% carbohydrate).
- Hypertonic drinks contain a higher concentration of salt and sugar than the human body (>10% carbohydrate).
- Hypotonic drinks contain a lower concentration of salt and sugar than the human body.

Most sports drinks marketed and consumed are isotonic, having between 4 and 5 heaped teaspoons of sugar per 8-ounce (13 and 19 gm per 250 mL) serving.[18]

Diet Drinks

Diet drinks or light drinks are sugar-free, artificially sweetened versions of carbonated beverages such as diet sodas, sports drinks, diet iced teas, carbonated soft drinks, low-calorie flavored waters, and energy drinks.[10,19] In the 1950s and the early 1960s, the first Diet drinks made their appearance. The initial purpose of the companies that introduced them was to create a sugar-free refreshment that could be consumed by diabetic people. In 1963, the Coca-Cola company was the first to launch the diet soda drink, marketed as "Tab," and it soon met with great success across the United States. During the 1980s and the 1990s, several alcohol companies started to launch "diet" or "sugar-free" alcoholic products. Nowadays, diet drinks companies bring into play artificial sweeteners in order to attain similar taste, mouthfeel, and aftertaste of traditional soda

Table 1: Definition, main ingredients, types, and examples of different types of beverages

General category	*Definition*	*Main ingredients*	*Types*	*Examples*
Soft drinks	Nonalcoholic beverages can be carbonated or noncarbonated.	Water, sweetening agents (natural or artificial), flavoring	Ready-to-drink essence-flavored beverages, Beverages containing fruits or fruit juice, Non-ready-to-drink beverages	Coca-Cola, Pepsi
Sports drinks	Functional beverages are intended to replenish water and electrolytes lost during athletic performance.	Flavoring, carbohydrates, minerals, electrolytes	Isotonic, Hypotonic, Hypertonic	Gatorade, Lucozade
Diet drinks	Sugar-free, artificially sweetened versions of carbonated beverages.	Artificial sweeteners, acids (like phosphoric, citric), stimulants (like caffeine, taurine)	Diet sodas, Diet iced teas, Low-calorie flavored waters, Diet energy drinks	Diet Coke, Tab
Energy drinks	Soft drinks that contain high doses of caffeine and varied other substances.	Caffeine, sugar, other sweeteners, vitamins, herbal extracts, amino acids	Ready-to-drink energy drinks, Energy drink powders, Energy shots	Red Bull, Lipovitan D

drinks, with Coca-Cola company focusing mainly on Diet Coke across the United States (Table 1).[20] Diet drinks are also marketed as sugar-free, zero-calorie and low-calorie drinks contain taurine, phosphoric acid, citric acid, guarana, and artificial sweeteners as main ingredients and ginseng and caffeine as stimulants. They do not include 100% fruit juices or unsweetened tea or coffee. Instead of sugar, several different sweeteners, such as aspartame, saccharin, sucralose, acesulfame potassium, or stevia, are used to sweeten them. Diet drinks are often confused with sports drinks; however, the absence of stimulants in sports drinks makes them different types of beverages.[10]

Energy Drinks

Energy drinks are defined as soft drinks that contain high doses of caffeine and varied other substances such as sugar, other sweeteners, taurine, vitamins, herbal extracts like ginko biloba, guarana and ginseng, glucuronolactone, and amino acids.[21–23]

Energy drinks made their first appearance in Japan, while in 1962, a company called Taisho rolled out Lipovitan D, a stimulant that could be found in minibar-sized bottles. By the 1980s, such extra-caffeinated beverages had become popular among Japanese people. As Japanese energy drinks were gaining more and more space in Europe, Dietrich Mateschitz came up with the supercharging tonics. In 1984, he collaborated with Krating Daeng, the creator of a drink consisting of caffeine and taurine. It wasn't until 1987 that he introduced a carbonated variant of the same drink in his homeland under the Red Bull label. In 1997, Mateschitz's beverage made its appearance in the United States, and the golden era for the market for energy drinks had just started.[24]

This type of beverage is provided ready-to-drink or served as nonready-to-drink powder.[5] Energy shots are a different kind of energy drink that is usually sold in smaller bottles but contain the same amount of caffeine and other functional ingredients and are considered concentrated forms of energy drinks (Table 1).[25] Energy drinks differ from sports drinks which do not contain caffeine and are used to replenish water and electrolytes lost during athletic performance.[26]

Dental Implications

Dental Erosion

Dental erosion (erosive tooth wear) is the situation of a progressive and irreversible loss of dental hard tissue due to a chemical process such as dissolution or chelation without bacterial involvement. Dental erosive wear may be caused by extrinsic or intrinsic causes. Extrinsic erosion is caused by acidic foods and drinks, medications, and environmental acids. Intrinsic erosive acids include gastric acids, which come in contact with teeth during regurgitation, reflux disorders, and bulimia.[27–31]

Surface enamel starts to demineralize as the pH drops to <5.5 (critical pH), causing erosion.[32–34] The pH of most soft drinks (excluding bottled waters) is highly acidic and ranges from 2.5 to 3.5 (Table 2).[33] Moreover, soft beverages contain acids such as carbonic acid, phosphoric acid, citric acid, and malic acid, which contribute to the low pH value.[29,30,35] Therefore, the consumption of soft drinks is strongly associated with dental erosion.[28,30,36]

The measured pH determines the initial and dissociated hydrogen ion concentration and provides no information about the presence of undissociated acid. The titratable acidity (TA) is the total number of acid molecules and indicates the actual hydrogen ion available for interaction with the tooth surface. Therefore, TA is a more realistic measurement of the total acid concentration of a drink and an important parameter for dental erosion development.[29,30,37,38] A higher TA is consistent with a higher buffering capacity and an increase in the erosion potential of dental enamel. In the study of Kitchens and Owens, the TA of Red Bull (energy drink) was higher than Gatorade (sports drink), Diet Coke, and Coca-Cola beverages, indicating an increased erosion potential.[29]

Other important factors that are involved in the erosive potential of soft drinks include the type and amount of acid, calcium chelating properties, duration and frequency of consumption, temperature of the drink, and salivary flow.[29,34,37]

Citric acid is considered one of the most erosive acids due to its ability to bind calcium from saliva to teeth (chelating capacity), maintaining the pH below the critical level (pH 5.5) for dental erosion and increasing TA levels. Therefore, soft drinks, such as energy drinks, sports drinks, and diet drinks, containing higher concentrations of citric acid and low pH, have the most increased risk for dental erosion.[9,29,38,39] Soft beverages contain high amounts of phosphoric acid, which is also thought to bind calcium from the teeth and thereby contribute to acidic erosion.[29,39,40]

Frequent and bedtime consumption of acidic drinks increases the dissolution of enamel and the severity of dental erosion.[29,30,37] The effect is also strengthened when increasing the flow rate of the soft drink and holding the drink for a long time or swishing it around the mouth combined with high temperature.[29,37,41] In addition, the consumption of chilled drinks and the use of a straw while drinking to eliminate the contact of the drink with the teeth surfaces can reduce the risk of enamel dissolution (Table 3).[37,41]

Decreased saliva flow can result in reduced buffering and rinsing of acids, increasing in that way the exposure time of the soft drink in the oral cavity.[9,34]

Dental Caries

Dental caries is a chronic and multifactorial disease related to several factors, such as sugar intake and dietary habits, salivary flow, susceptibility of the tooth, oral hygiene, and exposure to fluoride.[29,37] Sugars derived from diet is the most important factor in the development of dental caries. Sugar-sweetened drinks (SSDs), such as soft drinks (excluding bottled water), contain large amounts of refined carbohydrates in the form of sucrose, glucose syrup, high fructose corn syrup, and glucose polymers (Table 2).[37,42] Therefore,

Table 2: Description of the pH and sugar content of common beverages available on the market[37,39]

Soft drink	*Type*	*Serving size*	*Ph*	*Sugar*
Coca-Cola Classic	Soda	1 can/12 fl oz/355 mL	2.37	39 gm
Red Bull	Energy drink	1 can/12 fl oz/355 mL	3.3	39 gm
Gatorade Fruit Punch	Sports drink	1 bottle/12 fl oz/355 mL	3.01	21 gm
Diet Coca-Cola	Diet drink	1 can/12 fl oz/355 mL	3.10	0 gm

Table 3: Overview of dental health implications associated with dietary and lifestyle factors

Oral health issue	*Causes/aggravating factors*	*Implications*	*References*
Dental caries	Extrinsic/intrinsic acids Soft drink consumption High titratable acidity Frequent/bedtime consumption of acidic drinks Decreased saliva flow	Progressive and irreversible loss of dental hard tissue Increased erosion potential Increased dissolution of enamel	27–38,41
Dental caries	High sugar intake Salivary flow Oral hygiene Exposure to fluoride Frequent consumption of soft drinks	Chronic and multifactorial disease Organic acid production Demineralization of dental hard tissue	9,28–30,34–37,42–45
Effect on restorative materials	Acidic beverage consumption Surface roughness and micro-cracks formation Exposure time to acidic beverages Type and composition of restorative material	Discoloration Surface degradation Decreased microhardness Reduced surface hardness	46–60
Effect on orthodontic appliances	Frequent consumption of soft drinks Resin composite degradation	Enamel degradation around brackets Reduced brackets retention Corrosion of stainless-steel brackets and arch-wires Discoloration of elastomeric materials	61–72
Periodontal disease	Consumption of sugar-sweetened beverages	Gum bleeding Increased risk of gingivitis and periodontitis	73–75

frequent intake of drinks with high sugar content can contribute to a high risk of dental caries.[30] Many studies have shown a strong association between the consumption of soft drinks and dental caries development.[9,28,36,43] Sugars in soft drinks are metabolized by plaque microorganisms (*Streptococci mutans*, *Streptococcus sorbrinus*, and *Lactobacilli*) to produce organic acids, such as lactic acid.[29,34] Lactic acid then lowers the salivary and plaque pH, causing demineralization of the dental hard tissue and carious lesions.[34,44] In addition to the sugar content, soft beverages are acidic in nature, contributing to the fall in pH.[29] Although saliva promotes remineralization by the buffering capacity, the development of caries can be increased with frequent consumption of soft drinks, increased exposure time, and poor oral hygiene (Table 3).[30,42,45]

To reduce dental caries risk, sugar-free and low-calorie forms of soft drinks, known as diet drinks, have been introduced. These beverages contain artificial sweeteners instead of sugar; thus, they are noncariogenic. However, diet drinks contain phosphoric and citric acids, so they have similar erosive potential as SSDs.[28,44]

Effect on Restorative Materials

Acidic beverage consumption may affect the esthetic and physical properties of restorative materials, such as resin composites, compomers, and giomers.

Color stability is one of the most important features of tooth-colored restorative material, while discoloration of the restoration can lead to a major failure and need replacement.[46] Discoloration of resin composites can be caused by intrinsic and (or) extrinsic factors. Internal discolorations are caused by the material itself, and external discolorations are caused by the absorption and/or adsorption of water-soluble colorants into the resin matrix.[47,48] Internal discolorations are minimal after the complete polymerization of the resin, whereas discolorations by colorants, chemical dyes, or inadequate polymerization significantly affect color stability.[46] Soft beverages are among the extrinsic staining agents.[50] Colorants used in soft beverages, such as Caramel, Brilliant Blue, and Allura Red, are mainly responsible for the discoloration of resin composites.[46] Moreover, the surface roughness and microcracks formation can cause even more penetration of colorants and lead to discoloration of the composite. Acidic beverages, such as soft drinks, can cause chemical surface degradation affecting the gloss and increasing in that way the surface roughness and color stability.[46,50] Glass ionomers, in comparison with resin-modified glass ionomers, are more affected by the colorants leading to discoloration of the restorations.[46] Ozkanoglu and G Akin, in their study, observed that the color of high viscosity glass ionomer cement changed more by cola than tea and coffee, while nanohybrid composite resins color and hardness were not affected.[51] Many studies have shown the relationship between frequent soft beverage consumption and discoloration of restorative materials.[48,50,52,53] Surface texture and solubility of restorative materials can also be affected by acidic soft drinks consumption and lead to failure of the restoration. Polymer materials absorb water dissolving in that way the chemical bonds and leading to decreased microhardness.[54] The low pH and the acidic nature of soft beverages can result in erosion of dental materials, high solubility, and reduced surface hardness of restorative materials. Acids contained in these drinks penetrate into the resin matrix affecting the surface hardness of resin composites. Citric acid, which is present in large quantities in energy and sports drinks, is the most corrosive acid causing greater damage to organic fillers of composites.[46,55] Furthermore, the exposure time to acidic beverages and the type and composition of the restorative material are factors that affect the surface texture.[46,56] Many studies have shown that the consumption of soft drinks can lead to a reduced surface hardness of restorative materials.[50,54,56–59] In the study of Yazkan, the surface roughness of self-adhesive materials was more affected by energy drinks in comparison with soft drinks (Coca-Cola) and distilled water.[60] In addition, some studies have come to the conclusion that compomers are the most affected material in terms of surface hardness reduction (Table 3).[46,55]

Effect on Orthodontic Appliances

During orthodontic treatment, the frequent consumption of soft beverages can lead to dental erosion, causing enamel degradation around the brackets and reduced bracket retention. In the study of Oncag et al., Coca-Cola and Sprite proved to have a significant reduction of shear bond strength (SBS) of metal orthodontic brackets compared with artificial saliva.[61] The Cola group presented more extensive enamel defects because of the phosphoric acid present in Coca-Cola. Soft drinks' correlation with decreased SBS of orthodontic brackets has been found in several studies.[61–64]

Reduced bracket retention can also be caused by resin composite degradation[65] and increased microleakage around brackets.[61] Navarro et al., in their study, found that Coca-Cola and Schweppes Limón caused enamel erosion, loss of adhesive material, and microleakage beneath stainless-steel brackets.[66]

In terms of the clinical behavior of orthodontic components, Nanjundan and Vimala, in their study, showed degradation of the brackets and wires properties when exposed to acidic beverages (Pepsi-Cola).[67] Other studies also revealed corrosion of stainless-steel brackets and archwires after immersion in soft drinks.[68,69]

Discoloration of orthodontic elastomeric materials by soft drinks has also been evaluated in several studies. Some of them reported color changes of elastomeric ligatures[70] and elastomeric modules[71,72] by the soft drink Coca-Cola. In addition, the discoloration caused by Coca-Cola was less compared to tea, wine, coffee, and spices (Table 3).[70–72]

Periodontal Disease

Many studies support that the consumption of sugar-sweetened beverages is associated with periodontal disease.[73–75] Song et al., in their study, showed a positive association between consumption of carbonated beverages and periodontal disease in Korean adults. Higher intake of carbonated beverages increases the risk for periodontal disease in adults with body mass index <25 or waist circumference <80 cm for females and <90 cm for males.[73] Moreover, a recent systematic review also concluded that SSDs may increase gum bleeding, thus causing gingivitis and the risk of periodontitis.[74] A dose-dependent relationship between soft drinks and periodontal disease is also found in the study of Fann et al. in Taiwanese middle-aged adults.[75] Consumption of sugar-sweetened soft drinks should be added as an additional risk factor for periodontal disease, while additional studies should take place to verify the findings (Table 3).

Discussion

Soft drink consumption has increased dramatically in recent decades, with the largest increase among children and adolescents. The increased intake is associated with the pleasant taste of soft drinks and the variety of flavors, the increased advertising of these products in the media, the easy access and affordable price, as well as the variety of packaging, with something to suit every drinking occasion.[1]

The high sugar and acid content of soft drinks and other ingredients combined with frequent consumption can result in oral health complications. Acids, such as citric and phosphoric acid, are usually added to soft drinks providing tartness and tangy flavor and contributing to the beverage's taste. These acids turn soft drinks into acidic beverages and can lead to demineralization of surface enamel and dental erosion. Moreover, soft drinks usually contain 1–12% sugar in the form of sucrose, glucose, or fructose.[76] Frequent consumption of sugar-sweetened soft drinks is linked with a high risk of dental caries development. The World Health Organization (WHO) has reported that sugar-sweetened beverages are the basic cause of excessive sugar intake and increased health risks, such as dental caries, obesity, lower nutrient density, and chronic diseases. In addition, the WHO suggests that the daily sugar intake should not exceed 5–10% of the total daily energy intake.[77]

Dental restorative materials are also affected by the overconsumption of these beverages resulting in discoloration, reduced surface hardness, and failure of the restoration. Materials used in patients who undergo orthodontic therapy can also be affected by acidic soft drinks. Enamel decalcification or deterioration of resin composite and increased microleakage beneath the brackets can lead to decreased bracket retention. Furthermore, soft drinks have a great influence on the corrosion of orthodontic appliances and the color stability of elastomeric materials. In addition, sugar-sweetened soft drinks intake is linked with the appearance of gingivitis and periodontitis, with further studies needed to support the evidence.[74]

Many studies have been conducted on the relationship between the intake of soft drinks and dental problems, the results of which, however, remain controversial. All ingredients used in soft drinks must be approved in accordance with the regulations regarding maximum concentrations and acceptable daily doses.[76] Dental professionals should inform and educate children and adults about the consequences of frequent soft drink consumption and the harmful effects of several ingredients contained in such drinks on their oral health. For this purpose, dentists can advise and provide suggestions about better oral hygiene, less frequent consumption, decreased time holding of the drink in the mouth, use of a straw, and low temperature of soft drinks.[30] In addition to educating and informing consumers, strict regulatory changes in manufacturing, sales, and marketing can help prevent the negative effects of these beverages.[21]

Conclusion

In conclusion, the excessive consumption of soft drinks poses significant threats to oral health, causing dental erosion, and caries, affecting dental restorative materials and orthodontic appliances, and contributing to periodontal diseases. The high sugar and acid content of these beverages are key factors leading to these complications. Dental professionals play a critical role in educating and advising on improved oral hygiene practices and consumption habits to mitigate these risks. Further, stricter regulations in the production, sale, and marketing of these beverages are needed to curb their detrimental effects on oral health.

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