RELATIONSHIP BETWEEN CONSUMPTION OF SOFT AND ALCOHOLIC DRINKS AND ORAL HEALTH PROBLEMS

Hatice Çetinkaya, Piotr Romaniuk

Department of Health Policy, School of Health Sciences in Bytom, Medical University of Silesia in Katowice, Bytom, Poland

SUMMARY

Objectives: Oral health can affect quality of life in all course of life, which is a key factor of general health. Dental caries, periodontitis and oral cancer are of the highest burden of oral diseases. Rising prevalence of soft drinks and alcoholic beverages consumption due to easy access and socio-demographic altering has increased the concerns on oral health. In this review our purpose was to show effects of the most consumed beverages on oral health in people older than 15 years.

Methods: The review was based on papers published in last 10 years, searched with combined key words related to types of drinks and specific oral health problems. We included 4 older studies due to lack of newer studies on subjected topics.

Results: Sugar-free soft drinks are found less cariogenic and erosive than regular versions in limited number of studies. Alcohol consumption is shown as one of the risk factors of prevalence and severity of periodontitis and is proven to have synergistic effects along with tobacco on oral cancer risk. Consumption of soft drinks and alcoholic beverages was related with tooth loss whether dental caries or periodontal diseases.

Conclusion: There is good evidence for association between soft drinks and oral health problems, but still no clear answer exists about strength of association between sugar-free soft drinks and dental caries. Also the knowledge about influence of alcohol is inadequate. Since consuming style affects erosive potential of drinks manufacturers should be required to add some recommendations on labels about drinking style.

Key words: oral health, dental health, sugar sweetened beverages, alcohol consumption, carbonated drinks consumption

Address for correspondence: P. Romaniuk, Department of Health Policy, School of Health Sciences in Bytom, Medical University of Silesia in Katowice, Piekarska 18, 41-902 Bytom, Poland. E-mail: promaniuk@sum.edu.pl

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INTRODUCTION

Oral health can affect quality of life, which is a key factor of overall health and well-being. According to WHO definition oral health is "a state of being free from chronic mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial well-being." Oral diseases causing pain, discomfort, disfigurement and even death are being identified as the most common noncommunicable diseases (NCDs) (1). Oral disease was identified as a "silent epidemic" by former Surgeon General in 2000 (2).

Although people can access the effective prevention and treatment methods, oral health has improved only little over the past two decades (2). In accordance to estimation of the Global Burden of Disease Study 2016, half of the global population (3.58 billion people) are affected by oral diseases. Almost all of them are either largely preventable or can be treated in their early stages (1).

Dental caries (also known as tooth decay or dental cavities) is the most common noncommunicable disease across the world. Approximately, 2.4 billion people suffer from caries of permanent teeth and 486 million children suffer from caries of primary teeth worldwide (1). Treatment of dental caries is expensive, generating costs equal to 5–10% of healthcare budgets in industrialised countries (3).

"The chemical removal of mineral from the tooth structure" defines dental erosion. Origin of erosion are extrinsic (i.e. diet) or intrinsic (i.e. gastroesophageal) (4). Tooth erosion prevalence is high and continuously growing within populations (5).

Globally the 11th most prevalent disease is severe periodontal (gum) disease, which may cause tooth loss. One of the leading ten causes of Years Lived with Disability (YLD) in some high-income countries was severe tooth loss and edentulism (no natural tooth) (1). Oral and pharyngeal cancer ranked eighth in most common neoplasm and the eleventh reason of cancer mortality in Europe (6). Incidence of oral cancer (cancer of the lip and oral cavity) is within the leading three of all cancers in some Asian-Pacific countries (1).

In most high-income countries, around 5% of total health expenditure and 20% of out-of-pocket health expenditure is spent on dental treatment. In most low- and middle-income countries capacities of healthcare systems for oral health care are insufficient. Like other NCDs, unhealthy diet high in free sugars and harmful use of alcohol are among the major behavioural risk factors for oral diseases. Poor oral hygiene also impairs oral health (1).

Across the world, excessive alcohol consumption is attributed to a major public health issue (7). Alcoholics have higher risk of developing dental caries, gingival diseases and oropharyngeal cancers (8).

Soft drinks are one of the most popular beverages across the world (9), being a major source of free sugars in many countries. Free sugars content varies in sugar sweetened beverages (SSBs) but many popular carbonated beverages contain over 10 g/100 mL (3). Sugar-free soft drinks contain natural or artificial sweeteners instead of sucrose (10). Energy drinks are a kind of soft drinks, that include some forms of vitamins and other chemicals that increase energy for a very short term. Increasing physical resistance and the state of alertness are reasons of the increasing consumption of these drinks. Also, they can elevate concentration, stimulate metabolism and help to eliminate harmful substances from the body (11).

In literature, there are many studies for analysing effects of soft drinks on dental health, but most of the studies focused on children and adolescents. In this review, our aim is to assess the relationship between different kinds of cold beverages and oral health in people above 15 years of age. We mostly focused on effects of alcohol, regular and diet soft drinks on dental caries, tooth erosion, periodontitis, oral cancer, and tooth loss.

MATERIALS AND METHODS

In this study we focused on associations between oral health and consumption of alcohol and soft drinks. Periodontitis, tooth loss, oral cancer, root caries, and tooth erosion were included in this review. We applied the method of narrative review, having decided to browse the PubMed database using the following key words: alcohol AND oral health, beer AND oral health, carbonated drinks AND oral health AND adults, diet soft drinks AND oral health AND adults, energy drinks AND oral health AND adults, soda AND oral health AND adults, soft drinks AND oral health AND adults, sugar sweetened beverages AND oral health AND adults, wine AND oral health, alcohol AND dental health, alcohol AND tooth, oral cancer AND alcohol, energy drinks AND tooth AND adults. The query was performed from 6 to 20 November 2018. We aimed to analyse studies published in the last 10 years, however, we included also 4 older studies, of which the oldest one was published in 1943.

In total, after removing duplicates, we found 84 articles fitting the assumed thematic scope in PubMed database. Additional 6 papers were added based on other sources. After full text screening we excluded 41 of the identified papers, as they focused on people under 15 years, presented animal studies or infrequent oral problems. The final number of papers qualified for review was 43.

RESULTS

Dental Caries

The first study describing influence of fermentable carbohydrates on plaque pH had been conducted by Stephan and Miller (12) in 1943. The Stephan curve defined response to a cariogenic food in mouth (13). Direct association between dental caries and soft drinks has been shown in several studies (13). SSBs are defined as a universal major source for dietary sources of free sugars in most populations. Free sugars content varies in SSBs but many popular carbonated beverages contain over 10 g/100 mL. When free sugars constituted more than 10% of energy intake, dental caries was higher than in case of smaller share. Studies also show that when free sugars were less than 5% of energy intake, dental caries rates were lower than when it was between 5–10% (3).

In 2018, Giacaman et al. (10) compared the cariogenic potential of the sugar-containing drinks with the sugar-free commercial versions of two of the world most highly consumed commercial carbonated beverages (Fanta and Coca-Cola) with Streptococcus mutans biofilms. Authors assessed viable bacteria content in the biofilms after the experimental phase and compared among the different treatments. Sucrose concentration of the commercial carbonated beverages is 10.8% and 12.1% for Coca-Cola and Fanta, respectively. They reported that Fanta and Coca-Cola induced the formation of biofilms with similar and higher strength ($p < 0.001$) than the other treatments.

Sugar-free soft drinks are considered safe for dental caries but these products usually include other fermentable polysaccharides, such as maltodextrins or starches. Giacaman et al. (10) also reported that sugar-free version of the beverages showed lower cariogenic effects than their sugar-containing counterparts ($p < 0.05$), but higher than soda water. The sugar-free beverages could not induce bacterial proliferation.

Burt et al. (14) investigated dental health and diet in 1,021 participants whose household incomes were below 250% of the poverty level, as defined by the US federal government. Soft drink consumption was associated with D1MFS (decayed, missing, and filled tooth surfaces) weakly in bivariate analysis. Due to consumption differences among age (the older adults consumed less than the younger adults), this association was age confounded, so after age-adjustment significant relation between soft drink consumption and D1MFS scores was shown ($p < 0.01$). Soft drink consumption was significantly correlated with prevalence of caries in the full model ($p < 0.05$). In the final model, caries severity was related to age negatively and soft drink consumption positively (14).

Alcoholic beverages, which have acidic characteristic, lead to dental caries by diminishing in salivary pH (8). Niquille et al. (15) showed positive association between alcoholism and dental caries (crude odds ratio = 2.24, 95% CI = 1.15–4.31). Incidence of decayed teeth are more common in alcoholics, which leads to either missing teeth or restoration of teeth. Enberg et al. (16) found that number of missing teeth was higher in alcoholics than non-alcoholics (8). However, a cross sectional study of 458 workers aged 35–44 years showed that there was not significant association between alcohol consumption (no consumption, occasional consumer, weekend consumer, daily consumer) and root caries (17).

Manicone et al. (18) evaluated oral and dental health of twenty-three alcohol use disorders (AUD) patients and twenty-three healthy social drinkers. As compared with controls, oral hygiene scores were lower in alcoholic patients (5.65 ± 0.93 vs. 4.17 ± 1.47, $p < 0.001$). DMFT (decayed, missing, filled teeth) score was significantly higher in AUD patients than controls (14.9 ± 6.6 vs. 7.9 ± 5.0, $p < 0.001$). Significant differences in the community periodontal index (CPI) of treatment needs score (0–1 vs. 2–3–4; $p < 0.001$) and the Silness-Löe plaque index (SLI) score (0–1 vs. 2–3–4; $p < 0.001$) was shown in AUD patients compared

to controls. AUD is associated with increased risk of dental caries. AUD patients visit dentists more irregularly when compared to controls which causes increased decay in tooth surfaces.

Priyanka et al. (19) matched 76 alcoholic patients with non-alcoholics to compare prevalence of dental caries. Alcohol dependent subjects (5.92 ± 2.89) had significantly higher DMFT scores than controls (4.51 ± 2.04). However, decayed and filled components of DMFT have no significant differences among both groups. Alcoholic patients (1.81 ± 2.31) had higher missing component than non-alcoholic subjects (0.65 ± 0.96).

Borrell (20) looked for relation between alcohol consumption and dental health in 477 adults between 1970 and 1990 in Sweden. They found positive correlation between daily alcohol consumption of more than 5 cl and higher number of surfaces with caries ($r2xy|z = 0.16$, $p < 0.01$) after adjustment. When authors excluded subjects who consumed more than 5 cl of hard liquor per day, this association was not significant.

The summarised main findings regarding association between consumption of given types of drinks and dental caries are presented in Table 1.

Periodontitis

Periodontitis is a chronic and long-lasting low-grade inflammatory disease and periodontitis prevalence is particularly high in the adult population (21). According to the latest studies which were made in different parts of the world, the prevalence, extent and severity of the periodontitis is increasing (22).

Several studies indicated that alcohol consumption elevate severity of periodontitis, similar consequences were shown when other lifestyle factors, including smoking, have been adjusted. In 2012, a cross-sectional study found that severity of periodontitis rose with increase in amount of alcohol consumed (23). Gay et al. (24) reported a positive association between alcohol consumption and periodontitis as significant. Also dose-response analysis showed that 1 gram/day increment in alcohol consumption increased by 0.4% the risk of periodontitis.

A population-based cross-sectional study of Bhat et al. (22) on 35−54 years old participants from India showed that prevalence of moderate-severe periodontitis was higher in alcohol consumers (62.4%, 95% CI = 54.2–70.0) than non-alcohol consumers (41.2%, 95% CI = 36.8–45.7). Mean attachment loss was also significantly higher in alcohol consumers. Consumption of alcohol was associated with the severity of periodontitis without statistical significance (2.84, 95% CI = 2.70–2.98). Prevalence, extent and severity of periodontitis was correlated with use of smoking and alcohol only at a bivariate level, but there was no association at a multivariable level.

Susin et al. (25) evaluated the relationship between alcohol consumption and periodontitis among 1,115 subjects aged 18–65 years derived from a representative sample from south Brazil. The periodontitis prevalence was found significantly higher in individuals drinking > 1 glass/d than non-drinkers (OR = 1.94, p = 0.03) after adjusting for age and gender, but not significantly among lower levels of alcohol consumption. When adjusted for age, gender, race, socioeconomic status, dental care, BMI, diabetes and smoking, there was no significant association. However, females drinking > 1 glass/d (> 9.6 g/d of alcohol) were 4 times more likely to have periodontitis compared to non-drinkers even after adjusting for age, race, socioeconomic status, dental care, BMI, diabetes, and smoking (OR = 3.8, p = 0.007). Females who reported drinking > 1 glass/week and ≤ 1 glass/day showed significantly lower risk for periodontitis (OR = 0.49, p = 0.003). Association between alcohol consumption and periodontitis among males was not significant, although among males who reported drinking wine there was a significantly lower chance for having periodontitis than in case of non-drinkers, even after adjusting for other cofactors (OR = 0.17, p = 0.001). Association between drinking wine and periodontitis among females was not significant.

Tezal et al. (26) investigated the association between alcohol consumption and periodontitis in 25–74 years old 1,371 subjects from New York State. The study showed that people who consume ≥ 5 drinks/week have higher OR for gingival bleeding (OR = 1.65, 95% CI = 1.22–2.23) and attachment loss (OR = 1.36,

Table 1. *Impact of given types of drinks consumption on dental caries – summary of findings*

Type of drink	Impact on disease risk	Related articles
Soft drinks	Clear correlation between increased consumption of soft drinks and risk of dental caries.	Giacaman et al., 2018 (10)
		Idris et al., 2016 (13)
		Burt et al., 2006 (14)
		Niquille et al. (15)
Carbonated beverages	Clear correlation between increased consumption of carbonated beverages and risk of dental caries.	Giacaman et al., (10)
		Idris et al., 2016 (13)
Sugar-free carbonated drinks	Lower risk compared to sugar-sweetened drinks but higher compared to soda water.	Giacaman et al., 2018 (10)
Alcohol	A correlation between alcoholism/alcohol use disorders and increased risk of dental caries.	Khairnar et al., 2017 (8)
		Enberg et al. (16)
		Manicone et al., 2017 (18)
		Priyanka et al., 2017 (19)
		Borrell, 2009 (20)
	No significant correlation if consumption below 5 cl of hard liquor daily. No significant correlation between alcohol consumption and root caries.	Saura-Moreno et al., 2017 (17)
		Borrell, 2009 (20)

95% CI = 1.02–1.80) when compared to those who consume less than < 5 drinks/week. Higher gingival bleeding (OR = 1.62, 95% CI = 1.12–2.33) and attachment loss (OR = 1.44, 95% CI = 1.04–2.00) risk was found in ≥10 drinks/week consumers compared to those consuming < 10 drinks/week.

Alcoholic patients (89.61%) had higher prevalence of periodontitis when compared with non-alcoholics (78.67%). Alcohol dependent subjects (2.31 ± 1.68) had higher pockets than non-alcoholic subjects (1.39 ± 1.22). However, non-alcoholic subjects (1.43 ± 1.00) had higher bleeding without pockets than alcoholic subjects, attachment loss up to 4–8 mm was found higher in alcoholic subjects (0.96 ± 1.61) when compared to non-alcoholics (0.43 ± 0.99) (20).

Song et al. (27) analysed association between consumption of carbonated beverages and risk of periodontal disease in 5,517 respondents aged 19–39 years of the Korea National Health and Nutrition Examination Survey (KNANES). They found a positive correlation between carbonated beverages consumption and periodontal disease risk. Adjusted odds ratios of respondents consuming ≤1 per month, ≤1 per week and ≥2 per week were 1.109 (0.804, 1.528), 1.404 (1.035, 1.906), and 1.466 (1.059, 2.029), respectively. Higher risk of periodontal disease was seen in respondents consuming more carbonated beverages and having body mass index lower than 25.

A cross-sectional study was performed for showing association between frequency of soft drinks consumption and risk of periodontal disease in 35–44 years old Taiwanese people. Researchers found increase of adjusted OR from 1.05 (95% CI = 0.92–1.20) for frequency of 3–4 times/week to 1.17 (95% CI = 1.03–1.34) for frequency of ≥ 5 times/week when compared to infrequent intake of soft drinks (≤ 2 times/week) (28).

The summarised main findings regarding association between consumption of given types of drinks and periodontitis are presented in Table 2.

Dental Erosion

"The chemical removal of mineral from the tooth structure" defines dental erosion. Origin of erosion are extrinsic (i.e. diet) or intrinsic (i.e. gastroesophageal). Some, but not all, observational studies show a relationship between acidic beverage consumption and dental erosion (4). In 2012, Li et al. (29), assessed 6 risk factors (including soft drinks, sports drinks, juice, vitamin C, milk, and yoghurt) for the development of dental erosion in their meta-analysis and reported that soft drinks had the statistically significant highest odds ratio (2.41).

Zimmer et al. (5) analysed the mass loss of enamel and dentine after exposure to different non-alcoholic drinks in bovine teeth for evaluating erosivity of common non-alcoholic drinks. Coca-Cola and Coca-Cola light showed the least enamel and dentine mass losses after seven days ($p < 0.001$). Sprite appeared to be about five times more erosive than Coca Cola light.

Idris et al. (13) analysed sugar and pH of ten popular brands of soft drinks (6 regular carbonated drinks and 4 energy drinks) in 2016. They found that energy drinks have higher concentration of glucose, labelled and estimated sugar than the regular carbonated drinks which were statistically significant. Although insignificantly, fructose content is higher in energy drinks than in carbonated drinks, but pH for both drinks were 2.9 and 2.8, respectively.

Pinto et al. (11) analysed 11 different energy drinks with different applications in in vitro study for evaluating influence of energy drinks on removing smear layer and subsequent dentinal tubules exposure on root surface. The lowest and highest level of Ph among energy drinks was shown in Sports Drink (2.52 ± 0.11) and Red Bull (3.81 ± 0.21), respectively. Effects of energy drinks on smear layer removal between the following groups were: Flying Horse and control ($p < 0.05$); Bug and control ($p < 0.001$). Army Power energy drink could not remove the smear layer followed topical application. The study showed that energy drinks are aetiological factor for cervical dentine hypersensitivity.

Ehlen et al. (4) investigated in vitro erosion potential of the commercial beverages using extracted human permanent teeth. Lesion depths produced in enamel during exposure to Red Bull and Coke were more erosive than Diet Coke. Lesion depths produced in root surfaces were in order: Red Bull, Coke, and Diet Coke. Following exposure to Red Bull lesion depths were observed greater in root than in enamel surfaces. Authors found that the erosion followed exposure to beverages.

According to the manufacturer, both sugar-free and regular versions of the commercial carbonated beverages contain carbon dioxide, phosphoric and citric acids. Giacaman et al. (10) observed that both sugar-free and regular products have significantly higher demineralisation effect compared to the 0.9% NaCl negative

Table 2. *Impact of given types of drinks consumption on periodontitis – summary of findings*

Type of drink	Impact on disease	Related articles
Soft drinks	Rising risk of periodontitis along with increasing consumption of soft drinks.	Fann et al., 2016 (28)
Carbonated beverages	Rising risk of periodontitis along with increasing consumption of carbonated drinks.	Song et al., 2016 (27)
Alcohol	A correlation found between alcohol consumption and risk, prevalence and severity of periodontitis. The effect is rising along with the amount of alcohol consumed.	Borrell, 2009 (20)
		Lee et al., 2016 (21)
		Bhat et al., 2018 (22)
		Lages et al., 2012 (23)
		Gay et al., 2018 (24)
		Tezal et al., 2001 (26)
	No statistically significant rise of prevalence in case of lower levels of alcohol consumption. Decreased risk in case of males declaring drinking wine compared to non-drinkers.	Susin et al., 2015 (25)

control. The highest demineralisation among the treatments was seen in Fanta, being higher than sucrose ($p < 0.001$), but similar to Coca-Cola. Sugar-free version of the beverages led to lower demineralisation than regular versions ($p < 0.05$), but higher than soda water (10).

De Carvalho Sales-Peres et al. (30) studied effects of acid type (e.g. phosphoric acid or citric acid) buffer capacity and adhesion on the erosive properties of different kinds of drinks. They found that length of time the teeth are bathed in the acidic environment is more pivotal to erosion compared to the volume of beverage consumption. When consumed carbonated beverages holding in the mouth length of time is longer than non-carbonated drinks.

Increased buffering capacity of a beverage increases its erosive effect. The highest and lowest buffering capacity was shown in Sprite Light and Coca-Cola, respectively. Despite higher pH (3.6) of Sprite Light than Coca-Cola (pH = 2.9), they influenced %SMHC closely, which may be explained with higher buffering capacity of Sprite Light. But positive association between the %SMHC and buffering capacity of the drinks was not significant. The %SMHC was negatively correlated with pH ($p > 0.05$). The %SMHC was not affected by low concentrations of fluoride in the drinks. Sprite Light showed the highest fluoride concentration and the highest %SMHC.

Effects of frequency and type of soft drinks on dental erosion was analysed in 400 people 18–25 years old in a cross-sectional descriptive study. Daily soft drinks consumers had higher erosion than weekly consumers. Participants who consumed only carbonated soft drinks had greater erosion index values compared to those who consumed only non-carbonated soft drinks without significant differences among genders (31).

Khamverdi et al. (32) hypothesised that temperature of the soft drinks can affect enamel erosion due to its ability to alter the solubility of solutes. They evaluated influence of common diet and regular Coca-Cola on enamel erosion using microhardness method in refrigerator (2°C) and room temperatures (20°C) for 20 minutes, 3 times per day for 7 days. Although enamel erosion was not affected by temperature of the beverages, diet Coca-Cola was found to be more erosive compared to the regular type.

In 2014 George et al. (33) analysed association between wine and tooth erosion in 25 male professional wine tasters in Australia. Erosion index significantly correlated with years of wine tasting (0.42rs) and age of participants (0.43rs). With statistical significance, participants who have more than 10 years' experience ($n = 13$) had more erosion than those with shorter experience (erosion indexes were 2.31 ± 0.90 and 1.53 ± 0.74, respectively).

The summarised main findings regarding association between consumption of given types of drinks and dental erosion are presented in Table 3.

Oral Cancer

One of the potential risk factors of oral cancer is alcohol drinking, which is more risky when consumed along with tobacco (8).

Petti et al. (34) in 2012 analysed risk of oral cancer in 16 case control studies, which excluded smoking/betel-quid chewing drinkers. They found that odds ratio in case of drinking (95% CI = 0.677–0.914) was lower than in case of smoking combined with drinking (95% CI = 4.069–4.927) or smoking (95% CI = 2.010–2.519), so the interaction contrast ratio (ICR) was 2.444 (95% CI = 2.385–2.494). Because of drinking-smoking

Table 3. *Impact of given types of drinks consumption on dental erosion – summary of findings*

Type of drink	Impact on disease	Related articles
Soft drinks	Increased risk of dental erosion along with rising consumption of soft drinks.	Ehlen et al., 2008 (4)
		Idris et al., 2016 (13)
		Li et al., 2012 (29)
		Kannan et al., 2014 (31)
Carbonated beverages	Increased risk of dental erosion along with rising consumption of carbonated drinks. Evidenced to have higher erosive effect compared to non-carbonated drinks.	Ehlen et al., 2008 (4)
		Zimmer et al., 2015 (5)
		Giacaman et al., 2018 (10)
		Idris et al., 2016 (13)
		Kannan et al., 2014 (31)
	Length of time of holding drink in mouth found to have stronger erosive effect than the volume of consumption. Carbonated drinks found to be held in mouth longer than non-carbonated ones.	de Carvalho Sales-Peres et al., 2007 (30)
Sugar-free carbonated drinks	Increased risk of dental erosion along with rising consumption of sugar-free carbonated drinks. The effect is weaker than in case of regular versions of drinks.	Ehlen et al., 2008 (4)
		Giacaman et al., 2018 (10)
		Idris et al., 2016 (13)
	Diet Coke found to be more erosive compared to regular version.	Khamverdi et al., 2013 (32)
Energy drinks	Increased risk of dental erosion along with rising consumption of energy drinks.	Ehlen et al., 2008 (4)
		Pinto et al., 2013 (11)
		Idris et al., 2016 (13)
Alcohol	Wine tasters with longer experience and higher age found to have significantly higher erosion compared to younger and less experienced.	George et al., 2014 (33)

multiple exposure, attributable proportion (AP) was 54.6% (95% CI = 50.6–58.6).

Ferreira Antunes et al. (35) showed that drinking was not independently associated with oral/oropharyngeal cancer (OR = 0.78, 95% CI = 0.48–1.27) in a large case-control study despite significant association of joint effect of drinking and smoking.

Muwonge et al. (36), evaluated effects of drinking and other habits on risk of oral cancer using a nested case-control design on data derived from a randomised control trial conducted between 1996 and 2004 in Trivandrum, India. They found increased oral cancer risk among the males who reported drinking alcohol when adjusted for the other two habits without statistical significance (OR = 1.4, 95% CI = 0.9–2.0). Non-significant elevated risk of oral cancer was reported among both past and current male drinkers similarly. Participants who consume any type of alcohol showed increased effect without statistical significance. Increased amount and duration (years) of alcohol consumption correlated with increased risk of oral cancer. Dose-responses were shown for both frequency (day/week) (p for trend = 0.050) and duration (p for trend = 0.010) of drinking.

The ICARE study analysed correlation of lifelong alcohol drinking and incidence of oral cavity cancer in 772 oral cavity cancer cases and 3,555 controls in France. This study showed no association between risk of oral cavity cancer and duration of alcohol consumption, time since stopping drinking or age at starting drinking after adjustment with tobacco consumption (quantity, duration and status). However, lifetime cumulative quantity of alcohol increased risk of oral cavity cancer. The OR for oral cavity cancer was 3.2 (95% CI = 2.1–4.8) in individuals drinking more than 4.5 glasses of alcohol per day. No significantly increased risk was found in people who consumed less than 4.5 glasses per day. Furthermore, consumption of 2 or less glasses of alcohol per day was negatively associated with oral cavity cancer risk. Although moderate and heavy beer drinkers had increased risk for oral cavity cancer, just heavy drinkers of wine and spirits had increased risk (37).

Meta-analysis by Bagnardi et al. (38) investigated association between light alcohol drinking and cancer, having included 23 case-control or cohort studies published as original articles about oral cavity and pharynx cancer. The study shows that RR for oral cavity and pharynx cancer was 1.17 (95% CI = 1.06–1.29) in low alcohol consumption. Deaths of 3,521 males and 1,359 females from oropharyngeal cancer was estimated as possibly being due to light drinking.

Another meta-analysis which included 49 studies (18,387 cases) showed that overall RR of drinking was 2.55 (95% CI = 2.15–3.02) when compared to non- or occasional drinking. The overall RRs of moderate consumption of alcohol were 1.28 (95% CI = 1.08–1.51) for men and 1.17 (95% CI = 0.92–1.49) for women. Although no significant differentiation was found among genders, overall RR of heavy drinking was 5.40 (95% CI = 4.49–6.50) when compared to non- or occasional drinking. The pooled RRs for drinking were 1.32 (95% CI = 1.05–1.67) in never/non-current smokers and 2.92 (95% CI = 2.31–3.70) in smokers when compared with non- or occasional drinking. Overall RRs for any drinking without adjusting for smoking were 2.12 (95% CI = 1.37–3.29), 2.43 (95% CI = 1.92–3.07), 2.30 (95% CI = 1.78–2.98) for only intakes of wine, beer and spirits, respectively (39).

Wine contains phytochemicals and ethanol, where the former has protective effects and latter has harmful effects on oral carcinogenesis. Effects of phytochemicals in wine on cancer risk is unclear, probably due to poorly absorption and low level of them. Despite the still existing gaps in literature about light wine drinking, overall and heavy wine drinking was associated with increased RR for oral cancer (40). The pooled RRs for heavy drinking was found 4.92 (95% CI = 2.80–8.65) for wine when compared with non- or occasional drinking (39).

Ren et al. (9) showed that there is not any dose-response relationship between soft drink consumption and risks of upper gastrointestinal tract cancer (including cancers of the oral cavity, pharynx, larynx, oesophagus, and stomach) in their 2010 cohort study. Hazard ratios (95% CIs) for oral cavity cancer in people who did not drink carbonated soft drinks, for drinking ≤ 1 can/week, 2–6 cans/week, and ≥ 1 can/day were 0.62 (0.46, 0.85), 0.66 (0.49, 0.89) and 0.77 (0.54, 1.09), respectively (p for trend = 0.31).

The summarised main findings regarding association between consumption of given types of drinks and oral cancer are presented in Table 4.

Table 4. *Impact of given types of drinks consumption on oral cancer – summary of findings*

Type of drink	Impact on disease	Related articles
Soft drinks	No correlation found between oral cancer and soft drinks consumption.	Ren et al., 2010 (9)
Alcohol	Correlation between alcohol consumption and oral cancer risk found but without statistical significance.	Muwonge et al., 2008 (36)
	Clear correlation between increased consumption of alcohol and risk of oral cancer found when drinking combined with tobacco consumption.	Khairnar et al., 2017 (8)
		Petti et al., 2012 (34)
	Increased risk found in case of regular alcohol drinkers compared to non- or occasional drinkers. The effect significantly stronger when combined with tobacco consumption.	Turati et al., 2013 (39)
	Increased risk of oral cancer in case of light drinkers.	Bagnardi et al., 2013 (38)
	No influence of sole alcohol consumption on oral cancer incidence.	Ferreira et al., 2013 (35)
	Increased risk of oral cancer in case of consuming more than 4.5 glasses per day. No correlation below this threshold. No correlation with duration of consumption or age of starting drinking or time since stopping drinking.	Radoi et al., 2013 (37)
	Decreased risk in case of consuming 2 glasses or less per day.	

Tooth Loss

Kim et al. (41) in a cross-sectional study evaluated associations between tooth loss (0, 1–5, > 6 teeth) and frequency of SSBs consumption (0, 0–1, 1–2, > 2 times/day) of 22,526 US adults aged 18–39 years. The study showed that at least one permanent tooth loss was reported by approximately 26% of participants, which was associated with frequency of SSB intake.

After adjustment for sex, age, race/ethnicity, annual household income, education, marital status, recent dental visit, diabetes, and smoking status, there was an association between permanent tooth loss and frequency of SSB consumption. Losing 1–5 teeth odds were higher in participants who consumed SSBs 0–1 times/day (OR = 51.44, 95% CI = 51.16–1.79), 1–2 times/day (OR = 51.58, 95% CI = 51.25–1.99), and > 2 times/day (OR = 51.97, 95% CI = 51.51–2.58) compared with non-SSB consumers. Adults drinking SSBs 1–2 times/day (OR = 52.20, 95% CI = 51.15–4.22) and > 2 times/day (OR = 52.81, 95% CI = 51.37–5.76) had higher odds for losing more than 6 teeth compared with non-SSB consumers.

Wiener et al. (42) used data from the 2012 Behaviour Risk Factor Surveillance System questionnaire in USA (N = 95,897; 14,043 who had diabetes mellitus and 81,854 who did not have diabetes mellitus). In this cross-sectional study, they showed that SSB consumption was significantly associated with permanent teeth extracted among participants who had DM and who did not have DM ($p < 0.001$). Among participants who consumed 1–2 SSBs daily, 19.3% had at least 6 teeth extracted. Participants drinking 2 or more SSBs per day had likely higher odds for having 6 or more teeth extracted (AOR = 1.24, 95% CI = 1.02–1.52, $p = 0.0352$).

Heegaard et al. (43) examined 783 community-dwelling participants 65–95 years old in terms of effects of type and amount of specific alcohol consumption on missing teeth in a cross-sectional study between 1976–2003 in Denmark. Odds of having fewer than 20 teeth was lower in women who reported moderate and heavy amounts of alcohol consumption than abstainers with adjusted odds ratio for moderate drinkers and heavy drinkers 0.40 (95% CI = 0.22–0.76); 0.34 (95% CI = 0.16–0.74), respectively. Despite no association for men, women who consumed low amount of alcohol weekly and who were abstainers had lower number of teeth. Lower odds for having a lower number of teeth in female wine drinkers was with women who consumed more than six glasses of wine per week (adjusted OR = 0.44, 95% CI = 0.20–0.96). Women who preferred to drink wine had lower odds for having few teeth compared with abstainers (adjusted OR = 0.41, 95% CI = 0.22–0.77). Men who consumed more than six beers per week showed borderline significant lower odds of having a low number of teeth. Men beer drinkers had lower odds of having fewer teeth than abstainers (adjusted OR = 0.26, 95% CI = 0.07–0.93). Previous studies shown that tooth loss is majorly due to dental caries in young adults, but in this study authors could not differentiate the reason among dental caries or periodontal disease.

The summarised main findings regarding association between consumption of given types of drinks and tooth loss are presented in Table 5.

CONCLUSIONS

In this article our purpose was to review the existing literature and determine the current state of knowledge on the effects of the most commonly consumed drinks on oral health in people older than 15 years. Additionally, we addressed the consumption of alcohol, which can also affect oral health, as evidenced in research.

We found that association between consumption of soft drinks and oral health shows itself as evident, especially in terms of correlation between consumption of sugar sweetened beverages and carbonated drinks and some particular oral health problems like dental erosion, dental caries and tooth loss. Effects of soft drinks on dental caries are explained by sugar content and acidity. This association is less clearly visible in case of sugar-free soft drinks, which contain other polysaccharides and have different pH level than regular versions, although the negative effect tends to appear also in this case. The acidity of soft drinks is also associated with tooth erosion.

An important observation is that energy drinks are more erosive compared to other commercial soft drinks. Length of time of holding drink in the mouth, type of acids content and duration of consumption can affect strength of the erosive effect as well. Like in case of dental caries, some evidence has been delivered that diet soft drinks have weaker erosive effect than in case of the regular versions.

The negative effect of alcohol on tooth condition appears as evidenced in some studies, especially when consumed regularly and for a long time, but the association here turns to be less unambiguous. In case of periodontitis the association between its prevalence and alcohol consumption is particularly intensively investigated, and the existence of such association is proven in numerous studies. However, there is a tendency for differences in results to appear when adjusted for gender, tobacco consumption, types of alcoholic drink, and consumption amount. In consequence, we cannot determine the uniqueness of this relationship, neither the actual type of correlation between alcohol consumption and periodontitis. In turn, alcohol consumption remains connected with the prevalence of oral cancer, particularly in case of heavy drinking. Association between wine consumption and oral cancer is still disputable, and there are deficiencies in recent studies on light drinking. Like in case of periodontitis, drinking pattern, diet and other risk factors such as tobacco consumption seem to have important role in cancer incidence.

Based on our review we can conclude that although there is good evidence for association between soft drinks and oral health

Table 5. *Impact of given types of drinks consumption on tooth loss – summary of findings*

Type of drink	Impact on disease	Related articles
Soft drinks	Tooth loss risk found rising along with increasing sugar sweetened beverages consumption.	Kim et al., 2017 (41)
		Wiener et al., 2017 (42)
Alcohol	Alcohol drinking women found to have lower risk of tooth loss than abstainers. In case of men no statistically significant correlation found.	Heegaard et al., 2011 (43)

problems, still a number of gaps in knowledge exist. We found that the current knowledge does not give clear answer to the question about strength of association between sugar-free soft drinks and dental caries. Although they were generally found less erosive than regular versions, more evidence-based data are required for a better justification. Also the knowledge about influence of alcohol seems to be inadequate and we particularly suggest more studies to investigate effects of light wine drinking, as well as other alcoholic beverages consumption on dental erosion and tooth loss, where, according to our best knowledge, evidence is still unclear due to other confounder factors at different life stages.

Despite the existing gaps in knowledge, what we already know proves that there is a clear necessity for particular preventive actions. Since consuming style can affect erosive potential of drinks apart from amount and frequency of consumption, manufacturers of beverages should be required to add some recommendations on labels about drinking style. More information about pH level of beverages and warning people about consequences should also be recommended.

Authors' Contribution

HC and PR discussed the idea of the study and together outlined the study design. PR determined the methodology, HC performed the query in databases, as well as drafted the paper. HC and PR together agreed on the main conclusions and PR prepared the final version of paper.

Conflict of Interests

None declared

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