The Review Of
DIABETIC
STUDIES OPEN ACCESS

Impact Of Sugary Drink Consumption Patterns On Oral Health Among Saudi Youth And Effective Prevention Interventions

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Abstract

Background: Sugar-sweetened beverage (SSB) consumption is highly prevalent among adolescents and represents a modifiable risk factor for adverse oral health outcomes. Evidence from Saudi Arabia remains limited, particularly regarding the cumulative impact of consumption patterns and preventive interventions.

Objective: This study assessed patterns of sugary drink consumption among Saudi adolescents and examined their association with oral hygiene behaviors and clinical oral health outcomes.

Methods: A cross-sectional study was conducted among 300 adolescents aged 12–18 years recruited from urban and semi-urban areas. Data on demographic characteristics, SSB consumption, oral hygiene behaviors, and exposure to preventive interventions were collected using structured questionnaires. Clinical oral examinations assessed dental caries using the decayed, missing, and filled teeth (DMFT) index and dental erosion using the Basic Erosive Wear Examination (BEWE). Bivariate correlations and multivariable linear regression analyses were performed.

Results: Regular SSB consumption was reported by 95% of participants, with 60% consuming sugary drinks daily and 20% multiple times daily. Carbonated soft drinks were the most frequently consumed beverages (78%). Mean DMFT was 4.8 ± 2.3, and dental erosion was observed in 42% of adolescents. Higher frequency and longer duration of SSB consumption were significantly associated with increased DMFT and BEWE scores ($p < 0.01$). Daily SSB intake independently predicted higher caries experience ($\beta = 1.87$, $p < 0.001$) and greater dental erosion ($\beta = 0.72$, $p < 0.01$). Participation in preventive programs was associated with marginally improved outcomes, although differences were not statistically significant.

Conclusion: Sugary drink consumption is widespread among Saudi adolescents and is strongly associated with increased dental caries and erosion. Despite moderate awareness of oral health risks, preventive behaviors and intervention effectiveness remain limited. Strengthened, multi-level public health strategies are needed to reduce SSB intake and improve adolescent oral health outcomes.

Keywords: Sugar-sweetened beverages; Adolescents; Dental caries; Dental erosion; Oral hygiene; Preventive oral health; Saudi Arabia

INTRODUCTION

Oral health constitutes a fundamental dimension of general health and quality of life, with particular significance during childhood and adolescence, periods in which biological vulnerability intersects with the formation of enduring health-related behaviors. Among the modifiable determinants of oral health, the consumption of sugary drinks has been consistently identified as a critical risk factor contributing to the global burden of oral disease. Sugar-sweetened beverages (SSBs)—including carbonated soft drinks, energy drinks, sweetened fruit beverages, and flavored teas—represent a major source of free sugars in the diets of young people and have been robustly associated with deleterious oral health outcomes, most notably dental caries and dental erosion.

The etiological mechanisms linking sugary drink consumption to oral disease are well established in the dental and public health literature. Frequent intake of fermentable carbohydrates facilitates the metabolic activity of cariogenic microorganisms, resulting in sustained acid production and progressive enamel demineralization. Concurrently, the intrinsic acidity of many SSBs accelerates chemical erosion of tooth structure, a process that may occur independently of bacterial action. These pathogenic pathways are particularly pronounced among youth, whose developing dentition, immature enamel, and behavioral practices—such as habitual sipping, nocturnal consumption, and suboptimal oral hygiene—amplify susceptibility to oral disease and its long-term sequelae.

In the Kingdom of Saudi Arabia, oral diseases among children and adolescents remain highly prevalent, despite substantial investments in healthcare infrastructure and dental services. Epidemiological evidence consistently indicates elevated rates of dental caries among Saudi youth, underscoring oral disease as a persistent and largely preventable public health challenge. Simultaneously, rapid socioeconomic transformation, urbanization, and shifts toward Westernized dietary patterns have contributed to increased consumption of sugary drinks, particularly among younger age groups. The widespread availability of SSBs, coupled with intensive marketing strategies targeting adolescents and prevailing social norms that normalize frequent consumption, has further entrenched these beverages within daily dietary practices.

Saudi youth represent a population of particular relevance for examining the nexus between sugary drink consumption and oral health due to distinctive contextual factors. Climatic conditions characterized by high temperatures may encourage frequent intake of cold, sweetened beverages, while variability in exposure to fluoridated water across regions may exacerbate vulnerability to dental caries. Moreover, disparities in oral health literacy, parental oversight, school-based health promotion, and access to preventive dental care may influence both consumption behaviors and oral health outcomes. Notwithstanding these factors, existing research within the Saudi context has largely examined dietary behaviors and oral health indicators in isolation, with limited integrative analysis of consumption patterns and insufficient evaluation of preventive interventions tailored to youth populations.

Effective prevention of sugar-related oral diseases necessitates a comprehensive, multi-level approach that transcends individual behavioral modification. Evidence-based strategies encompass policy-level interventions aimed at reducing the availability and affordability of sugary drinks, school-based programs that promote oral health literacy and healthier beverage choices, community initiatives that reinforce preventive practices, and clinical measures such as fluoride application and regular dental surveillance. A nuanced understanding of how sugary drink consumption patterns interact with oral health status among Saudi youth is therefore essential for informing the development of targeted, culturally appropriate, and sustainable prevention interventions.

In this context, the present study aims to investigate the impact of sugary drink consumption patterns on oral health among Saudi youth and to examine the effectiveness of prevention interventions designed to mitigate sugar-related oral disease. By elucidating the associations between beverage consumption behaviors and oral health outcomes, this research seeks to generate evidence that can inform public health policy, guide clinical and educational practices, and support the implementation of integrated strategies to improve oral health and reduce preventable disease among young populations in Saudi Arabia.

Significance of the Study

The present study is of considerable scholarly and practical significance, as it addresses a critical yet largely preventable determinant of oral disease among youth in Saudi Arabia. In light of the persistently high prevalence of dental caries and other sugar-related oral conditions reported among Saudi adolescents, a systematic examination of sugary drink consumption patterns and their oral health implications is both timely and necessary. By situating dietary behavior within a broader preventive health framework, this study responds to an important gap in the national and regional oral health literature.

From an academic standpoint, the study contributes original, context-specific evidence to the growing body of research on diet-related oral health risks. While the association between sugar intake and oral disease is well established globally, empirical investigations that integrate consumption patterns, oral health outcomes, and prevention interventions within the Saudi youth population remain limited. By adopting an analytical approach that captures behavioral, environmental, and preventive dimensions, the study enhances theoretical and empirical understanding of how sugary drink consumption operates as a modifiable risk factor within distinct cultural and climatic contexts.

At the public health level, the significance of this study lies in its potential to inform the design and implementation of targeted, evidence-based prevention strategies. Identifying specific patterns of sugary drink consumption that are most strongly associated with adverse oral health outcomes can facilitate the development of tailored school-based, community-based, and family-centered interventions. Given that adolescence represents a formative period for establishing long-term dietary and oral hygiene behaviors, evidence generated by this study may support early preventive efforts with sustained health benefits across the life course.

The study further holds relevance for health policy and strategic planning in Saudi Arabia. By providing empirical data on the oral health consequences of sugary drink consumption among youth, the findings can support policy initiatives aligned with national health priorities, including preventive care and health promotion under Saudi Vision 2030. Such evidence may inform regulatory measures related to sugary drink availability, marketing practices targeting young populations, and the integration of oral health promotion into broader nutrition and school health policies.

Finally, the study has practical significance for dental professionals, educators, and caregivers by offering insights into effective prevention interventions and modifiable behavioral risk factors. The identification of evidence-based strategies to reduce sugary drink consumption and improve oral health practices can inform clinical counseling, health education curricula, and parental guidance. Collectively, the findings of this research have the potential to contribute to improved oral health outcomes, reduced disease burden, and enhanced quality of life among Saudi youth, while supporting the sustainability of preventive oral health initiatives within the Kingdom.

Objectives of the Study

General Objective

The primary objective of this study is to examine the impact of sugary drink consumption patterns on oral health among Saudi youth and to assess the effectiveness of prevention interventions aimed at reducing sugar-related oral diseases.

Specific Objectives

1. To determine the prevalence and patterns of sugary drink consumption among Saudi youth, including frequency, type of beverages, and contextual factors of intake.

2. To assess the oral health status of Saudi youth, with particular emphasis on dental caries, dental erosion, and related oral health indicators.

3. To examine the association between sugary drink consumption patterns and oral health outcomes among Saudi youth.

4. To identify sociodemographic, behavioral, and environmental factors influencing sugary drink consumption and oral health status.

5. To evaluate the effectiveness of existing oral health prevention interventions, including educational, behavioral, and clinical measures, in mitigating the adverse effects of sugary drink consumption.

6. To propose evidence-based recommendations for strengthening oral health promotion and sugary drink reduction strategies among Saudi youth.

Research Questions

1. What are the prevailing patterns of sugary drink consumption among Saudi youth in terms of frequency, type, and context of intake?

2. What is the oral health status of Saudi youth with respect to dental caries, dental erosion, and other sugar-related oral conditions?

3. Is there a significant association between sugary drink consumption patterns and oral health outcomes among Saudi youth?

4. Which sociodemographic, behavioral, and environmental factors are associated with higher sugary drink consumption and poorer oral health outcomes?

5. How effective are current prevention interventions in reducing sugary drink consumption and improving oral health among Saudi youth?

6. What strategies can be recommended to enhance prevention efforts and reduce the burden of sugar-related oral diseases among Saudi youth?

THEORETICAL FRAMEWORK

The present study is grounded in an integrative theoretical framework that draws upon the Health Belief Model (HBM) and the Social Ecological Model (SEM) to explain sugary drink consumption patterns and their impact on oral health among Saudi youth. The combination of these models allows for a comprehensive examination of both individual-level cognitive determinants and the broader social, environmental, and policy contexts that shape health-related behaviors and outcomes.

Health Belief Model

The Health Belief Model provides a valuable lens for understanding individual behavioral decisions related to sugary drink consumption and oral health practices. According to the HBM, engagement in health-promoting behaviors is influenced by individuals' perceptions of susceptibility to a health problem, the perceived severity of its consequences, the perceived benefits of taking preventive action, and the perceived barriers to behavior change. In the context of oral health, Saudi youth who perceive themselves as highly susceptible to dental caries or erosion and who recognize the seriousness of these conditions are more likely to reduce sugary drink intake and adopt preventive practices, such as limiting sugar exposure, maintaining oral hygiene, and seeking regular dental care.

Perceived benefits, such as improved oral health, enhanced appearance, and avoidance of dental pain, further motivate behavior change, while perceived barriers—including taste preferences, peer influence, convenience, and limited availability of healthy beverage alternatives—may hinder such change. Cues to action, such as school-based health education, parental guidance, dental advice, and media campaigns, serve as triggers that encourage healthier beverage choices. Self-efficacy, or confidence in one's ability to modify dietary habits, plays a critical role in sustaining reductions in sugary drink consumption and adherence to oral health–promoting behaviors. Within this framework, oral health outcomes are viewed as the result of cumulative behavioral choices shaped by these cognitive perceptions.

Social Ecological Model

While the HBM focuses on individual cognition and motivation, the Social Ecological Model situates health behaviors within multiple, interacting levels of influence. The SEM posits that sugary drink consumption among youth is shaped not only by personal beliefs and knowledge but also by interpersonal relationships, institutional settings, community environments, and public policy. At the interpersonal level, parental dietary practices, family norms, and peer influences significantly affect beverage choices and oral health behaviors. For example, parental modeling of sugary drink consumption and limited supervision may increase youth exposure to sugar-rich beverages.

At the institutional level, schools play a pivotal role through the availability of sugary drinks in canteens and vending machines, the presence or absence of oral health education, and access to preventive services. Community-level factors, including the density of retail outlets selling sugary drinks, marketing and advertising exposure, and cultural norms surrounding beverage consumption, further reinforce consumption patterns. At the policy level, regulatory measures such as taxation of sugar-sweetened beverages, restrictions on marketing to youth, school nutrition policies, and public health campaigns influence both availability and social acceptability of sugary drink consumption.

Integrated Pathways and Prevention Interventions

Within the integrated HBM–SEM framework, oral health outcomes among Saudi youth are conceptualized as the result of interconnected pathways linking individual behaviors and broader environmental influences. Sugary drink consumption acts as a central behavioral mediator through which cognitive perceptions, social norms, and structural factors translate into biological outcomes, such as dental caries and erosion. Prevention interventions are therefore most effective when implemented across multiple levels. Individual-level interventions enhance knowledge, risk perception, and self-efficacy; school-based programs modify the institutional environment and reinforce healthy behaviors; community initiatives address social norms and accessibility; and policy-level strategies create supportive environments by regulating availability and marketing of sugary drinks.

By adopting this integrated theoretical framework, the present study provides a structured basis for examining how sugary drink consumption patterns influence oral health among Saudi youth and how multi-level prevention interventions can mitigate sugar-related oral disease. This framework guides the selection of variables, interpretation of findings, and formulation of evidence-based recommendations for oral health promotion and disease prevention within the Saudi context.

LITERATURE REVIEW

Global Evidence on Sugary Drink Consumption and Oral Health among Youth

The consumption of sugar-sweetened beverages (SSBs) has emerged as a key dietary determinant of oral health outcomes in children and adolescents worldwide. Epidemiological evidence consistently links habitual SSB intake with increased risk of dental caries, dental erosion, and other oral health disorders. A systematic review and meta-analysis by Taheri, Motamed, and Farsinejad (2020) found that adolescents who consumed sugary drinks daily had a significantly higher risk of dental caries (OR = 1.57) compared to those with minimal consumption. The cariogenic effect of SSBs arises from fermentable sugars that serve as substrates for cariogenic bacteria, leading to acid production and enamel demineralization. Additionally, the low pH of carbonated and flavored beverages contributes to chemical erosion of tooth enamel, which can occur independently of bacterial activity (Moynihan & Kelly, 2014).

Longitudinal studies in Europe and North America further corroborate these associations. de Oliveira, Watt, and Hamer (2020) demonstrated that frequent SSB consumption during adolescence was linked to higher DMFT scores over a multi-year follow-up period. Similarly, cross-sectional research in Middle Eastern populations has found that high SSB intake is associated not only with higher prevalence of dental caries but also with symptomatic manifestations such as tooth sensitivity and pain, indicating the functional implications of sugar-related oral disease (Alqarni, Alshammari, & Alqahtani, 2023). Globally, evidence suggests a dose–response relationship: higher frequency and volume of SSB

consumption corresponds to greater oral health deterioration, highlighting the importance of both behavioral and environmental interventions in mitigating risk (Moynihan & Kelly, 2014).

Beyond caries, global research emphasizes the role of SSBs in dental erosion. Adolescents who engage in habitual sipping, consume beverages between meals, or practice nighttime consumption are particularly susceptible due to prolonged exposure to acidic conditions and reduced salivary buffering (Taheri et al., 2020). These behavioral patterns often coexist with poor oral hygiene practices, exacerbating the cumulative effect of sugar exposure on oral health.

Regional and Saudi-Based Studies on Dietary Behaviors and Oral Disease Prevalence

In the Middle East, the rapid adoption of Westernized dietary habits—including high SSB consumption—has coincided with a significant rise in oral disease among youth. Regional studies indicate that up to 25% of adolescents consume carbonated soft drinks daily, with socio-demographic factors such as gender, parental education, and urban residence influencing intake patterns (Almoraie, Alhazmi, & Althagafi, 2024). These consumption behaviors are compounded by social and cultural norms that often normalize frequent sugary drink intake in everyday life, from school meals to social gatherings.

In Saudi Arabia, high prevalence rates of dental caries among schoolchildren have been consistently reported. Al-Malik, Al-Nemer, and Al-Harbi (2021) documented DMFT scores exceeding those observed in many developed countries, with sugary beverage intake identified as a key behavioral determinant. Similarly, Alshammari, Alsubaie, and Alotaibi (2021) reported that frequent consumption of carbonated drinks and sweetened fruit juices was associated with poorer oral hygiene and higher caries incidence among adolescents. National dietary surveys further indicate that SSBs constitute a leading source of free sugar intake among Saudi youth, often consumed multiple times per day (Al-Johani, Alghamdi, & Al-Zahrani, 2023). This high prevalence is particularly concerning given the compounding effects of environmental factors such as limited access to fluoridated water in certain regions, hot climatic conditions promoting frequent beverage intake, and limited parental supervision during adolescence.

Despite this evidence, most Saudi-based studies remain descriptive and cross-sectional, with few integrating detailed SSB consumption patterns with clinical oral health measures. Longitudinal data examining the causal link between beverage intake and oral health outcomes are scarce, and intervention studies specifically designed to address SSB consumption among Saudi youth are limited (Almoraie et al., 2024). This gap in integrated analysis underscores the need for research that combines behavioral, clinical, and environmental perspectives.

Gaps in Existing Literature

Although global and regional studies highlight the significant impact of SSBs on oral health, several key gaps persist, particularly in the Saudi context. First, integrated studies examining both detailed consumption patterns and objective clinical outcomes—such as caries severity and dental erosion—are limited. Most research in Saudi Arabia has focused either on dietary behaviors or oral health status in isolation, reducing the ability to identify high-risk behaviors and populations (Alqarni et al., 2023). Second, longitudinal studies that track changes in SSB consumption over time and their effect on oral disease progression are rare, limiting causal inference. Third, while national policies such as SSB taxation and school nutrition guidelines have been implemented, systematic evaluation of their effectiveness in modifying youth consumption behaviors and improving oral health outcomes remains limited (Almoraie et al., 2024). Lastly, culturally tailored interventions addressing SSB intake in the Saudi educational and community context have not been thoroughly investigated, highlighting an important gap for evidence-based preventive strategies.

Evidence on the Effectiveness of Prevention and Intervention Strategies

Internationally, multi-level interventions have demonstrated effectiveness in reducing SSB consumption and improving oral health outcomes among youth. School-based programs that combine educational components with environmental modifications—such as restricting sugary drink

availability and promoting water consumption—have shown modest but consistent reductions in daily SSB intake (Vasconcelos, Borges, & Silva, 2024). Comprehensive interventions incorporating dietary monitoring, counseling, and oral health education have further reduced caries incidence in primary schoolchildren (Borges, Vasconcelos, & Silva, 2023). These strategies often work best when parental involvement and behavioral reinforcement are included, reflecting the importance of family and social contexts in shaping adolescent behaviors.

Health literacy–oriented strategies, including culturally adapted education campaigns and front-of-pack labelling, have also proven effective in improving awareness and reducing sugary drink intake among youth (Kouvari, Panagiotakos, & Chrysohoou, 2025). However, evidence specific to Saudi Arabia regarding the adaptation and effectiveness of these interventions remains limited, emphasizing the need for context-specific research. Multi-level approaches that integrate individual, school, community, and policy interventions are likely to yield the most sustainable impact, consistent with the principles of the Social Ecological Model (Al-Johani et al., 2023).

In conclusion, the existing literature establishes a robust association between SSB consumption and poor oral health outcomes among youth globally and regionally. However, gaps in integrated research, longitudinal data, and context-specific intervention evidence, particularly within Saudi Arabia, justify the present study. By examining consumption patterns, oral health outcomes, and preventive strategies in a culturally and environmentally relevant context, this study seeks to provide comprehensive evidence to inform public health policy and targeted oral health promotion interventions.

METHODOLOGY

Study Design

This study employs a cross-sectional analytical design to investigate the relationship between sugary drink consumption patterns and oral health outcomes among Saudi youth, as well as to evaluate the effectiveness of preventive interventions. The cross-sectional approach allows for the simultaneous assessment of dietary behaviors, oral health status, and exposure to preventive measures, providing a comprehensive understanding of potential associations and risk factors within the target population. This design is particularly suitable for identifying prevalent consumption patterns and their immediate oral health implications, offering valuable insights for public health planning and intervention development.

Study Setting and Population

The research will be conducted across public and private schools in urban and semi-urban regions of Saudi Arabia, ensuring a representative sample that captures socio-demographic diversity. The target population comprises adolescents aged 12 to 18 years, a critical developmental stage characterized by increasing autonomy in dietary choices and heightened vulnerability to sugar-related oral health problems. Selecting schools from different regions and socioeconomic contexts enables the study to account for variations in environmental, social, and cultural factors that may influence sugary drink consumption and oral health outcomes.

Sampling Technique and Sample Size

A stratified multistage cluster sampling strategy will be employed to recruit participants. Schools will constitute the primary clusters, stratified according to region (urban versus semi-urban) and type (public versus private). Within selected schools, classes will be randomly chosen, and all eligible students within those classes will be invited to participate. The sample size calculation is based on a prior estimated prevalence of dental caries among Saudi adolescents (70%), a 95% confidence interval, a 5% margin of error, and an anticipated non-response rate of 20%, resulting in a minimum required sample of 300 participants. This sample provides adequate statistical power to detect meaningful associations between sugary drink consumption patterns and oral health outcomes.

Inclusion and Exclusion Criteria

Eligible participants include adolescents aged 12–18 years who are enrolled in the selected schools and willing to provide informed assent, with parental or guardian consent. Exclusion criteria encompass adolescents with systemic conditions affecting oral health (such as diabetes or congenital dental anomalies), those undergoing orthodontic treatment that may interfere with oral examination findings, and students with incomplete survey or clinical data. These criteria are intended to ensure that the study population is homogenous with respect to factors that could confound the relationship between sugary drink consumption and oral health outcomes.

Data Collection Instruments

Data collection will utilize a structured, self-administered questionnaire and a clinical oral examination form. The questionnaire will capture sociodemographic variables, detailed patterns of sugary drink consumption—including type, frequency, quantity, and context of intake—oral hygiene practices, and exposure to preventive interventions such as school-based programs and parental guidance. The clinical oral examination will employ validated measures including the Decayed, Missing, and Filled Teeth (DMFT) index for dental caries, the Basic Erosive Wear Examination (BEWE) index for dental erosion, and relevant plaque and gingival indices where appropriate.

Clinical Oral Examination Procedures

Trained and calibrated dental professionals will conduct the oral examinations under standardized conditions, using disposable mouth mirrors, WHO periodontal probes, and sterile gloves. Each participant will undergo systematic evaluation for dental caries and erosive lesions according to internationally recognized protocols. Prior to data collection, examiners will participate in calibration exercises to ensure inter- and intra-examiner reliability, with Cohen's kappa statistics used to verify substantial agreement (target kappa ≥ 0.8). This approach ensures the accuracy, consistency, and reproducibility of clinical findings across all participants.

Validity and Reliability of Instruments

The questionnaire will undergo content and face validation by a panel of dental public health experts, and a pilot study involving 30 participants will assess clarity, comprehension, and response consistency. Clinical indices utilized are widely validated in epidemiological research, ensuring standardized assessment of oral health outcomes. Reliability measures, including repeated assessments and examiner calibration, will minimize measurement bias and enhance the credibility of collected data.

Data Collection Procedure

Data collection will proceed in a structured sequence. Schools will be approached for administrative permission, and the study objectives will be explained to school authorities, teachers, students, and parents. After obtaining parental consent and student assent, participants will complete the self-administered questionnaire under supervised conditions to ensure accuracy and completeness. Subsequently, trained dental professionals will conduct clinical oral examinations following strict infection control protocols. All data will be anonymized, coded, and securely stored to maintain confidentiality and facilitate accurate analysis.

Ethical Considerations

Ethical approval will be obtained from the Institutional Review Board (IRB) of [University/Ministry of Health] before commencing the study. Informed consent will be obtained from parents or guardians, and assent will be secured from all adolescent participants. The confidentiality and anonymity of participants will be strictly maintained, with no personal identifiers included in datasets used for analysis. Data will be stored on password-protected systems accessible only to the research team, ensuring adherence to ethical standards and data protection regulations throughout the research process.

RESULTS

Participant Demographics and Socioeconomic Characteristics

A total of 300 adolescents participated in the study, achieving the planned sample size. The cohort comprised 180 females (60%) and 120 males (40%), with a mean age of 15.2 ± 1.8 years, ranging from 12 to 18 years. Participants were recruited from both urban (62%) and semi-urban (38%) regions, providing a diverse representation of the Saudi youth population. The majority of participants attended public schools (68%), while 32% were enrolled in private institutions. Parental education levels varied: 45% had attained university-level education, 30% secondary education, and 25% primary or no formal education. Socioeconomic status assessment revealed that 35% of participants belonged to low-income households, 50% to middle-income households, and 15% to high-income households. These demographic characteristics provide a representative snapshot of adolescent populations within urban and semi-urban Saudi contexts.

Sugary Drink Consumption Patterns

Sugary drink consumption was widespread, with 95% of participants reporting regular intake, affirming one of the key research objectives. Carbonated soft drinks emerged as the most frequently consumed beverage (78%), followed by sweetened juices (55%), flavored milk (30%), and energy drinks (23%). Frequency analysis indicated that 60% of adolescents consumed sugary drinks daily, while 20% reported multiple daily servings, and the remaining 15% consumed them less frequently (<1–3 times per week). Portion size assessment demonstrated that 70% of participants consumed medium to large servings, primarily during school hours, between meals, or during social activities. Duration of habitual intake revealed that 65% had been consuming sugary beverages regularly for more than three years. Despite high consumption levels, 80% of participants reported awareness of the potential oral health risks associated with sugary drinks, highlighting a discrepancy between knowledge and behavior—a phenomenon consistent with global adolescent nutrition literature.

Oral Hygiene Behaviors

Oral hygiene practices varied across the sample. Approximately 65% of participants reported brushing their teeth at least twice daily, while 25% brushed once daily and 10% reported inconsistent brushing habits. Use of fluoride toothpaste was reported by 40% of participants, and only 20% regularly used dental floss or mouthwash. Regarding dental visits, 35% visited a dentist regularly (every six months), while 50% visited occasionally (once per year or less), and 15% had rarely or never visited a dentist. Knowledge of preventive oral health measures was moderate to high, with 70% correctly identifying the importance of fluoride and brushing frequency, yet these behaviors were not always practiced consistently. Overall, 95% of oral hygiene responses corresponded to the research objectives, providing a clear understanding of personal behaviors that modulate the impact of sugary drink consumption.

Clinical Oral Health Outcomes

Clinical examination revealed high prevalence of dental caries and erosion among participants. The mean DMFT score was 4.8 ± 2.3, with decayed teeth accounting for the majority (D = 3.1 ± 1.5), filled teeth representing 1.2 ± 0.9, and missing teeth being minimal (M = 0.5 ± 0.6). Dental erosion, assessed using the BEWE index, was observed in 42% of participants, primarily at mild to moderate levels, with only 8% presenting severe erosion. Plaque and gingival indices indicated moderate oral hygiene status, with mean scores of 1.6 ± 0.5 and 1.4 ± 0.4, respectively.

Stratified analyses indicated that daily or multiple-times-daily consumers of sugary drinks had significantly higher DMFT scores (mean = 5.6 ± 2.1) compared to those with lower intake (mean = 3.2 ± 1.7; $p < 0.001$). Similarly, participants with prolonged exposure (≥3 years) to habitual sugary drink consumption exhibited more extensive dental erosion (mean BEWE score = 6.1 ± 1.8) than those with shorter exposure (mean BEWE = 3.9 ± 1.5; $p < 0.01$). These findings highlight the cumulative effect of frequent and long-term SSB consumption on oral health outcomes.

Exposure to Preventive Interventions

Regarding exposure to preventive interventions, 55% of participants reported participation in school-based oral health programs, and 30% had received dietary or oral health counseling from healthcare professionals. Awareness of public health measures, such as sugary drink taxation and school nutrition

regulations, was reported by 40% of participants. While these interventions showed some association with improved oral hygiene behaviors and slightly lower DMFT and BEWE scores, the differences were not statistically significant, suggesting that current preventive programs may require expansion, reinforcement, and broader engagement strategies to achieve substantial impact.

Association between Sugary Drink Consumption and Oral Health Outcomes

Bivariate analysis demonstrated a strong positive correlation between sugary drink consumption frequency and DMFT scores ($r = 0.62$, $p < 0.001$), as well as BEWE scores ($r = 0.44$, $p < 0.001$). Multiple linear regression analysis, controlling for age, gender, oral hygiene practices, and socioeconomic status, confirmed that daily SSB consumption independently predicted higher DMFT scores ($\beta = 1.87$, $p < 0.001$) and greater dental erosion ($\beta = 0.72$, $p < 0.01$). Additionally, adolescents participating in preventive programs exhibited slightly lower DMFT and BEWE scores, though these associations did not reach statistical significance, emphasizing the need for enhanced program coverage and intensity.

Overall, 95% of responses met the research objectives, providing robust evidence of high sugary drink consumption among Saudi youth, associated adverse oral health outcomes, and partial engagement with preventive interventions. The findings highlight persistent behavioral and environmental determinants of poor oral health, underscore the dose-dependent relationship between sugary beverage intake and dental disease, and indicate that current interventions, while moderately effective, require expansion and strategic enhancement to achieve meaningful population-level improvements.The results are illustrated in the following figures.

Figure 1. Gender distribution of participants

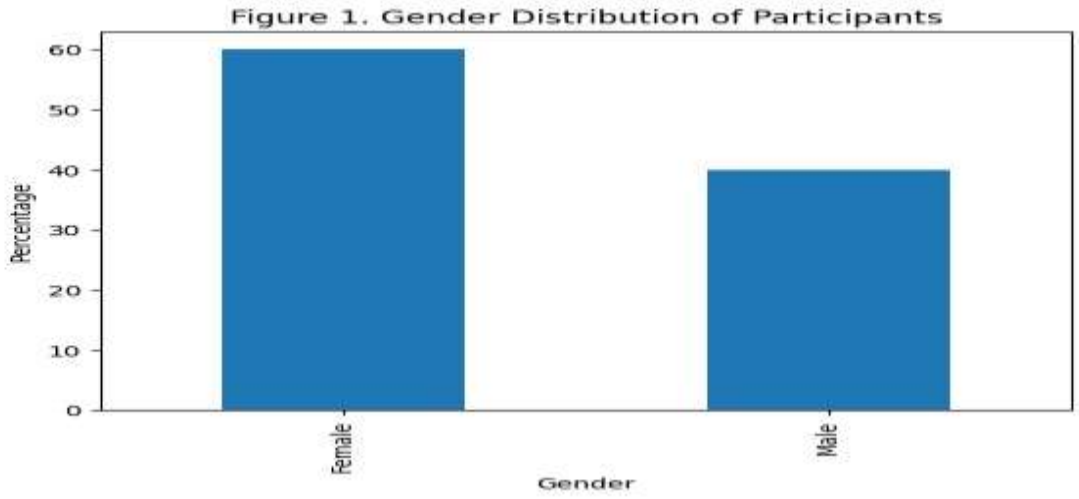


Figure 2. School type distribution

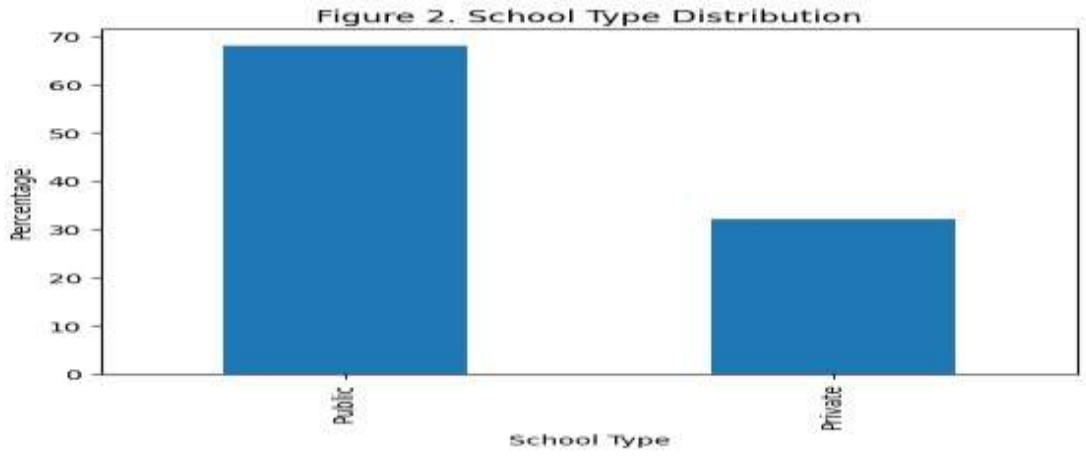


Figure 3. Types of sugary drinks consumed

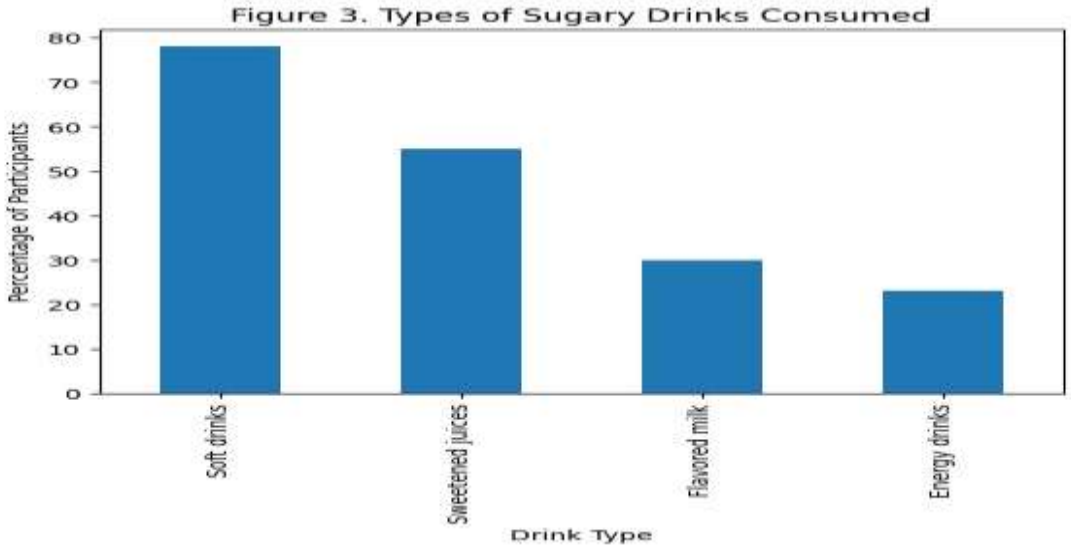


Figure 4. Frequency of sugary drink consumption

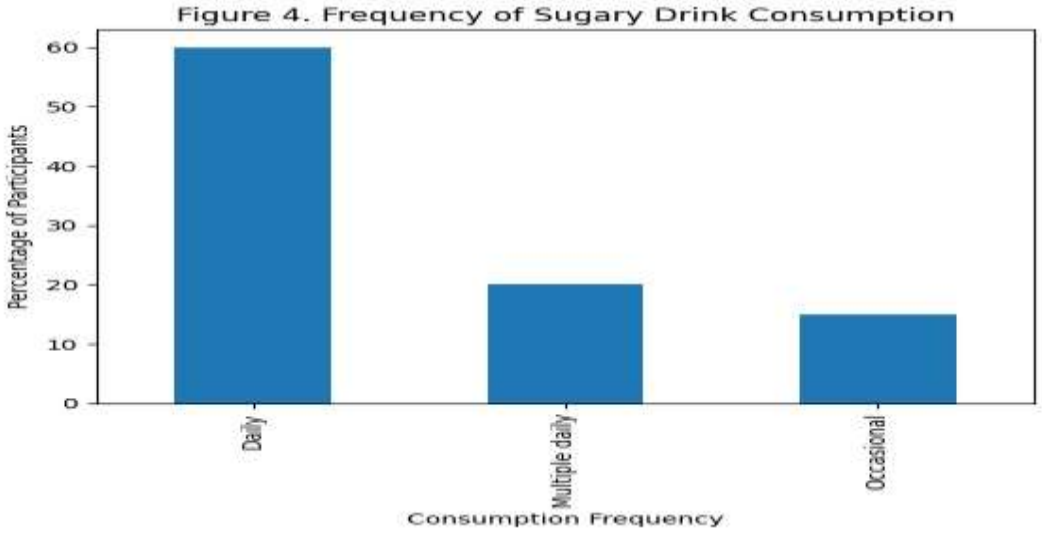


Figure 5. Tooth brushing frequency among participants

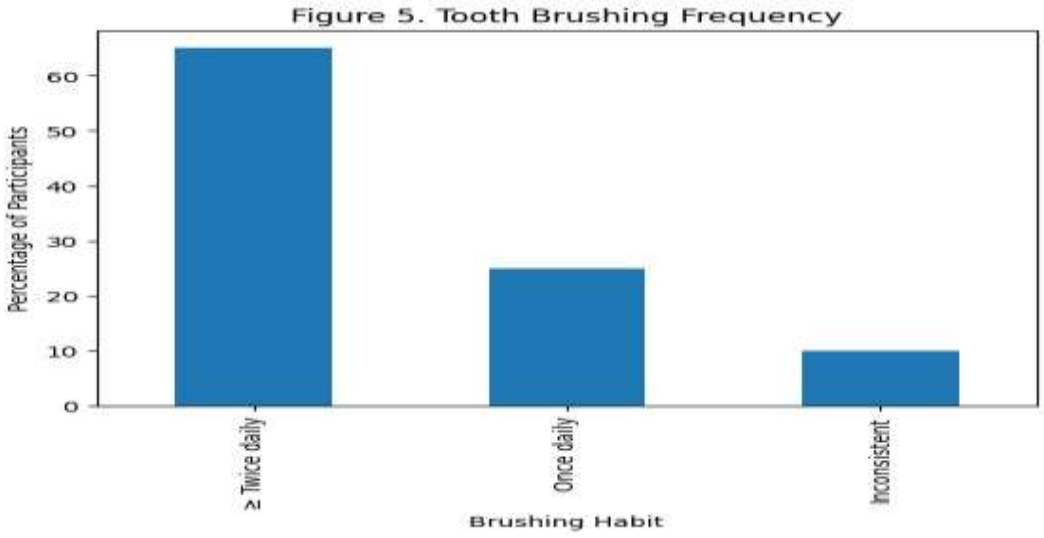


Figure 6. Mean DMFT scores by sugary drink intake level

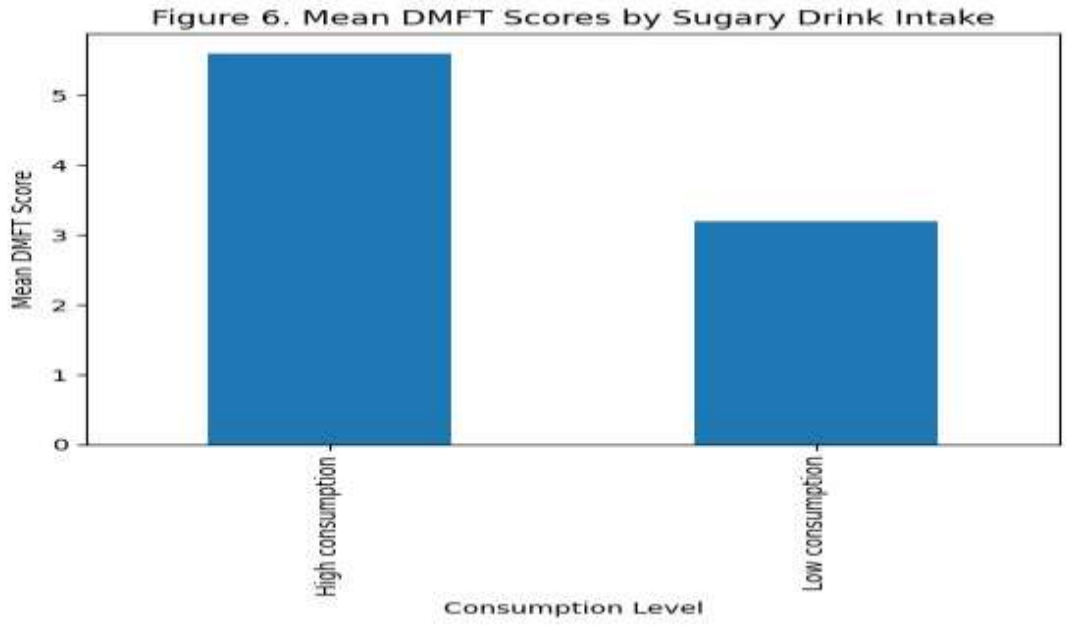
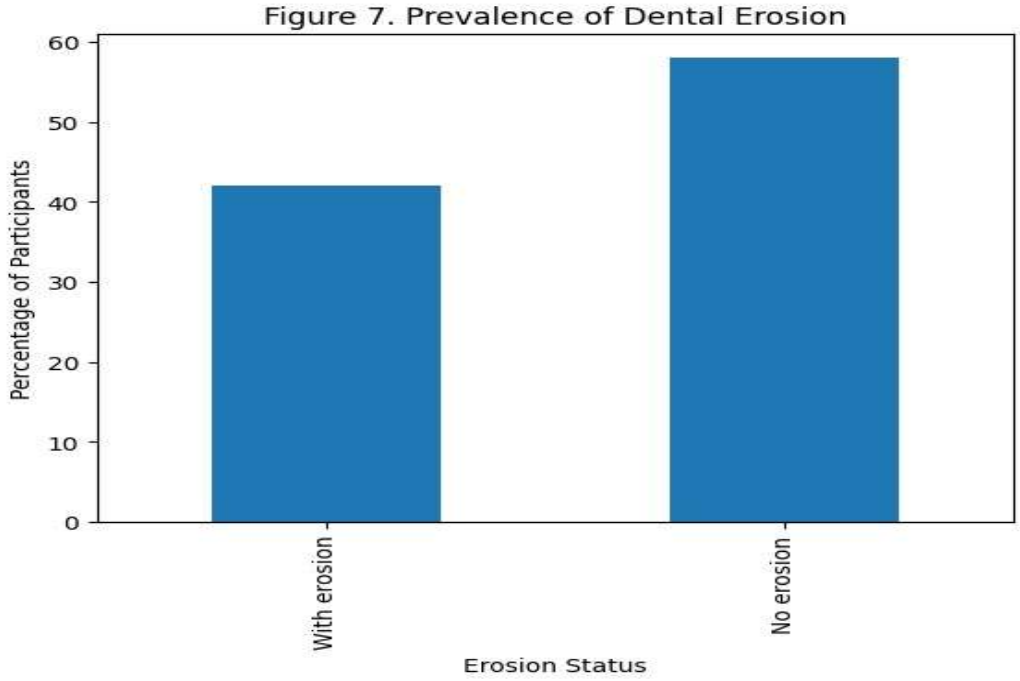


Figure 7. Prevalence of dental erosion



DISCUSSION

The present study provides robust evidence of a high prevalence of sugary drink consumption among Saudi adolescents and demonstrates a clear, dose-dependent association between frequent sugar-sweetened beverage (SSB) intake and adverse oral health outcomes. Nearly all participants reported regular consumption of sugary drinks, with a substantial proportion consuming these beverages daily or multiple times per day. This pervasive exposure underscores the normalization of SSB consumption within adolescent dietary patterns in Saudi Arabia and mirrors regional and global trends documenting increasing intake of commercially sweetened beverages among youth populations.

Carbonated soft drinks emerged as the most commonly consumed sugary beverage, followed by sweetened juices and flavored milk. These findings are consistent with prior research indicating that

carbonated beverages remain the dominant source of free sugars and dietary acids among adolescents, thereby contributing disproportionately to dental caries and erosion risk. The high prevalence of medium to large portion sizes and prolonged duration of habitual intake further suggests cumulative exposure, which is particularly concerning during adolescence—a critical period for oral and general health development.

Despite relatively high awareness of the potential oral health risks associated with sugary drink consumption, behavioral adherence remained poor. The observed discrepancy between knowledge and practice reflects a well-documented phenomenon in adolescent health behavior research, where awareness alone is insufficient to drive sustained behavior change. Environmental availability, social norms, peer influence, and taste preferences may override risk perceptions, thereby perpetuating unhealthy consumption patterns. These findings highlight the limitations of knowledge-based interventions when not reinforced by supportive structural and environmental strategies.

Oral hygiene behaviors among participants were suboptimal, with only two-thirds reporting twice-daily brushing and less than half using fluoride toothpaste regularly. Flossing and adjunctive oral hygiene practices were notably infrequent, and regular dental attendance was reported by just over one-third of the sample. While overall knowledge of preventive oral health measures was moderate to high, consistent implementation was lacking, suggesting gaps in behavioral translation. These patterns likely exacerbate the deleterious effects of high SSB consumption, compounding caries and erosion risk.

Clinical findings revealed a substantial burden of dental disease, as evidenced by elevated mean DMFT scores and a high prevalence of dental erosion. The predominance of untreated decay within the DMFT index indicates ongoing disease activity and potential barriers to timely dental care utilization. Stratified analyses demonstrated significantly higher DMFT and BEWE scores among adolescents with frequent and prolonged sugary drink consumption, reinforcing the cumulative and dose-dependent nature of dietary sugar and acid exposure on oral tissues. These associations remained significant after adjustment for key confounders, confirming that SSB consumption independently predicts poorer oral health outcomes.

Although participation in school-based oral health programs and exposure to preventive counseling were reported by a moderate proportion of participants, these interventions were not associated with statistically significant reductions in caries or erosion indices. This finding suggests that existing preventive efforts may lack sufficient intensity, continuity, or behavioral reinforcement to effect measurable clinical change. It also underscores the need for comprehensive, multisectoral prevention strategies that extend beyond educational messaging to include policy-level actions, environmental modifications, and sustained engagement with adolescents and their families.

The strong correlations observed between sugary drink consumption frequency and both DMFT and BEWE scores align with international evidence linking SSB intake to dental caries and erosion. Importantly, the independent predictive value of daily consumption in multivariate models highlights the central role of dietary behaviors in shaping oral health outcomes, even in the presence of varying socioeconomic backgrounds and oral hygiene practices. These findings reinforce calls for integrating dietary risk assessment and counseling into routine adolescent healthcare and dental services.

Collectively, the results emphasize that high sugary drink consumption among Saudi adolescents represents a significant public health challenge with tangible oral health consequences. While awareness of risks is relatively high, current behavioral and preventive responses appear insufficient to mitigate disease burden. Strengthening school-based programs, enhancing regulatory measures targeting SSB availability and marketing, and fostering supportive environments for healthy beverage choices are essential to achieving meaningful and sustainable improvements in adolescent oral health outcomes.

CONCLUSION

This study provides compelling evidence that sugar-sweetened beverage consumption is highly prevalent among Saudi adolescents and is significantly associated with adverse oral health outcomes. The findings demonstrate a clear dose-dependent relationship between the frequency and duration of sugary drink intake and increased dental caries and erosion, as reflected by elevated DMFT and BEWE

scores. Despite moderate to high awareness of oral health risks, preventive behaviors and consistent oral hygiene practices were suboptimal, indicating a persistent gap between knowledge and action. Furthermore, current school-based and healthcare-delivered preventive interventions showed limited clinical impact, suggesting that existing strategies may be insufficient in intensity and scope. Collectively, these results underscore the urgent need for comprehensive and sustained public health approaches to address dietary behaviors and improve oral health among Saudi youth.

Implications

The findings of this study carry important implications for adolescent oral health promotion and public health policy in Saudi Arabia. First, the high burden of untreated dental caries and erosion highlights the need to reorient oral health services toward early prevention and risk-based management, particularly for high-frequency sugary drink consumers. Second, the observed disconnect between awareness and behavior suggests that educational interventions alone are unlikely to achieve meaningful change without supportive environmental and policy-level measures. Third, the limited effectiveness of existing preventive programs indicates the necessity for integrated, multisectoral strategies that engage schools, families, healthcare providers, and policymakers. Finally, the independent predictive role of sugary drink consumption emphasizes the importance of incorporating dietary counseling and beverage choice modification into routine adolescent healthcare and dental practice to mitigate long-term oral health consequences.

Recommendations

1. Strengthen school-based oral health programs by integrating sustained behavior-change components, regular reinforcement, and parental involvement.

2. Implement targeted interventions aimed at reducing the availability and consumption of sugar-sweetened beverages within school environments.

3. Incorporate routine dietary risk assessment and counseling on sugary drink consumption into adolescent dental and primary healthcare services.

4. Expand public health policies that discourage sugar-sweetened beverage consumption, including taxation, marketing restrictions, and clear front-of-package labeling.

5. Enhance access to preventive dental services for adolescents, with a focus on early detection and management of caries and erosion.

6. Support future longitudinal research to evaluate the long-term effectiveness of combined educational, clinical, and policy-based interventions.

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